



NORTH-WEST UNIVERSITY  
YUNIBESITI YA BOKONE-BOPHIRIMA  
NOORDWES-UNIVERSITEIT  
POTCHEFSTROOM CAMPUS

# **The association between physical activity, blood pressure and renin in black African teachers:**

## **The SABPA Study**

**J. Boucher**

**Hons BSc.**

**20043190**

**Dissertation submitted in fulfilment of the requirements for the degree Master of Science at the Potchefstroom Campus of the North-West University**

**Supervisor: Prof J Hans de Ridder**

**Co-supervisor: Prof L Malan**

**November 2011**

## **ACKNOWLEDGEMENTS**

I would like to thank my Heavenly Father for gifting me with the ability to pursue and complete this dissertation, without whose strength and guidance it would not have been possible.

My appreciation and gratitude goes to the following people:

My supervisor, Prof. J.H. de Ridder, and co-supervisor, Prof. L. Malan, whose advice, patience and support has been invaluable throughout this process;

Prof. L.A. Greyvenstein for the language and grammar editing;

My parents, who have always led by example in showing that hard work and perseverance will always prevail in the pursuit of success.

Perseverance is the hard work you do after you get tired of doing the hard work you already did. Newt Gingrich

## DECLARATION

The co-authors of the article which forms part of this dissertation, Prof J Hans de Ridder (supervisor), and Prof L Malan (co-supervisor) hereby give permission to the candidate, Ms Juanita Bouwer, to include the article as part of a Masters dissertation. The contribution, both supervisory and supportive, of these co-authors was kept within limits, thereby enabling the candidate to submit this dissertation for examining purposes. This dissertation serves as fulfillment of the requirements for the M.Sc degree within the School of Biokinetics, Recreation and Sport Science in the faculty of Health Sciences at the North-West University, Potchefstroom Campus.

---

Prof J. Hans de Ridder

Supervisor and co-author

---

Prof Leoné Malan

Co-supervisor and co-author

## SUMMARY

**Objectives:** The aim of this study was to determine associations between physical activity (PA), blood pressure (BP) and renin in urban black Africans. **Methods:** The study sample included 137 urban African males (N=68) and females (N=69) (aged  $41.53 \pm 8.13$  and  $44.16 \pm 7.37$  years, respectively), from the North West Province, South Africa. Anthropometric measurements, ambulatory blood pressure and energy expenditure were determined. Actical® accelerometers were used to determine energy expenditure (METs) over a 24 hour period. Fasting blood samples were used to determine fasting blood glucose, serum cotinine (COT), gamma-glutamyl transferase (GGT) and plasma renin. **Results:** A greater percentage (64%) of African males were hypertensive compared to African females (33.33%). SBP ( $p < 0.001$ ) and DBP ( $p < 0.001$ ) were significantly higher in males than females. Female subjects were more obese ( $32.00 \pm 7.75 \text{ kg/m}^2$ ) whereas males demonstrated an overweight status ( $27.28 \pm 5.86 \text{ kg/m}^2$ ). Male subjects displayed overall higher lifestyle risks (BP, smoking, alcohol consumption, HIV-status) than females. Multivariate regression analyses demonstrated an inverse relationship between BP and renin in both males and females, but no associations existed between renin and physical inactivity. **Conclusion:** PA appeared not to buffer elevated blood pressure in this specific African sample, as no significant associations supported this hypothesis. The results confirm that black Africans display lower renin levels associated with elevated blood pressure. Furthermore, low renin and physical inactivity was not related to indicate elevated BP through elevated SNS activity.

**Key words:** hypertension, blood pressure, physical activity, Africans, renin.

## OPSOMMING

**Doel:** Die doel van hierdie studie was om die verband te bepaal tussen fisieke aktiwiteit (FA), bloeddruk (BD) en renien in verstedelike Afrikane. **Metode:** Die teiken populasie het bestaan uit 137 verstedelike Afrika mans (N=68) en vroue (N=69) (ouderdomme  $41.53 \pm 8.13$  en  $44.16 \pm 7.37$  onderskeidelik) uit die Noordwes Provinsie, Suid-Afrika. Data is verkry aangaande antropometriese parameters, ambulatoirese BD en energieverbruik. Actical® versnellingsmeters is gebruik om energieverbruik oor 24 uur te bepaal. Bloedglukose (vastend), serum kotinien (COT), gamma-glutamyl transferase (GGT) en plasma renien is bepaal d.m.v. vastende bloed monsters. **Resultate:** Afrika mans (64%) het 'n groter persentasie hipertensiewe individue verteenwoordig in vergelyking met die vroue (33.33%). SBD ( $p < 0.001$ ) en DBD ( $p < 0.001$ ) was betekenisvol hoër in mans as in vroue. Vroue is obees geklassifiseer ( $32.00 \pm 7.75 \text{ kg/m}^2$ ) terwyl mans oorgewig was ( $27.28 \pm 5.86 \text{ kg/m}^2$ ). Lewenstyl risiko's was opmerklik hoër in die mans groep (BD, rook, alkohol gebruik, HIV positiewe status). Veelvuldige liniêre regressiewe analyses dui 'n negatiewe assosiasie tussen BD en renien in mans en vroue aan. Daar was egter geen assosiasies tussen renien en fisieke onaktiwiteit nie. **Gevolgtrekking:** Dit blyk dat FA nie 'n beskermende effek op hierdie spesifieke Afrika populasie gehad het nie, aangesien daar geen betekenisvolle assosiasies was wat hierdie hipotese kon ondersteun nie. Die resultate bevestig die lae-renien-hoër BD verskynsel wat in swart Afrikane voorkom. Lae renien en fisieke onaktiwiteit hou nie verband met mekaar nie, en kan dus nie die verhoogde BD op grond van verhoogde simpatiese senuwee stelsel aktiwiteit verklaar nie.

**Sleutelwoorde:** hipertensie, bloeddruk, fisieke aktiwiteit, Afrikaan, renien.

## **TABLE OF CONTENTS**

Acknowledgements	ii
Declaration	iii
Summary	iv
Opsomming	v

### **Chapter 1**

#### Problem statement and aim of the study

1.1 Introduction and problem statement	1
1.2 Objective	2
1.3 Hypothesis	2
1.4 Structure of the dissertation	3
1.5 References	4

### **Chapter 2**

#### Physical activity, hypertension and sympathetic nervous system activity

2.1 Introduction	7
2.2 Hypertension	7
2.2.1 Prevalence	8
2.2.2 Etiology	9
2.2.3 Health Implications	10
2.2.4 Treatment	11
2.3 Physical Activity	12
2.3.1 Definitions	12
2.3.2 Measurement of Physical Activity	13

2.3.3 Physical Activity and Health	14
2.3.4 Physical Inactivity	16
2.3.5 Barriers to Physical Activity Participation	16
2.4 Sympathetic Nervous System Activity, Hypertension and Physical Activity	17
2.5 Questions Arising from the Literature	19
2.6 Objective	19
2.7 Hypothesis	19
2.8 References	20

### **Chapter 3**

The association between physical activity, blood pressure and renin in black African teachers: the SABPA Study

Abstract	29
Introduction	30
Method	32
Study Population	32
Clinical Examination	32
Biochemical Measurements	33
Lifestyle Factors	33
Anthropometric Measurements	33
Physical Activity: Objective Measurement	34
Blood Pressure	34
Statistical Evaluation	35
Results	35
Characteristics of the Study Population	35

Discussion	36
Acknowledgements	39
Conflict of Interest	39
References	40

## **Chapter 4**

### General Findings and Conclusions

4.1 Summary	50
4.2 Discussion of main findings	51
4.3 Conclusions	52
4.4 Recommendations	52
4.5 Shortcomings	53
4.6 References	54

## **Appendices**

1. References according to the guidelines of the North-West University	62
2. Guidelines for authors	63
3. Anthropometric and blood pressure proforma	64
4. Informed consent	66

