

Associations between specific measures of adiposity and high blood pressure in black South African women

M Doubell

10929401

BSc Dietetics, RD (SA)

Mini-dissertation submitted in *partial* fulfillment of the requirements for the degree *Magister Scientiae* in Dietetics at the Potchefstroom Campus of the North-West University

Supervisor: Prof HS Kruger
Co-supervisor: Dr C Botha-Ravyse
Co-supervisor: Dr L Havemann-Nel

April 2015
Potchefstroom

ACKNOWLEDGEMENTS

My sincere gratitude and appreciation go to the following who each contributed to this research project:

To Prof Salome Kruger, my supervisor, for being such a wonderful person, your expertise and experience, your valuable time, knowing you are always available to advise, and the opportunity you gave me to be part of this research study and complete it successfully

To Dr Lize Havemann-Nel and Dr Chrisna Botha-Ravyse, my co-supervisors, for your support and reading my manuscript making sure every page is perfect

To Prof Johannes van Rooyen for your valuable input

To Prof Faans Steyn and Marike Cockeran for your statistical advice and assistance

To Prof Lesley Greyvenstein for your reading and language editing of my manuscript

To all the personnel, colleagues and friends at the Centre of Excellence for Nutrition for your interest and inspiration

To Sr Chrissie Lessing, the manager of the Metabolic Unit, and Sr Sonia Lemmer for measuring blood pressure and offering much needed health advice to the study participants, and Sr Christa Smith at the Department of Health for your assistance with tests

To Magda Uys for your warm, friendly demeanour and your commitment to the DXA measurements

To Lianri Swanepoel and Arista Nienaber, for offering your time and your assistance with the anthropometric measurements

To Ntsako Khoza for your assistance in the anthropometric measurements and capturing all the data

To all the fieldworkers and the whole research team who each played an essential role in this study

To all the study participants without whom there wouldn't have been a research project

To my parents for your support and encouragement while accomplishing this task

To my sister for your understanding, strength, humour, calmness and keeping me grounded and mindful in life's challenging times

Thank you to everyone who instilled in me the thirst for knowledge and wisdom and my love for reading and books

Foremost to God my Father, Your Spirit, and Jesus Christ my Redeemer and Saviour, for Your presence in my mind and heart and soul and daily life, granting me the gifts of intellect and health, showing me all is possible and giving me the strength to overcome obstacles and continue this life's journey, with love, faith and hope. "And He said to me, 'My grace is sufficient for you, for My strength is made perfect in weakness.' For when I am weak then I am strong." – 2 Cor 12:9, 10 NKJV

Two roads diverged in a wood, and I -

I took the one less travelled by,

And that has made all the difference.

- Robert Frost

ABSTRACT

Title: Associations between specific measures of adiposity and high blood pressure in black South African women.

Introduction: The World Health Organisation (WHO) defines overweight and obesity as a condition in which an abnormal or excessive fat accumulation exists to an extent in which health and well-being are impaired. The most recent South African National Health and Nutrition Examination Survey (SANHANES) reported that the prevalence of overweight and obesity, according to body mass index (BMI) classification, in all South African women was significantly higher than in men (24.8% and 39.2% compared to 20.1% and 10.6% for women and men, respectively). Blood pressure is often increased in obese patients and is probably the most common co-morbidity associated with obesity. Currently approximately one third (30.4%) of the adult South African population has hypertension. Hypertension is responsible for a significant percentage of the high rates of cardiovascular disease and stroke in South Africa. Limited South African data are available regarding the agreement between the measures of adiposity, including BMI, waist circumference (WC) and percentage body fat (%BF), and the association with high blood pressure. Measures of adiposity were found in previous research to be ethnicity, age and gender specific. Measuring %BF to classify adiposity takes body composition into account and is a more physiological measurement of obesity than BMI.

Objective: This study aimed to investigate the agreement between adiposity classified by BMI categories and %BF cut-off points, and the association between the different measures of adiposity and high blood pressure.

Method: A representative sample of black women (n=435), aged 29 years to 65 years from Ikageng in the North West Province of South Africa were included in this cross-sectional epidemiological study. Socio-demographic questionnaires were completed. Pregnancy and HIV tests were performed and those with positive test results or those who declined HIV testing were excluded. Weight and height were measured and BMI was calculated. WC, %BF using dual-energy X-ray absorptiometry (DXA), and blood pressure were measured.

Results: The prevalence of overweight (BMI 25.0 kg/m² – 29.9 kg/m²) was 24.4% and obesity (BMI ≥ 30kg/m²) was 52.4%. High blood pressure was found to be present in more than two thirds of the study participants (68.5%). In this study BMI, WC and %BF as measures of adiposity were significantly correlated. There were significant agreements between combined overweight/obesity that was defined by %BF (≥35.8% 29-45 years; ≥37.7% ≥50 years) and BMI

$\geq 25\text{kg/m}^2$ ($\chi^2=199.0$, $p<0.0001$; $\kappa=0.68$, $p<0.0001$), and between the presence of high %BF and obesity only, that was defined by $\text{BMI} \geq 30 \text{ kg/m}^2$ ($\chi^2=129.1$, $p<0.0001$; $\kappa=0.48$, $p<0.0001$). The effect size of the agreement between the WHO BMI category for combined overweight/obesity and %BF cut-off points according to the kappa value of $\kappa=0.68$ was substantial (κ range 0.61-0.80). The effect size of the agreement between the WHO BMI category for obesity only and %BF cut-off points according to the kappa value of $\kappa=0.48$ was moderate (κ range 0.41-0.60). No association was found between high blood pressure and BMI categorised combined overweight/obesity ($\chi^2=3.19$; $p=0.74$), but a significant association was found between high blood pressure and BMI categorised obesity only ($\chi^2=4.10$; $p=0.043$). A significantly increased odds ratio (OR) of high blood pressure existed in the obesity BMI category (OR=1.52; $p=0.045$) as opposed to the overweight/obesity BMI category (OR=1.51; $p=0.075$). There were significant associations between high blood pressure and $\text{WC} \geq 80\text{cm}$ ($\chi^2=10.9$; $p=0.001$; OR=2.08; $p=0.001$), $\text{WC} \geq 92\text{cm}$ ($\chi^2=20.1$; $p<0.0001$; OR=1.79; $p=0.011$) and %BF above the age-specific cut-off points ($\chi^2=6.61$; $p=0.010$; OR=1.70; $p=0.011$).

Discussion and conclusion: This study found that in a sample of black urban South African women significant agreements existed between adiposity defined by %BF cut-off points for combined overweight/obesity and both WHO BMI categorised combined overweight/obesity ($\text{BMI} \geq 25 \text{ kg/m}^2$) and obesity only ($\text{BMI} \geq 30 \text{ kg/m}^2$), respectively. A stronger agreement was found between WHO categorised combined overweight/obesity and %BF. Furthermore, this study concluded that the BMI category according to the WHO cut-off point for overweight/obesity had insufficient sensitivity to detect the presence of high blood pressure, and that the BMI category according to the WHO cut-off point for obesity alone could detect the presence of high blood pressure. The WHO BMI classification for obesity, in contrast to the WHO BMI classification for combined overweight/obesity, is therefore appropriate to classify these black South African women at increased risk for high blood pressure. The WC and %BF cut-off points used which were specific to ethnicity, age and gender, had significant associations with high blood pressure and have good capacity to detect high blood pressure. In this study abdominal obesity as defined by the South African cut-off point of $\text{WC} \geq 92 \text{ cm}$ had a stronger association with high blood pressure, than the international cut-off point ($\text{WC} \geq 80 \text{ cm}$). The South African cut-off point is, therefore, more appropriate to screen black South African women for increased risk for high blood pressure. The study therefore concluded that a stronger agreement was found between WHO categorised combined overweight/obesity and %BF than with obesity only ($\text{BMI} \geq 30 \text{ kg/m}^2$). To ensure consistency and accuracy, and to take body composition into consideration, it is recommended that, where possible, in clinical practice the appropriate WC and %BF cut-off points together with BMI categories should be used as

measures of adiposity for diagnosis of overweight and obesity and to screen or detect an increased risk for high blood pressure.

Key terms: Body mass index, waist circumference, percentage body fat, high blood pressure, urban black women

OPSOMMING

Titel: Assosiasies tussen spesifieke bepalers van adipositeit en hoë bloeddruk onder swart Suid-Afrikaanse vroue.

Inleiding: Die Wêreldgesondheidsorganisasie (WGO) definieer oorgewig en vetsug as 'n toestand waarin abnormale of oormatige vetakkumulering tot so 'n mate voorkom dat gesondheid en welstand benadeel word. Volgens die mees onlangse "South African National Health and Nutrition Examination Survey (SANHANES)" is die voorkoms van oorgewig en vetsug, volgens die klassifikasie deur liggaamsmassa-indeks (LMI), in alle Suid-Afrikaanse vroue beduidend hoër as in mans (24.8% en 39.2% in vergelyking met 20.1% en 10.6%, respektiewelik). Bloeddruk is dikwels verhoog in vetsugtige pasiënte en is moontlik die mees algemene komorbiditeit wat met vetsug geassosieer word. Tans is ongeveer 'n derde (30.4%) van die volwasse Suid-Afrikaanse bevolking aan hipertensie. Hipertensie is vir 'n beduidende persentasie van die hoë vlakke van kardiovaskulêre siekte en beroerte in Suid-Afrika verantwoordelik. Daar bestaan beperkte Suid-Afrikaanse data oor die ooreenkoms tussen die bepalers van adipositeit, insluitende LMI, middelomtrek (MO) en liggaamsvetpersentasie (LV%) en die assosiasie met bloeddruk. Vorige navorsing het bevind dat die bepalers van adipositeit etnisiteit-, ouderdom- en geslagspesifiek is. Die bepaling van LV% om adipositeit te klassifiseer neem liggaamsamestelling in ag en is 'n meer fisiologiese bepaler van vetsug as LMI.

Doelstelling: Hierdie studie se doel was om die ooreenkoms tussen LMI kategorieë en %LV afsnyppunte as adipositeitklassifikasie te bepaal, asook om die assosiasie tussen die verskillende bepalers van adipositeit en hoë bloeddruk te bepaal.

Metode: 'n Verteenwoordigende steekproef van swart vroue (n=435), 29 tot 65 jaar oud, vanaf Ikageng in die Noordwes provinsie van Suid-Afrika, is in hierdie dwarsdeursnit epidemiologiese studie ingesluit. Sosio-demografiese vraelyste is voltooi. Swangerskapstoetse en MIV toetse is gedoen en diegene met positiewe toetsuitslae of wat MIV-toetsing geweier het, is uitgesluit. Gewig en lengte is gemeet en LMI is bepaal. MO, LV%, deur middel van dubbel-energie X-straal absorpsiometrie (DXA), en bloeddruk, is gemeet.

Resultate: Die voorkoms van oorgewig (LMI 25.0 kg/m² – 29.9 kg/m²) was 24.4% en van vetsug (LMI ≥ 30kg/m²) 52.4%. Hoë bloeddruk het in meer as twee derdes van die studie deelnemers voorgekom (68.5%). In hierdie studie het beduidende korrelasies tussen LMI, MO en LV% as bepalers van adipositeit voorgekom. 'n Beduidende ooreenstemming is gevind tussen gekombineerde oorgewig/vetsug wat deur LV% gedefinieer is (≥35.8% 29-45 jaar; ≥37.7% ≥50 jaar) en LMI ≥ 25kg/m² ($\chi^2=199.0$, $p<0.0001$; $\kappa=0.68$, $p<0.0001$), asook tussen die

voorkoms van hoë LV% en vetsug alleen wat deur $LMI \geq 30\text{kg/m}^2$ gedefinieer is ($\kappa=0.50$; $p<0.0001$). Die effekgrootte van die ooreenkoms tussen die WGO LMI kategorie vir gekombineerde oorgewig/vetsug en LV% afsnypunte volgens die kappa waarde van $\kappa=0.68$ was substansieel (κ reikwydte 0.61-0.80). Die effekgrootte van die ooreenkoms tussen die WGO LMI kategorie vir vetsug alleen en LV% afsnypunte volgens die kappa waarde van $\kappa=0.48$ was matig (κ reikwydte 0.41-0.60). Geen assosiasie is tussen hoë bloeddruk en LMI gekategoriseerde gekombineerde oorgewig/vetsug ($LMI \geq 25\text{kg/m}^2$) gevind nie ($\chi^2=3.19$; $p=0.074$), maar 'n beduidende assosiasie is tussen hoë bloeddruk en LMI gekategoriseerde vetsug alleen ($LMI \geq 30\text{kg/m}^2$) gevind ($\chi^2=4.10$; $p=0.043$). 'n Beduidend verhoogde kansverhouding (KV) van hoë bloeddruk het voorgekom in die vetsug LMI kategorie (KV=1.52; $p=0.045$) teenoor die oorgewig/vetsug LMI kategorie (KV=1.51; $p=0.075$). Daar was beduidende assosiasies tussen hoë bloeddruk en $MO \geq 80\text{cm}$ ($\chi^2=10.9$; $p=0.001$; KV=2.08; $p=0.001$), $MO \geq 92\text{cm}$ ($\chi^2=20.1$; $p<0.0001$; KV=1.79; $p=0.011$), en LV% bokant die ouderdomspesifieke afsnypunte ($\chi^2=6.61$; $p=0.010$; KV=1.70; $p=0.011$).

Bespreking en gevolgtrekking: Hierdie studie het gevind dat daar in 'n steekproef van swart stedelike Suid-Afrikaanse vroue beduidende ooreenkomste tussen adipositeit gedefinieer deur LV% afsnypunte vir gekombineerde oorgewig/vetsug en WGO LMI gekategoriseerde gekombineerde oorgewig/vetsug ($LMI \geq 25\text{kg/m}^2$) en vetsug alleenlik ($LMI \geq 30\text{kg/m}^2$), respektiewelik, voorgekom het, met 'n sterker ooreenkoms tussen WGO gekategoriseerde oorgewig/vetsug en LV%. Die studie het verder tot die gevolgtrekking gekom dat die LMI kategorie volgens die WGO afsnypunt vir gekombineerde oorgewig/vetsug onvoldoende sensitiviteit gehad het om die voorkoms van hoë bloeddruk waar te neem, en dat die LMI kategorie volgens die WGO afsnypunt vir vetsug alleenlik wel die voorkoms van hoë bloeddruk kon waarneem. Die WGO LMI klassifikasie vir vetsug teenoor die WGO LMI klassifikasie vir gekombineerde oorgewig/vetsug, is dus geskik om hierdie steekproef swart Suid-Afrikaanse vroue vir die verhoogde risiko van hoë bloeddruk te klassifiseer. Die MO - en LV% afsnypunte wat gebruik is, was etnisiteit-, ouderdom- en geslagspesifiek en besit goeie kapasiteit om hoë bloeddruk waar te neem. In hierdie studie het abdominale vetsug, wat deur die Suid-Afrikaanse afsnypunt van $MO \geq 92\text{cm}$ gedefinieer is, 'n sterker assosiasie met hoë bloeddruk gehad as die internasionale afsnypunt ($MO \geq 80\text{cm}$). Die Suid-Afrikaanse afsnypunt is dus meer geskik om as sifting gebruik te word vir hoë bloeddruk onder swart Suid-Afrikaanse vroue. Hierdie studie het tot die gevolgtrekking gekom dat 'n sterker ooreenkoms tussen adipositeit gedefinieer deur die LV% afsnypunt en WGO LMI gekategoriseerde gekombineerde oorgewig/vetsug ($LMI \geq 25\text{kg/m}^2$) voorgekom het as met vetsug alleenlik ($LMI \geq 30\text{kg/m}^2$). Om konsekwentheid en akkuraatheid te verseker en liggaamsamestelling in ag te neem, word daar aanbeveel dat in die kliniese praktyk, waar moontlik, die gepaste MO- en LV% afsnypunte saam met LMI kategorieë

gebruik word as bepalers van adipositeit om oorgewig en vetsug te diagnoseer en te dien as sifting en om 'n verhoogde risiko van hoë bloeddruk waar te neem.

Sleutelterm: Liggaamsmassa-indeks, middelomtrek, liggaamsvetpersentasie, hoë bloeddruk, stedelike swart vroue

TABLE OF CONTENTS

Acknowledgements.....	i
Abstract (English).....	ii
Opsomming (Afrikaans).....	v
List of tables.....	xi
List of figures.....	xii
List of abbreviations.....	xiii
Chapter 1: Introduction.....	1
1.1 Background and problem statement.....	1
1.2 Aims and objectives.....	2
1.3 Hypothesis.....	3
1.4 Structure of dissertation.....	3
1.5 Contribution of author.....	4
1.6 References.....	4
Chapter 2: Literature review.....	6
2.1 Introduction.....	6
2.2 Prevalence of overweight and obesity.....	7
2.3 Classification of overweight and obesity.....	8
2.3.1 General obesity.....	8
2.3.1.1 Body mass index.....	8
2.3.1.2 Percentage body fat.....	9
2.3.1.2.1 Methods to measure %BF.....	9
2.3.2.2.2 Obesity cut-off points based on %BF.....	10
2.3.2 Abdominal obesity.....	11
2.3.2.1 Waist circumference.....	11
2.4 Agreement between measures of body composition in predicting adiposity.....	12
2.5 Effect of ethnicity on measures of adiposity threshold values.....	14
2.5.1 Body mass index and waist circumference.....	15
2.5.2 Percentage body fat.....	20
2.6 Effect of HIV-status on body composition.....	22

2.7	Hypertension.....	24
2.7.1	Obesity as etiological risk factor of hypertension.....	24
2.7.2	Hypertension as cardiovascular disease risk.....	26
2.7.3	Classification of hypertension.....	27
2.7.4	Prevalence of hypertension.....	28
2.7.5	Measurement of blood pressure.....	29
2.7.6	Management of hypertension.....	29
2.8	Measures of body composition and associated metabolic disease.....	31
2.9	Possible implications regarding measures of body composition in defining adiposity and the link to disease.....	34
2.10	Conclusion.....	36
2.11	References.....	36
Chapter 3: Methodology.....		44
3.1	Introduction.....	44
3.2	Study design and setting.....	44
3.3	Study participants.....	44
3.3.1	Recruitment.....	44
3.3.2	Inclusion and exclusion criteria.....	45
3.3.3	Representativeness.....	45
3.3.4	Informed consent.....	45
3.4	Measurements.....	46
3.4.1	Questionnaire.....	46
3.4.2	Anthropometric measurements.....	46
3.4.2.1	Height and weight measurements.....	46
3.4.2.2	Waist circumference measurements.....	47
3.4.3	Percentage body fat measurements.....	47
3.4.4	Blood pressure measurements.....	47
3.4.5	HIV testing.....	48
3.5	Ethical considerations.....	48
3.6	Statistical analyses.....	48

3.7	References.....	50
Chapter 4:	Article.....	51
	Title: Associations between specific measures of adiposity and high blood pressure in black South African women.....	51
	Abstract.....	52
	Introduction.....	53
	Materials and methods.....	55
	Results.....	59
	Discussion and conclusions.....	65
	References.....	73
Chapter 5:	Summary, conclusions and recommendations.....	78
5.1	Aims of the study.....	78
5.2	Summary.....	78
5.3	Conclusions.....	79
5.4	Recommendations.....	80
5.5	References.....	82
Annexures.....		84
	Annexure A: Research participation informed consent.....	85
	Annexure B: Checklist.....	91
	Annexure C: Socio-demographic questionnaire.....	93
	Annexure D: Blood pressure referral letter.....	97
	Annexure E: HIV test informed consent.....	99
	Annexure F: HIV referral letter.....	101
	Annexure G: Ethics approval of project.....	103
	Annexure H: Journal author guidelines.....	105

LIST OF TABLES

Table 2.1 Classification of overweight and obesity based on BMI..... 8

Table 2.2 Predicted %BF based on BMI for African American women according to age
using 4-compartment estimates of percentage body fat..... 10

Table 2.3 Cut-off points of %BF using DXA in reference to BMI cut-off points (in kg/m²)
in NHB women according to age..... 11

Table 2.4 Waist circumference cut-off points for African women related to
health risk..... 12

Table 2.5 Recommended WC thresholds for abdominal obesity by organisation..... 15

Table 2.6 BMI and WC thresholds of African-American and white women and men in
predicting cardiometabolic risk factors..... 16

Table 2.7 Predicted %BF based on 4-compartment estimates of %BF and ethnicity..... 20

Table 2.8 Cut-off points of %BF in reference to BMI cut-offs (in kg/m²)
in US men and women..... 21

Table 2.9 Classification of hypertension..... 27

Table 2.10 Criteria for clinical diagnosis of the metabolic syndrome..... 31

Table I Characteristics of the study participants (n = 435)..... 62

Table II Prevalence of adiposity, high blood pressure, menopausal status and smoking
amongst the study participants (n = 435)..... 63

Table III Association between measures of adiposity and high blood pressure..... 65

LIST OF FIGURES

Figure 1 Study participants..... 60

Figure 2 Frequency of adiposity according to BMI categories (in kg/m²)..... 64

LIST OF ABBREVIATIONS

%	percent
%BF	percentage body fat
AA	African American
AHA	American Heart Association
AIDS	acquired immune deficiency syndrome
ARV	antiretroviral
BIA	bio-electrical impedance analysis
BMI	body mass index
BP	blood pressure
CEN	Centre of Excellence for Nutrition
CHD	coronary heart disease
CI	confidence interval
cm	centimetre(s)
CTF	Cooperative Task Force
CVD	cardiovascular disease
DASH	dietary approaches to stop hypertension
DBP	diastolic blood pressure
DSTV	digital satellite television
DXA	dual-energy X-ray absorptiometry
ECS	European Cardiovascular Societies
e.g.	<i>exempli gratia</i> (Latin which means “for example” in English)
ESC	European Society of Cardiology
ESH	European Society of Hypertension
<i>et al.</i>	<i>et alli</i> (Latin which means “and others” in English)
g	gram(s)
HCT	HIV counseling and testing
HDL	high-density lipoprotein
HIV	human immunodeficiency virus
HTN	hypertension
IDF	International Diabetes Federation
i.e.	<i>id est</i> (Latin which means “that is” in English)
JOS	Japanese Obesity Society
JNC	Joint National Commission
κ	kappa
kg	kilogram(s)
kg/m ²	kilograms divided by metres squared
l	litre(s)
LBF	lower body fat
m	metre(s)

MEX	Mexican American
mg	milligram(s)
mg/dl	milligram per decilitre
mmHg	millimetre of mercury
mmol/l	millimol per litre
n/N	sample size
NC	North-Carolina
NCDs	non-communicable diseases
NGO	non-governmental organisation
NHANES	National Health and Nutrition Examination Survey
NHB	non-Hispanic black
NHLBI	National Heart, Lung and Blood Institute
NHW	non-Hispanic white
NWU	North-West University
OR	odds ratio
p	probability (level of significance)
Prof	Professor
PURE	Prospective Urban Rural Epidemiology
r	Pearson's correlation value
ROC	Receiver Operating Characteristic
SA	South Africa
SAHS	Southern African Hypertension Society
SANHANES	South African National Health and Nutrition Examination Survey
SAT	subcutaneous adipose tissue
SBP	systolic blood pressure
SD	standard deviation
SOP	standard operating procedures
Sr	Sister (in nursing)
TBC	total body carbon
TBCa	total body calcium
TBN	total body nitrogen
TBW	total body water
TG	triglyceride
US	United States
USA	United States of America
VAT	visceral adipose tissue
WC	waist circumference
WHO	World Health Organisation
χ^2	Pearson's chi square
y	years

CHAPTER 1: INTRODUCTION

1.1 BACKGROUND AND PROBLEM STATEMENT

The World Health Organisation (WHO) defines overweight and obesity as a condition in which an abnormal or excessive fat accumulation exists to an extent in which health and well-being are impaired (WHO, 2013). Based on European populations, the WHO defined cut-off points for body mass index (BMI), which are used in large-scale epidemiological studies to identify and classify individuals as overweight, obese or underweight and to identify individuals at risk for obesity-related diseases (WHO, 1998:9). In 2008, globally, 35% of adults aged 20 years and above were overweight (BMI 25 to 29.9 kg/m²) and 11% were obese (BMI ≥ 30 kg/m²) (WHO, 2013). According to the most recent South African National Health and Nutrition Examination Survey (SANHANES), the prevalence of overweight and obesity, according to BMI classification, in all South African women was significantly higher than in men (24.8% and 39.2% compared to 20.1% and 10.6% for women and men respectively) (Shisana *et al.*, 2013:136).

Relative body fat, or percentage body fat (%BF), is used to classify levels of body adiposity. Measuring %BF takes body composition into account and is a more physiological measurement of obesity than BMI. When defining overweight/obesity, care must be taken when using BMI alone as tool for diagnosis. Factors including body composition and epidemiological factors, such as ethnicity, age and sex, should be considered when classifying individuals as overweight and obese (De Schutter *et al.*, 2013:82). Gallagher *et al.* (2000:699) developed prediction models for %BF based on BMI which had age, gender and ethnicity (black-American, Asian and white) as independent variables. More recently, adult data from the United States of America (USA) National Health and Nutrition Examination Survey (NHANES) 1999-2004 were used, including Mexican American (MEX), non-Hispanic Black (NHB) and non-Hispanic white (NHW) ethnicity populations, aged 18 years to 84 years, to develop cut-off points of %BF on the basis of the relation between dual-energy X-ray absorptiometry (DXA) measured fat mass and BMI by gender, age and race-ethnicity (Heo *et al.*, 2012:594).

Waist circumference (WC) is a measure of abdominal subcutaneous and visceral fat and is used to identify individuals with abdominal obesity and at risk for cardiometabolic disease. Consensus was reached by the International Diabetes Federation (IDF) and the American Heart Association/National Heart, Lung and Blood Institute (AHA/NHLBI), on the current recommended WC thresholds for abdominal obesity based on different ethnic groups, as part of

criteria for clinical diagnosis of metabolic syndrome (Alberti *et al.*, 2009:1642). Due to established ethnic differences in body composition (Alberti *et al.*, 2009:1642; Deurenberg-Yap & Deurenberg, 2003:s82; Heo *et al.*, 2012:599; WHO, 2004:161), specific cut-off points for BMI, WC and %BF for different population groups might need to be implemented, also in South-Africa, to classify overweight/obesity, as well as detect obesity-related cardiometabolic risk factors. Several international studies have indicated the association between BMI, WC and %BF as measures of adiposity used to define overweight/obesity. Limited South African data in this regard is available, which warrants further research. Only one study has determined the relationship between BMI and WC in white and black South-African women and has shown no difference in the WC-BMI relationship between the groups of black women, as well as between the white and black women (Sumner *et al.*, 2011:671). Therefore, more research is needed to determine the agreement between BMI, %BF and WC as measures of adiposity and compare classification of overweight/obesity according to BMI and %BF.