## **TABLES AND FIGURES**

### **CHAPTER 2:**

Table 1: Recent reclassifications of SBP and DBP levels in mmHg for adults 18 years and older	8
Table 2: Identified contributing factors of hypertension	10
Table 3: Target end organ damage associated with hypertension	11
Table 4: Health benefits resulting from participation in regular moderate physical activity	15

### **CHAPTER 3:**

Table 1: Baseline characteristics of the study population	45
Table 2: Forward stepwise regression analyses predicting associations with systolic blood pressure (SBP) and diastolic blood pressure (DBP) in urban Africans	46
Figure 1a: Associations between renin and SBP in African males (n=67) and females (n=67). Data is represented as r-values, adjusted for age, BMI, COT and GGT	47
Figure 1b: Associations between renin and DBP in African males (n=67) and females (n=67). Data is represented as r-values, adjusted for age, BMI, COT and GGT	47

Figure 2: Associations between renin and METS in African males (n=67) and females (n=67). Data is represented as r-values, adjusted for age, BMI, COT and GGT

48

## LIST OF ABBREVIATIONS

ACSM	American College of Sports Medicine
AIDS	Acquired Immune Deficiency Syndrome
ANCOVAS	Analyses of covariance
ATP	Adenosine triphosphate
BMI	Body mass index
BP	Blood pressure
CDC	Centres for Disease Control
CI	Confidence interval
cm	Centimetres
COT	Cotinine
CVD	Cardiovascular disease
DBP	Diastolic blood pressure
ESC	European Society of Cardiology
ESH	European Society of Hypertension
GGT	Gamma-glutamyl transferase
HIV	Human Immunodeficiency Virus
HT	Hypertension
ISH	International Society of hypertension
JNC-7	The Seventh report of the Joint National Committee on the prevention, detection and evaluation of high blood pressure
kCal	Kilocalories
kg/m <sup>2</sup>	Kilograms per meter squared
METs	Metabolic equivalents of task
mmHg	Millimetres of mercury

mmol	Millimoles
N	Number of participants
ng/mL	Nanograms per millilitre
p	P-value of significant level
PA	Physical activity
pg	Picograms
r	Observed r value (Pearson product-moment correlation)
RAAS	Renin Angiotensin Aldosterone System
SABPA	<u>S</u> ympathetic activity and <u>A</u> mbulatory <u>B</u> lood <u>P</u> ressure in <u>A</u> fricans.
SBP	Systolic blood pressure
SMAC	Sequential Multiple Analyzer Computer
SNS	Sympathetic nervous system
u/L	Units per litre
WC	Waist circumference
WHO	World Health Organization

## **CHAPTER 1: PROBLEM STATEMENT AND AIM OF THE STUDY**

1.1 Introduction and problem statement	1
1.2 Objective	2
1.3 Hypothesis	2
1.4 Structure of the dissertation	3
1.5 References	4

## 1.1 Introduction and problem statement

Hypertension, a major cardiovascular disease (CVD) risk factor, is gaining epidemic proportions globally (Antic *et al.*, 2003:84; Kuller, 2007:1005). In Sub-Saharan Africa, 37 million men and 39.4 million women had hypertension in the year 2000. The current hypertension prevalence predicts that by the year 2025, 71.2 million men and 72 million women will be hypertensive (Kearney *et al.*, 2005:221). Currently, more than 20% of adults are hypertensive and are, therefore, at risk for several cardiovascular pathologies including myocardial infarction, stroke and renal insufficiency (Antic *et al.*, 2003:84; Pescatello *et al.*, 2004:534). Africans in particular may be more likely to develop hypertension (Mathenge *et al.*, 2010:2) as they develop hypertension at a much earlier age and display higher mean blood pressures (Yusuf *et al.*, 2001:2860; Berra & Miller, 2009:66).

Hypertension is further closely associated with sympathetic nervous system (SNS) over-activity (Mueller, 2007:377). Increased central sympathetic nerve activity can lead to the activation of the Renin-Angiotensin-Aldosterone System (RAAS), contributing to an increase in blood pressure variability as well as hypertension (Fisher *et al.*, 2009:8). Activation of the SNS leads to the secretion of renin, a vasoconstrictor (Hamer *et al.*, 2010:5), increasing vascular resistance and blood pressure. Elevated plasma renin activity in combination with increased SNS activity has been found in mild hypertensive patients (Esler *et al.*, 1978:74611). Although it is known that Africans, in particular, display lower plasma renin levels (Sagnella, 2001:19; Opie & Seedat, 2005:3564; Malan *et al.*, 2006:164), few studies have documented the prevalence of hypertension and low renin levels among urbanised Africans.

Conversely, it is suggested that physical inactivity actually exacerbates sympathetic nerve activity, possibly contributing to increased blood pressure (Mueller, 2007:3787). Furthermore, sedentary conditions enhance the activation of the RAAS, but the underlying mechanisms responsible are not fully known yet (Mueller, 2008:730). Regular moderate physical activity may reduce increased SNS in hypertensive individuals (Pescatello *et al.*, 2004:543) and it has also been found to reduce sympathetic activity and resting blood pressure in normal (non-hypertensive) individuals (Mueller, 2007:377). The inhibitory effect of regular physical activity on SNS may contribute to a reduced incidence of cardiovascular

diseases in physically active individuals. Sedentary lifestyles may, therefore, produce heightened sympathetic responses, leading to cardiovascular diseases over a period of time (Meuller, 2007:382). The World Health Survey, conducted in 2003, found that less than a third of South Africans meet the ACSM and Centres for Disease Control's (CDC) recommended 30 minutes of moderate physical activity per day (Lambert & Kolbe-Alexander, 2005:25). Sedentary individuals are at a much higher risk of developing hypertension compared to those who do meet the recommended dose of physical activity (Hayward, 2006:2).

Knowledge of healthy lifestyles and factors influencing an individual's health, such as physical activity levels, blood pressure and renin are necessary to intervene effectively in the alarming increase in the prevalence of chronic diseases worldwide (Coopoo *et al.*, 2008:40). By gaining insight into the contributing factors of the development of hypertension among black urban Africans can lead to early detection and preventative measures can be implemented to reduce the incidence.

When reviewing the literature, the following questions arise:

- To what extent is physical activity associated with elevated BP in urban Africans?
- Are physical activity levels related to renin in urban Africans?
- What are the main contributing factors to elevated BP and/or hypertension in urban Africans?

## **1.2 Objective**

The aim of this study was to determine if physical activity is associated with elevated blood pressure and low renin levels in urban African teachers.

## **1.3 Hypothesis**

Low renin and physical activity levels will be associated with elevated SBP and DBP in urban African teachers.

#### **1.4. Structure of the dissertation**

This dissertation will be presented in an article format, approved and recommended by the North-West University, consisting of a manuscript ready for submission to a peer reviewed journal. The manuscript includes a literature review as well as interpretation of the results. The outline of the study is as follows:

Chapter 1 provides an introduction, objectives and hypothesis of the study, clarifying the purpose of the study. Chapter 2 is a literature overview of the research topic. Chapter 3 is presented in article format, according to the instructions set by the peer reviewed accredited **Journal of Clinical and Experimental HyperTension**, titled: *The association between physical activity, blood pressure and renin in black African teachers: the SABPA Study*. Chapter 4 summarizes the main findings of this study, highlights shortcomings and provides recommendations to future studies. A list of appendices follows at the end of this dissertation.

## 1.5 References

- ANTIC, V., DULLOO, A. & MONTANI, J. 2003. Multiple mechanisms involved in obesity-induced hypertension. *Heart, lung and circulation*, 12:84-94.
- BERRA, K. & MILLER, N.H. 2009. Inhibiting the renin-angiotensin system: why and in which patients. *Journal of the American academy of nurse practitioners*, 21:66-75.
- COOPOO, Y., CONSTANTINOU, D. & ROTHBERG, A.D. 2008. Energy expenditure in office workers with identified health risks. *South African journal of sports medicine*, 20(2):40-44.
- ESLER, M., ZWEIFLER, A., RANDALL, O., JULIUS, S. & DEQUATTRO, V. 1978. Determinants of plasma-renin activity in essential hypertension. *Annals of internal medicine*, 88:746-752.
- FISHER, J.P., YOUNG, C.N. & FADEL, P.J. 2009. Central sympathetic overactivity: maladies and mechanisms. *Neuroscience: basic and clinical*, 148:5-15.
- HAMER, M., MALAN, L., SCHUTTE, A.E., HUISMAN, H.W., VAN ROOYEN, J.M. & SCHUTTE, R. 2010. Plasma renin responses to mental stress and carotid intima-media thickness in black Africans: the SABPA study. *Journal of human hypertension*, 25:437-443.
- HAYWARD, V.H. 2006. Advanced fitness assessment and exercise prescription. 5<sup>th</sup> ed. Champaign, Ill.: Human Kinetics. 424 p.
- KEARNEY, P.M., WHELTON, M., REYNOLDS, K., MUNTNER, P., WHELTON, P.K. & HE, J. 2005. Global burden of hypertension: analysis of worldwide data. *Lancet*, 365(9455):217-223.
- KULLER, L.H. 2007. Epidemic hypertension in sub-Saharan Africa. *Hypertension*, 50: 1004-1005.
- LAMBERT, E.V. & KOLBE-ALEXANDER, T.L. 2005. Physical activity and chronic diseases of lifestyle in South Africa. *Chronic diseases of lifestyle in South Africa since 1995-2005*, 3:23-32.

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

MATHENGE, W., FOSTER, A. & KUPER, H. 2010. Urbanization, ethnicity and cardiovascular risk in a population in transition in Nakuru, Kenya: a population-based survey. *BMC public health*, 10:569.

MUELLER, P.J. 2007. Exercise training and sympathetic nervous system activity: evidence for physical activity dependent neural plasticity. *Clinical and experimental pharmacology and physiology*, 34:377-384.

MUELLER, P.J. 2008. Influence of sedentary versus physically active conditions on regulation of plasma renin activity and vasopressin. *American journal of physiology - regulatory, integrative and comparative physiology*, 295:R727-R732.

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

PESCATELLO, L.S., FRANKLIN, B.A., FAGART, R., FARQUHAR, W.B., KELLEY, G.A. & RAY, C.A. 2004. American College of Sports Medicine position stand: exercise and hypertension. *Medicine and science in sports exercise*, 36:533-553.

SAGNELLA, G.A. 2001. Why is plasma renin activity lower in populations of African origin? *Journal of human hypertension*, 15:17-25.

YUSUF, S., REDDY, S., ÔUNPUU, S. & ANAND, S. 2001. Global burden of cardiovascular diseases, Part II: Variations in cardiovascular disease by specific ethnic groups and geographic regions and prevention strategies. *Circulation*, 104:2855-2864.

## **CHAPTER 2: Physical activity, hypertension and sympathetic nervous system activity**

2.1 Introduction	7
2.2 Hypertension	7
2.2.1 Prevalence	8
2.2.2 Etiology	9
2.2.3 Health implications	10
2.2.4 Treatment	11
2.3 Physical activity	12
2.3.1 Definitions	12
2.3.2 Measurement of physical activity	13
2.3.3 Physical activity and health	14
2.3.4 Physical inactivity	16
2.3.5 Barriers to physical activity participation	16
2.4 Sympathetic nervous system activity, hypertension and physical activity	17
2.5 Questions arising from the literature	19
2.6 Objective	19
2.7 Hypothesis	19
2.8 References	20

## **2.1 INTRODUCTION**

It has been reported that South Africans generally display high levels of physical inactivity, with a reported 43% of adult men and 49% of adult women not reaching the recommended physical activity dose for health benefits (Joubert *et al.*, 2007:726). Regular moderate physical activity is generally associated with beneficial effects on the cardiovascular system, as opposed to the cardiovascular risks that sedentary lifestyles present (Mueller, 2007:377). However, not much data on total energy expenditure and physical activity patterns from developing country populations are available (Dugas *et al.*, 2009:806). Furthermore, improved data on the prevalence of hypertension and cardiovascular diseases, as well as the related risk factors, are needed in order to blunt this growing epidemic in Sub-Saharan Africa effectively (Kuller, 2007:1004).

Although the mechanisms are not yet fully understood, it appears that physical activity decreases, and physical inactivity increases the incidence of cardiovascular diseases via changes in the sympathetic nervous system (SNS) activity (Mueller, 2007:377). Cardiovascular disease is often accompanied by sympathetic overactivity, and a high incidence of morbidity and mortality (Mueller, 2007:382). It is, however, highly relevant from a clinical, economic and public health perspective, that the mechanisms by which physical activity, and the lack thereof, influence the cardiovascular system, in order to develop new strategies in the prevention and treatment of cardiovascular disease.

## **2.2 HYPERTENSION**

Blood pressure (BP) is the force exerted by the blood against the vessel wall (Guyton & Hall, 2006:166) and is measured in millimetres of mercury (mmHg). An individual is considered to have hypertension if the mean arterial pressure is above the upper range of the normal measure (Guyton & Hall, 2006:220). Several definitions of hypertension exist. The WHO/ISH (World Health Organisation/International Society of Hypertension) classifies hypertension into Grade I (SBP 140-159 mmHg; DBP 90-99 mmHg), Grade II (SBP 160-179 mmHg; DBP 100-109 mmHg) and Grade III (SBP  $\geq$ 180 mmHg; DBP  $\geq$  110 mmHg). Most recently, The Seventh Joint National Committee on prevention, detection, evaluation and treatment of high blood pressure (JNC-7) considers a SBP of 120-139 mmHg and/or a DBP of 80-89 mmHg as the pre-hypertensive state. Stage I hypertension is present when SBP reaches 140-159

mmHg and/or DBP, 90-99 mmHg, whereas SBP  $\geq$ 160 and/or DBP  $\geq$  100 mmHg is considered Stage II hypertension (Chemla *et al.*, 2006:321). Subtypes of hypertension exist, brought on by pathophysiological mechanisms. These include isolated systolic and diastolic hypertension. Isolated systolic hypertension develops when SBP is elevated above 140mm Hg, but DBP is below 90 mmHg. Isolated diastolic hypertension occurs when SBP is below 140 mmHg, and DBP elevated above 90 mmHg (Chemla *et al.*, 2006:321). Another form of hypertension, whitecoat-hypertension occurs when blood pressure increases during stressful and often within clinical environments, and is associated with increased sympathetic nervous system (SNS) activation (Malpas, 2010:536).

**Table 1: Recent reclassifications of SBP/DBP levels in mmHg for adults 18 years and older (Chemla *et al.*, 2006:321).**

SBP/DBP (mmHg)	JNC-7	ESH/ESC	WHO/ISH
<120/80	Normal	Optimal	-----
120-129/80-84	Pre-hypertensive	Normal	-----
130-139/85-89		High normal	-----
140-159/90-99	HT stage I	HT grade I (mild)	HT grade I
160-179/100-109	HT stage II	HT grade II (moderate)	HT grade II
>180/110		HT grade III (severe)	HT grade III

\*SBP: systolic blood pressure; DBP: diastolic blood pressure; JNC-7: The Seventh report of the Joint National Committee on prevention, detection, evaluation of high blood pressure; ESH/ESC: The European Society of Hypertension/The European Society of Cardiology; WHO/ISH: World Health Organization/International Society of Hypertension.

### 2.2.1 PREVALENCE

Hypertension is considered an important contributor to disability and mortality (Núñez-Córdoba *et al.*, 2009:339), and being a major cardiovascular risk factor, it is gaining epidemic proportions worldwide (Antic *et al.*, 2003:84). Cardiovascular diseases account for more than half of all deaths in developed countries (Antic *et al.*, 2003:84). Globally, more than 20% of adults are hypertensive and are, therefore, at risk for several cardiovascular pathologies, including myocardial infarction, stroke and renal failure (Antic *et al.*, 2003:84).