Overweight and obesity are modifiable risk factors for the development of non-communicable diseases (NCD's) (Mbochi *et al.*, 2012: 823). Obesity can promote a cascade of secondary cardiometabolic pathologies such as hypertension, hyperlipidaemia, insulin resistance and hyperuricaemia, alone or in combination, all of which exacerbate the progression of cardiovascular disease (CVD) (Zhang *et al.*, 2013:e70893). In South-Africa currently approximately one third (30.4%) of the adult population has hypertension (Seedat *et al.*, 2014:139). Classifications based on BMI, WC and %BF to screen and identify people at risk for hypertension and refer them for monitoring and diagnostic tests could prove to be useful. The evaluation of the specific role of anthropometric indices on the development of hypertension may help to understand the pathogenesis of arterial hypertension better, and provide more accurate means of prevention (Silva *et al.*, 2012: 113).

1.2 AIMS AND OBJECTIVES

The study aimed to investigate the agreement between BMI categories classified adiposity and %BF cut-off point classified adiposity. The study, furthermore, aimed to investigate the association between the different measures of adiposity and high blood pressure. It was determined which measure of overweight/obesity is most strongly associated with high blood pressure. These findings could help to determine if the WHO BMI cut-off points for overweight and obesity are appropriate to classify black South African women at an increased risk for hypertension.

The objectives of the study were:

- To determine the prevalence of different types of adiposity (general, based on BMI and %BF, and abdominal based on WC) amongst a group of black urban women in South Africa.
- To determine the agreement between these measures of body composition to define adiposity in black women.
- To determine the association between adiposity according to the specific measures and blood pressure amongst the sample of women.
- To determine the proportion of overweight and obese women according to the WHO cut-off points for combined overweight and obesity (BMI ≥ 25 kg/m²) and obesity (BMI ≥ 30 kg/m²) with high blood pressure.

1.3 HYPOTHESIS

The following hypotheses were formulated for this study:

In a sample of black women aged 29 years to 65 years from Ikageng in the North West Province of South Africa:

- There are strong agreements between measures of adiposity to define overweight and obesity. The categories for these measures were high %BF ($\geq 35.8\%$ for ages 29-45 years; $\geq 37.7\%$ for ages ≥ 50 years) and combined overweight/obesity (BMI ≥ 25 kg/m²), and high %BF and obesity only (BMI ≥ 30 kg/m²), respectively.
- The WHO BMI categories for combined overweight/obesity (BMI ≥ 25 kg/m²) and obesity only (BMI ≥ 30 kg/m²), respectively, have low sensitivity to detect the presence of high blood pressure.

1.4 STRUCTURE OF DISSERTATION

This mini-dissertation is divided into five chapters, in which Chapter 1 as the introduction consists of a background and problem statement, the study aims and objectives, and the hypothesis. Chapter 2 includes a literature review describing the topic in full, referencing relevant literature. Chapter 3 consists of the methodology of the study. In Chapter 4 the study is described in article format as a research paper, containing an abstract, introduction, materials and methods, results, and a discussion and conclusions section. In Chapter 5 a summary of the essential findings, a conclusion and recommendations are given. All forms, the questionnaire and the referral letters that were used during the study data collection are in Annexures displayed as Annexure A to F. The North-West University (NWU) Ethics Committee approval

letter is found in Annexure G. Chapters 1, 2, 3 and 5 are written according to South African English spelling and the NWU guidelines, with references in text and reference lists according to the reference guidelines of the NWU. Chapter 4 follows United States English spelling and the style of writing and referencing according to the selected journal in which publishing of the article is intended. Author guidelines for the relevant journal are found in Annexure H.

1.5 CONTRIBUTION OF AUTHOR

The author was involved in the execution of the data-collecting process of the study. The author took part in anthropometric measures, pregnancy testing and questionnaire interviewing. The author was responsible for literature searches, statistical analysis of data and the writing of the manuscript.

1.6 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 Federation; International Atherosclerosis Society and International Association for the Study of Obesity. *Circulation*, 120:1640-1645.

De Schutter, A., Lavie, C.J., Arce, K., Menendez, S.G. & Milani, R.V. 2013. Correlation and discrepancies between obesity by body mass index and body fat in patients with coronary heart disease. *Journal of cardiopulmonary rehabilitation and prevention*, 33:77-83.

Deurenberg-Yap, M. & Deurenberg, P. 2003. Is a re-evaluation of WHO body mass index cut-off values needed? The case of Asians in Singapore. *Nutrition reviews*, 61(5):s80-s87.

Gallagher, D., Heymsfield, S.B., Heo, M., Jebb, S.A., Murgatroyd, P.R. & Sakamoto, Y. 2000. Healthy percentage body fat ranges: an approach for developing guidelines based on body mass index. *American journal of clinical nutrition*, 72:694-701.

Heo, M., Faith, M.S., Pietrobelli, A. & Heymsfield, S.B. 2012. Percentage of body fat cutoffs by sex, age, and race-ethnicity in the US adult population from NHANES 1999-2004. *American journal of clinical nutrition*, 95:594-602.

Mbochi, R.W., Kuria, E., Kimiywe, J., Ochola, S. & Steyn, N.P. 2012. Predictors of overweight and obesity in adult women in Nairobi province, Kenya. *BMC public health*, 12:823-831.

Seedat, Y.K., Rayner, B.L. & Veriava, Y. 2014. South African hypertension guideline 2014. *South African journal of diabetes and vascular disease*, 11(4):139-144.

Shisana, O., Hoosain, E., Dwane, N., Maluleke, T., Reddy, P., Jacobs, L., Labadarios, L., Zuma, K., Dhansay, A., Parker, W., Naidoo, P., Mchiza, Z., Steyn, N.P., Makoae, M., Ramlagan, S., Zungu, N., Evans, M.G., Faber, M. & Hongoro, C. 2013. South African National Health and Nutritional Examination Survey, 2012: SANHANES-1.

Silva, D.A.S., Petroski, E.L. & Peres, M.A. 2012. Is high body fat estimated by body mass index and waist circumference a predictor of hypertension in adults? A population-based study. *Nutritional journal*, 11(1):112-120.

Sumner, A.E., Micklesfield, L.K., Ricks, M., Tambay, A.V., Avila, N.A., Thomas, F., Lambert, E.V., Levitt, N.S., Evans, J., Rotimi, C.N., Tulloch-Reid, M.K. & Goedecke, J.H. 2011. Waist circumference, BMI, and visceral adipose tissue in white women and women of African descent. *Obesity*, 19(3):671-674.

World Health Organisation (WHO). 1998. Obesity: preventing and managing the global epidemic. Report on a WHO consultation on obesity. WHO/NUT/NCD/98.1. Geneva, Switzerland.

World Health Organisation (WHO). 2004. Appropriate body-mass index for Asian populations and its implications for policy and intervention strategies. *Lancet*, 363:157-163.

World Health Organisation (WHO). 2013. Obesity and overweight. Fact sheet no 311, WHO media centre. <http://www.who.int/mediacentre/factsheets/fs311/en/>. Date of access: 20 February 2014.

Zhang, Z., Deng, J., He, L., Ling, W., Su. & Chen, Y. 2013. Comparison of various anthropometric and body fat indices in identifying cardiometabolic disturbances in Chinese men and women. *PlosOne*, 8(8):e70893.

CHAPTER 2: LITERATURE REVIEW

2.1 INTRODUCTION

The WHO defines overweight and obesity as a condition in which an abnormal or excessive fat accumulation exists to an extent in which health and well-being are impaired (WHO, 2013). Obesity was classified as a disease by the WHO in 1990 in its document of International Statistical Classification of Diseases (Chuang *et al.*, 2012:284).

Overweight and obesity are modifiable risk factors for the development of NCDs (Mbochi *et al.*, 2012: 823). Obesity can promote a cascade of secondary cardiometabolic pathologies such as hypertension, hyperlipidemia, insulin resistance and hyperuricemia, alone or in combination, all of which exacerbate the progression of CVD (Zhang *et al.*, 2013:e70893).

In order to classify overweight and obesity the WHO developed cut-off points of BMI. These cut-off points are based on observational studies of the relationship between BMI and morbidity and mortality (WHO, 1998:9). WC is a measure of abdominal subcutaneous and visceral fat and is also used to identify individuals at risk for disease (Heyward & Wagner, 2004:67). Consensus was reached by different organisations as to the current recommended WC thresholds for abdominal obesity based on different ethnic groups, as part of measured criteria for clinical diagnosis of metabolic syndrome (Alberti *et al.*, 2009:1642).

In clinical practice, the use of BMI and WC as an indicator of overweight and obesity is easy, but its reliability as a tool to represent adiposity on an individual level can be questioned. Direct %BF measurements would be a better tool for diagnosis of obesity (De Lorenzo *et al.*, 2003:s254). Research relating %BF cut-off points to obesity and based on BMI was done. Significant age, gender and ethnicity terms were included as independent variables, taking epidemiological factors into account (De Lorenzo *et al.*, 2013:115; Gallagher *et al.*, 2000:699). Studies' results suggest also different %BF values in different ethnic populations with the same BMI values (WHO, 2004:161).

Cut-off points for BMI and WC according to the presence of cardiometabolic risk factors, however, differ vastly across ethnic populations and suggest the need for population-specific cut-off points (Alberti *et al.*, 2009:1642; WHO, 2004:161). Therefore, specific threshold values might need to be implemented. These values are useful in clinical practice to identify individuals with increased risk for obesity-related morbidity and mortality.

2.2 PREVALENCE OF OVERWEIGHT AND OBESITY

Worldwide obesity has nearly doubled since 1980. In 2008 more than 1.4 billion adults globally, 20 years and older, were overweight and of these over 200 million men and nearly 300 million women were obese (WHO, 2013). This means that 35% of adults aged 20 and above were overweight and 11% were obese. Of the world population, 65% live in countries where more people are killed by overweight and obesity related diseases than by underweight (WHO, 2013). The WHO projects that more than 700 million adults worldwide will be obese by 2015 (Amole *et al.*, 2011:188).

The incidence of obesity, and consequently, obesity-related comorbidities, is rapidly increasing, reaching epidemic proportions in both the developed and developing worlds (Crowther & Ferris, 2010:115). In most African countries, the number of obese women surpasses the number of obese men, sometimes as much as 2 to 1 (Van der Merwe, 2009: 139). Overweight and obesity in Sub-Saharan Africa are most common in women and specifically in the 25 to 44 year old age group (Mbochi *et al.*, 2012:823).

In South Africa, overweight and obesity are thought to be on the rise. Several studies have reported that obesity amongst black women is the highest of all race groups. Prinsloo *et al.* (2011:369) noted a high prevalence of overweight (32.2%) and obesity (44.1%) in a group of black women (18-50 years of age) in Mangaung, South Africa. The increased caloric intake and reduced physical activity track this pattern, with more than 70% of women and 45% of men in total being overweight or obese in South Africa, with an increasing trend over time (Mungal-Singh, 2012:13). According to the SANHANES, the black women group was found to be significantly heavier and taller than both the coloured and Asian/Indian women race groups. The prevalence of overweight and obesity, according to BMI classification, in all South African women was significantly higher than in men (24.8% and 39.2% compared to 20.1% and 10.6% for women and men, respectively) (Shisana *et al.*, 2013:136).

Women living in urban formal areas had the highest prevalence of obesity (42.2%). The prevalence of overweight was the highest in women living in urban informal areas (27.9%). Rural formal areas had the relatively lowest prevalence of obesity (31.8%) (Shisana *et al.*, 2013:138). The North West Province was recorded to have the third lowest prevalence of overweight amongst women (22.3%) (preceded by Eastern Cape at 21.7% and Free State at 20.7%) and had relatively the lowest prevalence of obesity (31.7%) compared to the other eight provinces of South Africa (Shisana *et al.*, 2013:140).

2.3 CLASSIFICATION OF OVERWEIGHT AND OBESITY

2.3.1 General obesity

2.3.1.1 Body mass index

The BMI (weight in kilograms divided by height in metres squared) is used in large-scale epidemiological studies to identify and classify individuals as overweight, obese or underweight and to identify individuals at risk for obesity-related diseases. The WHO defined cut-points for BMI as provided in Table 2.1 (WHO, 1998:9). These cut-off points or threshold values were based on visual inspection of the relationship between BMI and morbidity and mortality in European populations (WHO, 1998:9).

Table 2.1: Classification of overweight and obesity based on BMI

Classification	BMI value (kg/m²)
Underweight	< 18.5
Normal weight	18.5 – 24.9
Overweight	25.0 – 29.9
Obesity	
Class I	30.0 – 34.9
Class II	35.0 – 39.9
Class III	≥ 40.0

(WHO, 1998:9); BMI = Body mass index.

Body mass index (BMI) does not take the body composition of the individual into account. In addition, factors such as gender, age, ethnicity, body build and frame size affect the relationship between BMI and body fat percentage. Misclassifications of underweight, overweight and obesity may result when BMI is used as an only index of obesity. BMI is often used as a measure of total body fat, therefore, other anthropometric indices need to be used to assess fat distribution (Heyward & Wagner, 2004:76). There is considerable variability in body composition for any given BMI. BMI is not sensitive enough to identify individuals with a normal BMI that are actually obese based on a high percentage body fat and are, therefore, metabolically obese (Chuang *et al.*, 2012:284). Despite its wide-spread use, BMI has limited use in some populations, such as very muscular individuals. Though BMI has its limitations, it independently contributes to the prediction of body fat (Bodicoat *et al.*, 2014:e90813). Cut-off points for BMI

based on different ethnic groups have been determined, which are discussed later in this chapter.

2.3.1.2 Percentage body fat

Percentage body fat (%BF) or relative body fat is used to classify levels of body fatness or adiposity. Relative body fat is the fat mass expressed as a percentage of total body weight (%BF = fat mass/body weight x 100) (Heyward & Wagner, 2004:5).

2.3.1.2.1 Methods to measure %BF

Various methods have been developed for measuring body composition, including %BF, accurately, such as isotopic dilution techniques, body density (hydrodensitometry), bio-electrical impedance analysis (BIA) and DXA (De Lorenzo *et al.*, 2013:112). Among these, DXA has proved the most reliable in clinical practice to assess directly total and regional body fat and fat free mass (lean body mass), which includes lean soft tissues and bone mineral (De Lorenzo *et al.*, 2013:112).

DXA is often used as a reference method for body composition analysis and is considered by some as the “gold standard” (Heinrich *et al.*, 2008:67). Clinical studies have developed equations to assess %BF by means of anthropometric indicators of obesity, such as BMI and WC, and these equations show a strong association with body fat when estimated by DXA (Silva *et al.*, 2012:212).

In the four-compartment model the amount of minerals, protein and water in the body is measured, and body fat (fourth compartment) is, therefore, calculated by difference. The number of assumptions is small, and consequently the possible bias is small, which proves the four-compartment model to be the most accurate method of measuring %BF. Unfortunately it is expensive and time-consuming and few laboratories have the capacity for using it, since densitometry or neutron activation analysis, deuterium oxide dilution, and DXA must be available. The maximum bias in measured body fat is 3% for densitometry, 2% for deuterium oxide solution, 3-4% for DXA, and about 1% for a four-compartment model (WHO, 2004:159).

In a study by Aloia *et al.* (1996:43), female white subjects', aged 51.4 ± 13.5 years, body fat was measured by examining the four-compartment model of body composition, consisting of mineral ash, fat, protein, and water, through measurement of total body carbon (TBC), nitrogen (TBN),

calcium (TBCa) and water (TBW). Several two-compartment models using radioactive techniques have previously been developed where fat mass is calculated by subtracting estimated fat free mass, determined using TBW and TBN, from body weight (Aloia *et al.*, 1996:43).

The mentioned study measured TBW, TBC using inelastic neutron scattering, TBN using prompt-gamma neutron activation and TBCa using DXA. The results of the study demonstrated a linear change with age for protein and water was found, whereas mineral and fat were curvilinear. Each of the four compartments changed with age, with fat increasing and the other compartments declining (Aloia *et al.*, 1996:43). The two compartments, mineral and fat, also showed differences in premenopausal and postmenopausal rates of change. It was observed that women at menopause experienced gain of fat mass and a loss of lean mass (Aloia *et al.*, 1996:46).

2.3.2.2.2 Obesity cut-off points based on %BF

Current research suggests that the obesity cut-off points for %BF ranged from 23%-25% in men and 30%-35% in women (De Lorenzo *et al.*, 2013:111). In a study by De Lorenzo *et al.* (2003:s255), obesity was determined with %BF values of more than 25% in males and more than 35% in females. Gallagher *et al.* (2000:699) developed prediction models for %BF based on BMI which had significant age, gender and ethnicity terms (African-American, Asian and white) as independent variables. This accounted for epidemiological factors, which include genetics and physical build, ethnicity, age, gender, social and cultural characteristics, and the economic environment. The %BF standards for African American women are presented in Table 2.2.

Table 2.2: Predicted %BF based on BMI for African American women according to age using 4-compartment estimates of percentage body fat

	20-39 y	40-59 y	60-79 y
BMI < 18.5	20	21	23
BMI ≥ 25-29.9	32	34	35
BMI ≥ 30	38	39	41

Gallagher *et al.* (2000:699); BMI = Body mass index.

More recently, data from the USA NHANES 1999-2004 were used of adult subjects, including Mexican American (MEX), non-Hispanic Black (NHB) and non-Hispanic white (NHW) ethnicity

populations, aged 18 years to 84 years to develop cut-offs of %BF on the basis of the relation between DXA measured fat mass and BMI by gender, age and race-ethnicity (Heo *et al.*, 2012:594). The cut-offs for %BF for NHB women are presented in Table 2.3. Later in this chapter %BF cut-off points for different ethnic population groups will be discussed.

Table 2.3: Cut-off points of %BF using DXA in reference to BMI cut-off points (in kg/m²) in NHB women according to age

	18-29 y	30-49y	50-84 y
BMI 18.5	24.6	25.8	28.0
BMI 25	35.0	35.8	37.7
BMI 30	39.9	40.6	42.3
BMI 35	43.4	44.0	45.6
BMI 40	46.1	46.6	48.1

(Heo *et al.*, 2012:599); BMI = Body mass index.

2.3.2 Abdominal obesity

2.3.2.1 Waist circumference

Waist circumference (WC) is a measure of abdominal subcutaneous and visceral fat and is used to identify individuals at risk for cardiometabolic disease (Heyward & Wagner, 2004:67). WC does not, however, directly measure the amount of adipose tissue and cannot differentiate between fat and lean mass (Zhang *et al.*, 2013:e70893). Ethnic differences in body fat distribution have been studied and it was found that the level of visceral fat is higher in Indian than in European individuals when matched for BMI or WC (Lear *et al.*, 2007:2819). This might explain the higher prevalence of cardiovascular disease (CVD) in the former population (Crowther & Ferris, 2010:118). It has been shown that African women have lower visceral, but higher subcutaneous fat mass than BMI-matched European women (Goedecke *et al.*, 2009:1508).

Waist circumference (WC) provides an accurate indirect measure of visceral fat and is not greatly influenced by age, standing height and degree of overall adiposity. Consensus was reached by the International Diabetes Federation (IDF) and the American Heart Association/National Heart, Lung and Blood Institute (AHA/NHLBI), as to the current recommended WC thresholds for abdominal obesity based on different ethnic groups, as part of measured criteria for clinical diagnosis of metabolic syndrome (Alberti *et al.*, 2009:1642). WC

cut-off points for Caucasian and African women as risk factors for metabolic complications and coronary heart disease (CHD) are shown in Table 2.4. Later in this chapter WC cut-off points based on different ethnic population groups will be discussed.

Table 2.4: Waist circumference cut-off points for African women related to health risk

Risk of coronary heart disease	Waist circumference
No risk	< 80 cm
High risk	≥ 80 cm
Very high risk	≥ 88 cm

(Alberti *et al.*, 2009)

In the SANHANES, it was determined that in South Africa the mean WC for men and women was 81.4 cm and 89.0 cm, respectively (Shisana *et al.*, 2013:138). One in ten men (9.8%) had a WC equal or larger than 102 cm, while 50.8% of women had a WC equal to or larger than 88 cm (Shisana *et al.*, 2013:138). Nationally, women 45 – 54 years of age had the highest mean WC (95.8 cm) and the highest prevalence of increased WC was seen in women 55 – 64 years of age (70%) (Shisana *et al.*, 2013:141). Participants living in urban formal areas had the highest mean WC and prevalence of increased WC was observed in women (53%) (Shisana *et al.*, 2013:141). In both men and women, the highest mean WC (86.4 cm and 89.9 cm respectively) and prevalence of increased WC (24.3% and 54.1% respectively) were seen in the Asian/Indian population (Shisana *et al.*, 2013:141).

2.4 AGREEMENT BETWEEN MEASURES OF BODY COMPOSITION IN PREDICTING ADIPOSITY

Simple anthropometric measurements such as BMI and WC predict cardiometabolic risk just as well as %BF as assessed by their associations with obesity-related risk factors for CVD (Mallikharjuna Rao, 2012:54). Given that WC and BMI independently contribute to the estimation of total non-abdominal fat as well as abdominal subcutaneous and visceral fat, experts suggest using both of these anthropometric indices to assess total body and central adiposity in the general population, excluding athletes (Heyward & Wagner, 2004:79).

In a study of white Canadian and North-American female and male subjects varying widely in age and adiposity, independent of age, BMI and WC independently contributed to the prediction of non-abdominal, abdominal subcutaneous and visceral fat. In as much as excess non-abdominal, abdominal subcutaneous or visceral fat predict the relative risk of disease, this

observation underscores the importance of incorporating both anthropometric methods into routine clinical practice (Janssen *et al.*, 2002:686). These results indicate that the use of WC in combination with BMI is a better predictor of abdominal fat than BMI alone and that WC measurements are able to predict visceral fat (Janssen *et al.*, 2002:687).

Heinrich *et al.* (2008:70) showed in their study of female and male North-Americans of mixed ethnicity, that WC was an accurate predictor of BMI-based obesity in men and women. Furthermore, estimated WC and BMI obesity rates were much lower than those derived from %BF. WC measurements correlated with %BF for women, but not for men (Heinrich *et al.* (2008:70). Chuang *et al.* (2012:289) found from their results that in Korean subjects, %BF correlated with BMI and WC and %BF appears to be an accurate predictor of CVD, particularly in women with normal WC and low or normal BMI.

Mallikharjuna Rao *et al.* (2012:56) also found a significant correlation between %BF and BMI in both Indian men and women. In another study in Italian Europeans, results obtained suggested a low agreement between BMI and %BF classifications. For example, among obese people according to %BF, only 48% were also classified as obese according to BMI and the differences between BMI and %BF persisted within gender and age groups. Only 43% of women were in the same category by %BF and BMI cut-off points (De Lorenzo *et al.*, 2013:116). The rate of false negatives increased with age, as older individuals had higher %BF than younger individuals with the same BMI (Heinrich *et al.*, 2008:67).

A study by De Schutter *et al.* (2013:79) in North-America included female and male patients, mean age 64 ± 11 years, of a mainly white population that presented with CHD in which hypertension was present in 34% of the subjects. In the female subgroup there was a good correlation between %BF and BMI. In the obese group, BMI and %BF correlated more closely than in the overweight group. A fair to moderate agreement was present between BMI categories and %BF thresholds proposed by Gallagher *et al.* (2000:699), with 59% classified similarly according to BMI and %BF. Twenty seven percent of the patients were in a lower category based on BMI than based on %BF. Fourteen percent were overweight by %BF but estimated lower by BMI and 13% were obese by BF and estimated lower by BMI. Fourteen percent of patients were in a lower category based on %BF than based on BMI (De Schutter *et al.*, 2013:80).

Data from studies were combined of women including white - and black South Africans, black Americans, West-Africans, and black Africans living in the USA to determine the relationship

between WC and BMI (Sumner *et al.*, 2011:671). No difference in the WC-BMI relationship between the groups of black women, as well as between the white and black women was found (Sumner *et al.*, 2011:674).

When defining overweight/obesity, care must be taken when using BMI alone as a screening tool. Other more physiological measurements of obesity, for example %BF, are based on actual adiposity. Factors, therefore, including body composition and epidemiological factors, such as age and gender, should be considered when classifying individuals as overweight and obese (De Schutter *et al.*, 2013:82). In a previous study by De Schutter *et al.* (2011:220) of female and male subjects with CHD, BMI and %BF were highly correlated, although some patients were classified differently, as BMI classified obesity less often than %BF. In this study the WHO BMI categories and the %BF thresholds for obesity were used as > 25% in men and > 35% in women, which unfortunately did not account for age (De Schutter *et al.*, 2011:220).

De Lorenzo *et al.* (2013:116) reported that women generally have greater estimated mean %BF, but less total body lean mass than men and that mean values of %BF were higher in older than younger subjects, supporting the hypothesis that, particularly at older age, total body fat increases at the expense of total body lean mass.

2.5 EFFECT OF ETHNICITY ON MEASURES OF ADIPOSITY

The relationship between %BF and BMI differs among ethnic groups, suggesting that BMI-based criteria for “overweight” and “obesity” classifications need to be ethnic specific (Heyward & Wagner, 2004:135). Most studies show that the relation between BMI and %BF depends on age, gender, and differs across ethnic groups (WHO, 2004:159). In men and women of European ancestry, a BMI of 30 kg/m² corresponds to 25% and 30% body fat in males and females, respectively. However, body composition is altered by physiological conditions such as age and hormonal imbalance; and, due to ethnic differences, differences in height, weight, architecture and proportion of bone, muscle and fat, also exist (Mallikharjuna Rao, 2012:54).

When the relationship between BMI and %BF was studied, Singaporean subjects (multi-ethnic comprising of Chinese, Malays and Indians), were found to have higher %BF compared to Caucasians with the same lower levels of BMI indicating that the BMI-%BF relationships in these ethnic groups are different from that of Caucasian populations (Deurenberg-Yap & Deurenberg, 2003:s81).

2.5.1 Body mass index and waist circumference

The utility of the anthropometric measures BMI and WC in identifying patients at increased obesity-related health risk is evidenced by their associations with chronic disease risk factors, incidence of chronic disease, and rates of premature mortality (Katzmarzyk *et al.*, 2011:1272). International recommendations proposed by the IDF for thresholds of abdominal obesity to be used as one component of the metabolic syndrome are displayed in Table 2.5.

Table 2.5: Recommended WC thresholds for abdominal obesity by organisation

Population	Organisation	Recommended WC threshold	
		Men	Women
Europid	IDF	≥ 94 cm	≥ 80 cm
Caucasian	WHO	≥ 94 cm (increased risk) ≥ 102 cm (still higher risk)	≥ 80 cm (increased risk) ≥ 88 cm (still higher risk)
United States of America	AHA/NHLBI	≥ 102 cm	≥ 88 cm
Canada	Health Canada	≥ 102 cm	≥ 88 cm
European	ECS	≥ 102 cm	≥ 88 cm
Asian (including Japan)	IDF	≥ 90 cm	≥ 80 cm
Asian	WHO	≥ 90 cm	≥ 80 cm
Japanese	JOS	≥ 85 cm	≥ 90 cm
China	CTF	≥ 85 cm	≥ 80 cm
Middle East, Mediterranean	IDF	≥ 94 cm	≥ 80 cm
Sub-Saharan Africa	IDF	≥ 94 cm	≥ 80 cm
Ethnic Central and South America	IDF	≥ 94 cm	≥ 80 cm

(Alberti *et al.*, 2009:1642); AHA/NHLBI = American Heart Association/National Heart, Lung and Blood Institute; CTF = Cooperative Task Force; ECS = European Cardiovascular Societies; IDF = International Diabetes Federation; JOS = Japanese Obesity Society; WC = Waist circumference.

WC thresholds listed above are as recommended in several different populations and ethnic groups. Guidelines by AHA/NHLBI for metabolic syndrome recognise an increased risk for CVD and diabetes at WC thresholds of ≥ 94 cm in men and ≥ 80 cm in women of European descent (Alberti *et al.*, 2009:1642).

The WHO defines overweight and obesity as a BMI range of 25–29.9 kg/m² and ≥30 kg/m², respectively. These values were obtained from the BMI and mortality associations in European populations (WHO, 1998). These cut-off points have since been used as a standard in different populations and ethnic groups with the assumption that different ethnic groups have similar mortality and morbidity risk at these BMI cut-off points. However, controversy regarding the optimal BMI range in various ethnic populations still exists (Javed *et al.*, 2011:1183).

There is great heterogeneity in WC across populations in sensitivity and specificity for identifying people who are considered overweight (BMI ≥25 kg/m²) (Katzmarzyk *et al.*, 2011:1272). In a study in the USA with a sample of African American (AA) women and men and white women and men, aged 18 – 64 years, BMI and WC cut-off points at the presence of two or more cardiometabolic risk factors, including blood pressure, fasting blood glucose levels, and fasting blood lipids, were determined (Katzmarzyk *et al.*, 2011:1273). These thresholds are displayed in Table 2.6.

Table 2.6: BMI and WC cut-off points of African-American and white women and men in predicting cardiometabolic risk factors

	Women		Men	
	AA	white	AA	white
BMI (kg/m²)	32.9	30.0	30.4	29.1
WC (cm)	96.8	91.9	99.1	99.4

(Katzmarzyk *et al.*, 2011:1276); AA = African-American; BMI = Body mass index; WC = Waist circumference.

There were no apparent ethnic differences in men; however, in African-American women the optimal BMI and WC cut-off points were ~3 kg/m² and 5 cm higher than in white women (Katzmarzyk *et al.*, 2011:1277). The optimal cut-off points identified for BMI closely approximated the currently recommended threshold for obesity (30 kg/m²) in all gender-by-ethnicity groups with the exception of African-American women (~33 kg/m²) (Katzmarzyk *et al.*, 2011:1275). The optimal WC cut-off points in men (~99 cm) were also close to the recommended cut-off point of 102 cm, and whereas the optimal cut-off point in white women (~92 cm) was about 4 cm higher than the recommended cut-off point of 88 cm, the optimal cut-off point was ~9 cm higher than the recommended cut-off point in African-American women (~97 cm) (Katzmarzyk *et al.*, 2011:1275).

A South African study that was conducted in a black rural KwaZulu-Natal population, defined WC cut-off points to detect metabolic syndrome. The cut-off point for women was determined at 92.0 cm (which is higher than the IDF recommendation for female Africans of 80 cm) and for men at 86.3 cm (which is lower than the IDF recommendation for male Africans of 94 cm) (Motala *et al.*, 2011:1035). Another South African study aimed to determine the appropriate WC cut-off point for diagnosing metabolic syndrome in an urban female population aged 40.0 ± 10.6 years, demonstrated a clear ethnic difference in the relationship between abdominal adiposity and metabolic disease risk. This study found that the WC cut-off point currently recommended for the diagnosis of the metabolic syndrome (80.0 cm) in this population should be increased to 91.5 cm (Crowther & Norris, 2012:e48883).

It was determined from data of combined studies of women including white and black South Africans, black Americans, West-Africans, and black Africans living in the USA that there was no difference in the WC-BMI relationship between the groups of black women, as well as between the white and black women, and the WC-visceral adipose tissue (VAT) relationship between the black groups of women was similar, but the WC-VAT relationship was different between the white women and each of the groups of black women (Sumner *et al.*, 2011:674). Compared to whites, blacks had higher BMI, similar WC and lower VAT. Whites had a greater increase in VAT per unit increase in WC (Sumner *et al.*, 2011:671). Based on these data, if there is a consensus that the BMI of risk is the same for black and white women, the same WC may be appropriate in both groups. If the WC-VAT relationship is the important determinant of central obesity, WC thresholds will be different in black and white women (Sumner *et al.*, 2011:674).

A WHO expert consultation addressed the debate about interpretation of recommended BMI cut-off points for determining overweight and obesity in Asian populations, and considered whether population-specific cut-off points for BMI are necessary. Diversity in Asian countries is based on ethnic and cultural subgroups, degrees of urbanisation, social and economic conditions, and nutrition transitions. Data from studies in China, India, Indonesia, Japan, Republic of Korea, Malaysia, Philippines, Singapore, Taiwan, and Thailand were considered. The cut-off point for observed risk of type 2 diabetes mellitus and CVD was substantially below the existing WHO BMI cut-off point of 25 kg/m^2 and varied from 22 kg/m^2 to 25 kg/m^2 in different Asian populations, and for high risk it varied from 26 kg/m^2 to 31 kg/m^2 . The WHO expert consultation concluded that Asians generally have a higher %BF than white people of the same age, gender and BMI (WHO, 2004:161).

As part of the China National Diabetes and Metabolic Disorders Study of Chinese adults from June 2007 to May 2009, central obesity was defined as WC \geq 90 cm in men and \geq 85 cm in women according to the Chinese Joint Committee for Developing Chinese Guidelines on Prevention and Treatment of Dyslipidemia in Adults (2007). Overweight and obesity were respectively identified as BMI of 24 – 27.9 kg/m² and BMI \geq 28 kg/m² according to the Working Group on Obesity in China (Hou *et al.*, 2013:e57319).

The analysis of the 2010 Korean National Health and Nutrition Examination Survey data determined cut-off values with the presence of two or more metabolic risk factors in pre- and post-menopausal women with BMI cut-off values as 23.1 kg/m² and 23.9 kg/m² and WC cut-off values as 76.1 cm and 82.5 cm respectively. The WC cut-off value of 76.1 cm for pre-menopausal women was found to be more sensitive and more effective at screening for metabolic syndrome risks than the cut-off value of 85 cm as given by the Korean Society for the Study of Obesity (Lee *et al.*, 2013:315).

Data of Malaysian female and male adults who participated in the Third National Health and Morbidity Survey in 2006, were collected from a sample with an ethnic distribution of mostly Malays (at 54.9%), and also included Chinese, Indians and other ethnic groups. BMI cut-off values were determined with the presence of diabetes mellitus (fasting blood glucose level of \geq 6.1 mmol/l), hypertension (systolic blood pressure \geq 140 mmHg and/or diastolic blood pressure \geq 90 mmHg), hypercholesterolemia (total cholesterol level \geq 5.2 mmol/l) or at least one of these three cardiovascular risk factors (Cheong *et al.*, 2012:454).

The BMI cut-off points for predicting diabetes, hypertension, hypercholesterolemia or at least one risk factor in all the men were 23.7 kg/m², 24.1 kg/m², 23.3 kg/m² and 23.3 kg/m² respectively, and in all the women were 24.9 kg/m², 25.4 kg/m², 23.9 kg/m² and 24.0 kg/m² respectively (Cheong *et al.*, 2012:455). Comparing the BMI cut-off points for the three main ethnic groups with at least one risk factor present, it was found that Indian men had the lowest BMI cut-off point at 22.2 kg/m² (compared to Malay at 23.3 kg/m² and Chinese at 23.7 kg/m²) and Chinese women the lowest BMI cut-off point at 23.6 kg/m² (compared to Malay at 24.4 kg/m² and Indian at 24.3 kg/m²) (Cheong *et al.*, 2012:457).

The WC cut-off points for predicting the presence of diabetes, hypertension, hypercholesterolemia and at least one of the three risk factors, varied from 81.4 cm to 85.5 cm for all men and 79.8 cm to 80.7 cm for all women. The optimal cut-off point is, therefore, the lowest of the four cut-off values which is 81 cm for men and 80 cm for women (Cheong *et al.*,

2014:e157). Among the three major ethnic groups in Malaysia, Indians (both genders) had the highest WC cut-off points compared to Malays and Chinese for all the cardiovascular risk factors (Cheong *et al.*, 2014:e159). A study of Asians in Singapore (including Chinese, Malaysian and Indian ethnic groups) revealed that based on higher %BF and the presence of cardiovascular risk factors at low BMIs, the WHO recommended BMI cut-off points for overweight (BMI ≥ 25 kg/m²) and obesity (BMI ≥ 30 kg/m²) were likely not to be relevant for Singaporeans. BMI cut-off points of ≥ 23 kg/m² for overweight and ≥ 27 kg/m² for obesity were determined as more consistent with the findings (Deurenberg-Yap & Deurenberg, 2003:s82).

The cut-off points for BMI and WC for detecting hypertension was determined in an endogamous North Indian population including male and female subjects with mean age 43.4 ± 5.3 and 38.7 ± 4.9 respectively (Gupta & Kapoor, 2012:441). The BMI cut-off point for men was 22.8 kg/m² and for women was 28.8 kg/m². The WC cut-off point for men was 92.0 cm and for women was 91.3 cm (Gupta & Kapoor, 2012:443). In this study, the cut-off points of anthropometric variables for detecting cardiovascular risk factors were lower than those recommended by the WHO (BMI of 25 kg/m² and 30 kg/m² for overweight and obesity respectively, and WC of 102 cm for men and 88 cm for women) (Gupta & Kapoor, 2012:445).

In Cambodia data from the 2010 STEP survey conducted by the Cambodian Department of Preventive Medicine of the Ministry of Health were used to determine BMI and WC cut-off points for a study sample of adults of both genders and aged 25 years to 64 years. Cardiovascular risk factors tested were hypertension (systolic blood pressure ≥ 140 mmHg and/or diastolic blood pressure ≥ 90 mmHg), fasting hyperglycemia (fasting blood glucose level ≥ 7.0 mmol/l) and hypercholesterolemia (fasting total cholesterol level ≥ 4.9 mmol/l) (An *et al.*, 2013:e77897). Significant association of subjects with the cardiovascular risk factors was found in those with BMI ≥ 23.0 kg/m² and with WC of 80 cm in both genders, which were lower than the WHO classifications (An *et al.*, 2013:e77897).

Shabnam *et al.* (2012:615) studied the data collected by The First Iranian Non-Communicable Disease Survey in 2005, which focused on a sample of 25 years to 64 years old with equal gender distribution. Cut-off points for BMI detecting hypertension, diabetes and hypercholesterolemia in men were 25.7 kg/m², 24.8 kg/m² and 24.0 kg/m² and in women were 26.9 kg/m², 26.3 kg/m² and 26.1 kg/m² respectively. Cut-off points for WC detecting hypertension, diabetes and hypercholesterolemia in men were 89.7 cm, 89.4 cm and 88.2 cm and in women were 93.9 cm, 96.2 cm and 90.0 cm respectively (Shabnam *et al.*, 2012:616). These cut-off values for WC in women were higher than the WHO recommended higher risk

WC cut-off value of 88.0 cm and the IDF recommended Middle-Eastern WC cut-off value of 80.0 cm (Alberti *et al.*, 2009:1642). Data from the discussed literature indicate that the determined cut-off values for the different populations are closely related, although significant differences do occur. Research is necessary to develop cut-off points for BMI and WC to detect cardiometabolic risk factors for all population groups.

2.5.2 Percentage body fat

Gallagher *et al.* (2000:699) developed prediction models for %BF based on BMI which had significant age, gender and ethnicity terms with African-American (AA), Asian and white groups, as independent variables. The %BF standards for the different ethnic groups are presented in Table 2.7.

Table 2.7: Predicted %BF based on 4-compartment estimates of %BF and ethnicity

Age and BMI	Women			Men		
	AA	Asian	white	AA	Asian	white
20-39 y						
BMI < 18.5	20	25	21	8	13	8
BMI ≥ 25	32	35	33	20	23	21
BMI ≥ 30	38	40	39	26	28	26
40-59 y						
BMI < 18.5	21	25	23	9	13	11
BMI ≥ 25	34	36	35	22	24	23
BMI ≥ 30	39	41	41	27	29	29
60-79 y						
BMI < 18.5	23	26	25	11	14	13
BMI ≥ 25	35	36	38	23	24	25
BMI ≥ 30	41	41	43	29	29	31

(Gallagher *et al.*, 2000:699); AA = African American; BMI = Body mass index.

More recently, data from the USA NHANES 1999-2004 were used of adult subjects, including non-Hispanic white (NHW), non-Hispanic Black (NHB) and Mexican American (MEX) ethnicity populations, aged 18 years to 84 years to develop cut-off points of %BF on the basis of the relation between DXA measured fat mass and BMI by gender, age and race-ethnicity (Heo *et al.*, 2012:594). Cut-off points were determined on the basis of estimated prediction equations as presented in Table 2.8.

The prediction of %BF using BMI and WC differed by ethnicity, as compared in individuals of Chinese, South Asian and European origin in a study of female and male subjects aged between 30 and 65 years (Lear *et al.*, 2007:2817). The results indicated that BMI underestimated %BF of South Asians, whereas no difference was found between the Chinese and European groups (Lear *et al.*, 2007:2820). Optimal cut-off points for %BF in Korean adults aged 18 years to 92 years were determined with the prevalence of obesity-related CVD risk factors. The first cut-off points for men and women were 17% and 32% body fat, respectively; the second cut-off points were 21% and 37% body fat respectively. Overweight was defined as the range between the first and second cut-off points, and obese was defined as %BF higher than the second cut-off point (Kim *et al.*, 2011:36).

Table 2.8: Cut-off points of %BF in reference to BMI cut-off points (in kg/m²) in USA men and women

Age and BMI	Women			Men		
	NHW	NHB	MEX	NHW	NHB	MEX
18-29 y						
BMI < 18.5	26.9	24.6	28.5	14.5	12.2	14.8
BMI ≥ 25	37.0	35.0	37.8	24.9	22.6	25.6
BMI ≥ 30	41.8	39.9	42.3	29.8	27.5	30.7
BMI 35	45.2	43.4	45.4	33.3	31.0	34.4
BMI 40	47.7	46.1	47.8	35.9	33.6	37.1
30-49 y						
BMI < 18.5	27.5	25.8	29.8	15.6	13.4	16.1
BMI ≥ 25	37.4	35.8	38.2	25.4	23.2	25.6
BMI ≥ 30	42.2	40.6	42.1	30.0	27.9	30.1
BMI 35	45.6	44.0	45.0	33.3	31.2	33.4
BMI 40	48.1	46.6	47.1	35.8	33.7	35.8
50-84 y						
BMI < 18.5	31.0	28.0	32.3	19.0	16.3	18.3
BMI ≥ 25	39.9	37.7	40.2	28.0	25.6	27.5
BMI ≥ 30	44.1	42.3	44.0	32.3	30.0	31.9
BMI 35	47.1	45.6	46.7	25.3	33.2	35.0
BMI 40	49.4	48.1	48.7	37.6	35.6	37.3

(Heo *et al.*, 2012:599)

All cut-off points for measuring body composition, i.e. BMI, WC and %BF, are indicated for population groups who are apparently healthy or in the presence of cardiometabolic risk factors, e.g. hypertension. Certain chronic diseases and health conditions, and behaviour factors that adversely affect health, could influence and alter body composition and cause misinterpretation of measured values, one of which is discussed next in this chapter.

2.6 EFFECT OF HIV-STATUS ON BODY COMPOSITION

Acquired immune deficiency syndrome (AIDS) is caused by the human immunodeficiency virus (HIV). Medication, which is called antiretroviral (ARV) therapy, is used to enhance the quality of life and increase life expectancy of HIV-infected individuals. ARVs slow the replication of the virus but do not eliminate the HIV infection (Dong & Imai, 2012:864).

More than half of HIV-infected patients treated with ARV therapy, experience changes in body composition and lipodystrophy or abnormal fat distribution. This includes peripheral adipose tissue atrophy (lipoatrophy) in the face and limbs and visceral adipose tissue accumulation (lipohypertrophy). In addition to lipohypertrophy of existing fat depots, HIV-infected individuals also exhibit increased prevalence of ectopic fat distribution in the liver, muscles, and dorsocervical area. Although certain ARV medications appear more highly associated with abnormalities in fat redistribution than others, changes in body composition may occur to some degree with any ARV strategy. Studies of ARV naïve patients beginning treatment show clear increases in visceral adipose tissue and trunk fat even with contemporary regimens (Stanley & Grinspoon, 2012: s383).

HIV invades the genetic core of CD₄ cells, T-helper lymphocyte cells, which are the principal agents involved in protection against infection and affects the body's ability to fight off infection and disease, which can ultimately lead to death (Dong & Imai, 2012:864). Wasting implies unintentional weight loss and loss of lean body mass, which have been strongly associated with an increased risk of this disease's progression and mortality. Despite the efficacy of ARV therapy, wasting continues to be a common problem in the HIV-infected population. Wasting may be caused by a combination of factors including inadequate dietary intake, malabsorption and increased metabolic rates from viral replication or complications from the disease. Obesity in HIV infected individuals has also been noted. In the era of ARV therapy, it is no longer believed that continuously gaining body weight is a protective cushion against HIV-related wasting and progression to AIDS (Dong & Imai, 2012:878).

Visceral lipohypertrophy leads to cardiometabolic comorbidities, including dyslipidemia, decreased insulin sensitivity and impaired glucose homeostasis, increased risk for CVD, specifically progression of subclinical atherosclerosis and increased risk of myocardial infarction, and increased overall mortality (Stanley & Grinspoon, 2012: s385).

Wrottesley *et al.* (2014:1604) examined body composition, including adipose and lean tissue, in ARV-naïve HIV-positive (divided into a HIV-positive non-ARV group with preserved CD4 counts of $\geq 350 \times 10^6$ cells/l, not eligible for ARV therapy and a HIV-positive pre-ARV group with low CD4 counts of $\leq 200 \times 10^6$ cells/l, eligible for ARV-therapy) and HIV-negative black urban South African women. They also examined whether the relationship between HIV infection and body composition is influenced by differences in disease severity by comparing affected women with low and relatively preserved CD4 counts. The subjects in the three groups had similar mean ages and height measurements.

The results showed a high prevalence of overweight and obesity according to BMI categorising (BMI $\geq 25\text{kg/m}^2$ and BMI $\geq 30\text{ kg/m}^2$ respectively) in the whole sample of subjects (59%). There was a significant difference in distribution of subjects across BMI categories between the groups, with the HIV-positive pre-ARV group having significantly fewer obese subjects (16%) than the HIV-positive non-ARV (37%) and the HIV-negative (30%) groups. The HIV-positive pre-ARV group also had a higher underweight prevalence (11%); approximately 3- and 11-fold higher than the HIV-negative and HIV-positive non-ARV groups, respectively. The HIV-positive pre-ARV group status was associated with an approximately 4.5 kg/m^2 lower BMI (Wrottesley *et al.*, 2014:1608).

There was a significant difference in fat mass between the groups, as showed by DXA scanning, with the HIV-positive pre-ARV group having lower total fat mass and %BF than the other two groups. The trunk and limb fat masses, when expressed as a percentage of whole body fat mass, were not different between the groups (Wrottesley *et al.*, 2014:1608). Correlations confirmed the relationship between CD4 count and fat mass and CD4 count and lean mass. The HIV-positive pre-ARV group status was associated with an 8 kg lower fat mass and a 3 kg lower lean mass (Wrottesley *et al.*, 2014:1608).

The groups did not show differences in trunk and limb fat percentages, which suggest lower body fat across all sites rather than an altered fat distribution with advanced HIV infection. This contradicts previous USA data which showed an increase in both percent trunk fat and trunk:limb fat ratio and a decrease in peripheral fat independent of ARV treatment in HIV-

positive women compared to HIV-negative controls. It might suggest a different pattern of fat loss than that associated with ARV-treatment, where lipodystrophy is characterised by abdominal fat accumulation and subcutaneous fat loss, predominantly at the face, limbs and buttocks (Wrottesley *et al.*, 2014:1610).

In this study of a sample of black, urban, South-African women, the HIV-positive subjects had lower weight and BMIs, as well as lower fat and lean mass and %BF than the HIV-negative counterparts. This was primarily as a result of the HIV-positive subjects with low CD4 counts having low measures. The HIV-positive pre-ARV, but not the HIV-positive non-ARV status was a key contributor to differences in fat mass and lean mass. This challenges the stereotypical view of HIV as a disease associated with involuntary weight loss and wasting prior to ARV initiation and suggests that weight loss may only become a symptom in this population at more severe disease states (Wrottesley *et al.*, 2014:1609).

Immunosuppression may be a predictor of anthropometric and body composition changes in HIV-positive women, and in populations with high obesity prevalence, as shown in black women in South Africa, these differences become evident only at advanced stages of infection (Wrottesley *et al.*, 2014:1611).

Treatment strategies for body composition changes and cardiometabolic abnormalities in HIV infection include lifestyle modification, lipid-lowering agents, insulin sensitizers, and treatments to reverse endocrine abnormalities in HIV. None of these strategies has comprehensively addressed the abnormalities experienced by this population, however, and further research is needed into combined strategies to improve body composition and ameliorate cardiovascular risk (Stanley & Grinspoon, 2012: s383). Since HIV affects body composition, the general cut-off values of measuring body composition cannot be used in this specific group and as yet no clear indications or adjusted cut-off values exist in the literature.

2.7 HYPERTENSION

2.7.1 Obesity as etiological risk factor of hypertension

Obesity is the major risk factor for hypertension, being responsible for 20% to 30% of disease cases (Silva *et al.*, 2012:112). Blood pressure is often increased in obese patients and is probably the most common co-morbidity that is associated with obesity (Smith, 2012:29). Forty nine percent of persons with hypertension and 27% of normotensive persons are obese

(Prinsloo *et al.*, 2011:367). Risk factors of behaviour, including higher BMI, have been found to be associated with hypertension (Peltzer & Phaswana-Mafuya, 2013:66). Javed *et al.* (2011:1186) concluded that increasing BMI predicted hypertension in elderly black American females and their results indicated that the risk of hypertension increased significantly at a BMI of > 23 kg/m² in this ethnic group. This supports the relationship between obesity and hypertension, in that obesity increases the incidence and prevalence of hypertension as a disease. Zhang *et al.* (2013:e70893) compared their adiposity measurements and determined that BMI was the best screening tool for hypertension in both genders in this Chinese study population.

Chandra *et al.* (2014:997) determined that amongst North-American women and men of multiple ethnicities with a mean age of 40 years, higher BMIs, measuring total adiposity, were significantly associated with incident hypertension. In a study conducted in postmenopausal women, BMI was positively and significantly associated with systolic blood pressure (SBP) (Shidfar *et al.*, 2012:442).

The risk of hypertension is greater in those with upper body and abdominal obesity. WC was positively and significantly correlated with SBP and diastolic blood pressure (DBP) similar to previous studies, which found that visceral obesity, measured by WC, was more closely associated with the presence of hypertension than overall obesity, measured by BMI (Shidfar *et al.*, 2012:444).

Chandra *et al.* (2014:1000) concluded that among individuals who were initially normotensive, a greater amount of visceral adiposity was associated with an increased risk for the development of hypertension after a median of 7 years of follow-up. Addition of VAT to the multivariable model, including also subcutaneous adipose tissue (SAT) and lower body fat (LBF), attenuated the association of BMI with incident hypertension, suggesting that visceral adiposity, rather than total adiposity, is more important in this relationship.

The findings by Silva *et al.* (2012:119) were consistent with other studies in reporting that high levels of body fat is associated with hypertension and concluded that in both genders the prevalence of hypertension is approximately twice as high in subjects with high %BF compared to those with normal %BF. Mallikharjuna Rao *et al.* (2012:56) found that for Indian women with a %BF of 30%, the prevalence of hypertension was significantly higher than in women with a lower %BF.

Equations that estimate %BF using anthropometric indicators such as BMI and WC have good predictive capacity for hypertension. The screening of hypertension through %BF estimated by equations was found to be more useful in women, regardless of age, if the equation with WC was used; in men, regardless of age, the screening was most useful if BMI was used (Silva *et al.*, 2012: 119). Classifications based on BMI and WC are useful to screen and identify people at risk for hypertension and refer them for monitoring and diagnostic tests. Moreover, the evaluation of the specific role of anthropometric indices on the development of hypertension may help to understand better the pathogenesis of arterial hypertension, and to provide more accurate means of prevention (Silva *et al.*, 2012: 113).

2.7.2 Hypertension as cardiovascular disease risk

Hypertension is a powerful, consistent and independent risk factor for CVD (AHA, 2005:144). CVD is one of the leading causes of deaths worldwide, killing 17 million people annually. Hypertension is responsible for a significant percentage of the high rates of heart disease and stroke in South Africa (Mungal-Singh, 2012:12). Hypertension as a measurable indicator also is part of criteria used for clinical diagnosis of metabolic syndrome (Alberti *et al.*, 2009:1642). Subjects in the high-normal stage of BP (SBP 130-139 and/or DBP 85-89), are already at higher CVD risk (Seedat *et al.*, 2014:139).