In the year 2000, 26.4% of the world's adult population had hypertension, with a predicted 29.2% in 2025 (Kearney *et al.*, 2005:219). This amounts to nearly one billion hypertensive individuals in 2000, and a staggering 1.56 billion in 2025 (Kearney *et al.*, 2005:221). In Sub-Saharan Africa alone, 37 million men and 39.4 women had hypertension in the year 2000. Kearney *et al.* (2005:221) predict that by 2025, 71.2 million men and 76 million women will have developed hypertension. An estimated 5.5 million people in South Africa display elevated blood pressure of which 3 million are black males (Peltzer, 2001:52).

Africans in particular may be more likely to develop hypertension (Mathenge *et al.*, 2010:2) as they develop hypertension at a much earlier age, displaying higher mean blood pressures (Yusuf *et al.*, 2001:2860; Chemla *et al.*, 2006:326; Berra & Miller, 2009:66). Urban societies display a much higher prevalence of hypertension, compared to rural communities (Van Rooyen *et al.*, 2000:785; Opie & Seedat, 2005:3563; Malan *et al.*, 2008:326).

Nationally, the prevalence of hypertension among black individuals is 24.4% (Wright & Ramukumba, 2009:69). Hypertension has been found to be a serious health problem in urban Sub-Saharan Africa, as the control thereof is low and not all hypertensive individuals undergo treatment (Addo *et al.*, 2007:1016), resulting in high morbidity and mortality from preventable complications such as heart attacks, stroke and renal failure. The increased prevalence of hypertension in urban areas could be explained by the characteristics of urban lifestyle (Addo *et al.*, 2007:1016; Malan *et al.*, 2008:327; Hamer *et al.*, 2011:240), including higher sodium and fat intake from processed foods and work environments with minimal physical activity and high levels of obesity.

### **2.2.2 ETIOLOGY**

Despite thorough research into the pathophysiology of hypertension, a mere 5% of hypertensive individuals have an identifiable cause (Kakar & Lip, 2006:833). It is well known, however, that hypertension is the result of interaction between genetic, physiological, environmental and psychosocial factors (Kakar & Lip, 2006:833), and often occurs coexistent as a combination of symptoms, including dyslipidemia, obesity and glucose intolerance. Several factors are considered to be hypertensiogenic, including age, obesity, insulin resistance, high levels of alcohol consumption, tobacco smoking, stress, low calcium and potassium intake as well as sedentary lifestyles (Reid & Thrift, 2005:375; Chemla *et al.*,

2006:321; De Ramirez *et al.*, 2010:791). Obesity is considered as one of the most important risk factors contributing to the development of hypertension (Kakar & Lip, 2006:833). A possible explanation for the abovementioned phenomenon is the high levels of leptin, insulin and free fatty acids associated with obesity that can lead to sympathetic activation and vasoconstriction (Antic *et al.*, 2003:84; Malpas, 2010:534).

**Table 2: Identified contributing factors of hypertension (JNC-7, 2004:16)**

*Excessive dietary sodium intake*

*Inadequate fruit and vegetable intake*

*Inadequate potassium intake*

*Excess body weight*

*Sedentary lifestyles*

*Excessive alcohol consumption*

**2.2.3 HEALTH IMPLICATIONS**

Hypertension is independently and continuously associated with increased cardiovascular disease mortality, stroke, coronary heart disease, heart failure, peripheral artery disease as well as renal insufficiency (JNC-7, 2004:12; Pescatello *et al.*, 2004:534). Hypertensive individuals are, furthermore, at an increased risk of developing diabetes (Chemla *et al.*, 2006:323), combined, resulting in a 7.2-fold increase in mortality. In fact, the coexistence of hypertension and diabetes significantly increases the risk of cardiovascular disease, stroke, renal disease as well as diabetic retinopathy (Chemla *et al.*, 2006:323; Berra & Miller, 2009:71). Blood pressure levels above 115/75 mmHg increase the risk of stroke across genders, stroke subtypes and fatal and non-fatal events (Chemla *et al.*, 2006:324; Berra & Miller, 2009:65). Stroke risk can be reduced by lowering SBP by as little as 10 mmHg and DBP with 5 mmHg (Chemla *et al.*, 2006:324; Cené & Cooper, 2008:486).

Hypertension has lethal effects on an individual's health, which are mainly observed (Guyton & Hall, 2006:220):

- Excessive workload on the heart leads to premature heart failure, coronary heart disease and often heart attacks;
- High pressure damages blood vessels in the brain, resulting in stroke;
- High pressure causes injury to the kidneys, leading to renal destruction, kidney failure, uremia and death.

Hypertension is, furthermore, associated with target end organ damage, as summarized in Table 3:

**Table 3: Target end organ damage associated with hypertension (JNC-7, 2007:20):**

---

**Target organs:**

---

**1. Brain**

- *Dementia*
- *Stroke*

**2. Chronic kidney disease**

**3. Heart**

- *Angina*
- *Heart failure*
- *Left ventricular hypertrophy*
- *Prior myocardial infarction*
- *Prior coronary revascularisation*

**4. Peripheral artery disease**

**5. Retinopathy**

#### **2.2.4 TREATMENT**

Hypertension therapy often includes health promoting lifestyle modification strategies in combination with anti-hypertensive agents (Chemla *et al.*, 2006:327). Some lifestyle modifications, like smoking cessation and reduced alcohol consumption could decrease an individual's expenses (JNC-7, 2004:64). The cost of adherence to lifestyle modifications and anti-hypertensive medication versus non-adherence should be considered rather, as the

latter may result in cardiovascular events, kidney failure, stroke, impaired quality of life and even premature death (JNC-7, 2004:64; Moulton, 2009:166). Lifestyle modifications to prevent or manage existing hypertension include weight reduction, adhering to the DASH eating plan, dietary sodium reduction, increased physical activity and moderation of alcohol consumption (JNC-7, 2004:26; Scheltens *et al.*, 2010:566). With regards to physical activity, current recommendations regarding the dose thereof, involve at least three exercise sessions of 30 minutes, consisting of endurance type PA, supplemented with resistance training (Pescatello *et al.*, 2004:542), at a moderate intensity (Choudhury & Lip, 2005:586).

By lowering blood pressure, future vascular diseases can be prevented (Scheltens *et al.*, 2010:561). More than half of hypertensive individuals are either untreated or inadequately treated, resulting in poor hypertension control (National Institutes of Health, 2002:VII-16). Africans in particular display poor adherence to recommended hypertension treatment (JNC-7, 2004:64). Patients' perceptions of the Dietary Approach to Stop Hypertension (DASH) eating plan being expensive and additional medical expenses, such as anti-hypertensive medication, are barriers to effective treatment (JNC-7, 2004:64).

There remains a definite need for improving health education and hypertension awareness and prevention programmes in order to control the development of hypertension (Agrawal *et al.*, 2005:25; Moulton, 2009:169).

## **2.3 PHYSICAL ACTIVITY**

### **2.3.1 DEFINITIONS**

Physical activity can be defined as any bodily movement, produced by skeletal muscle contraction, which increases energy expenditure (EE) substantially above the base level (USDHHS, 1996:20; ACSM, 2006:3; Warburton *et al.*, 2006:809). Physical fitness, a multidimensional concept, is seen as the ability to perform daily tasks, as well as physical activities, with vigour and alertness, without undue fatigue and to enjoy leisure-time pursuits (USDHHS, 1996:20; ACSM, 2006:3). Health-related fitness can, therefore, be defined as the components of physical fitness related to an individual's health status. This includes cardio-respiratory fitness, muscular strength and endurance, body composition, flexibility and metabolic status (USDHHS, 1996:22; ACSM, 2006:3; Warburton *et al.*,

2006:809). The intensity of physical activity can be categorized into light or low, moderate or mild, hard or vigorous and very hard or strenuous (USDHHS, 1996:32). Relative to an individual's capacity for a specific type of activity, light physical activity can be classified between 50-63% of the individual's maximal heart rate (HR max) and moderate intensity in the range of 64-70%. Physical activity regarded as hard or vigorous will be at a maximal heart rate of 77-93%, whereas very hard physical activity is considered to be above 94% (ACSM, 2006:4).