There is growing evidence that VAT represents a pathological adipose tissue depot, which accumulates when subcutaneous depots are overwhelmed or otherwise unavailable for storage. Relative to SAT, visceral fat is more sensitive to lipolysis and secretes higher amounts of inflammatory cytokines (Chandra *et al.*, 2014:1001). VAT is associated with a higher atherosclerotic risk profile and also recently has been prospectively linked to adverse cardiovascular events (Chandra *et al.*, 2014:1001). These results suggest that VAT may be the important link between BMI and cardiovascular disease, and that VAT may be acting in part by promoting the development of hypertension and insulin resistance (Chandra *et al.*, 2014:1001).

The black population is more prone to complications of HTN, that of stroke, heart failure and renal failure, while the incidence of CVD, although increasing in frequency, is less common compared with that in white and Asian populations (Seedat *et al.*, 2014:143). Hypertension remains the most important, well-documented modifiable stroke risk factor, and treatment of hypertension is among the most effective strategies for preventing both ischemic and hemorrhagic stroke. Across age groups, including adults ≥ 80 years of age, the benefit of hypertension treatment in preventing stroke is clear (AHA/ASA, 2014:14).

2.7.3 Classification of hypertension

The Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure (JNC 7) in the USA has continued the definition of hypertension (HTN) or high blood pressure beginning at a blood pressure (BP) of 140/90 mmHg for adults aged 18 years or older (AHA, 2005:145). This classification is based on the average of ≥ 2 seated blood pressure measurements, properly measured with well-maintained equipment, at each of ≥ 2 visits to the place of measurement (AHA, 2005:145). HTN can be classified as shown in Table 2.9 according to the sixth hypertension guideline published by the Southern African Hypertension Society (SAHS), adapted from recommendations from the European Society of Hypertension (ESH) and the European Society of Cardiology (ESC) (Seedat *et al.*, 2014:139).

Table 2.9: Classification of hypertension

Blood pressure stage	Systolic blood pressure (mmHg)	Diastolic blood pressure (mmHg)
Normal	< 120	< 80
Optimal	120-129	80-84
High normal	130-139	85-89
Grade 1 hypertension	140-150	90-99
Grade 2 hypertension	160-179	100-109
Grade 3 hypertension	≥ 180	≥ 110
Isolated systolic hypertension	≥ 140	<90

(Seedat *et al.*, 2014:139)

HTN is defined as a persistent elevation of office BP $\geq 140/90$ mmHg. The optimal BP is a value < 130/85 mmHg. High normal is BP levels from 130–139 mmHg systolic and/or 85–89 mmHg diastolic. HTN is stratified into three grades depending on severity, which is useful in defining the approach to treatment (Seedat *et al.*, 2014:139). In previous HTN classification, prehypertension was defined as SBP of 120-139 mmHg and/or DBP of 80-89 mmHg (AHA, 2005:145).

2.7.4 Prevalence of hypertension

The prevalence of hypertension in the USA has plateaued over the past decade. On the basis of national survey data from 1999 to 2000 and 2007 to 2008, the prevalence of hypertension remained stable at 29% (AHA/ASA, 2014:12).

In South Africa in 2012 approximately 6.3 million people were hypertensive of which only 14% were controlled (Mungal-Singh, 2012:12). Currently approximately one third (30.4%) of the adult South African population has hypertension (Seedat *et al.*, 2014:139). Hypertension alone is the leading reason for attending primary care and is the most common diagnosis (13.1%) in South Africa (Peltzer & Phaswana-Mafuya, 2013:66). According to the SANHANES, SBP and DBP were measured in female and male participants 15 years and older. Overall more than one third (38.3%) of participants had SBP levels in the prehypertensive and hypertensive ranges (Shisana *et al.*, 2013:80).

Adult black South Africans are becoming heavily affected by increases in hypertension levels. In a study that was done fifteen years ago, results indicated that in the North West Province of South Africa hypertension prevalence in a black population sample was 20.8% with an elevated DBP and 22.8% with an elevated SBP. In the female subjects, hypertension as elevated SBP or elevated DBP ranged from 10% to 31% in the different living areas (Van Rooyen *et al.*, 2000:782).

Various factors have been found to be associated with hypertension, including socio-demographics (older age, female gender, lower education level, lower household income) and geolocality (urban residence) (Peltzer & Phaswana-Mafuya, 2013:66). A study by Peltzer and Phaswana-Mafuya (2013:68) among South African subjects 50 years and older, which included mixed population groups, found significant rates of hypertension of 77.3% (male 74.4%, female 79.6%). As shown by the SANHANES, hypertension prevalence was also age-related, with an increasing percentage of the population having high SBP with increasing age. More than half of adults (50.5%) over 55 years of age had elevated SBP. Almost a third (31.0%) and a quarter (22.7%) of participants in the age group 45 years to 54 years of age had prehypertensive and hypertensive mean DBP respectively (Shisana *et al.*, 2013:80). According to SANHANES, the highest mean SBP was found in the age group 65 years and older (149.3 mmHg) and the highest mean DBP was found in the age group 45 years to 54 years (80.6 mmHg) (Shisana *et al.*, 2013:80).

The North West Province of South Africa had the third highest recorded mean SBP (131 mmHg). The rural formal areas had the highest recorded mean SBP (130.1 mmHg) and the highest recorded mean DBP (75.6 mmHg) (Shisana *et al.*, 2013:80).

By race, the coloured population group had the highest mean SBP (132.1 mmHg), followed by white, then Indian and then black population groups (Shisana *et al.*, 2013:81). The coloured race group had the highest mean DBP (75.6 mmHg), followed by Indian, then white and then black population groups (Shisana *et al.*, 2013:81). The study by Peltzer and Phaswana-Mafuya (2013:68) also found that being in the coloured population group was associated with higher rates of hypertension compared to white, Indian or Asian, and African black population groups.

2.7.5 Measurement of blood pressure

Blood pressure (BP) measurement is a vital clinical sign that should be correctly performed by healthcare professionals according to the SAHS recommendations which apply to both clinic and self-measurement of BP. Failure to follow the guidelines leads to significant errors in BP measurement. The most important recommendations include the patient to be allowed to sit 3-5 minutes before commencing measurement; to take two readings 1-2 minutes apart; the patient should be seated with the back supported and the arm bared and supported at heart level; and the patient should not have smoked, ingested caffeine-containing beverages or food in the previous 30 minutes. BP should be recorded using an approved and calibrated electronic device or mercury sphygmomanometer. Repeat measurements should be performed on at least three separate occasions within four weeks unless BP is $\geq 180/110$ mmHg (Seedat *et al.*, 2014:140).

2.7.6 Management of hypertension

In general, it is estimated that in South Africa only 26% of men and 51% of women are aware of their hypertension. Evidence suggests that the rates of awareness, treatment and control among the hypertensive subjects aged 50 years and older were low (38.1%, 32.7% and 17.1% respectively) (Peltzer & Phaswana-Mafuya 2013:69). All patients with HTN should receive lifestyle counseling, and this is the cornerstone of management. Subjects in the high-normal stage of BP (SBP 130-130 and/or DBP 85-89) are at risk of developing HTN, but do not require drug treatment (Seedat *et al.*, 2014:139). Patients with grade 1 HTN should receive lifestyle modification for three to six months unless they are stratified as high risk by the following criteria: three or more major risk factors (including smoking, dyslipidemia, family history of early onset CVD and WC indicating abdominal obesity), diabetes, target-organ damage or

complications of HTN. Once the diagnosis of HTN is established, patients with BP \geq 160/100 mmHg should commence drug therapy and lifestyle modification (Seedat *et al.*, 2014:140). According to the SAHS, before an antihypertensive agent is chosen, considerations should be allowed based on the cost of the various antihypertensive drug classes, the patient-related risk factors, the conditions favouring use and the contra-indications of the major classes of antihypertensive drugs, as well as the possible complications and target-organ damage (Seedat *et al.*, 2014:141).

Weight reduction to a greater extent than previously indicated could play an integral role in prevention and control of hypertension, specifically in populations in which hypertension was found to be correlated to increased BMI values. The optimal management of obesity includes a combination of lifestyle modifications, including diet and exercise, and behavioural modifications, for a duration of approximately three to six months for the majority of patients (Smith, 2012:29). The recommendation by SAHS is to reach a normal BMI of 18.5 – 24.9 kg/m² which could lower SBP approximately 5-20 mmHg per 10 kg of weight lost (Seedat *et al.*, 2014:141). Modifiable risk factors of behaviour, including an unhealthy diet and insufficient fruit and vegetable intake, physical inactivity, tobacco use and the harmful use of alcohol, lead to hypertension, as well as overweight and obese states. Addressing these risk factors can help avoid up to 80% of heart disease and stroke (Mungal-Singh, 2012:12).

Evidence supporting the direct relationship between hypertension and sodium consumption is overwhelming with numerous types of study designs indicating this relationship (Steyn *et al.*, 2013:7). In a recent meta-analysis it was reported that a direct association between high dietary sodium intake and risk of stroke exist (Strazzullo *et al.*, 2009:162). Furthermore, they concluded from the meta-analysis that dose dependent association can be seen with sodium intake and its association with incidence of strokes and total cardiovascular events. The WHO strongly recommends a reduction in sodium (<2000 mg sodium per day OR 5 g salt per day) intake to reduce blood pressure and risk of CVD and stroke in adults (WHO, 2010). According to the WHO in most countries average per-person salt intake is too high and is between 9 and 12 g/day. In the past 15 years the amount of salt consumed by South Africans and the profound effect it has on health received more attention. A limited number of studies have been conducted in the South African population and it has been estimated that the average South African consume between 6 – 11 g of salt per day (Wentzel-Viljoen *et al.*, 2013:108). The SAHS recommendations are to follow the Dietary Approaches to Stop Hypertension (DASH) which consists of a low saturated fat and low total fat intake, an increased fruit and vegetable intake, as well as limiting daily dietary sodium intake to \leq 2400 mg sodium or 6 g salt; to engage in

physical activity of brisk walking for 30 minutes per day most days; to have a moderate alcohol intake of no more than two drinks per day; and to cease smoking completely (Seedat *et al.*, 2014:141).

2.8 MEASURES OF BODY COMPOSITION AND ASSOCIATED METABOLIC DISEASE

Body composition evaluation is indispensable to assess the efficacy of primary and secondary preventive nutritional strategies (De Lorenzo *et al.*, 2013:112). Maintaining a healthy body weight and level of body fatness is key to a healthier and longer life. Overweight individuals with body fat levels falling at or near the extreme upper level of the body fat continuum are likely to have serious cardiometabolic health problems that reduce life expectancy and threaten the quality of life (Heyward & Wagner, 2004:3).

More recently emphasis has been placed on abdominal obesity, as measured by WC. Using WC rather than BMI as an indicator of increased cardiometabolic risk, is exemplified by its incorporation as one of the five criteria used to make a diagnosis of metabolic syndrome (Alberti *et al.*, 2009:1642). The International Diabetes Federation (IDF) and the American Heart Association/National Heart, Lung and Blood Institute (AHA/NHLBI) compiled the five criteria, of which three of the five risk factors being present constitute a diagnosis of metabolic syndrome. The criteria are shown in Table 2.10.

Table 2.10: Criteria for clinical diagnosis of the metabolic syndrome

Measure	Categorical cut points
Elevated WC	≥ 80 cm in females and 94cm in males (Sub-Saharan Africa)
Elevated triglycerides (TG) or drug treatment	≥ 1.7 mmol/l
Reduced high density lipoprotein (HDL) cholesterol or drug treatment	< 1.3 mmol/l in females and <1.0 mmol/l in males
Elevated blood pressure or antihypertensive drug treatment	SBP ≥ 130 and/or DBP ≥ 85 mmHg
Elevated fasting glucose or drug treatment	≥ 5.6 mmol/l (100 mg/dl)

(Alberti *et al.*, 2009:1642)

As part of the China Diabetes and Metabolic Disorders Study, the results showed that WC can be used as a good indicator of visceral fat or central fat and is closely associated with diabetes, whereas BMI better reflects body volume and total mass (combination of fat mass and lean mass) which is associated with blood viscosity and blood volume and is closely related to blood pressure. It was found that the combination of WC and BMI measures was superior to the separate indices in identifying CVD risk (Hou *et al.* 2013:8).

In a study by Abassi *et al.* (2013:637) of women and men, mostly European, the goal was to identify individuals at increased cardiometabolic risk associated with excess adiposity and the results showed there were essentially as many identified as being overweight/obese using BMI as abdominally obese using WC. Most (95%) of the overweight/obese subjects were abdominally obese and basically the same proportion (94%) of abdominally obese individuals were overweight/obese. In the female and male subjects, both indexes of obesity, BMI and WC, correlated with SBP as a cardiometabolic risk factor.

In Canadian female and male subjects of various ages, with BMI-defined normal weight, it was demonstrated that a wide range in %BF existed, indicating the prevalence of metabolically obese normal weight individuals. The prevalence of cardiometabolic abnormalities or risk factors was the highest among individuals with high %BF (%BF \geq 20.8% in men, \geq 35% in women) compared to those with medium %BF (15.3 – 20.7% in men, 29.8-34.9% in women) and low %BF (\leq 15.2% in men, \leq 29.7% in women) (Shea *et al.*, 2012:745).

Percentage BF, measured by DXA, correlated positively with SBP and DBP, TG levels and insulin resistance, but not with fasting glucose levels (Shea *et al.*, 2012:744). Moreover, %BF was negatively associated with HDL cholesterol levels (Shea *et al.*, 2012:744). Similar to %BF, WC was positively associated with TG and insulin resistance, and negatively correlated with HDL cholesterol (Shea *et al.*, 2012:744). No significant associations were evident with SBP or DBP as well as blood glucose concentrations (Shea *et al.*, 2012:744). These findings indicate that individuals cannot be classified as obese solely on their BMIs and that individuals with elevated %BF are at increased risk of developing cardiometabolic disease despite having a normal BMI (Shea *et al.*, 2012:741).

A study of data of individuals in the European countries Spain, Iceland and Ireland, found that despite similar age and BMI, differences in body fatness and cardiovascular risk factors were indicated. Significantly higher WC and %BF were among Irish participants in comparison with Spanish and Icelandic subjects, with subsequent more unfavourable cardiometabolic risk

factors among the Irish participants than the Spanish and Icelandic subjects (Ramel *et al.*, 2013:255). These results showed that different populations within Europe may have different cardiometabolic risk profiles, partly due to differences in body fat distribution (Ramel, *et al.*, 2013:257).

Among the Asian population, as determined by Cheong *et al.* (2012:453) from data of Malaysian adults (including Malays, Chinese, Indians and other ethnic groups), who participated in the Third National Health and Morbidity Survey in 2006, in men and women the odds ratio for having diabetes mellitus (fasting blood glucose level of ≥ 6.1 mmol/l), hypertension (SBP ≥ 140 mmHg and/or DBP ≥ 90 mmHg), hypercholesterolemia (total cholesterol level ≥ 5.2 mmol/l) or at least one of these three cardiovascular risk factors, increased significantly as the BMI values increased.

A Singaporean study including Chinese, Malays and Indians, determined that absolute and relative risks, for all three ethnic groups, of developing cardiovascular risk factors were markedly elevated at BMIs that were much lower than WHO-recommended cut-off points for obesity. The discrepancy between the high cardiovascular mortality and apparently low national obesity prevalence (defined as BMI ≥ 30 kg/m² by the WHO) could be partially explained by the presence of excessive %BF among Singaporeans at low levels of BMI when compared with Caucasians (Deurenberg-Yap & Deurenberg, 2003:s82). High %BF, as found in Asian populations, irrespective of weight, is associated with a high prevalence of CVD and its risk factors (Kim *et al.*, 2011:34).

Similar to the Asian studies, were the findings of a Cambodian study by An *et al.* (2013:e77897) that the risk for developing metabolic syndrome, with the cardiovascular risk factors including hypertension, diabetes and hypercholesterolemia, increased significantly in accordance with the increase of BMI and WC. The net result of increased visceral adiposity and ectopic fat deposition will be much higher levels of insulin resistance with subsequent increased levels of metabolic disorders (Crowther & Ferris, 2010:116).

Goedecke *et al.* (2009:1508) determined in their study that the centralisation of adipose tissue in South African obese black women was attributable to a greater amount of SAT and not VAT. The obese black women had significantly less VAT, but more superficial SAT than obese white women. For the same level of adiposity, black women were more insulin resistant than white women, where the insulin sensitivity in black women was most closely associated with the subcutaneous depots, in particular deep SAT. In contrast, in white women the association with

insulin sensitivity was equal between the VAT and SAT depots (Goedicke *et al.* 2009:1510). In another South African study of a black rural KwaZulu-Natal population, with mean age 46.5 ± 18.1 years, a higher prevalence of metabolic syndrome was found amongst the women (30.2%) than in the men (11.6%), in which the most frequent individual component was a high WC (96.9% in the women and 90.9% in the men) (Motala *et al.*, 2011:1034). In a study by Javed *et al.* (2011:1182), it was found that in black American females aged 65 years and older, BMI was an independent and significant predictor of hypertension. This supports the higher prevalence of obesity and higher cardiovascular mortality in this population and ethnic group (Javed *et al.* (2011:1183).

2.9 POSSIBLE IMPLICATIONS REGARDING MEASURES OF BODY COMPOSITION IN DEFINING ADIPOSITY AND THE LINK TO DISEASE

The necessity for ethnic specific cut-off values in various populations for measures of body composition to define adiposity, including %BF, BMI, and WC, was emphasised in the literature. Using the modified cut-off points as determined by studies of populations of various ethnicities, would enable the detection of groups with high-risk obesity and its co-morbidities for further investigations and intervention where necessary (Deurenberg-Yap & Deurenberg, 2003:s85).

A WHO expert consultation addressed the debate about interpretation of recommended BMI cut-off points for determining overweight and obesity and the related health risks in Asian populations. The purpose of a BMI cut-off point is to identify, within each population, the proportion of people with a high risk of an undesirable health state that warrants a public health or clinical intervention. When applied to a population, the purpose of anthropometric cut-off points is to identify independent and interactive risks of adverse health outcomes associated with different body compositions, so as to inform policy, trigger action, facilitate prevention programmes and assess the effect of interventions (WHO, 2004:161).

Reducing BMI cut-off points for action on overweight and obesity would increase their prevalence rates overnight and, therefore, increase governmental and public awareness. However, such a change would require public health policies and clinical management guidelines to be changed, and could lead to increased costs for governments (i.e., more treatment at lower thresholds). The expert consultation, therefore, agreed that BMI cut-off points should be: based on easy-to-obtain valid and reliable measurement in surveys and clinical settings; sensitive to important health-related change over time for monitoring purposes; science-based, with a sound general foundation, and with validity in the population in question;

able to predict risks in populations and detect difference in risks between population groups; useful for comparisons across populations; and based on ideas that are easy for policy-makers, clinicians, and the public to understand (WHO, 2004:161).

However, available data do not necessarily indicate a clear BMI-cut-off point for all Asians for overweight or obesity. No attempt was made, therefore, to redefine cut-off points then for each population separately. The consultation proposed methods by which countries could make decisions about the definitions of increased health risk for their populations (WHO, 2004:157).

The WHO, therefore, recommended that where possible, in populations with a predisposition to central obesity and related increased risk of developing metabolic syndrome, WC should also be used to refine action levels on the basis of BMI. For example, action levels based on BMI might be increased by one level if the WC is above a specified action level. The choice of that level should be based on population-specific data and considerations. Therefore, a WHO working group was formed to examine available data on the relation between WC and morbidity and the interaction between BMI, WC, and health risk to investigate further next action and develop recommendations for the use of additional waist measurements to define further risks (WHO, 2004:161).

The WHO defined obesity in terms of BMI when associated with various comorbidities, on the other hand, WHO defines overweight and obesity also in terms of body fatness (WHO, 2013). When defining overweight/obesity, BMI is the most widely used screening tool because of its practicality. WC and %BF measures of obesity are, however, more physiologic in character and are diagnostic of obesity-related health risks and metabolic diseases, such as hypertension, diabetes mellitus and CVD (Alberti *et al.*, 2009:1642; Shea *et al.*, 2012:745). Agreement between BMI categories and %BF cut-off points needs to be assessed, also with the impact of gender, age and ethnicity. BMI and %BF often differ in classifying subjects as obese, with BMI tending to identify obesity less often than %BF (De Schutter *et al.* 2011:223).

While it is not expected that all clinicians perform a %BF measurement during routine patient encounters, the results of the correlation studies as indicated, may be helpful to guide clinicians and researchers who are considering different aspects of body composition (De Schutter *et al.*, 2013:82).

2.10 CONCLUSION

Overweight and obesity is becoming a worldwide epidemic with increasing prevalence in developed and developing countries. Obesity is associated with various comorbidities and NCDs, such as hypertension and CVD, which are major causes of mortality and morbidity amongst many ethnic population groups worldwide and in South Africa.

BMI categories, %BF cut-off points and WC cut-off points have been developed to measure adiposity and the prevalence of obesity-related health risks, and new cut-off points have been determined based on ethnicity. Little data regarding optimal cut-off points are available for black South-Africans, particularly women, but studies have determined WC cut-off points for black women and men based on metabolic syndrome to be approximately 92 cm and 86 cm respectively (Crowther & Norris, 2012:e48883; Motala *et al.*, 2011:1035).

The study that will be described in Chapter 4 was proposed and executed, since few studies on overweight/obesity based on %BF have been performed in South Africa as a whole or amongst this specific female black population in the North West Province of South Africa.

2.11 REFERENCES

Abassi, F., Blasey, C. & Reaven, G.M. 2013. Cardiometabolic risk factors and obesity: does it matter whether BMI or waist circumference is the index of obesity? *American journal of clinical nutrition*, 98:637-640.

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 Federation; International Atherosclerosis Society and International Association for the Study of Obesity. *Circulation*, 120:1640-1645.

Aloia, J.F., Vaswani, A., Ma, R., & Flaster, E. 1996. Aging in women – the four compartment model of body composition. *Metabolism*, 45(1):43-48.

American Heart Association (AHA). 2005. Hypertension. *Journal of the American heart association*, 45:142-161. (<http://hyper.ahajournals.org/>)

American Heart Association (AHA)/American Stroke Association (ASA). 2014. Guidelines for the primary prevention of stroke. *Stroke*, 45:1-90.

Amole, I.O., Olaolorun, A.D., Odeigah, L.O. & Adesina, S.A. 2011. The prevalence of abdominal obesity and hypertension amongst adults in Ogbomoso, Nigeria. *African journal of primary health care and family medicine*, 3(1):188-192.

An, Y., Yi, S., Fitzpatrick, A., Gupta, V., Prak P.R., Oum, S., Logerfo, J.P. 2013 Appropriate body mass index and waist circumference cutoff for overweight and central obesity among adults in Cambodia. *PlosOne*, 8(10):e77897.

Chandra, A., Neeland, I.J., Berry, J.D., Ayers, C.R., Rohatgi, A., Das, S.R., Khera, A., McGuire, D.K., De Lemos, J.A. & Turer, A.T. 2014. The relationship of body mass and fat distribution with incident hypertension - observations from the Dallas Heart Study. *Journal of the American college of cardiology*, 64(10):997-1002.

Cheong, K.C., Ghazali, S.M., Hock, L.M., Yusoff, A.F., Selvarajah, S., Haniff, J., Zainuddin, A.A., Ying, C.Y., Lin, K.G., Rahman, J.A., Shahar, S., Mustafa, A.N. 2014. Optimal waist circumference cut-off values for predicting cardiovascular risk factors in a multi-ethnic Malaysian population. *Obesity research and clinical practice*, 8:e154-e162.

Cheong, K.C., Yusoff, A.F., Ghazali, S.M., Lim, K.H., Selvarajah, S., Haniff, J., Khor, G.L., Shahar, S., Rahman, J., Zainuddin, A. & Mustafa, A.N. 2012. Optimal BMI cut-off values for predicting diabetes, hypertension and hypercholesterolaemia in a multi-ethnic population. *Public health nutrition*, 16(3):453-459.

Chuang, H., Li, W., Sheu, B., Liao, S., Chen J., Chang K. & Tsai, Y. 2012. Correlation between body composition and risk factors for cardiovascular disease and metabolic syndrome. *Biofactors*, 38(4):284-291.

Crowther, N.J. & Ferris, W.F. 2010. The impact of insulin resistance, gender, genes, glucocorticoids and ethnicity on body fat distribution. *The journal of endocrinology, metabolism and diabetes of South Africa*, 15(3):115-120.

Crowther, N.J. & Norris, S.A. 2012. The current waist circumference cut point used for the diagnosis metabolic syndrome in sub-Saharan African women is not appropriate. *PlosOne*, 7(11):e48883.

De Lorenzo, A., Bianchi, A., Maroni, P., Iannarelli, A., Di Danielle, N., Iacopino, L. & Di Renzo, L. 2013. Adiposity rather than BMI determines metabolic risk. *International journal of cardiology*, 166(2013):111-117.

De Lorenzo, A., Deurenberg, P., Pietrantuono, M., Di Daniele, N. & Andreoli, A. 2003. How fat is obese? *Acta diabetologica*, 40:s254-s257.

Deurenberg-Yap, M. & Deurenberg, P. 2003. Is a re-evaluation of WHO body mass index cut-off values needed? The case of Asians in Singapore. *Nutrition reviews*, 61(5):s80-s87.

De Schutter, A., Lavie, C.J., Arce, K., Menendez, S.G. & Milani, R.V. 2013. Correlation and discrepancies between obesity by body mass index and body fat in patients with coronary heart disease. *Journal of cardiopulmonary rehabilitation and prevention*, 33:77-83.

De Schutter, A., Lavie, C.J., Gonzales, J. & Milani, R.V. 2011. Body composition in coronary heart disease: how does body mass index correlate with body fatness? *The Ochsner journal*, 11:220-225.

Dong, K.R. & Imai, C.M. 2012. Medical nutrition therapy for HIV and AIDS. (In Mahan, L.K., Escott-Stump, S. & Raymond, J.L., eds. Krause's food and the nutrition care process. St Louis: Elsevier. p864-883).

Gallagher, D., Heymsfield, S.B., Heo, M., Jebb, S.A., Murgatroyd, P.R. & Sakamoto, Y. 2000. Healthy percentage body fat ranges: an approach for developing guidelines based on body mass index. *American journal of clinical nutrition*, 72:694-701.

Goedecke, J.H., Levitt, N.S., Lambert, E.V., Utzschneider, K.M., Faulenbach, M.V., Dave, J.A., West, S., Victor, H., Evans, J., Olsson, T., Walker, B.R., Seckl, J.R. & Kahn, S.E. 2009. Differential effects of abdominal adipose tissue distribution on insulin sensitivity in black and white South African women. *Obesity*, 17(8):1506-1512.

Heyward, V.H. & Wagner, D.R. 2004. Applied body composition assessment. Champaign: Human Kinetics. 268p.

Heinrich, K.M., Jitnarin, N., Suminski, R.R., Berkel, L., Hunter, C.M., Alvarez, L., Brundige, A.R., Peterson, A.L., Foreyt, J.P., Haddock, C.K. & Poston, W.S.C. 2008. Obesity classification in military personnel: a comparison of body fat, waist circumference and body mass index measurements. *Military medicine*, 173(1):67-73.

Heo, M., Faith, M.S., Pietrobelli, A. & Heymsfield, S.B. 2012. Percentage of body fat cutoffs by sex, age, and race-ethnicity in the US adult population from NHANES 1999-2004. *American journal of clinical nutrition*, 95:594-602.

Hou, X., Lu, J., Weng, J., Ji, L., Shan, Z., Liu, J., Tian, H., Ji, Q., Zhu, D., Ge, J., Lin., Chen, L., Guo, X., Zhao, Z., Li, Q., Zhou, Z., Shan, G., Yang, Z., Yang, W. & Jia, W. 2013. Impact of waist circumference and body mass index on risk of cardiometabolic disorder and cardiovascular disease in Chinese adults: a national diabetes and metabolic disorders survey. *PlosOne*, 8(3):e57319.

Janssen, I., Heymsfield, S.B., Allison, D.B., Kotler, D.P. & Ross, R. 2002. Body mass index and waist circumference independently contribute to the prediction of nonabdominal, abdominal subcutaneous, and visceral fat. *American journal of clinical nutrition*, 75:683-688.

Javed, F., Aziz, E.F., Sabharwal, M.S., Nadkarni, G.N., Khan, S.A., Cordova, J.P., Benjo, A.M., Gallagher, D., Herzog, E., Messerli, F.H. & Pi-Sunyer, X. 2011. Association of BMI and cardiovascular risk stratification in the elderly African-American females. *Obesity*, 19(6):1182-1186.

Katzmarzyk, P.T., Bray, G.A., Greenway, F.L., Johnson, W.D., Newton, R.L., Ravussin, E., Ryan, D.H. & Bouchard, C. 2011. Ethnic-specific BMI and waist circumference thresholds. *Obesity*, 19(6):1272-1278.

Kim, C., Park, H.S., Park, M., Kim, H. & Kim, C. 2011. Optimal cutoffs of percentage body fat for predicting obesity-related cardiovascular disease risk factors in Korean adults. *American journal of clinical nutrition*, 94:34-39.

Lear, S.A., Humphries, K.H., Kohli, S. & Birmingham, C.L. 2007. The use of BMI and waist circumference as surrogates of body fat differs by ethnicity. *Obesity*, 15(11):2817-2824.

Lee, O., Hur, Y., Kang, J., Park, H., Kim, K., Cho, Y., Choi, W., Park, H. & Lee, H. 2013. The cut-off value of waist circumference for predicting metabolic risks in pre- and post-menopausal Korean women: analysis of 2010 Korean National Health and Nutrition Examination Survey data. *Korean journal of family medicine*, 34(5):307-317.

Mallikharjuna Rao, K., Arlappa, N., Radhika, M.S., Balakrishna, N., Laxmaiah, A. & Brahman, G.N.V. 2012. Correlation of fat mass index and fat-free mass index with percentage body fat and their association with hypertension among urban South Indian adult men and women. *Annals of Human Biology*, 39(1):54-58.

Mbochi, R.W., Kuria, E., Kimiywe, J., Ochola, S. & Steyn, N.P. 2012. Predictors of overweight and obesity in adult women in Nairobi province, Kenya. *BMC public health*, 12:823-831.

Motala, A.A., Esterhuizen, T., Pirie, F.J., Omar, M.A.K. 2011. The prevalence of metabolic syndrome and determination of the optimal waist circumference cutoff points in a rural South African community. *Diabetes Care*, 34:1032-1037.

Mungal-Singh, V. 2012. Lifestyle changes for hypertension. *South African family practice*, 54(2):12-16.

Peltzer, K. & Phaswana-Mafuya, N. 2013. Hypertension and associated factors in older adults in South Africa. *Cardiovascular journal of Africa*, 24(3):66-71.

Prinsloo, E.A.M., Joubert, G., Mohale, M., Nyindi, N., Matu, N., Ntechane, L. & Struwig, M.C. 2011. The prevalence and perception of obesity and its association with the lifestyle of women at the Mangaung University Community Partnership Project healthcare centre, Bloemfontein. *South African family practice*, 53(4):366-372.

Ramel, A., Halldorsson, T.I., Tryggvadottir, E.A., Martinez, J.A., Kiely, M., Bandarra, N.M. & Thorsdottir, I. 2013. Relationship between BMI and body fatness in three European countries. *European journal of clinical nutrition*, 67:254-258.

Seedat, Y.K., Rayner, B.L. & Veriava, Y. 2014. South African hypertension guideline 2014. *South African journal of diabetes and vascular disease*, 11(4):139-144.

Shabnam, A., Homa, K., Reza, M.M., Bagher, L., Hossein, F.M., Hamidreza, A. 2012. Cut-off points of waist circumference and body mass index for detecting diabetes, hypercholesterolemia and hypertension according to National Non-Communicable Disease Risk Factors Surveillance in Iran. *Archives of medical science*, 8(4): 614-621.

Shea, J.L., King, M.T.C., Yi, Y., Gulliver, W. & Sun, G. 2012. Body fat percentage is associated with cardiometabolic dysregulation in BMI-defined normal weight subjects. *Nutrition, metabolism and cardiovascular diseases*, 22:741-747.

Shidfar, F., Alborzi, F., Salehi, M. & Nojomi, M. 2012. Association of waist circumference, body mass index and conicity index with cardiovascular risk factors in postmenopausal women. *Cardiovascular journal of Africa*, 23(8):442-445.

Shisana, O., Hoosain, E., Dwane, N., Maluleke, T., Reddy, P., Jacobs, L., Labadarios, L., Zuma, K., Dhansay, A., Parker, W., Naidoo, P., Mchiza, Z., Steyn, N.P., Makoae, M., Ramlagan, S., Zungu, N., Evans, M.G., Faber, M. & Hongoro, C. 2013. South African National Health and Nutritional Examination Survey, 2012: SANHANES-1.

Silva, D.A.S., Petroski, E.L. & Peres, M.A. 2012. Is high body fat estimated by body mass index and waist circumference a predictor of hypertension in adults? A population-based study. *Nutritional journal*, 11(1):112-120.

Smith, H. 2012. Obesity and its complications in women. *South African pharmacy journal*, 79(10):26-30.

Stanley, T.L. & Grinspoon, S.K. 2012. Body composition and metabolic changes in HIV-infected patients. *The journal of infectious diseases*, 205:s383-390.

Steyn, K., Mungai-Singh, V., Wentzel-Viljoen, E., Hoffman, K. & Freeman, M. 2013. Benefits of salt reduction in South African food. *SA Cardiology & Stroke*:7-10

Strazzullo, P., Cairella, G., Campanozzi, A., Carcea, M., Galeone, D., Galletti, F., et al. 2009. Population based strategy for dietary salt intake reduction: Italian initiatives in the European framework. *Nutrition, Metabolism and Cardiovascular Diseases*, 22 (3):161-166.

Sumner, A.E., Micklesfield, L.K., Ricks, M., Tambay, A.V., Avila, N.A., Thomas, F., Lambert, E.V., Levitt, N.S., Evans, J., Rotimi, C.N., Tulloch-Reid, M.K. & Goedecke, J.H. 2011. Waist circumference, BMI, and visceral adipose tissue in white women and women of African descent. *Obesity*, 19(3):671-674.

Van der Merwe, M.T. 2009. Obesity in women – a life cycle of medical risk. *The journal of endocrinology, metabolism and diabetes of South Africa*, 14(3):139-142.

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.

Wentzel-Viljoen, E., Steyn, K., Ketterer, E. & Charlton, K. 2013. “Use salt and foods high in salt sparingly”: a food-based dietary guideline for South Africa. *South African Journal of Clinical Nutrition*, 26(3):S105-S113.

World Health Organisation (WHO). 1998. Obesity: preventing and managing the global epidemic. Report on a WHO consultation on obesity. WHO/NUT/NCD/98.1. Geneva, Switzerland.

World Health Organisation (WHO). 2004. Appropriate body-mass index for Asian populations and its implications for policy and intervention strategies. *Lancet*, 363:157-163.

World Health Organisation (WHO). 2010. Global status report on non-communicable diseases. http://whqlibdoc.who.int/publications/2011/9789240686458_eng.pdf. Date of access: 20 February 2014.

World Health Organisation (WHO). 2013. Obesity and overweight. Fact sheet no 311, WHO media centre. <http://www.who.int/mediacentre/factsheets/fs311/en/>. Date of access: 20 February 2014.

Wrottesley, S.V., Micklesfield, L.K., Hamil, M.M., Goldberg, G.R., Prentice, A., Pettifor, J.M., Norris, S.A. & Feeley A.B. 2014. Dietary intake and body composition in HIV-positive and negative South African women. *Public health nutrition*, 17(7): 1603-1613.

Zhang, Z., Deng, J., He, L., Ling, W., Su. & Chen, Y. 2013. Comparison of various anthropometric and body fat indices in identifying cardiometabolic disturbances in Chinese men and women. *PlosOne*, 8(8):e70893.

CHAPTER 3: METHODOLOGY

3.1 INTRODUCTION

Methods will be described in this chapter in detail and again in a more concise form in the article due to the limited word count of the article.

3.2 STUDY DESIGN AND SETTING

This study is an analytical epidemiological research project with a cross-sectional design. The study was carried out by measuring and testing the subjects, recruited from Ikageng township in the North West Province of South Africa, in the metabolic unit at the Centre of Excellence for Nutrition (CEN) at the Potchefstroom Campus of the North-West University (NWU).

3.3 STUDY PARTICIPANTS

3.3.1 Recruitment

A sample of female, black participants ($n = 387$) residing in Ikageng in the North West Province in South Africa was recruited to participate in the study. An advisory community committee was appointed to advise on recruitment. Posters in Setswana and English were prepared and placed at shops, community halls, churches, taxi ranks and clinics in Ikageng, four weeks before commencement of the study to provide information about the study.

The sampling framework was a map of Ikageng, consisting of six extensions. Six fieldworkers, one from each extension of Ikageng, were trained to explain the study information to women in the community by door to door visits and invite those who qualify according to inclusion and exclusion criteria to participate.

Appointments for study participation at the metabolic unit at the NWU were scheduled for those who agreed to participate. The participants received information about comfortable clothes to wear, the date and time of the participation and what to expect on the day.

3.3.2 Inclusion and exclusion criteria

Inclusion criteria included: Female gender, black ethnicity, 29 years to 65 years of age, apparently healthy and able to walk, hear and speak and understand English, Afrikaans or Setswana. The participants did not have to be able to read or write, since the questionnaires were completed by an interviewer. They could have hypertension, and use anti-hypertensive medication. The participants ideally had to possess a cellphone to make communication regarding study visits possible by call or texting.

Exclusion criteria included: Pregnancy, lactation up to six months post-partum, women younger than 29 years, or older than 65 years and subjects with any other (except hypertension) diagnosed acute- or non-communicable chronic diseases, including known HIV infection. The participants were not asked specifically to disclose their HIV status. On the day of research, each participant was tested for HIV-infection, and the participants who tested positive were excluded from the study. When high blood pressure was detected in a study participant, but the person did not already use medication, such a person was included in the study, but she was referred by a referral letter from the registered nurse who measured the blood pressure for further medical assistance.

3.3.3 Representativeness

The sampling framework was a map of Ikageng, consisting of six extensions. Six fieldworkers, one from each extension of Ikageng, had to recruit at least 60 participants from his/her extension according to the inclusion and exclusion criteria. Each extension was divided into six areas, from which ten participants were recruited by each fieldworker. This is not strictly random selection, but still strives to result in a sample that is representative of the area. This could result in at least 360 participants in total recruited by the fieldworkers from Ikageng, which was the minimum sample size needed for the study.

3.3.4 Informed consent

The subjects were informed of the nature of the study by the fieldworkers at recruitment, as well as by the research team on the study days. The participants had opportunities for questions on the study days and could refuse participation at any time. The study subjects with witnesses present signed informed consent forms before participation (Annexure A).

3.4 MEASUREMENTS

On the study days the participants were received in the living room of the metabolic unit. All measurements and questionnaires were completed in separate, private rooms, which were marked, in the metabolic unit of the NWU. There were a questionnaire room, anthropometry room, DXA room, blood pressure room, and HIV test room. The particular member of the study team signed a checklist for each participant after completion and recording of the measurements, tests, and the questionnaire (Annexure B).

3.4.1 Questionnaire

Demographic and health information was collected by an interviewer who asked each participant questions as specified by the questionnaire (Annexure C). Questions relating to socio-economic status, age, health status, smoking, and menopausal status were answered. The participants were asked whether they had hypertension, where self-reporting of hypertension and taking of prescribed blood pressure lowering medication, were regarded as being hypertensive.

3.4.2 Anthropometric measurements

3.4.2.1 Height and weight measurements

Before anthropometric measurements were taken, participants were requested to remove their shoes, jackets and/or coats, and head accessories and empty their pockets, in order to ensure accurate measurements.

Standard operating procedures (SOP) were used for the anthropometric measuring and were present and visible in the room where the measurements were done to ensure correctness and accuracy. The author, students and intern are registered professionals who had extensive training in anthropometry. Before the study they received refresher training in anthropometric measurements by a level III anthropometrist at the CEN. Two measurements of height, weight and waist circumference were taken and recorded, and an average measurement of each was used.

A digital scale with stadiometer (Seca 264, Hamburg, Germany) was used. Calibrating of the scale using two standardised calibration weights of 10 kg each and of the stadiometer using a standardised calibration rod of 80 cm was done daily to ensure accuracy of weight and height

measurements. The digital scale with stadiometer was placed on a hard tile surfaced floor in the examination room and was checked to be level and stable.

Height (cm) was measured with the participant barefoot, standing erect and with the head in the Frankfort plane. Height was measured to the nearest 0.1 cm. Weight (kg) was measured with the participant standing in the centre of the platform with weight spread equally between the two legs, and standing with hands loosely hanging next to the sides of the body. Weight was measured to the nearest 0.01 kg.

The BMI of each subject was calculated with the formula: weight (kg) divided by height (m) squared.

3.4.2.2 Waist circumference measurements

Waist circumference was measured to the nearest 0.1 cm at the narrowest part of the torso as seen from the front of the section between the base of the ribs and top of the iliac crest, using a steel tape (Lufkin, Apex, NC, USA).

3.4.3 Percentage body fat measurements

Participants may not be pregnant to be able to undergo DXA measurements (an exclusion criterion); therefore pregnancy tests were performed on all participants before DXA measurements to confirm non-pregnancy. Fat and fat-free tissue masses of the whole body were measured by a registered radiographer, by using DXA, with the default Hologic settings (Hologic Discovery W, APEX system software version 2.3.1). The participant had to remove shoes and head accessories as well as any metal-containing jewellery, clothing and belts and wear a dressing gown over underclothes. Full body percentage body fat was calculated by the DXA software.

3.4.4. Blood pressure measurements

Blood pressure of the participants was measured by a registered nurse with a Hi-Care sphygmomanometer (Mr First Aid, Johannesburg, SA), in a sitting position, after sitting for 3-5 minutes, with backs supported and legs uncrossed, using the participants' right arms bared and supported at heart level (Seedat *et al.*, 2014:139). Two readings at 1-2 minutes intervals were recorded, and the average of the two recordings was recorded as well. If the blood pressure of

any participant was above normal and categorised as high ($\geq 140/90$ mmHg), a referral letter was given to be taken to any medical doctor or clinic (Annexure D).

3.4.5. HIV testing

A finger prick (capillary) HIV test was performed on each participant after they received counseling and signed consent for the HIV-test, if they were willing to undergo the HIV testing (Annexure E). Trained HIV counselors conducted the counseling and the HIV-testing. Standard Department of Health HIV counseling and testing (HCT) procedures were used (DOH, 2010). A positive test result was made known only to the tested participant by the HIV counselor doing the test in private. The participant then received individual counseling and a referral letter to be taken to any medical clinic for confirmation and treatment (Annexure F).

The participants with positive HIV test results were allowed to continue in the study, so that the status was not known to other participants, but the data were not used in the statistical analysis and were marked in the Excel data sheet as 1 for positive HIV-status, since HIV-status has an effect on body composition. Participants who chose not to receive the results of their HIV tests did not receive the results. Participants will not have access to any data sheets. The researchers included only participants with HIV-data marked 0 (negative) in data analysis.

3.5 ETHICAL CONSIDERATIONS

Ethical approval was obtained by the NWU Ethics Committee (NWU-00060-14-A1) (Annexure G). The subjects were informed of the nature of the study by the study-coordinator and the subjects had opportunities to ask questions to the research team at any time during participation. Informed consent forms to participate in the study project were signed by all the participants as well as additional consent forms were signed by the participants consenting to HIV-testing. The project was conducted under strictly controlled ethical conditions at all times, according to the World Medical Association (WMA) Declaration of Helsinki (WMA, 2013).

3.6 STATISTICAL ANALYSES

Data management and statistical analyses were performed by using the SPSS version 22 statistical software program. The level of significance was set at $p \leq 0.05$.

Descriptive statistics were used for description of study participants' variables (age, socio-demographic variables, height, weight, BMI, WC, %BF, BP). The descriptive statistics included

frequencies, means, and standard deviations (SD). The prevalence of different types of adiposity was determined, including general, using BMI and %BF measures and abdominal, using WC measures.

Correlation analysis was used to investigate associations between the clinical continuous variables (BMI, WC, %BF, BP). The analysis included calculations using the Pearson's correlation coefficient and the Spearman's rank order correlation. The agreement between the different measures of adiposity (BMI, %BF and WC), and the association between adiposity and blood pressure, were determined using Pearson's chi square statistical tests with two way tables or cross-tabulation. Odds ratios were then calculated to determine the practical significance of the results. The 95% confidence intervals (CI) and p-values were included. The Pearson's chi-square statistical test with a two-way table and the kappa coefficient statistic test were used to determine the agreement between BMI categories and %BF categories according to cut-off values (obesity present or not present) as measures of body composition to detect adiposity in black women.

A sample size power calculation was done based on kappa statistics to determine the agreement between BMI categories and %BF categories. As an example, out of existing data of a sample of women (n = 240) from a previous study, it was calculated which proportion was overweight/obese (BMI ≥ 25 kg/m²) and which proportion had a %BF $\geq 35\%$ (De Lorenzo *et al.*, 2003:s255; WHO, 1998:9). It was calculated that the proportion overweight/obese women was 0.54 and the proportion with %BF ≥ 35 was 0.76. According to a table of Q values based on different combinations of proportions (Cantor, 1996:152), the Q value for these two proportions was 0.64. In the power calculation d represents the limits for kappa, and is set at 0.1, which corresponds to a power of 80% (Cantor 1996:151). The α -level of significance was set at 0.05 which corresponds to a z-level of 1.96. The sample size (n) was calculated from these three values (0.64, 0.1 and 1.96) using the formula below (Cantor, 1996:152):

$$N = \frac{Q}{\left(\frac{d}{z\left(\frac{\alpha}{2}\right)}\right)^2}$$

= 256

Therefore, according to the power calculation the sample size was determined to be at least n = 256 to determine agreement between BMI classification and %BF classification.

3.7 REFERENCES

Cantor, A.B. 1996. Sample-size calculations for Cohen's kappa. *Psychological methods*, 1(2):150-153.

De Lorenzo, A., Deurenberg, P., Pietrantuono, M., Di Daniele, N. & Andreoli, A. 2003. How fat is obese? *Acta diabetologica*, 40:s254-s257.

Department of Health (DOH) South Africa. 2010. HIV counselling and testing (HCT) policy guidelines. Pretoria: Department of Health. (www.sanac.org.za/.../2-department-of-health-hct-policy-guidelines)

Seedat, Y.K., Rayner, B.L. & Veriava, Y. 2014. South African hypertension guideline 2014. *South African journal of diabetes and vascular disease*, 11(4):139-144.

World Health Organisation (WHO). 1998. Obesity: preventing and managing the global epidemic. Report on a WHO consultation on obesity. WHO/NUT/NCD/98.1. Geneva, Switzerland.

World Medical Association (WMA). 2013. World Medical Association Declaration of Helsinki: Ethical principles for medical research involving human subjects. *Journal of the American Medical Association*, 310(20):2191-2194.

CHAPTER 4: ARTICLE

The article is intended for submission to the journal: “Annals of human biology”.

Author guidelines for the relevant journal are found in Annexure H.

RESEARCH PAPER

Associations between specific measures of adiposity and high blood pressure in black South African women

M. Doubell, H.S. Kruger, C. Botha-Ravyse, L. Havemann-Nel, J.M. van Rooyen

*Centre of Excellence for Nutrition, North-West University, Potchefstroom Campus,
Potchefstroom, South Africa*

Correspondence:

Prof H.S. Kruger

Box 594

Centre of Excellence for Nutrition

North-West University, Potchefstroom Campus

Potchefstroom

South Africa, 2520

Telephone Office: +27182992482

Fax: +27182992464

E-mail: Salome.Kruger@nwu.ac.za

Key terms: Body mass index, waist circumference, percentage body fat, high blood pressure, urban black women

ABSTRACT

Background: Measuring percentage body fat (%BF) to classify adiposity takes body composition into account and is a more physiological measurement of obesity than body mass index (BMI).

Aim: To investigate the agreement between adiposity classified by BMI and %BF categories and the association between adiposity measures and high blood pressure.

Participants and methods: Black women aged 29-65 years (n=435) from Ikageng, South Africa were included in this cross-sectional study. Socio-demographic questionnaires were completed. Body weight and height were measured and BMI was calculated. Waist circumference (WC), %BF using dual-energy X-ray absorptiometry (DXA), and blood pressure were measured.

Results: There were significant agreements between high %BF ($\geq 35.8\%$ age 29-45 years; $\geq 37.7\%$ ages ≥ 50 years) and BMI categories ($\geq 25\text{kg/m}^2$; $\kappa=0.68$, $p<0.0001$ and $\geq 30\text{kg/m}^2$; $\kappa=0.48$, $p<0.0001$). High blood pressure was significantly associated with high WC ($\geq 80\text{cm}$; $\chi^2=10.88$, $p=0.001$ and $\geq 92\text{cm}$; $\chi^2=20.1$, $p<0.0001$), and high %BF ($\chi^2=6.61$, $p=0.010$). A significant association was found between high blood pressure and obesity ($\text{BMI}\geq 30\text{kg/m}^2$) ($\chi^2=4.10$, $p=0.043$), but not combined overweight/obesity ($\text{BMI}\geq 25\text{kg/m}^2$) ($\chi^2=3.19$, $p=0.074$).

Conclusion: A stronger agreement existed between WHO BMI categories and %BF at a cut-off point of 25kg/m^2 than at 30kg/m^2 . A significant association was found between high blood pressure and obesity, but not combined overweight/obesity.

INTRODUCTION

The World Health Organization (WHO) defines overweight and obesity as a condition in which an abnormal or excessive fat accumulation exists to an extent in which health and well-being are impaired (WHO 2013). Overweight and obesity are modifiable risk factors for the development of non-communicable diseases (NCDs) (Mbochi *et al.* 2012). Obesity can promote a cascade of secondary cardiometabolic pathologies such as hypertension, hyperlipidemia, insulin resistance and hyperuricemia, alone or in combination, all of which exacerbate the progression of cardiovascular disease (CVD) (Zhang *et al.* 2013).

According to the South African National Health and Nutrition Examination Survey (SANHANES 2013), black women were significantly heavier and taller than both the Colored - and Asian/Indian women groups. The prevalence of overweight and obesity, according to BMI classification, in all South African women was significantly higher than in men (24.8% and 39.2% compared to 20.1% and 10.6% for women and men respectively) (Shisana *et al.* 2013).

Based on European populations, the WHO defined cut-off points for body mass index (BMI), which is used in large-scale epidemiological studies to identify and classify individuals as underweight (BMI < 18.5 kg/m²), overweight (BMI 25.0 – 29.9 kg/m²) or obese (BMI > 30 kg/m²) and to identify individuals at risk for obesity-related diseases (WHO 1998).

Measuring percentage body fat (%BF) to classify levels of adiposity takes body composition into account and is a more physiological measurement of obesity than BMI. Factors such as body composition and epidemiological factors, including ethnicity, age and sex, should be considered when classifying individuals as overweight and obese (De Schutter *et al.* 2013).

Gallagher *et al.* (2000) developed prediction models for %BF based on BMI and Heo *et al.* (2012) developed cut-off points for %BF as a measure of adiposity based on the agreement between dual-energy X-ray absorptiometry (DXA) measured fat mass and BMI. The %BF cut-off points for non-Hispanic black women to predict adiposity corresponding to BMI ≥ 25 kg/m² for age 29 – 49 years is 35.8% and the cut-off point for age ≥ 50 years is 37.7% (Heo *et al.* 2012).

Waist circumference (WC) is a measure of abdominal subcutaneous and visceral fat and is used to identify individuals with abdominal obesity who are at risk for cardiometabolic disease. Consensus was reached by different health organizations on the current recommended WC cut-off points for abdominal obesity based on different ethnic groups, as part of the criteria for clinical diagnosis of the metabolic syndrome (Alberti *et al.* 2009). According to the International Diabetes Federation (IDF), the WC cut-off point for African women to predict high risk for coronary heart disease (CHD) is ≥ 80 cm and very high risk is ≥ 88 cm (Alberti *et al.* 2009). South African studies determined a higher WC cut-off point of ~ 92 cm for black women for diagnosing the metabolic syndrome, which demonstrated a clear ethnic difference in the relationship between abdominal adiposity and metabolic disease risk (Crowther & Norris 2012; Motala 2011).