### **2.3.2 MEASUREMENT OF PHYSICAL ACTIVITY**

Research investigating the importance of energy expenditure related to health leads to evidence-based public health guidelines to enhance health status through physical activity (Lambert *et al.*, 2001:S12). It has, therefore, become important to monitor physical activity levels and energy expenditure of daily activities, in order to have an impact on the prevention and management of chronic diseases (Keim *et al.*, 2004:1400). Measurement of physical activity habits in a free-living environment is important in order to gain more insight into the relationship between physical activity and health, as well as the effectiveness of physical activity as an intervention strategy (Westerterp, 2009:823).

Currently, different methods of physical activity assessment exist, including behavioural observation, physical activity questionnaires, as well as physiological markers (such as heart rate monitoring), calorimetry and motion sensors (Westerterp, 2009:824). Instruments considered for the measurement of physical activity vary in their validity, reliability, obtrusiveness, cost, ease of administration and intended use (Seefeldt *et al.*, 2002:145).

Among electronic monitoring devices (including accelerometers, pedometers and heart rate monitors), accelerometers are considered to be the most promising monitoring tool, due to their small size, long-term data storage capabilities, as well as potential assessment of physical activity intensity, frequency and duration (Heil, 2006:64). Several types of accelerometers are available for physical activity assessment, ranging in complexity and cost. Accelerometers detect total body displacement electronically, varying in degrees of sensitivity (Ainslie *et al.*, 2003:690), and allow for the detection and recording of the magnitude of accelerations, mostly in the vertical plane (Kwak *et al.*, 2007:193). Accelerometers detecting motion in a single plane are referred to as uni-axial

accelerometers, whereas accelerometers detecting motion in three planes are tri-axial (Heil, 2006:64). Accelerometers measure an individual's acceleration in signals that are filtered by an analogue bypass and digitized by a converter. The magnitude of these accelerations is measured by the converter over a set time-period or epoch (Kolbe-Alexander *et al.*, 2004:101; Abel *et al.*, 2009:S141). The recorded counts in each epoch are then substituted into equations to calculate energy expenditure (METS). The data has to be downloaded to a computer via the manufacturer's software and imported to a spread sheet for analysis (Abel *et al.*, 2009:S142).

### **2.3.3 PHYSICAL ACTIVITY AND HEALTH**

The Surgeon's General Report on Physical Activity and Health (USDHHS, 1996:3) states that health benefits appear to be proportional to the amount of activity and that every increase thereof adds to the benefits obtained. Moderate physical activity performed on all or most days of the week, substantially lowers the risk of coronary heart disease, hypertension, obesity and overweight, adult onset diabetes mellitus and osteoporosis (Warburton *et al.*, 2006:803; Vuori, 2001:517). The acute responses to physical activity display a dose-response relationship to the intensity and volume of the activity performed. Vuori (2001:518), furthermore, explains that the repetitive loading stimulus at a suitable frequency, intensity and volume, results in the structural and functional adaptations in the targeted organs to handle the loading better. Most of these acute responses and almost all of the adaptive responses to physical activity, corresponding to the individual's capabilities, can enhance the individual's health, functional capacity or well-being, immediately or over weeks, months or years (Vuori, 2001:518). Higher levels of physical activity and physical fitness are associated with a reduced incidence of hypertension in White men. Due to fewer studies in women and black subjects, no significant relationships are visible (Pescatello *et al.*, 2004:536). Physical activity is, furthermore, associated with reduced all cause morbidity and mortality from chronic disease (Lambert & Kolbe-Alexander, 2005:23).

Considering the benefits of regular moderate intensity physical activity, it may also decrease the financial burden of health costs, brought upon by chronic diseases (USDHHS, 2002:7). The increased prevalence of chronic diseases, related to sedentary lifestyles, cause unnecessary costs to the health care systems globally. These costs include health care

expenses related to the prevention, diagnosis and treatment of chronic diseases, losses associated with low productivity as well as future financial losses due to premature deaths linked to physical inactivity (USDHHS, 2002: 4).

**Table 4: Health benefits resulting from participation in regular moderate physical activity (Vuori, 2001:518):**

<i>Fitness of body</i>	<i>Cancer</i>
Improved heart and lung fitness	Prevention of colon cancer
Improved muscular strength/size	Prevention of breast cancer
<i>Osteoporosis</i>	Prevention of uterine cancer
Helps build up bone density	Prevention of prostate cancer
Prevention of osteoporosis	<i>Infection and immunity</i>
Treatment of osteoporosis	Prevention of the common cold
<i>Osteoporotic fractures</i>	Improvement in overall immunity
Prevention of fracture	Improvement in life quality of HIV-infected
<i>Arthritis</i>	<i>Psychological well-being</i>
Prevention of arthritis	Elevation in mood
Treatment of arthritis	Buffering of effects of mental stress
Improvement in life quality/fitness	Alleviation/prevention of depression
<i>Low back pain</i>	Anxiety reduction
Prevention of low back pain	Improvement in self-esteem
Treatment of low back pain	<i>Nutrition and diet quality</i>
<i>Blood cholesterol/lipoproteins</i>	Improvement in diet quality
Lower blood total cholesterol	Increase in total energy intake
Lower LDL-cholesterol	<i>Cigarette smoking</i>
Lower triglycerides	Improvement in success in quitting
Raised HDL-cholesterol	<i>Sleep</i>
<i>High blood pressure</i>	Improvement in sleep quality
Prevention of high blood pressure	<i>Children and youth</i>
Treatment of high blood pressure	Prevention of obesity
<i>Diabetes</i>	Control of disease risk factors
Prevention of NIDDM	Reduction of unhealthy habits
Treatment of NIDDM	Improved odds of adult activity
Treatment of IDDM	<i>Special issues for women</i>
Improvement in diabetic life quality	Improved total body fitness
<i>Weight management</i>	Improved fitness while pregnant
Prevention of weight gain	Improved birthing experience
Treatment of obesity	Improved health of foetus
Maintenance of weight loss	Improved health during menopause
<i>Cardiovascular disease</i>	<i>Elderly and the aging process</i>
Coronary heart disease prevention	Improvement in physical fitness
Regression of atherosclerosis	Countering of loss in heart/lung fitness
Treatment of heart disease	Countering of loss of muscle
Prevention of stroke	Countering of gain in fat
<i>Asthma</i>	Improvement in life expectancy
Improvement in life quality	Improvement in life quality

#### **2.3.4 PHYSICAL INACTIVITY**

Sedentarism, or physical inactivity, in contrast to physical activity, is the absence of whole-body movement, associated with obesity and other metabolic disorders (Healy *et al.*, 2008:661). Individuals spending more time on sedentary activities display higher blood pressure compared to individuals who are moderately physically active (Gaya *et al.*, 2009:385) and is, therefore, considered as one of the major contributors to hypertension (Geleijnse *et al.*, 2005:S3). Physical inactivity is, furthermore, considered to be an independent risk factor for cardiovascular disease (Yusuf *et al.*, 2001:2750; Hayward, 2006:2; Mueller, 2008:727). Sedentary individuals are at a much greater risk of developing chronic diseases, such as coronary heart disease, hypertension, hypercholesteremia, cancer, obesity, type 2 diabetes, mellitus and musculoskeletal disorders, when compared to individuals who are meeting the recommended physical activity dose (Hayward, 2006:2; Lambert & Kolbe-Alexander, 2005:23). The Physician's Health Study (PHS), investigating factors influencing longevity, found that physical inactivity was significantly associated with reduced longevity (Yates *et al.*, 2008:288).

South Africans display high levels of physical inactivity, with a reported 43% of adult men and 49% of adult women not reaching the recommended physical activity dose for health benefits (Joubert *et al.*, 2007:729). The increased rate of urbanisation, in combination with behavioural changes, has resulted in sedentary lifestyle habits and less exercise (Choudhury & Lip, 2005:585). Mechanisation and technology reduce the necessity of physical activity in the workplace, further contributing to sedentary lifestyles (Lambert & Kolbe-Alexander, 2005:30).

#### **2.3.5 BARRIERS TO PHYSICAL ACTIVITY PARTICIPATION**

Despite warnings of the potential negative health consequences of a sedentary lifestyle, a large proportion of adults remain physically inactive (Seefeldt *et al.*, 2002:143). Several factors determine an individual's participation to exercise: age, gender, race and ethnicity are considered invariable factors, whereas behavioural and personality characteristics, environmental circumstances and community settings are modifiable (Seefeldt *et al.*, 2002:143). Lifestyle choices, however, are based upon prior fitness levels, education level and socio-economic status (Seefeldt *et al.*, 2002:146), and are often determined by

childhood habits. Most commonly, a lack of time, energy and social support, access to convenient and safe facilities and the cost of exercise are barriers to adults engaging in physical activities (Brown, 1999:522). Ethnic minority groups experience unaffordable facilities, unavailable childcare, high crime rates, personal safety and culturally inappropriate activities as barriers to be physically active (Seefeldt *et al.*, 2002:143). Black, obese women, furthermore, identify the lack of transport to safe exercise locations and difficulty to find appropriate clothing for exercise as barriers to engage in exercise (Thomas *et al.*, 2008:179).

#### **2.4 SYMPATHETIC NERVOUS SYSTEM ACTIVITY, HYPERTENSION AND PHYSICAL ACTIVITY**

Sympathetic activity and hypertension are closely related in Africans (Opie & Seedat, 2005:3563). The sympathetic nervous system (SNS) is considered as one of the most important controllers of the cardiovascular system and regulates arterial pressure by controlling the amount of activity and vasoconstriction in blood vessels. Over-activity of the SNS is associated with various cardiovascular diseases (Malpas, 2010:514).

The SNS activates the flight response during stress situations which involves an accelerated heart rate, increased blood pressure and blood flow to the brain and skeletal muscles as well as increased blood glucose (Gutman, 2007:106). Activation of the SNS leads to the secretion of renin, a vasoconstrictor (Hamer *et al.*, 2010:5), which increases the vascular resistance and, therefore, blood pressure (Pescatello *et al.*, 2004:543). Decreased sympathetic activity reduces blood pressure by deactivating the renin-angiotensin-aldosterone system (RAAS) activity, resetting baroreceptors and promoting arterial vasodilatation (USDHHS, 1996:111).

Various environmental factors such as psychological stress, increased salt intake, obesity and physical inactivity interact to activate the renin-angiotensin-aldosterone system (RAAS), resulting in over-activity of the sympathetic nervous system (Sowers *et al.*, 2009:778), which is closely associated with hypertension (Strazzullo, 2001:26; Mueller, 2007:377). SNS over-activity activates the Renin-Angiotensin-Aldosterone System (RAAS), contributing to an increase in blood pressure variability, resulting in elevated blood pressure or hypertension (Fisher *et al.*, 2009:8). Elevated renin in combination with increased SNS activity is associated with hypertension (Esler *et al.*, 1978:746; Grassi *et al.*, 2008:S34; Fisher *et al.*,

2009:8). It is known, however, that Africans in particular, display low plasma renin coexistent with elevated blood pressure (Sagnella, 2001:19; Opie & Seedat, 2005:3564). This phenomenon in Africans could be explained by mechanisms responsible for excessive sodium renal reabsorption and genetic abnormalities in the renin-angiotensin-aldosterone system (RAAS) (Sagnella, 2001:23; Mackenzie & Brown, 2009:1). Sub-optimal  $\text{Ca}^{2+}$  intake is associated with low plasma renin, which suppresses  $\text{Ca}^{2+}$ -ATPases mediated  $\text{Ca}^{2+}$  efflux leading to increased intracellular  $\text{Ca}^{2+}$  ( $\text{Ca}_i$ ), vascular resistance and hypertension (Cooper & Borke, 1993:181).

Sedentary conditions exacerbates activation of the renin-angiotensin-aldosterone system (RAAS) (Mueller, 2008:R730; Sowers *et al.*, 2009:778), but the underlying mechanisms involved are not yet fully known. In contrast to physical inactivity, baroreflex-mediated sympatho-excitation can be inhibited by means of physical activity (Chemla *et al.*, 2006: 328; Fraga *et al.*, 2007:634; Mueller, 2007:378). Elevated blood pressure can be prevented or delayed by means of regular physical activity, resulting in greater reductions in hypertensive individuals' high blood pressure (USDHHS, 1996:7; Pescatello, 2004:534). Normotensive individuals display a reduction of 8-10 mmHg in SBP and a 3-5 mmHg lowering in diastolic DBP after a single bout of exercise. Hypertensive patients, on the other hand, display greater reductions in blood pressure, twice as much as normotensives (Lakka & Laaksonen, 2007:79). Regular moderate physical activity lowers blood pressure by means of direct and indirect mechanisms. These mechanisms are classified as follows (Vouri, 2001:523): The direct physiological mechanisms consist of the reduction of adrenergic sympathetic activity, increased sensitivity of cellular insulin with decreased levels of circulating insulin, reduced peripheral resistance, increased baroreflex sensitivity, changes in renin-angiotensin-aldosterone system (RAAS), as well as a reduction in body fat. Improved relaxation and reduced tension and anxiety can be seen as indirect mechanisms by which blood pressure is lowered (Vuori, 2001:523).

Further research is needed to identify the mechanisms involved in physical activity dependent changes in SNS activity (Mueller, 2007:382).

## **2.5 QUESTIONS ARISING FROM THE LITERATURE**

When reviewing the literature, the following questions arise:

- To what extent is physical activity associated with elevated BP in urban Africans?
- Are physical activity levels related to renin in urban Africans?
- What are the main contributing factors to elevated BP and/or hypertension in urban Africans?

## **2.6 OBJECTIVE**

The aim of this study is to determine if physical inactivity is associated with elevated blood pressure and low renin levels in Africans.

## **2.7 HYPOTHESIS**

Low renin and physical activity levels will be associated with elevated SBP and DBP in urban Africans.

## 2.8 REFERENCES

ABEL, M., HANNON, J., LILLIE, T. & ANDERSON, K. 2009. Comparison of Kenz Lifecorder versus actigraph physical activity output in free-living conditions. *Journal of physical activity and health*, 6:S141-S147.

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

AGRAWAL, V.K., BHALWAR, R. & BASANNAR, D.R. 2007. Prevalence and determinants of hypertension in a rural community. *Medical journal armed forces India*, 64(1):21-25.

AINSLIE, P.N., REILLY, T. & WESTERTERP, K.R. 2003. Estimating human energy expenditure: a review of techniques with particular reference to doubly labelled water. *Sports medicine*, 33(9):683-698.

AMERICAN COLLEGE OF SPORTS MEDICINE. 2006. ACSM's guidelines for exercise testing and prescription. 7<sup>th</sup> ed. Baltimore: Williams & Wilkens. 366 p.

ANTIC, V., DULLOO, A. & MONTANI, J. 2003. Multiple mechanisms involved in obesity-induced hypertension. *Heart, lung and circulation*, 12(2):84-94.

BERRA, K. & MILLER, N.H. 2009. Inhibiting the renin-angiotensin system: why and in which patients. *Journal of the American academy of nurse practitioners*, 21:66-75.

BROWN, J. 1999. Barriers of physical activity in people at risk of coronary heart disease. *British journal of nursing*, 8:517-523.

CENÉ, C.W. & COOPER, L.A. 2008. Death toll from uncontrolled blood pressure in ethnic populations: universal access and equality improvement may not be enough. *Annals of family medicine*, 6(6):486-489.