In South Africa more research is needed to determine the agreement between BMI, %BF and WC as measures of adiposity and to compare the classification of overweight and obesity according to BMI and %BF categories. Most studies show that the agreement between BMI and %BF depends on age, sex and ethnic group (Gallagher *et al.* 2000; WHO 2004; Heo *et al.* 2012; De Schutter *et al.* 2013). Due to the ethnic differences in body composition, specific cut-off points for BMI, WC and %BF for different population groups might need to be implemented, also in South-Africa, to classify overweight and obesity, as well as to predict obesity-related cardiometabolic risk factors.

In South-Africa currently approximately one third (30.4%) of the adult population has hypertension (Seedat *et al.* 2014). Classifications based on BMI, WC and %BF to screen and identify people at risk for hypertension and refer them for monitoring and diagnostic tests could prove to be useful (Silva *et al.* 2012).

The present study aimed to investigate the agreement between adiposity classifications according to WHO BMI cut-off points and %BF cut-off points, as well as the association between the different measures of adiposity and high blood pressure.

MATERIALS AND METHODS

This study was an analytical epidemiological research study with a cross-sectional design. Data from the Prospective Urban Rural Epidemiology (PURE) study (n=248) collected in 2012 and 2013 were combined with data collected during 2014 (n=387). Female, black participants (n=635), were recruited from Ikageng township in the North

West Province of South Africa. Fieldworkers were assigned to six different living areas of the township and each had to recruit a number of participants in proportion to the number of houses in the area, in an effort to recruit a representative sample of women from the area.

Inclusion criteria were female gender, black ethnicity, 29 years to 65 years of age, apparently healthy and not disabled. Hypertensive women using antihypertensive medication were included because exclusion of these women would result in a small, non-representative sample. Exclusion criteria were pregnancy, lactation and participants with any other (except hypertension) diagnosed acute or non-communicable chronic disease, including known HIV infection. The participants were not asked specifically to disclose their HIV status, since on the day of research, each participant was tested for HIV-infection, and the participants who tested positive were excluded from the study.

Ethical approval was obtained from the North-West University (NWU) Ethics Committee (NWU-00060-14-A1). The project was conducted under strictly controlled ethical conditions at all times, according to the World Medical Association (WMA) Declaration of Helsinki (WMA, 2013). The study participants signed informed consent forms before participation. Demographic and health information were collected by interviewer administered questionnaires. Questions relating to socio-economic status, age, health status, smoking, and menopausal status were answered. Self-reported hypertension and taking of prescribed antihypertensive medication were regarded as hypertensive.

Height and weight measurements were performed using a digital scale with stadiometer (Seca 264, Hamburg, Germany). The scale and stadiometer were calibrated daily using

20 kg calibration weights and a calibration rod of 80 cm to ensure accuracy of weight and height measurements. Height (cm) was measured to the nearest 0.1 cm with the participant barefoot, standing erect and with the head in the Frankfort plane. Weight (kg) was measured with the participant standing in the centre of the platform with weight spread equally between the two legs, and standing with hands loosely hanging next to the sides of the body. Weight was measured to the nearest 0.01 kg. The BMI of each study participant was calculated as weight (kg) divided by height (m) squared. Waist circumference was measured to the nearest 0.1 cm at the narrowest part of the torso as seen from the front of the section between the base of the ribs and top of the iliac crest, using a steel tape (Lufkin, Apex, NC, USA).

Pregnancy tests were performed before DXA measurements to confirm non-pregnancy. Fat tissue mass and fat-free tissue mass of the whole body were measured by a registered radiographer, by using DXA with the default Hologic settings (Hologic Discovery W, APEX system software version 2.3.1). Percentage body fat was calculated by the DXA software. Study participants whose body weights were above the DXA measuring stipulations (130 kg) could not be measured by DXA.

Blood pressure (BP) of the participants was measured by a registered nurse with a Hi-Care sphygmomanometer (Mr First Aid, Johannesburg, SA), in a resting position, after sitting for 3-5 minutes, with backs supported and legs uncrossed, using the participants' right arms bared and supported at heart level (Seedat *et al.* 2014). Two readings at 1-2 minute intervals were recorded.

A finger prick (capillary) HIV test (First Response Rapid Card Test, Premier Medical Corporation Ltd, Kachigam, India) was performed on each participant after they received counseling and signed consent for the HIV-test, by trained HIV counselors. The participants with positive HIV test results received post-test counseling and were excluded in the statistical analysis.

Statistical analysis

Statistical analyses were performed by using the SPSS version 22 statistical software programme. The level of significance was set at $p \leq 0.05$.

A sample size power calculation was done based on kappa statistics to determine the agreement between BMI categories and %BF categories. From existing data of a sample of women ($n = 240$) from a previous study, it was calculated which proportion had a BMI ≥ 25 kg/m² and which proportion had a %BF $\geq 35\%$ (De Lorenzo *et al.* 2003; WHO 1998). It was calculated that the proportion overweight/obese women was 0.54 and the proportion with %BF ≥ 35 was 0.76. According to a table of Q values based on different combinations of proportions (Cantor 1996), the Q value for these two proportions was 0.64. In the power calculation d represents the limits for kappa, and is set at 0.1, which corresponds to a power of 80% (Cantor 1996). The α -level of significance was set at 0.05 which corresponds to a z-level of 1.96. The sample size was calculated from these three values (0.64, 0.1 and 1.96) using the formula of Cantor (1996). The sample size was calculated to be at least $n = 256$ to determine agreement between BMI classification and %BF classification.

Descriptive statistics were used to present the study participants' variables (age, socio-demographic variables, height, weight, BMI, WC, %BF and BP). The descriptive statistics included frequencies, means and standard deviations (SD). The prevalence of different types of adiposity was calculated, which included general obesity, based on BMI and %BF measures, and abdominal obesity, using WC measures.

Correlation analysis was performed to investigate associations between the clinical continuous variables (BMI, WC, %BF and BP). The analysis included calculations using the Pearson's correlation coefficient for normally distributed data and the Spearman's rank order correlation for non-normally distributed data.

The association between adiposity categories (based on BMI, %BF and WC) and blood pressure (below vs. above cut-points) were tested using Pearson's chi square tests with cross-tabulation. Odds ratios were then calculated. The kappa coefficient statistic test was used to determine the agreement between BMI categories and %BF categories according to cut-off values (obesity present or not present) as measures of body composition to detect adiposity in black women.

RESULTS

Figure 1 shows that a total of 435 participants were available for analysis following the exclusion of participants' data because of age being older than 65 years, positive HIV test results or HIV testing that was declined, incomplete data, and DXA measurements not taken.

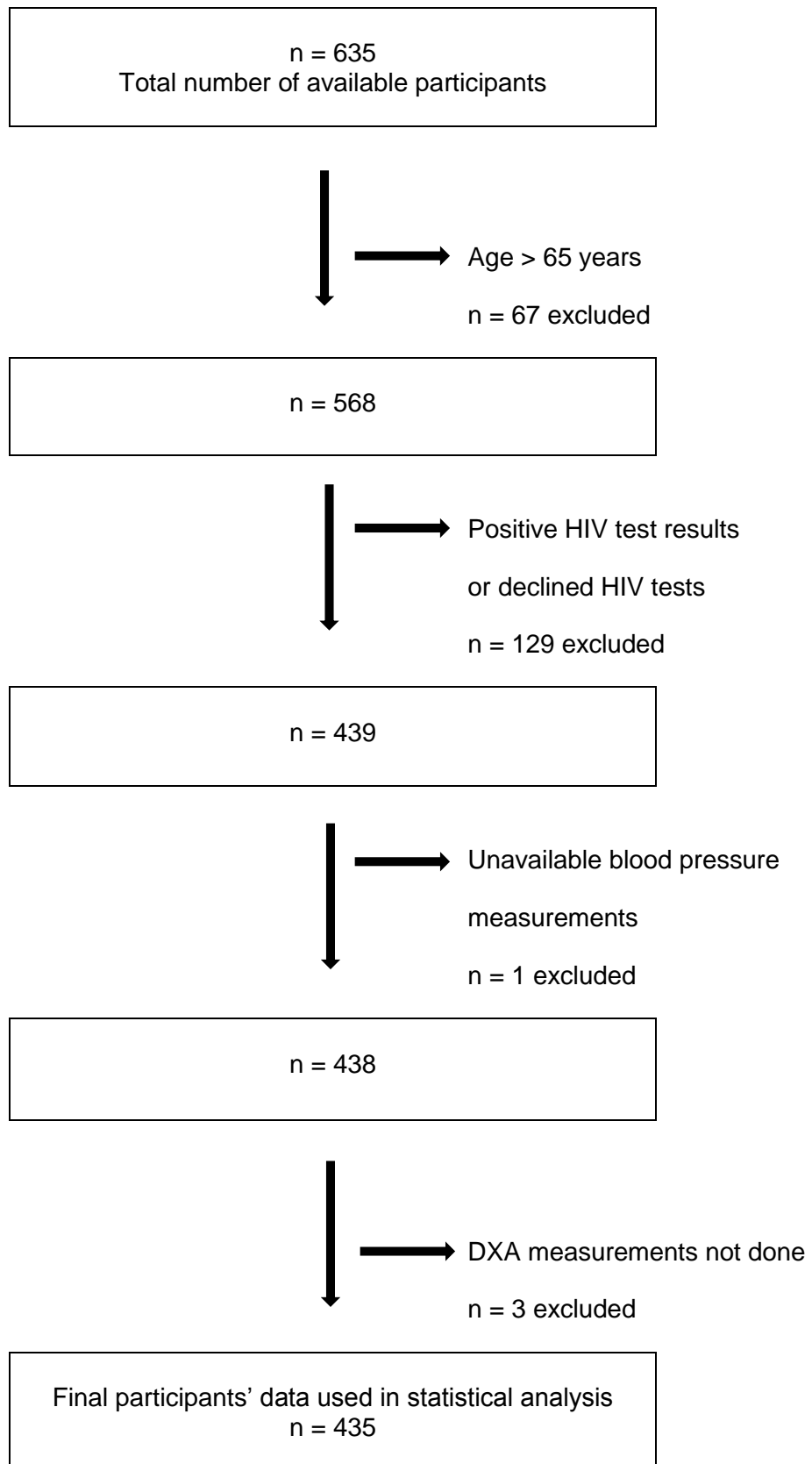


Figure 1: Study participants

Socio-demographic data revealed that the majority (67.9%) of participants' ethnicity and home language was Setswana, followed by Xhosa (14.5%) and Sotho (13.8%). Other languages spoken included Zulu, Afrikaans and English. Housing was mainly formal brick houses (84.3%) and 15.7% consisted of informal dwellings. The mean number of people sleeping per house according to the study sample was 4, which ranged from one person to 13 people per house. Cars were owned by 12.8% of the study participants. Households mostly had drinking water from their own taps (98.4%) and flushing toilets (94.8%), and used electric stoves for cooking (69.7%) and the rest used paraffin as fuel for cooking. A large proportion of households had microwave ovens (66.1%), fridges with freezers (87.2%), washing machines (41.2%), televisions (91.1%) and even Digital Satellite Television (DSTV) (30.2%).

The education level of the study sample varied. Almost eighteen percent of the study sample had no formal school education. Primary school education level was reached by 33.6%, followed by lower high school grades (grades 8-10, 28.7%) and higher grades (grades 11-12, 17.7%), whereas only 2.3% of the study sample had tertiary level education. Unemployment in this study sample was high at 74.6%, of which 31.3% were pensioners, while 22.8% were wage earners, only 3.2% were in the formal sector and 1.4% was self-employed. Household incomes varied, but most were in the low income range (100-250 US dollars per month).

Table I displays the characteristics of the study participants.

Table I: Characteristics of the study participants (n = 435)

	Mean	Standard deviation
Age (years)	52.3	8.19
Height (cm)	156.7	5.97
Weight (kg)	76.5	21.7
Body mass index (kg/m ²)	31.1	8.63
Waist circumference (cm)	89.9	14.96
Percentage body fat	40.7	7.38
Systolic blood pressure (mmHg)	133.2	20.2
Diastolic blood pressure (mmHg)	83.2	11.76

Adiposity according to BMI was classified using the WHO BMI cut-off points (WHO, 1998). Abdominal obesity was set at the WC cut-off point for black sub-Saharan African women of WC \geq 80 cm (Alberti *et al.* 2009), as well as the WC cut-off point of WC \geq 92 cm based on previous studies with South African black women (Crowther & Norris 2012; Motala 2011). Adiposity according to %BF was classified using the %BF cut-off point of 35.8% for black women aged 29 years to 49 years and 37.7% for black women aged 50 years and older, as recommended based on BMI and DXA measurements (Heo *et al.* 2012). Study participants were regarded as having high blood pressure if previously diagnosed with hypertension or antihypertensive medication was taken or SBP \geq 140 mmHg and/or DBP \geq 90 mmHg (Seedat *et al.* 2014).

Analysis of the data distribution according to skewness and kurtosis values revealed that %BF, weight, BMI, SBP and DBP were not normally distributed. Prevalence of adiposity, high blood pressure, menopausal status and smoking are shown in Table II.

Table II: Prevalence of adiposity, high blood pressure, menopausal status and smoking amongst the study participants (n = 435)

	n Frequency	Percentage (%)
General combined overweight/obesity (BMI \geq 25 kg/m ²)	334	76.8
Abdominal obesity (WC \geq 80 cm)	321	73.8
Abdominal obesity (WC \geq 92 cm)	206	47.4
High %BF (\geq 35.8% 29-49 years; 37.7% \geq 50 years)	324	74.5
High SBP (\geq 140 mmHg)	168	38.6
High DBP (\geq 90mmHg)	142	32.6
High blood pressure (antihypertensive medication use or SBP \geq 140 mmHg or DBP \geq 90 mmHg)	298	68.5
Pre-menopausal	149	34.3
Post-menopausal	286	65.7
Smoking	107	24.6

The prevalence of combined overweight/obesity according to all international standards was high (73.8-76.8%). More than two thirds (68.5%) of study participants had high blood pressure. From these results the high frequency (n = 228) of obesity according to the WHO BMI cut-off point of BMI \geq 30 kg/m² in this study sample is clearly illustrated in Figure 2.

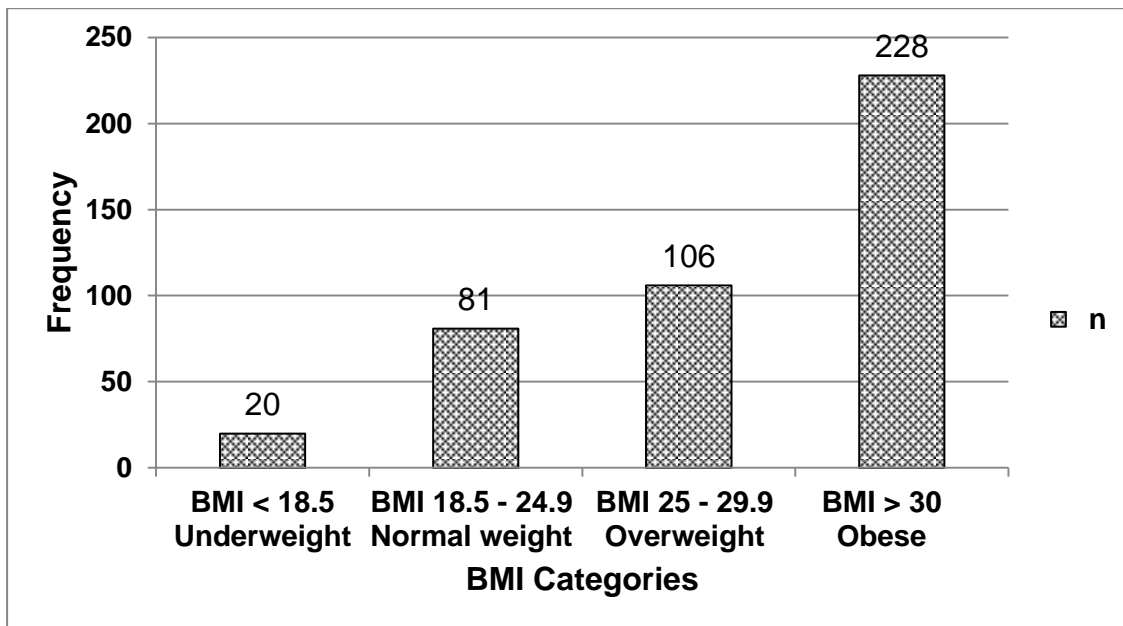


Figure 2: Frequency of adiposity according to BMI categories (in kg/m²)

Significant positive correlations were present between BMI and WC ($r = 0.84$), between BMI and %BF ($r = 0.84$), and between WC and %BF ($r = 0.75$) (all $p < 0.0001$).

Agreement between the presence of combined overweight/obesity defined as BMI ≥ 25 kg/m² and high %BF to indicate adiposity, as well as between the presence of obesity only (BMI ≥ 30 kg/m²) and high %BF as a measure of adiposity, were tested. There were significant agreements between the presence of high %BF and combined overweight/obesity ($\chi^2 = 199.0$, $p < 0.0001$; $\kappa = 0.68$, $p < 0.0001$), and between the presence of high %BF and obesity only ($\chi^2 = 129.1$, $p < 0.0001$; $\kappa = 0.48$, $p < 0.0001$). The effect size of the agreement between the WHO BMI category for combined overweight/obesity and %BF cut-off points, according to the kappa value $\kappa = 0.68$, was substantial (Landis & Koch 1977). The effect size of the agreement between the WHO BMI category for obesity and %BF cut-off points, according to the kappa value $\kappa = 0.48$, was moderate (Landis & Koch 1977).

Odds ratios to determine risk for high blood pressure according to different measures of adiposity are shown in Table III.

Table III: Association between measures of adiposity and high blood pressure

Adiposity classification	Pearson's chi square	p value	Odds ratio	95% CI	p value
BM \geq 25 kg/m ²	3.19	0.074	1.51	0.96-2.39	0.075
BMI \geq 30 kg/m ²	4.10	0.043	1.52	1.01-2.27	0.045
WC \geq 80 cm	10.9	0.001	2.08	1.34-3.22	0.001
WC \geq 92 cm	20.1	<0.0001	2.17	1.43-3.29	0.003
High %BF	6.61	0.010	1.79	1.14-2.79	0.011

BMI classification as a measure of general adiposity with BMI \geq 25 kg/m² resulted in no association with high blood pressure ($p = 0.074$), but BMI \geq 30 kg/m² resulted in significant association with high blood pressure ($p = 0.043$). Increased odds of high blood pressure existed in the higher BMI category. High %BF as a measure of general adiposity, as well as both classifications based on WC (\geq 80 cm and \geq 92 cm), resulted in significant associations with high blood pressure ($p = 0.010$, $p = 0.001$ and $p < 0.0001$ respectively) and significantly higher odds to have high blood pressure.

DISCUSSION AND CONCLUSIONS

This study found that adiposity categorized according to the WHO BMI cut-off points for combined overweight/obesity had a stronger significant agreement with adiposity categorized according to age-specific %BF cut-off points than adiposity categorized

according to the WHO BMI cut-off point for obesity only. The classification using BMI as a measure of general adiposity with $\text{BMI} \geq 25 \text{ kg/m}^2$ resulted in no association with high blood pressure, while $\text{BMI} \geq 30 \text{ kg/m}^2$ resulted in a significant association with high blood pressure. High %BF, as well as both classifications based on WC, resulted in significant associations with high blood pressure.

Overweight and obesity prevalence are increasing worldwide and in 2008 an estimated 35% of the adult population above 20 years of age was overweight and 11% was obese (WHO 2013). According to SANHANES, the prevalence of overweight and obesity, in South African women was significantly higher than in men (24.8% and 39.2% compared to 20.1% and 10.6% for women and men, respectively). Based on ethnicity, black women were significantly heavier and urban women had the highest prevalence of obesity (42.2%) (Shisana *et al.* 2013). In our study the prevalence of general combined overweight/obesity was high and the results similar, as determined by BMI and %BF measured adiposity (76.8% and 74.5% respectively). The prevalence of obesity as measured by $\text{BMI} \geq 30 \text{ kg/m}^2$ was 52.4% in this study sample. The prevalence of abdominal obesity according to the IDF WC cut-off point for sub-Saharan Africa of $\text{WC} \geq 80 \text{ cm}$ was 73.8%, however, the prevalence of abdominal obesity according to the WC cut-off point recommendation for South African black women of $\text{WC} \geq 92 \text{ cm}$ was 47.4%.

Some cut-off points used in this study to indicate adiposity were based on specific ethnicity, gender and age variables, which are imperative to ensure consistency and accuracy as evident from several studies (Alberti *et al.* 2009; Motala 2011; Crowther & Norris 2012; Heo *et al.* 2012). Previous research has shown that body composition is

altered by physiological conditions such as age and hormonal imbalance, as well as ethnicity, which influence height, weight, and the architecture and proportion of bone, muscle and fat (Mallikharjuna Rao 2012). In this study %BF cut-off points were ethnicity, gender and age based (Heo *et al.* 2012), whereas the BMI cut-off points were not specifically based on ethnicity, gender or age. In this study the WC cut-off point (≥ 92 cm) was specifically proposed for black South African women (Motala 2011; Crowther & Norris 2012). Sumner *et al.* (2011) reported that from data of combined studies of women that included white and black South Africans, the WC-visceral adipose tissue (VAT) relationship was different between white and black women, where black women had higher BMI, similar WC, but lower VAT than white women. Based on these data, WC cut-off points should be different in black and white women (Sumner *et al.* 2011). In this study abdominal obesity as defined by the South African cut-off point of WC ≥ 92 cm had the strongest association with high blood pressure with a significantly higher odds ratio for high blood pressure.

The agreement between the combined overweight/obesity category (BMI ≥ 25 kg/m²) and high %BF as indicators of adiposity was stronger than the agreement between obesity (BMI ≥ 30 kg/m²) and high %BF. The WHO combined overweight/obesity BMI cut-off point proved, therefore, to agree significantly with the %BF cut-off points in this sample of South African black women. Heo *et al.* (2012) also found in adults from the United States of America (USA) that %BF cut-off points that corresponded to USA BMI cut-off points are a function of sex, age and race-ethnicity and recommended that these factors should be taken into account when considering the appropriateness of levels of %BF.

Previous studies found discrepancies in the BMI-%BF relationship. Heinrich *et al.* (2008) in their North-American study of mixed ethnicity found that BMI obesity rates were much lower than those derived from %BF. In Canadian women and men of various ages, with BMI-defined normal weight, it was also demonstrated that a wide range of %BF existed (Shea *et al.* 2012). The cross-tabulation results in our study showed a small number of study participants in the normal BMI range (BMI < 25 kg/m²) but high %BF, and also a small number of participants who were categorized as overweight/obese (BMI ≥ 25 kg/m²), but who had normal %BF. Therefore, considering either BMI or %BF alone as an adiposity measure is not accurate in all circumstances. BMI measurement, unlike %BF measurement, gives no indication of body composition and %BF measurement is a more physiological and metabolic measurement of obesity, taking actual adiposity into account (De Schutter *et al.* 2013:82). For heavier individuals with greater lean tissue mass, such as athletes or those doing regular resistance training exercise, %BF would give a more accurate indication of adiposity than BMI.

As the incidence of obesity increases, consequently obesity-related comorbidities also increase rapidly, reaching epidemic proportions in both the developed and developing worlds (Crowther & Ferris 2010). Seedat *et al.* (2014) reported that currently approximately one third (30.4%) of the adult South African population has hypertension, but evidence suggests that the rates of awareness, treatment and control among the hypertensive subjects aged 50 years and older are low (Peltzer & Phaswana-Mafuya 2013). More than two thirds of our study sample had high blood pressure (68.5%).

Obesity is related to cardiometabolic risk factors and NCDs, amongst others the most common being hypertension, which exacerbate the progression of CVD (Smith 2012;

Zhang *et al.* 2013). Hypertension is responsible for a significant percentage of the high rates of heart disease and stroke in South Africa (Mungal-Singh 2012). Hypertension is also part of the criteria used for clinical diagnosis of metabolic syndrome (Alberti *et al.* 2009). Many studies confirmed the association between high BMI and hypertension (Shidfar *et al.* 2012; Peltzer & Phaswana-Mafuya 2013; Chandra *et al.* 2014). Zhang *et al.* (2013) compared different adiposity measurements and reported that BMI was the best screening tool for hypertension in both genders in their Chinese study population. In a study by Abassi *et al.* (2013) of European subjects, in both women and men, both indexes of obesity, BMI and WC, correlated with SBP as a cardiometabolic risk factor.

This study found no association between high blood pressure and BMI according to the WHO cut-off point for the classification of combined overweight/obesity (BMI ≥ 25 kg/m²), however, a significant association was found between high blood pressure and BMI according to the higher WHO cut-off point for the classification of obesity only (BMI ≥ 30 kg/m²). As reported by WHO (2004), diversity could exist based on ethnic and cultural subgroups, degrees of urbanisation, social and economic conditions, and nutrition transitions.

In this study the proportion of participants with high blood pressure in agreement with combined overweight/obesity according to the WHO BMI ≥ 25 kg/m² was 53.4%, compared to 14.6% of study participants with normal BMIs (BMI < 25 kg/m²), while 22.6% of participants with normal blood pressure agreed with combined overweight/obesity according to the WHO BMI ≥ 25 kg/m². Previous studies have shown that metabolic syndrome risk factors, including high blood pressure, were detected in participants in the normal BMI categories, and these particular participants had high

%BF, which could be a contributing etiological factor. These findings indicate that BMI could incorrectly classify some individuals, as compared to %BF. Shea *et al.* (2012) reported that the prevalence of cardiometabolic abnormalities or risk factors was the highest among individuals with high %BF ($\geq 35\%$ in women) and that %BF, measured by DXA, correlated positively with SBP and DBP. Their findings demonstrated that individuals cannot be classified as obese solely on their BMIs and that individuals with elevated %BF are at increased risk of developing cardiometabolic disease despite having a normal BMI. Further research is needed to investigate these dissimilarities to determine the possible physiological and metabolic reasons and etiological factors.

In measuring abdominal adiposity by means of WC, ethnicity and gender are integral components in the application of specific WC cut-off points. This study found that although the WC ≥ 80 cm and WC ≥ 92 cm categories both had significant associations with high blood pressure, a stronger association existed between the WC ≥ 92 cm category and high blood pressure. This cut-off point was proposed as a more appropriate cut-off point to WC ≥ 80 cm in black South African women. Shidfar *et al.* (2012) also found that the risk of hypertension is greater in those with upper body and abdominal obesity than in generally obese persons. Chandra *et al.* (2014) concluded that VAT is associated with a higher atherosclerotic risk profile as well as adverse cardiovascular events. Relative to subcutaneous adipose tissue, VAT is more sensitive to lipolysis and secretes higher amounts of inflammatory cytokines and may be acting in part by promoting the development of hypertension (Chandra *et al.* 2014).

A few limitations to the study were identified. The sample included mainly study participants of a low socio-economic status and the participants were recruited from a

specific urban residential area of South Africa. Therefore the results may not be generalized to the whole black female population of South Africa. Some of the study participants tested HIV-positive and their data were excluded, but the study sample that was available for data analysis still amounted to a large enough size as calculated by the power calculation.

This study concluded that the BMI category, according to the WHO cut-off point for combined overweight/obesity, had low sensitivity to detect the presence of high blood pressure, and that the BMI category according to the WHO cut-off point for obesity only had significantly higher sensitivity to detect the presence of high blood pressure. The WHO BMI classification for obesity, in contrast to the WHO BMI classification for combined overweight/obesity is, therefore, appropriate to classify these South African black women at increased risk for high blood pressure. Further research and studies amongst South African urban black women need to be conducted in order to determine and redefine BMI categories to detect the presence of high blood pressure and other obesity-related diseases.

This study, furthermore, concluded that significant agreements were found between adiposity categorized according to age-specific %BF cut-off points and WHO BMI categories for combined overweight/obesity ($\text{BMI} \geq 25 \text{ kg/m}^2$) and obesity only ($\text{BMI} \geq 30 \text{ kg/m}^2$). The %BF cut-off points used accounted for specific population ethnicity, gender and age variables, which affect the diagnosis of overweight and obesity and the ability to detect increased risk for high blood pressure.

When defining overweight and obesity, BMI is the most widely used screening tool because of its practicality and clinical use. It can be concluded that both WC and %BF have good capacity to identify individuals with high blood pressure. It is, therefore, recommended that in clinical practice, where possible, the appropriate WC and %BF cut-off points together with BMI categories should be used as measures of adiposity and as a screening tool to detect an increased risk for high blood pressure. Moreover, the anthropometric indices as measures of adiposity can initiate preventative interventions for hypertension and CVD.

Acknowledgements

This research was funded by the South African Medical Research Council (SAMRC). The authors would like to express their thanks to the CEN of the NWU, Potchefstroom Campus for the use of the Metabolic Unit. The authors would like to thank each member of the research team for their specific role, including the recruitment of study participants, study co-ordination and data collection in the conducting of interviews and tests and taking the measurements. The authors are very grateful to all the study participants of this study.

Declaration of Interest

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of this research paper.

REFERENCES

Abassi F, Blasey C. & Reaven G.M. 2013. Cardiometabolic risk factors and obesity: does it matter whether BMI or waist circumference is the index of obesity? *Am J Clin Nutr* 98:637-640.

Alberti KGMM, Eckel RH, Grundy SM, Zimmet PZ, Cleeman JI, Donato KA, Fruchart J, James WPT, Loria CM, Smith SC. 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 Federation; International Atherosclerosis Society and International Association for the Study of Obesity. *Circulation* 120:1640-1645.

Altman DG. 1991. *Practical statistics for medical research*. London: Chapman and Hall.

Cantor AB. 1996. Sample-size calculations for Cohen's kappa. *Psychol Meth* 1:150-153.

Chandra A, Neeland IJ, Berry JD, Ayers CR, Rohatgi A, Das SR, Khera A, McGuire DK, De Lemos JA, Turer AT. 2014. The relationship of body mass and fat distribution with incident hypertension - observations from the Dallas Heart Study. *J Am Coll Cardiol* 64:997-1002.

Crowther NJ, Ferris WF. 2010. The impact of insulin resistance, gender, genes, glucocorticoids and ethnicity on body fat distribution. *JEMDSA* 15:115-120.

Crowther NJ, Norris SA. 2012. The current waist circumference cut point used for the diagnosis metabolic syndrome in sub-Saharan African women is not appropriate. *PlosOne* 7:e48883.

De Lorenzo A, Deurenberg P, Pietrantuono M, Di Daniele N, & Andreoli A. 2003. How fat is obese? *Acta diabetologica* 40:s254-s257.

De Schutter A, Lavie CJ, Arce K, Menendez SG, Milani RV. 2013. Correlation and discrepancies between obesity by body mass index and body fat in patients with coronary heart disease. *J Cardiopulm Rehab Prev* 33:77-83.

Gallagher D, Heymsfield SB, Heo M, Jebb SA, Murgatroyd PR, Sakamoto Y. 2000. Healthy percentage body fat ranges: an approach for developing guidelines based on body mass index. *Am J Clin Nutr* 72:694-701.

Heo M, Faith M.S., Pietrobelli A, Heymsfield SB. 2012. Percentage of body fat cutoffs by sex, age, and race-ethnicity in the US adult population from NHANES 1999-2004. *Am J Clin Nutr* 95:594-602.

Heinrich KM, Jitnarin N, Suminski RR, Berkel L, Hunter CM, Alvarez L, Brundige AR, Peterson AL, Foreyt JP, Haddock CK, Poston WSC. 2008. Obesity classification in military personnel: a comparison of body fat, waist circumference and body mass index measurements. *Mil Med* 173:67-73.

Kim C, Park HS, Park M, Kim H, Kim C. 2011. Optimal cutoffs of percentage body fat for predicting obesity-related cardiovascular disease risk factors in Korean adults. *Am J Clin Nutr* 94:34-39.

Landis JR & Koch GG. 1977. The measurement of observer agreement for categorical data. *Biometrics* 33:139-174.

Mallikharjuna Rao K, Arlappa N, Radhika MS, Balakrishna N, Laxmaiah A, Brahman GNV. 2012. Correlation of fat mass index and fat-free mass index with percentage body fat and their association with hypertension among urban South Indian adult men and women. *Ann Hum Biol* 39:54-58.

Mbochi RW, Kuria E, Kimiywe J, Ochola S, Steyn NP. 2012. Predictors of overweight and obesity in adult women in Nairobi province, Kenya. *BMC public health* 12:823-831.

Motala AA, Esterhuizen T, Pirie FJ, Omar MAK. 2011. The prevalence of metabolic syndrome and determination of the optimal waist circumference cutoff points in a rural South African community. *Diab Care* 34:1032-1037.

Mungal-Singh V. 2012. Lifestyle changes for hypertension. *SA Fam Pract* 54:12-16.

Peltzer K, Phaswana-Mafuya N. 2013. Hypertension and associated factors in older adults in South Africa. *Cardiovasc J Africa* 24:66-71.

Seedat YK, Rayner BL, Veriava Y. 2014. South African hypertension guideline 2014. *SA J Diab Vasc Dis* 11:139-144.

Shea JL, King MTC, Yi Y, Gulliver W, Sun G. 2012. Body fat percentage is associated with cardiometabolic dysregulation in BMI-defined normal weight subjects. *Nutr Metab Cardiovasc Dis* 22:741-747.

Shidfar F, Alborzi F, Salehi M, Nojomi M. 2012. Association of waist circumference, body mass index and conicity index with cardiovascular risk factors in postmenopausal women. *Cardiovasc J Africa* 23:442-445.

Shisana O, Hoosain E, Dwane N, Maluleke T, Reddy P, Jacobs L, Labadarios L, Zuma K, Dhansay A, Parker W, Naidoo P, Mchiza Z, Steyn NP, Makoae M, Ramlagan S, Zungu N, Evans MG, Faber M, Hongoro C. 2013. South African National Health and Nutritional Examination Survey, 2012: SANHANES-1.

Silva DAS, Petroski EL, Peres MA. 2012. Is high body fat estimated by body mass index and waist circumference a predictor of hypertension in adults? A population-based study. *Nutr J* 11:112-120.

Smith H. 2012. Obesity and its complications in women. *SA Pharm J* 79:26-30.

Sumner AE, Micklesfield LK, Ricks M, Tambay AV, Avila NA, Thomas F, Lambert EV, Levitt NS, Evans J, Rotimi CN, Tulloch-Reid MK, Goedecke JH. 2011. Waist

circumference, BMI, and visceral adipose tissue in white women and women of African descent. *Obesity* 19:671-674.

World Health Organization (WHO). 2013. Obesity and overweight. Fact sheet no 311, WHO media center. <http://www.who.int/mediacentre/factsheets/fs311/en/>. Date of access: 20 February 2014.

World Health Organization (WHO). 2004. Appropriate body-mass index for Asian populations and its implications for policy and intervention strategies. *Lancet* 363:157-163.

World Health Organisation (WHO). 1998. Obesity: preventing and managing the global epidemic. Report on a WHO consultation on obesity. WHO/NUT/NCD/98.1. Geneva, Switzerland.

World Medical Association (WMA). 2013. World Medical Association Declaration of Helsinki: Ethical principles for medical research involving human subjects. *JAMA* 310:2191-2194.

Zhang Z, Deng J, He L, Ling W, Su Y, Chen Y. 2013. Comparison of various anthropometric and body fat indices in identifying cardio metabolic disturbances in Chinese men and women. *PlosOne* 8:e70893.

CHAPTER 5: SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 AIMS OF THE STUDY

The study aimed to investigate the agreement between adiposity classified according to BMI categories and %BF cut-off points, and to investigate the associations between the different measures of adiposity (BMI, WC and %BF) and high blood pressure. The measure of overweight/obesity which is most strongly associated with high blood pressure was determined. These findings determined whether the WHO BMI categories for overweight and obesity are appropriate to classify a study sample of black women from the North West Province in South Africa at an increased risk for high blood pressure.

5.2 SUMMARY

In this epidemiological study with a cross-sectional design, 435 black women were included, aged 29 to 65 years, from Ikageng, an urban residential area in the North West Province of South Africa. Socio-demographic questionnaires were completed and pregnancy tests and HIV tests were performed (data with positive results or those who declined HIV testing were excluded). Body weight and height were measured and BMI was calculated. WC, %BF, using DXA, and blood pressure were measured.

General combined overweight/obesity according to the WHO BMI cut-off point of BMI ≥ 25 kg/m² was 76.8%, with the prevalence of overweight (BMI 25.0 – 29.9 kg/m²) at 24.4% and obesity (BMI ≥ 30 kg/m²) at 52.4%. The prevalence of abdominal obesity according to the international cut-off point of WC ≥ 80 cm was 73.8% and with the proposed South African cut-off point of WC ≥ 92 cm the prevalence was 47.4%. The prevalence of general obesity according to high %BF (%BF cut-off point 35.8% for black women aged 29 to 49 years and 37.7% for black women aged 50 years and older) was 74.5%. More than two thirds of this study sample (68.5%) had high blood pressure defined as the use of antihypertensive medication or SBP ≥ 140 mmHg or DBP ≥ 90 mmHg.

In this study significant correlations were found between the continuous variables of BMI, WC and %BF (all $p < 0.0001$). Significant agreements were found between adiposity classified according to BMI and %BF. However, a stronger agreement existed between BMI categorised as combined overweight/obesity (BMI ≥ 25 kg/m²) and high %BF ($\chi^2 = 199.0$, $p < 0.0001$; $\kappa = 0.68$, $p < 0.0001$) than between BMI categorised as obesity only (BMI ≥ 30 kg/m²) and high %BF ($\chi^2 = 129.1$, $p < 0.0001$; $\kappa = 0.48$, $p < 0.0001$). The effect size of the agreement between

the WHO BMI category for combined overweight/obesity and %BF cut-off points according to the kappa value $\kappa = 0.68$ was substantial (κ range 0.61-0.80) (Landis & Koch, 1977:165). The effect size of the agreement between the WHO BMI category for obesity and %BF cut-off points according to the kappa value $\kappa = 0.48$ was moderate (κ range 0.41-0.60) (Landis & Koch, 1977:165). No association was found between high blood pressure and BMI categorized combined overweight/obesity ($\chi^2=3.19$; $p = 0.74$), but a significant association was found between high blood pressure and BMI categorised obesity ($\chi^2=4.10$; $p=0.043$). An increased odds ratio (OR) of high blood pressure existed in the obesity BMI category (OR 1.52; $p = 0.045$) as opposed to the combined overweight/obesity BMI category (OR 1.51; $p = 0.075$). Significant associations were found between high blood pressure and WC ≥ 80 cm ($\chi^2 = 10.9$; $p = 0.001$; OR 2.08; $p = 0.001$) and between high blood pressure and WC ≥ 92 cm ($\chi^2 = 20.1$; $p < 0.0001$; OR 1.79; $p = 0.011$). There was a significant association between high blood pressure and high %BF ($\chi^2 = 6.61$; $p = 0.01$; OR 1.70; $p = 0.011$).

5.3 CONCLUSIONS

It was hypothesised that in a sample of black South African women aged 29 to 65 years, firstly, that there are strong agreements between measures of adiposity to define overweight and obesity. The categories for these measures were high %BF and combined overweight/obesity (BMI ≥ 25 kg/m²), and high %BF and obesity only (BMI ≥ 30 kg/m²), respectively. Secondly, we hypothesised that the WHO BMI categories for combined overweight/obesity (BMI ≥ 25 kg/m²) and obesity only (BMI ≥ 30 kg/m²), respectively, have low sensitivity to detect the presence of high blood pressure.

This study concluded that significant agreements were found between the %BF cut-off points for overweight/obesity and WHO BMI categories for combined overweight/obesity and obesity only, respectively. However, a stronger agreement existed between the %BF categories and the cut-off point BMI ≥ 25 kg/m² than the cut-off point BMI ≥ 30 kg/m². This study, furthermore, concluded that the BMI category according to the WHO cut-off point for combined overweight/obesity had insufficient sensitivity to detect the presence of high blood pressure, but the BMI cut-off point for obesity could detect the presence of high blood pressure. This cut-off point is, therefore, more appropriate to be used to classify this sample of South African black women at an increased risk for high blood pressure. In this study BMI, WC and %BF as measures of adiposity were significantly correlated. Measuring %BF to classify adiposity takes body composition into account and is a more physiological measurement of obesity than BMI (De Schutter *et al.*, 2013:82). The %BF cut-off points used according to Heo *et al.* (2012:599)

were specific to ethnicity, age and gender, and had a significant association with high blood pressure. The abdominal adiposity measure of WC \geq 92 cm, which was the cut-off point proposed specifically for the South African black ethnicity and female gender (Crowther & Norris, 2012:e48883; Motala, 2011:1035), had a stronger association with high blood pressure, than the international cut-off point of WC \geq 80 cm (Alberti *et al.*, 2009:1642). Therefore, according to these cut-off points, WC and %BF have good capacity to detect high blood pressure.

The first hypothesis, therefore, was accepted because in our study strong agreements were found between measures of adiposity classifying combined overweight/obesity as defined by %BF cut-off points and the WHO BMI category for combined overweight/obesity (BMI \geq 25 kg/m²), as well as between the %BF cut-off points and the WHO BMI category for obesity only (BMI \geq 30 kg/m²). The second hypothesis was partly accepted because it was found in our study that combined overweight/obesity, as defined by the WHO BMI category of BMI \geq 25 kg/m², had an insufficient sensitivity to detect the presence of high blood pressure. The hypothesis was partly rejected because, in contrast to the hypothesis, it was found in our study that obesity, as defined by the WHO BMI category of BMI \geq 30 kg/m², had a sufficient sensitivity to detect the presence of high blood pressure.

5.4 RECOMMENDATIONS

Further research and studies amongst South African urban black women need to be conducted in order to determine and redefine BMI cut-off points to detect the presence of high blood pressure and other obesity-related diseases. In this study the proportion of participants with high blood pressure in agreement with the adiposity measure of WHO BMI cut-off point 25 kg/m² was 53.4%, compared to 14.6% of study participants with normal BMIs (BMI < 25 kg/m²), while 22.6% of participants with normal blood pressure agreed with combined overweight/obesity (BMI \geq 25 kg/m²). These results confirm that obesity is not the only etiological factor contributing to high blood pressure, but that high BMI plays an important role in the etiology of hypertension. Further research is needed to investigate the distribution of other obesity-related diseases according to BMI cut-off points.

In this study the measurement of %BF was done using DXA. This method is by some considered as the “gold standard” of measuring body composition and to be the most reliable in clinical practice. Where DXA is not generally available to measure %BF, especially in developing countries often due to cost, time and expertise, BIA can be used as an alternative

way of measuring %BF in epidemiological research studies (Sun *et al.*, 2003:331). Our study's results showed that high %BF, as was measured using DXA, significantly agreed with adiposity defined as BMI ≥ 25 kg/m².

To ensure consistency and accuracy, and to use body composition instead of BMI only, it is, therefore, recommended in clinical practice to apply ethnicity, gender and age specific cut-off points for WC or %BF together with WHO BMI categories as measures of adiposity to diagnose overweight/obesity and to detect an increased risk for high blood pressure. According to our results, the South African WC cut-off point of WC ≥ 92 cm is more appropriate to screen South African black women for increased risk for high blood pressure than the international cut-off point of WC ≥ 80 cm. Anthropometric indices as measures of adiposity can, furthermore, be used as a screening tool to detect the risk and initiate preventative interventions for hypertension and CVD.

All who are diagnosed with hypertension should receive lifestyle counseling (Seedat *et al.*, 2014:139). Patients with hypertension and on antihypertensive medication should be educated on the correct use of their prescribed treatment and be encouraged to adhere to the correct treatment and control practices. Our results confirmed that a BMI higher than 30 kg/m² or a WC greater than 92 cm is associated with high blood pressure. These cut-off points are, therefore, proposed to screen South African black women for increased risk for high blood pressure. Weight reduction should, therefore, play an integral role in prevention and management of hypertension. The optimal management of obesity includes a combination of lifestyle modifications, including healthy, balanced diet and exercise, and behavioural modifications (Smith, 2012:290). The recommendation by the Southern African Hypertension Society (SAHS) is to reach a normal BMI of 18.5 – 24.9 kg/m² which could lower SBP approximately 5-20 mmHg per 10 kg of weight lost (Seedat *et al.*, 2014:141).

The SAHS recommendations to treat and manage hypertension are to follow the Dietary Approaches to Stop Hypertension (DASH) diet (Seedat *et al.*, 2014:141), which consists of a low saturated fat and low total fat intake, an increased fruit and vegetable intake, as well as limiting daily dietary sodium intake to ≤ 2400 mg sodium or 6 g salt; to engage in physical activity of brisk walking for 30 minutes per day most days; to have a moderate alcohol intake of no more than two drinks per day; and to cease smoking completely (Seedat *et al.*, 2014:141).

5.5 REFERENCES

Alberti KGMM, Eckel RH, Grundy SM, Zimmet PZ, Cleeman JI, Donato KA, Fruchart J, James WPT, Loria CM, Smith SC. 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 Federation; International Atherosclerosis Society and International Association for the Study of Obesity. *Circulation* 120:1640-1645.

Crowther, N.J. & Norris, S.A. 2012. The current waist circumference cut point used for the diagnosis metabolic syndrome in sub-Saharan African women is not appropriate. *PlosOne*, 7(11):e48883.

De Schutter, A., Lavie, C.J., Arce, K., Menendez, S.G. & Milani, R.V. 2013. Correlation and discrepancies between obesity by body mass index and body fat in patients with coronary heart disease. *Journal of cardiopulmonary rehabilitation and prevention*, 33:77-83.

Heo, M., Faith, M.S., Pietrobelli, A. & Heymsfield, S.B. 2012. Percentage of body fat cutoffs by sex, age, and race-ethnicity in the US adult population from NHANES 1999-2004. *American journal of clinical nutrition*, 95:594-602.

Landis, J.R. & Koch, G.G. 1977. The measurement of observer agreement for categorical data. *Biometrics*, 33:139-174.

Motala, A.A., Esterhuizen, T., Pirie, F.J., Omar, M.A.K. 2011. The prevalence of metabolic syndrome and determination of the optimal waist circumference cutoff points in a rural South African community. *Diabetes Care*, 34:1032-1037.

Seedat, Y.K., Rayner, B.L. & Veriava, Y. 2014. South African hypertension guideline 2014. *South African journal of diabetes and vascular disease*, 11(4):139-144.

Smith, H. 2012. Obesity and its complications in women. *South African pharmacy journal*, 79(10):26-30.

Sun, S.S., Chumlea, W.C., Heymsfield, S.B., Lukaski, H.C., Schoeller, D., Friedl, K., Kuczmarski, R.J., Flegal, K.M., Johnson, C.L. & Hubbard, V.S. 2003. Development of

bioelectrical impedance analysis prediction equations for body composition with the use of a multicomponent model for use in epidemiologic surveys. *American journal of clinical nutrition*, 77:331-340.

ANNEXURES

ANNEXURE A

Associations between specific measures of adiposity and high blood pressure in black South African women

CONSENT TO BE A RESEARCH PARTICIPANT

We, Professor Salome Kruger, Doctors Lize Nel and Chrisna Botha and Ms Maretha Doubell and Ntsako Khosa are a team of researchers from the North-West University working on body measurements and effect on blood pressure and we would like to invite you to give consent and participate in our study. To follow is information about the study so that you can make an informed decision.

1. PURPOSE OF THE STUDY

The purpose of this study is to do body measurements and measure blood pressure of black women, 29 to 65 years old, in Ikageng, Potchefstroom, North West Province, South Africa. You are being asked to participate in this study because you are healthy and able to walk, hear, see and speak. We want to test what measurements of a healthy person's body show us if they will have high blood pressure. We also want to learn how much salt healthy women eat in one day and can find this from the amount of salt in their urine. You may have high blood pressure and may use pills for high blood pressure. If you have any other diseases, you cannot take part. If we take your blood pressure and find that you have high blood pressure, but you do not already use pills, you can take part, but we will write a letter to refer you to the clinic to see a doctor. Your taking part in our study helps us and means a lot to us. You will be given a consent form when the fieldworker comes to explain the study at your house, then you get 1-2 days to decide if you want to take part in the study. Remember to bring the consent form with you when you are picked up at your house to come to the university to take part in the study.

2. PROCEDURE

If you agree to be in this study you will have to do the following:

- You must be ready at your house by 7 o'clock in the morning with your ID and pills from the clinic. A driver will pick you up and bring you to the university.
- At the university you will be shown where to wait for measurements and when and where to go for measurements.
- In private in a room, you must answer questions honestly from a questionnaire which someone will ask you, about your age, language, your house, school grade, work, diseases and medications. You do not have to write, the fieldworker will write the answers on the questionnaire.
- Weight, height and waist circumference will be measured privately in a room on the same day.
- The amount of fat, muscles and bone in your body will be measured on a DXA machine by a radiographer privately in a room. The measurement is like a photo of your whole body with bones, muscles and fat, and is taken while you lie on a bed with clothes on. This test gives no pain or discomfort and is not dangerous at all.
- We will ask you for urine to do a pregnancy test to make sure that the DXA does not do any harm to an unborn child. If you are pregnant, we will not do a DXA test.
- An HIV test will be done after you have received counselling. You are free to decline the test. If your test is positive, you will receive counselling on what to do. You are free to say if you want to know the test result or not.
- You will receive tea or coffee and sandwiches by 10 o'clock.
- To complete all the measurements and the questionnaire will take about 4-5 hours. All measurements and the questionnaire will be done during one morning visit to the university. After all is done, you will be taken home by the driver.

3. RISKS/DISCOMFORTS

A fieldworker will ask the questions from the questionnaire in a private room.

The height, weight and waist measurements will be done by two female researchers in another private, closed room. You must take your shoes and hat and any heavy jerseys off for the measurements. For the waist measurement you have to lift or remove your top clothing (skipper). Blood pressure will be measured by a nursing sister and DXA will be measured by a radiographer, each in a private, closed office. You will never have to take off all your clothes. You will lie comfortably on a DXA bed and will not feel any pain or heat. Because the X-rays may be dangerous for an unborn baby, no pregnant woman will do the DXA test.

We will give you a glass for urine to do a pregnancy test. You will go into the toilet on your own and give the glass with urine to the testing person.

An HIV test will be done after you have received counselling. You are free not to have the test if you don't want to. For the test the counsellor will clean and prick your finger with a small needle and stop the bleeding with cotton wool. If your test is positive, you will receive counselling on what to do. You are free to say if you want to know the test result or not.

No names will be written on your questionnaire and forms –only a study number. All numbers from measurements will be typed in a password protected computer, but no names. Your information will be kept locked in an office and protected in a computer with only the researchers who can see it. None of your information will be given to any other person.

4. BENEFITS

The results of this study will be used to learn at what weight for height and at what intake of salt will a woman get high blood pressure. From this information we can give women better advice on how to prevent high blood pressure.

5. COSTS

There will be no cost to you if you participate in this study.

6. PAYMENT

After all the tests and measurements have been done, you will receive R50.00 (fifty rand) Shoprite voucher as a token of appreciation because you took part in the study.

7. QUESTIONS

You are welcome to ask any questions to any member of the research team before you decide to give consent. You are also welcome to call the team leader, Professor Salome Kruger, at telephone number 018 299 2482. If you have any further questions concerning your consent, you can contact Mrs Carolien van Zyl at the Ethics office of the university at telephone number 018 299 2094.

8. FEEDBACK OF FINDINGS

We will tell you the findings of your height and weight, blood pressure, HIV status and pregnancy test directly after measurements. If you are pregnant, or have high blood pressure we will write a letter to take with you to the clinic. If you are HIV positive, the counsellor will give you counselling in a private room and we will write a letter to take with you to the clinic for treatment. We will also write reports about the findings for a congress and a magazine as information to persons who work with people with high blood pressure, so that they can use the information to help women with high blood pressure. Your name will never be mentioned in any of the reports and no photos of you will be shown.

CONSENT FORM

PARTICIPATION IN THIS RESEARCH IS YOUR CHOICE.

You are free to choose not to be in this study, or to withdraw at any point even after you have signed the form to give consent without any consequences.

Should you be willing to participate you are requested to sign below:

I _____ hereby give consent to participate in the above mentioned study. I am not forced in any way to participate and I understand that I can withdraw at any time should I feel uncomfortable during the study. I also understand that my name will not be disclosed to anybody who is not part of the study and that the information will be kept confidential and not linked to my name at any stage. I also understand what I might benefit from participation as well as what might be the possible risks and should I need further discussions someone will be available.