CHEMLA, D., ANTONY, I., PLAMANN, K., ABASTADO, P. & NITENBERG, A. 2006. Hypertension, prehypertension and blood pressure related diseases. *Immunology, endocrine & metabolic agents-medical chemistry*, 6:319-330.

CHOUDHURY, A. & LIP, G.Y.H. 2005. Exercise and hypertension. *Journal of human hypertension*, 19:585-587.

COOPER, R.S. & BORKE, J.L., eds. 1993. Intracellular ions and hypertension in blacks. (In Fray, J.C.S. & Douglas, J.G., eds. Pathophysiology of hypertension in blacks. New York: Oxford University Press. p. 181-213.)

DE RAMIREZ, S.S., ENQUOBAHRIE, D.A., NYADZI, G., MJUNGU, D., MAGOMBO, F., RAMIREZ, M., SACHS, S.E. & WILLET, W. 2010. Prevalence and correlates of hypertension: a cross-sectional study among rural populations in sub-Saharan Africa. *Journal of human hypertension*, 24:786-795.

DUGAS, L.M., CARSTENS, M.A., EBERSOLE, K., SCHOELLER, D.A., DURAZO-ARVIZU, R.A., LAMBERT, E.V. & LUKE, A. 2009. Energy expenditure in young adult urban informal settlement dwellers in South Africa. *European journal of clinical nutrition*, 63:805-807.

ESLER, M., ZWEIFLER, A., RANDALL, O., JULIUS, S. & DE QUATTRO, V. 1978. The determinants of plasma-renin activity in essential hypertension. *Annals of internal medicine*, 88:746-752.

FISHER, J.P., YOUNG, C.N. & FADEL, P.J. 2009. Central sympathetic overactivity: maladies and mechanisms. *Autonomic neuroscience: basic and clinical*, 148:5-15.

FRAGA, R., FRANCO, F.G., ROVEDA, F., DE MATOS, L.N., BRAGA, A.M., RONDON, M.U., ROTTA, D.R., BRUM, P.C., BARRETTO, A.C., MIDDLEKAUFF, H.R. & NEGRAO, C.E. 2007. Exercise training reduces sympathetic nerve activity in heart failure patients treated with Carvedilol. *European journal of heart failure*, 9:630-636.

GAYA, A.R., ALVES, A., AIRES, L., MARTINS, C., RIBEIRO, J.C. & MOTA, J. 2009. Association between time spent in sedentary, moderate to vigorous physical activity, body mass index, cardiorespiratory fitness and blood pressure. *Annals of human biology*, 36(4):379-387.

GELEIJNSE, J.M., GROBBEE, D.E. & KOK, F.J. 2005. Impact of dietary and lifestyle factors on the prevalence of hypertension in Western populations. *Journal of human hypertension*, 19:S1-S4.

GRASSI, G., QUARTI-TREVANO, F., DELL'ORO, R. & MANCIA, G. 2008. Essential hypertension and the sympathetic nervous system. *Neurological science*, 29:S33-S36.

GUTMAN, S.A. 2007. Quick reference neuroscience for rehabilitation professionals: the essential neurologic principles underlying rehabilitation practice. 2<sup>nd</sup> ed. Thorofore, N.J.: Slack. 357 p.

GUYTON, A.C. & HALL, J.E. 2006. Textbook of medical physiology. 11<sup>th</sup> ed. Philadelphia, Penn.: Elsevier/Saunders. 1116 p.

HAMER, M., MALAN, L., SCHUTTE, A.E., HUISMAN, H.W., VAN ROOYEN, J.M. & SCHUTTE, R. 2010. Plasma renin responses to mental stress and carotid intima-media thickness in black Africans: the SABPA study. *Journal of human hypertension*, 25(7):437-443.

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

HAYWARD, V.H. 2006. Advanced fitness assessment and exercise prescription. 5<sup>th</sup> ed. Champaign, Ill.: Human Kinetics. 424 p.

HEALY, G.N., DUNSTAN, D.W., SALMON, J., CERIN, E., SHAW, E., ZIMMET, P.Z. & OWEN, N. 2008. Breaks in sedentary time. *Diabetes care*, 31:661-666.

HEIL, D.P. 2006. Predicting activity energy expenditure using the Actical® activity monitor. *Research quarterly for exercise and sport*, 77(1):64-80.

JNC 7. NATIONAL HIGH BLOOD PRESSURE EDUCATION PROGRAM. 1997. The sixth report of the Joint National Committee on Prevention, Detection, Evaluation and Treatment of High Blood Pressure. *Archives of internal medicine*, 157:2413-2446.

JOUBERT, J., NORMAN, R., LAMBERT, E.V., GROENEWALD, P., SCHNEIDER, M., BULL, F. & BRADSHAW, D. 2007. Estimating the burden of disease attributable to physical inactivity in South Africa in 2000. *South African medical journal*, 97(8):725-731.

KAKAR, P. & LIP, G.Y.H. 2006. Towards understanding the aetiology and pathophysiology of human hypertension: where are we now? *Journal of human hypertension*, 20: 833-836.

KEARNEY, P.M., WHELTON, M., REYNOLDS, K., MUNTNER, P., WHELTON, P.K. & HE, J. 2005. Global burden of hypertension: analysis of worldwide data. *Lancet*, 365(9455):217-223.

KEIM, N.L., BLANTON, C.A. & KRETSCH, M.J. 2004. America's obesity epidemic: measuring physical activity to promote active lifestyles. *Journal of the American diet association*, 104(9):1398-1409.

KOLBE-ALEXANDER, T.L., LAMBERTE, E.V., HARKINS, J.B. & EKULAND, U. 2004. Comparison of two methods of measuring physical activity in South African older adults. *Journal of aging and physical activity*, 14:98-114.

KULLER, L.H. 2007. Epidemic hypertension in sub-Saharan Africa. *Hypertension*, 50:1004-1005.

KWAK, L., KREMERS, S.P.J., BRUG, J. & VAN BAAK, M. 2007. Measuring physical activity in field studies: comparison of a questionnaire, 24-hour recall and an accelerometer. *European journal of sport science*, 7(4):193-201.

LAKKA, T.A. & LAAKSONEN, D.E. 2007. Physical activity in prevention and treatment of the metabolic syndrome. *Applied physiology, nutrition and metabolism*, 32(1):76-88.

LAMBERT, E.V., BOHLMANN, I. & KOLBE-ALEXANDER, T. 2001. 'Be Active' - physical activity for health in South Africa. *South African journal of clinical nutrition*, 14:S12-S16.

LAMBERT, E.V. & KOLBE-ALEXANDER, T. 2005. Physical activity and chronic diseases of lifestyle in South Africa. *Chronic diseases of lifestyle in South Africa since 1995-2005*, 3:23-32.

MACKENZIE, I.S. & BROWN, M.J. 2009. Molecular and clinical investigations in patients with low-renin hypertension. *Clinical and experimental nephrology*, 13:1-8.

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

MALPAS, S.C. 2010. Sympathetic nervous system overactivity and its role in the development of cardiovascular diseases. *Physiology reviews*, 90:513-557.

MATHENGE, W., FOSTER, A. & KUPER, H. 2010. Urbanization, ethnicity and cardiovascular risk in a population in transition in Nakuru, Kenya: a population-based survey. *BioMed central public health*, 10:569.

MOULTON, S.A. 2009. Hypertension in African Americans and its related chronic diseases. *Journal of cultural diversity*, 16(4):165-170.

MUELLER, P.J. 2007. Exercise training and sympathetic nervous system activity: evidence for physical activity dependent neural plasticity. *Clinical and experimental pharmacology and physiology*, 34:377-384.

MUELLER, P.J. 2008. Influence of sedentary versus physically active conditions on regulation of plasma renin activity and vasopressin. *American journal of physiology-regulatory, integrative and comparative physiology*, 295:R727-R732.