Date

Signature of the participant

Date

Signature of the person obtaining consent

Date

Signature of the witness

ANNEXURE B

CHECKLIST

Subject number: _____ Date of birth: _____

Contact number: _____

	Test / Activity				Signature
1.	Consent form signed				
2.	Pregnancy test	Pregnant	Not pregnant		
3.	HIV test and counselling				
4.	Anthropometry	Measure1	Measure2	Average	
4.1	Height (cm)				
4.2	Weight (kg)				
4.3	Waist (cm)				
5.	Blood pressure (mmHg)				
6.	DXA	% Body fat:			
7.	Questionnaire filled in				
8.	Urine sample give	Yes	No		

ANNEXURE C

SOCIO-DEMOGRAPHIC QUESTIONNAIRE

(All information in this questionnaire is confidential)

Interview Date: ___/___/201__

Participant number: _____

Interviewer: _____

1. Ethnicity and language:

1	Tswana		1		Setswana	
2	Zulu		2		Zulu	
3	Xhosa		3		Xhosa	
4	Coloured		4		Afrikaans	7 English
5	Sotho		5		Sotho	
6	Other (specify)		6		Other (specify)	

2. Housing

Code	1	2	3	4	5	6
Type of dwelling? Tick more than one block if necessary	Brick	Traditional mud	Tin	Wood	Other (Specify)
Where do you get drinking water from most of the time? (Tick one)	Own tap	Communal tap	Dam	Borehole	Other (Specify)
What type of toilet do you have? (Tick one)	Flush	Pit	Bucket		Other (Specify)
What fuel is used for cooking most of the time? (Tick more than one if necessary)	Electric	Gas	Paraffin	Wood/Coal	Solar/sun	Open fire
Number of people sleeping in the house for at least 4 nights per week?						
Number of rooms in the house? (excluding bathroom, toilet and kitchen if separate)						

3. Does anyone in the household own a motor car?

1 yes	0 no

4. Number of motor cars owned in the household?

1	2	3	>3

5. Does the household have a working...

	Yes (1)	No (2)*	Codes
Fridge with freezer			1
Fridge only			2
Freezer only			3
Electric stove with oven			4
Gas stove with oven			5
Coal stove with oven			6
Microwave			7
Primus / Paraffin stove			8
2-plate hot plate			9
Radio			10
TV			11
DSTV			12
DVD Player			13
Other electrical appliances (Specify)			14
.....			

Code for "Yes" = 1, "No" = 0

6. Information with regards to own education and household income:

Codes	Education	Employment	Codes
1	None	Unemployed	1
2	Primary School	Self-employed small business	2
3	Grade 8-10	Wage earner e.g. cleaner/domestic/gardener	3
4	Grade 11-12 (matric)	Salaried trained worker	4
5	Tertiary Education	Other (specify).....	5
		Pensioner	6

Total household income per month (including wages, rent, grants, sales of products, etc)

1	2	3	4	5	6	7
None	<R500	R500-1000	R1001-3000	R3001-6000	>R6001	Don't know

HEALTH QUESTIONNAIRE

1. Has a doctor or nurse told you that you had or have any of the following:

1.1 High blood pressure

1	2	3	Duration (y)
Yes	No	Do not know	

1.2. Diabetes or high blood sugar

1	2	3	Duration (y)
Yes	No	Do not know	

1.3. Heart attack

1	2	3	Duration (y)
Yes	No	Do not know	

1.4. Stroke

1	2	3	Duration (y)
Yes	No	Do not know	

1.5. High blood cholesterol (fats)

1	2	3	Duration (y)
Yes	No	Do not know	

1.6. Pain in knees/back/elbow/hands

1	2	3	Duration (y)
Yes	No	Do not know	

1.7. Other (specify):

1	2	3	Duration (y)
Yes	No	Do not know	

2. Do you use any medication for high blood pressure prescribed by a doctor?

1	Type of medication	0
Yes		No

3. Do you use any medication for diabetes or high blood sugar prescribed by a doctor?

1	0
Yes	No

4. Do you still have regular menstruation periods?

1	2	3
Yes	No	Irregular

5. Is there a possibility that you may be pregnant now?

1	2	3
Yes	No	Not sure

6. Do you currently or did you over the past 6 months use any tobacco products (cigarette, pipe, snuff)?

1	0
Yes	No

NB: If there is a possibility that you could be pregnant, do not go to the DXA station.

ANNEXURE D

Referral Letter.: Body composition and blood pressure study

Dear Doctor

We are currently carrying out a research project in the North-West University on the body composition and effect on blood pressure in women.

_____ participated in this project. We measured her blood pressure and it was _____ mmHg which is higher than the normal level.

Height:

Weight:

Bone mineral density:

We tested for pregnancy and the woman was found to be pregnant. Yes ___/No ___

We kindly request to please assist her in this matter.

Kind regards

Prof HS Kruger/ Dr C Botha-Ravyse/ Dr L Havemann-Nel

Signature: _____

Date: _____

ANNEXURE E

VCT-Form

HIV TEST INFORMED CONSENT

I, _____ (full name) hereby confirm that

I have received pre-test counselling and information stated in the table below is correct.

1. Currently in window period?	
2. Previously tested for HIV?	
3. Risk behaviour that might influence status	
4. The current knowledge and basic facts concerning HIV/Aids	
5. Nature of HIV tests in use	
6. Influence of a negative result	
7. Lifestyle precautions	
8. Influence of a positive result	
9. Basic information about course and treatment	
10. Available support network and person(s) to inform	

I hereby consent to be tested for Human Immunodeficiency Virus (HIV) Serostatus.

On client's request results disclosed to client:

Yes No

I hereby refuse to be tested for Human Immunodeficiency Virus (HIV) Serostatus.

Client is advised to consider further counselling before continuing the VCT.

Indicate whether any of the following are applicable to you:

- Bleeder
 - Plaster allergy
 - Alcohol allergy
-

	Client	Counsellor	Tester
Name			
Signature			
Date			

Time: _____
Date of birth: _____

ANNEXURE F

Metabolic Unit

Centre of Excellence for Nutrition

Tel: (018) 299 -2480/

(018) 299 2482

(Professor HS Kruger)

Referral Letter : Body composition and blood pressure study

Dear Doctor

We are currently carrying out a research project in the North-West University on the body composition and effect on blood pressure in women.

_____ participated in this project. We tested her HIV status with a rapid finger prick test and the result was positive.

We kindly request to assist the patient with further testing and treatment, if applicable.

Kind regards

HIV Councillor

Signature:

Date:

Name:

ANNEXURE G



Private Bag X6001, Potchefstroom
South Africa 2520

Tel: (018) 299-4900
Faks: (018) 299-4910
Web: <http://www.nwu.ac.za>

Ethics Committee

Tel +27 18 299 4852
Email Ethics@nwu.ac.za

ETHICS APPROVAL OF PROJECT

The North-West University Ethics Committee (NWU-EC) hereby approves your project as indicated below. This implies that the NWU-EC grants its permission that provided the special conditions specified below are met and pending any other authorisation that may be necessary, the project may be initiated, using the ethics number below.

Project title: Body mass index and body fat percentage as measures of adiposity and predictors of high blood pressure amongst black women																															
Project Leader: Prof Kruger																															
Ethics number:	<table border="1"> <tr> <td>N</td><td>W</td><td>U</td><td>-</td><td>0</td><td>0</td><td>0</td><td>6</td><td>0</td><td>-</td><td>1</td><td>4</td><td>-</td><td>A</td><td>1</td> </tr> <tr> <td colspan="3">Institution</td> <td colspan="5">Project Number</td> <td colspan="2">Year</td> <td colspan="5">Status</td> </tr> </table>	N	W	U	-	0	0	0	6	0	-	1	4	-	A	1	Institution			Project Number					Year		Status				
	N	W	U	-	0	0	0	6	0	-	1	4	-	A	1																
Institution			Project Number					Year		Status																					
<small>Status: S = Submission, R = Re-Submission, P = Provisional Authorisation; A = Authorisation</small>																															
Approval date: 2014-08-07	Expiry date: 2015-08-30																														

Special conditions of the approval (if any): None

General conditions:

While this ethics approval is subject to all declarations, undertakings and agreements incorporated and signed in the application form, please note the following:

- The project leader (principle investigator) must report in the prescribed format to the NWU-EC:
 - annually (or as otherwise requested) on the progress of the project,
 - without any delay in case of any adverse event (or any matter that interrupts sound ethical principles) during the course of the project.
- The approval applies strictly to the protocol as stipulated in the application form. Would any changes to the protocol be deemed necessary during the course of the project, the project leader must apply for approval of these changes at the NWU-EC. Would there be deviated from the project protocol without the necessary approval of such changes, the ethics approval is immediately and automatically forfeited.
- The date of approval indicates the first date that the project may be started. Would the project have to continue after the expiry date, a new application must be made to the NWU-EC and new approval received before or on the expiry date.
- In the interest of ethical responsibility the NWU-EC retains the right to:
 - request access to any information or data at any time during the course or after completion of the project;
 - withdraw or postpone approval if:
 - any unethical principles or practices of the project are revealed or suspected,
 - it becomes apparent that any relevant information was withheld from the NWU-EC or that information has been false or misrepresented,
 - the required annual report and reporting of adverse events was not done timely and accurately,
 - new institutional rules, national legislation or international conventions deem it necessary.

The Ethics Committee would like to remain at your service as scientist and researcher, and wishes you well with your project. Please do not hesitate to contact the Ethics Committee for any further enquiries or requests for assistance.

Yours sincerely

Prof Amanda Lourens
(chair NWU Ethics Committee)

ANNEXURE H

AUTHOR GUIDELINES

Journal: Annals of Human Biology

About the Journal

Aims and Scope

Annals of Human Biology is an international, peer-reviewed journal published six times a year in simultaneous print and electronic editions. *Annals of Human Biology* is an important vehicle for the dissemination of papers concerning research into human population biology, reporting investigations on the nature, development and causes of human variation, embracing the disciplines of human genetics, auxology, environmental physiology, ecology, epidemiology ageing and global health.

Annals of Human Biology has a wide readership of human biologists, epidemiologists, auxologists, paediatricians, population geneticists, biological and physical anthropologists, gerontologists, physiologists and public health workers. *Annals of Human Biology* is the official journal of the Society for the Study of Human Biology. Further information about the Journal, including links to the online sample copy and contents pages, can be found on the Journal homepage: <http://informahealthcare.com/ahb>.

Editors

Noel Cameron
School of Sport, Exercise and Health Sciences,
Loughborough University,
Leicestershire,
U.K.

Olga Rickards
Dipartimento di Biologia,
Università di Roma "Tor Vergata",
Italy

Babette Zemel
The Children's Hospital of Philadelphia,
Philadelphia, PA
U.S.A.

Manuscript Submission

All submissions should be made online at *Annals of Human Biology's* ScholarOne Manuscripts site. New users should first create an account. Once a user is logged onto the site, submissions should be made via the Author Centre. If you experience any problems with your submission or with the site, please contact ScholarOne support through the 'get help now' link.

All submissions must include full disclosure of all relationships that could be viewed as presenting a potential conflict of interest. If there are no conflicts of interest, authors should state that there are none. This must be stated at the point of submission (within the manuscript, after the main text under a subheading "Declaration of interest", and, within the appropriate field on the journal's ScholarOne Manuscripts site). Please see our full Declaration of Interest Policy for further information. Authors are required to provide the names of at least three potential reviewers who are not collaborators.

Article types considered by *Annals of Human Biology*:

- Research Papers
- Review Articles
- Short Reports
- Human Biological Surveys
- Book Reviews

Manuscript Preparation

Authors should prepare manuscripts according to Council of Science Editors (CSE) Scientific Style and Format (7th edition) and are also referred to recent copies of the Journal and encouraged to copy the published format of papers therein. Microsoft Word format (.doc or .docx files) is preferred. Documents must be typed in 12pt font, double-spaced, with margins of at least 2.5 cm on all sides. Tables and figures should not appear in the main text, but should be submitted as separate digital files and designated with the appropriate file type on ScholarOne Manuscripts. Manuscripts must be submitted in grammatically correct English. Manuscripts which do not meet this standard cannot be reviewed and will be returned to the author. References should be given in Harvard style (see References section for example). Manuscripts should be compiled in the following order: title page; abstract; main text; acknowledgments; Declaration of Interest statement; appendices (as appropriate); references; tables with captions (on separate pages); figures; figure captions (as a list).

Title Page

A title page should be provided comprising the manuscript title plus the full names, affiliations and email addresses of all authors involved in the preparation of the manuscript. One author should be clearly designated as the corresponding author and full contact information, including phone number, provided for this person. Three to five key terms that are not in the title should also be included on the title page. These keywords will assist indexers in cross indexing your article.

Abstract

Authors submitting papers should note that structured abstracts (up to 200 words) are required. These should outline the questions investigated, the design, essential findings and main conclusions of the study under the following sub-headings: Background, Aim, Subjects and methods, Results, Conclusion.

Main Text

The main text should, in general, but not necessarily, be divided into sections with the headings: Introduction, Methods, Results, Discussion, and Conclusion. Research papers, which must report original research, will typically be between 5000 and 8000 words, debating and exploring theoretical and methodological issues, methodological approaches, and original studies relevant to human biology. However, there is not necessarily an upper limit on length. Authors of longer papers are encouraged to contact the Editors with a synopsis.

Acknowledgments and Declaration of Interest Statement

Acknowledgments and Declaration of interest sections are different, and each has a specific purpose.

The Acknowledgments section details special thanks, personal assistance, and dedications. Contributions from individuals who do not qualify for authorship should also be acknowledged here. Declarations of interest, however, refer to statements of financial support and/or statements of potential conflict of interest. Within this section also belongs disclosure of scientific writing assistance (use of an agency or agency/ freelance writer), grant support and numbers, and statements of employment, if applicable. For a more detailed list of points to include, please see "Declaration of Interest section" below.

Acknowledgments section

Any acknowledgments authors wish to make should be included in a separate headed section at the end of the manuscript preceding any appendices, and before the references section. Please do not incorporate acknowledgments into notes or biographical notes.

Declaration of Interest section

All declarations of interest must be outlined under the subheading 'Declaration of interest'. If authors have no declarations of interest to report, this must be explicitly stated. The suggested, but not mandatory, wording in such an instance is: *The authors report no declarations of interest*. Please note: grant number(s) of NIH/Wellcome Trust-funded papers must be included in the Declaration of Interest statement.

References

References should be given in the Harvard style. Citation in the text is by author and date (Smith 2001). The list of references appears alphabetically by primary author's last name.

Examples:

Journal: Cameron N, Grieve CA, Kruger A, Leschner KF. 1993. Secondary sexual development in rural and urban South African black children. *Ann Hum Biol.* 20:583-593.

Book: Bogin B, 1999. *Patterns of Human Growth*, 2nd ed. Cambridge, Cambridge University Press.

Book edited: Weiner JS, Lourie JA, eds. 1981. *Practical human biology*. London: Academic Press.

Contribution to a Book: Faiman C Winter JSD. 1974. Gonadotropins and sex hormone patterns in puberty. In: Grumbach MM, Grave CD, Mayer EF, editors. *The Control of the Onset of Puberty*. New York: Wiley. 32p.

Electronic Resource: British Heart Foundation. 2003. Coronary heart disease statistics. Available online at: www.dphpcox.ac.uk/bhfhprg/stats, accessed 9 September 2009.

Periodical titles should be abbreviated and conform to the style given by Index Medicus.

Tables and figures

Tables and figures should be referred to in text as follows: Figure 1, Figure 2; Table I, Table II. The place at which a table or figure is to be inserted in the printed text should be indicated clearly on a manuscript. Each table and/or figure must have a legend that explains its purpose

without reference to the text. Tables should be used only when they can present information more efficiently than running text. Care should be taken to avoid any arrangement that unduly increases the depth of a table, and the column heads should be made as brief as possible, using abbreviations liberally. Lines of data should not be numbered nor run numbers given unless those numbers are needed for reference in the text. Columns should not contain only one or two entries, nor should the same entry be repeated numerous times consecutively. Tables should be grouped at the end of the manuscript on separate pages.

Figures/Illustrations (line drawings, halftones, photos, photomicrographs, etc.) should be submitted as digital files for highest quality reproduction and should follow these guidelines:

- 300 dpi or higher
- Sized to fit on journal page
- EPS, JPG, TIFF, or PSD format only
- Submitted as separate files, not embedded in the text
- Legends or captions for figures should be listed on a separate page, double spaced

Notes on Style

General Style

Authors are asked to take into account the diverse audience of the journal. Please avoid the use of terms that might be meaningful only to a local or national audience, or provide a clear explanation where this is unavoidable. Some specific points on style follow:

1. Authors should write in clear, concise English. If this is not your native language please ensure the manuscript has been reviewed by a native speaker. Please note: extensive rewriting of the text will not be undertaken by the editorial staff.
2. Acronyms for protein and gene names should in all cases be explained the first time they appear. In articles where acronyms are numerous, authors should include a table that lists all acronyms, each acronym's meaning or origin, and a short description of the function of each gene or protein.
3. Latin terminology, including microbiological and species nomenclature, should be italicized.
4. Use standard convention for human and animal genes and proteins: italics for genes and regular font for proteins, and upper case for human products and lower case for animal products.
5. "US" is preferred to "American", "USA" to "United States", and "UK" to "United Kingdom".
6. Double quotation marks rather than single are to be used unless the "quotation is 'within' another".

7. Punctuation of common abbreviations should adhere to the following conventions: “e.g.”; “i.e.”; “cf.”. Note that such abbreviations should not generally be followed by a comma or a (double) point/period.
8. Upper case characters in headings and references should be used sparingly, e.g. only the first word of paper titles, subheadings and any proper nouns begin upper case; similarly for the titles of papers from journals in the references and elsewhere.
9. Apostrophes should be used sparingly. Thus, decades should be referred to as follows: “The 1980s [not the 1980’s] saw ...”. Possessives associated with acronyms (e.g. APU), should be written as follows: “The APU’s findings that ...” but note that the plural is “APUs”.
10. All acronyms for national agencies, examinations, etc., should be spelled out the first time they are introduced in text or references. Thereafter the acronym can be used if appropriate, e.g. “The work of the Assessment of Performance Unit (APU) in the early 1980s ...” and subsequently, “The APU studies of achievement ...”, in a reference “(Department of Education and Science [DES] 1989a)”.
11. Brief biographical details of significant national figures should be outlined in the text unless it is quite clear that the person concerned would be known internationally. Some suggested editorial comments in a typical text are indicated in the following with square brackets: “From the time of H. E. Armstrong [in the 19th century] to the curriculum development work associated with the Nuffield Foundation [in the 1960s], there has been a shift from constructivism to heurism in the design of [British] science courses”.
12. Non-discriminatory language is mandatory. Sexist or racist terms should not be used.
13. The referred local (national) usage for ethnic and other minorities should be used in all papers. For the USA, “African-American”, “Hispanic” and “Native American” are used, e.g. “The African-American presidential candidate, Jesse Jackson ...”; for the UK, “Afro-Caribbean” (not “West Indian”).
14. Material to be emphasised by italicisation in the printed version should be italicised in the typescript rather than underlined. Please use such emphasis sparingly.
15. Numbers in text should take the following forms: 300, 3000, 30 000 (not 30,000). Spell out numbers under 10 unless used with a unit of measure, e.g. nine pupils but 9 mm (do not use full stops (periods) within units). For decimals, use the form 0.05 (not .05, × 05 or 0× 05). “%” (not “per cent”) should be used in typescripts.
16. Authors must adhere to SI Units.
17. Appendices should appear before the references section and after any acknowledgments section. The style of the title is shown by the following example:

Appendix C: The random network generator

Figures and tables within appendices should continue the sequence of numbering from the main body of the text. Sections within appendices should be numbered, for example, C.1, C.2. Equations in appendices should be numbered, for example, (C 1), (C 2). If there is only one appendix, it is referred to as “the appendix” and not called “Appendix A”.

Abbreviations and nomenclature

For abbreviations and nomenclature, authors should consult the most recent edition of the *CSE Style Manual* available from the Council of Science Editors, 60 Revue Drive, Suite 500 Northbrook, IL, 60062, USA.

Footnotes

Footnotes are not to be used except for designation of the corresponding author of the paper or current address information for an author (if different from that shown in the affiliation). Information concerning grant support of reviews should appear in a separate declaration of interest section at the end of the paper. Acknowledgments of the assistance of colleagues or similar notes of appreciation belong in a separate Acknowledgments section.

Footnotes to tables should be typed directly below the table and are indicated by the following symbols: * (asterisk or star), † (dagger), ‡ (double dagger), ¶ (paragraph mark), § (section mark), || (parallels), # (number sign). Reinitialize symbol sequence within tables.

Editorial Policies

Authorship

Anyone meeting the International Committee on Medical Journal Ethics (ICJME) requirements for authorship should be included as an author of the manuscript and anyone designated as an author should meet all points of the ICJME criteria for authorship. Any other form of specific personal contribution should be included in the Acknowledgements section of the manuscript, which must be provided under the subheading ‘Acknowledgements’. All submissions are expected to comply with the ICMJE authorship definition. Changes to the authorship list after submission will result in a query from the publisher requesting written explanation.

Annals of Human Biology considers all manuscripts on the strict condition that they have not been published already, nor are they under consideration for publication or in press elsewhere. *Annals of Human Biology* will not consider, in general, redundant publications, i.e. “publication of a paper that overlaps substantially with one already published in print or electronic media” (International Committee on Publication Ethics: http://www.icmje.org/publishing_4overlap.html). This rule applies whether the overlapping papers are from the same authors or not.

In addition, Informa has a strict policy against plagiarism. We define plagiarism as the use of extracts from another person's work that are not placed in quotation marks, without the permission of that person, and without acknowledgement to that person (using the appropriate reference style), with the result that your article presents these extracts as original to you. By submitting your work to an Informa Healthcare journal, you warrant that it is your original work, and that you have secured the necessary written permission from the appropriate copyright owner or authority for the reproduction of any illustration or other material.

Paraphrasing, defined as “taking portions of text from one or more sources, crediting the author/s, but only changing one or two words or simply rearranging the order, voice (i.e., active vs. passive) and/or tense of the sentences” by the US Office on Research Integrity (<http://ori.dhhs.gov/education/products/plagiarism/7.shtml>), will not be accepted if found to be used extensively and to make up large sections of the manuscript. Extensive paraphrasing will not be deemed original work and will be viewed as redundant publication and/or plagiarism.

Informa Healthcare adheres to the Code of Conduct and Best Practice Guidelines set forth by the Committee on Publication Ethics (COPE). As per these guidelines, failure to adhere to the above conditions will result in the editor and Informa publishing an appropriate correction, a statement of retraction, or enacting a withdrawal of the article. In extreme cases (e.g. when an article is retracted), offending authors will be reported to their institution's Ethics committee and may be banned from submitting to Informa Healthcare journals in the future. Please refer to the COPE website for the detailed workflows for handling allegations of plagiarism or redundant publication (<http://www.publicationethics.org/resources/flowcharts>).

Inclusion of Unpublished Data

Unpublished data in the form of figures, tables, or quantitative statements in the text, should not be included in an article under any circumstances. A *brief* mention of the tentative conclusions of unpublished work is sometimes acceptable, as long as it is clearly identified as unpublished and tentative (not yet peer-reviewed).

Peer Review

All manuscripts will be subjected to confidential peer review by experts in the field and, on the basis of reviewers' feedback, papers will be accepted unconditionally, accepted subject to revision, rejected with an option to resubmit or rejected.

Ethics and Consent

Papers including human subject research, animal experiments or clinical trials must be conducted with approval by the local animal care or human subject committees, respectively. All manuscripts, except reviews, must include a statement in the Introduction or Methods section that the study was approved by an Investigational Review Board (Human Studies Committee or Ethics Committee or Animal Care and Use Committee), if applicable, and whether written informed consent was obtained. Authors who do not have formal ethics review committees should include a statement that their study followed principles in the Declaration of Helsinki (<http://www.wma.net/e/policy/b3.htm>).

Do not use patients' names, initials, or hospital numbers, especially in illustrative material. Identifying information should not be published in written descriptions, photographs, and pedigrees unless the information is essential for scientific purposes and the patient (or parent or guardian) gives written informed consent for publication. Informed consent for this purpose requires that the patient be shown the manuscript to be published.

To comply with FDAAA legislation, Informa Healthcare requires trial registration as a condition of publication for all studies involving clinical trials. Trial registration numbers should be included in the abstract, with full details provided in the methods section.

When a product has not yet been approved by an appropriate regulatory body for the use described in the manuscript, the author must specify that the product is not approved for the use under discussion or that the product is still under investigation.

Copyright and Permissions

It is a condition of publication that authors assign copyright or license the publication rights in their articles, including abstracts, to Informa UK Ltd. This enables us to ensure full copyright protection and to disseminate the article, and the Journal, to the widest possible readership in print and electronic formats as appropriate.

Authors are required to sign an agreement for the transfer of copyright to the publisher. All accepted manuscripts, artwork, and photographs become the property of the publisher. A copyright agreement form can be downloaded by corresponding authors of accepted manuscripts with proofs. This should be signed and returned to InformaHealthcare.

Authors are themselves responsible for obtaining permission to reproduce copyright material from other sources.

Declaration of Interest

It is the policy of InformaHealthcare to adhere in principle to the Conflict of Interest policy recommended by the ICMJE. All authors must disclose any financial and personal relationships with other people or organizations that could inappropriately influence (bias) their work. It is the sole responsibility of authors to disclose any affiliation with any organization with a financial interest, direct or indirect, in the subject matter or materials discussed in the manuscript (such as consultancies, employment, paid expert testimony, honoraria, speakers bureaus, retainers, stock options or ownership, patents or patent applications or travel grants) that may affect the conduct or reporting of the work submitted. All sources of funding for reviews are to be explicitly stated. If uncertain as to what might be considered a potential conflict of interest, authors should err on the side of full disclosure.

If there are no declarations, authors should explicitly state that there are none. This must be stated at the point of submission (within the manuscript, after the main text, under a subheading "Declaration of interest", and within the appropriate field on the journal's Manuscript Central site). Manuscript submission cannot be completed unless a declaration of interest statement (either stating the disclosures or reporting that there are none) is included. This will be made available to reviewers and will appear in the published article. If any potential conflicts of interest are found to have been withheld following publication, the journal will proceed according to COPE guidance.

The intent of this policy is not to prevent authors with any particular relationship or interest from publishing their work, but rather to adopt transparency such that reviewers, editors, the publisher, and most importantly, readers can make objective judgements concerning the work product.