NATIONAL INSTITUTES OF HEALTH. 2002. Detection, evaluation and treatment of high blood cholesterol in adults (Adult treatment panel III): Final report. 284 p.

NÚÑES-CÓRDOBA, J.M., VALENCIA-SERRANO, F., TOLEDO, E., ALONSO, A. & MARTÍNEZ-GONZÁLEZ, A. 2009. The Mediterranean diet and incidence of hypertension. *American journal of epidemiology*, 169:339-346.

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

PELTZER, K. 2001. Knowledge and attitudes of primary care nurses and midwives towards health promotion in rural South Africa. *Curationis*, 24(4):52-58.

PESCATELLO, L.S., FRANKLIN, B.A., FAGART, R., FARQUHAR, W.B., KELLEY, G.A. & RAY, C.A. 2004. Exercise and hypertension. *Medicine & science in sport & exercise*, 36(3):533-553.

REID, C.M. & THRIFT, A.G. 2005. Hypertension 2020: confronting tomorrow's problem today. *Clinical and experimental pharmacology and physiology*, 32:374-376.

SAGNELLA, G.A. 2001. Why is plasma renin activity lower in populations of African origin? *Journal of human hypertension*, 15:17-25.

SCHELTENS, T., BEULENS, J.W., VERSCHUREN, W.M.M., BOER, J.M., HOES, A.W., GROBBEE, D.E. & BOTS, M.L. 2010. Awareness of hypertension: will it bring about a healthy lifestyle? *Journal of human hypertension*, 24:561-567.

SEEFELDT V., MALINA, R.M. & CLARK, M.A. 2002. Factors affecting levels of physical activity in adults. *Sports medicine*, 32(3):143-168.

SOWERS, J.R., WHALEY-CONNELL, A. & EPSTEIN, M. 2009. Narrative review: the emerging clinical implications of the role of aldosterone in the metabolic syndrome and resistant hypertension. *Annals of internal medicine*, 150:776-783.

STRAZULLO, P., BARBATO, A., VUOTTO, P. & GALETTI, F. 2001. Relationships between salt sensitivity of blood pressure and sympathetic nervous system activity: a short review of evidence. *Clinical and experimental hypertension*, 23:25-33.

THOMAS, A.M., MOSELEY, G., STALLINGS, R., NICHOLS-ENGLISH, G. & WAGNER, P.J. 2008. Perceptions of obesity: black and white differences. *Journal of cultural differences*, 15(4):174-180.

UNITED STATES. Department of Health and Human Services (USDHHS). 1996. Physical activity and health: a report of the Surgeon General. Washington, D.C.: United States. Department of Health and Human Services (USDHHS). 278 p.

UNITED STATES. Department of Health and Human Services (USDHHS). 2002. Physical activity fundamental to preventing disease. Washington, D.C.: United States. Department of Health and Human Services (USDHHS). Office of the Assistant Secretary for Planning and Evaluation. 19 p.

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.

VUORI, I.M. 2001. Health benefits of physical activity with special reference to interaction with diet. *Public health nutrition*, 4(2B):517-528.

WARBURTON, D.E.R., NICOL, C.W. & BREDIN, S.S.D. 2006. Health benefits of physical activity: the evidence. *Canadian medical association journal*, 174(6):801-809.

WESTERTERP, K.R. 2009. Assessment of physical activity: a critical appraisal. *European journal of applied physiology*, 105:823-828.

WRIGHT, S.C.D. & RAMUKUMBA, T.S. 2008. Lifestyle risk factors in an urban South African community. *Curationis*, 31(1):68-76.

YATES, L.B., DJOUSSE, L., KURTH, T., BURING, J.E. & GAZIANO, M. 2009. Modifiable factors associated with survival and function to age 90 years. *Archives of internal medicine*, 168(3):284-290.

YUSUF, S., REDDY, S., ÔUNPUU, S. & ANAND, S. 2001. Global burden of cardiovascular regions and prevention strategies. *Circulation*, 104:2855-2864.



NORTH-WEST UNIVERSITY  
YUNIBESITI YA BOKONE-BOPHIRIMA  
NOORDWES-UNIVERSITEIT  
POTCHEFSTROOM CAMPUS

# The association between physical activity, blood pressure and renin in black African teachers: the SABPA Study

Running Head: Physical activity, blood pressure and renin in Africans

Juanita Bower, J Hans de Ridder, Leoné Malan.

*School for Biokinetics, Recreation and Sport Science; Hypertension in Africa Research Team (HART); School for Physiology, Nutrition, and Consumer Sciences; North-West University (Potchefstroom Campus); Private Bag X6001; Potchefstroom; 2520; South Africa.*

## Correspondence:

Leoné Malan (RN, PhD)

Hypertension in Africa Research Team (HART),

Private Bag x6001,

North-West University (Potchefstroom Campus),

Potchefstroom,

2520

South Africa

Telephone: +27-18-299-2438

Facsimile: +27-18-299-1053

e-mail: [leone.malan@nwu.ac.za](mailto:leone.malan@nwu.ac.za)

**Conflict of Interest:** All authors declare no conflict of interest.

*Article has been submitted to Journal of Clinical and Experimental Hypertension.*

## **Abstract**

The aim of this study was to determine associations between physical activity (PA), blood pressure (BP) and renin in urban African teachers (Males, N=101; Females, N=99), aged 25-65 years. We measured energy expenditure, ambulatory BP and renin. Actical<sup>®</sup> accelerometers were used to determine PA (measured in METS). African males were more hypertensive (64%) compared to the females (33.33%). Renin levels of both gender groups displayed an inverse relationship with BP, but no relationship with physical inactivity existed. PA was positively associated with DBP in males only. In conclusion, PA did not have a buffering effect on the low renin-high BP profile Africans.

**Key words:** hypertension, blood pressure, physical activity, Africans, renin.

## Introduction

Hypertension, a major cardiovascular disease (CVD) risk factor, is gaining epidemic proportions globally (1). In Sub-Saharan Africa, 37 million men and 39.4 million women had hypertension in the year 2000. Kearney et al. (2) predicted that by the year 2025, 71.2 million men and 72 million women will be hypertensive. More than 20% of adults are currently hypertensive and are, therefore, at risk for several cardiovascular pathologies including myocardial infarction, stroke and renal insufficiency (1, 3). Africans in particular may be more likely to develop hypertension (4) as they develop hypertension at a much earlier age and display higher mean blood pressures (5, 6).

Hypertension is further closely associated with sympathetic nervous system (SNS) over-activity (7). Increased central sympathetic nerve activity may enhance the Renin-Angiotensin-Aldosterone System (RAAS) activity, contributing to a further increase in blood pressure variability as well as hypertension (8). Activation of the SNS leads to the secretion of renin, a vasoconstrictor (9), increasing vascular resistance and blood pressure. Hypertensive patients have been found to display elevated plasma renin in combination with increased SNS activity (10). Contradictorily, Africans, in particular, display lower plasma renin levels (11, 12), although only a few studies have documented the prevalence of hypertension and low renin levels among urbanized Africans.

Furthermore, Mueller (13) suggested that physical inactivity actually exacerbates sympathetic nerve activity, also contributing to increased blood pressure. Consequently, sedentary conditions may enhance the activation of the RAAS, but the underlying mechanisms responsible are not fully known yet (13). Regular moderate physical activity may reduce increased SNS in hypertensive individuals (3) and it has also been found to

reduce sympathetic activity and resting blood pressure in normal (non-hypertensive) individuals (7,20). The inhibitory effect of regular physical activity on SNS may contribute to a reduced incidence of cardiovascular diseases in physically active individuals. Sedentary lifestyles may, therefore, produce heightened sympathetic responses, leading to cardiovascular diseases over a period of time (7). The World Health Survey, conducted in 2003, found that less than a third of South Africans meet the ACSM and Centres for Disease Control's (CDC) recommended 30 minutes of moderate physical activity per day (14). Sedentary individuals are at a much higher risk of developing hypertension compared to those who do meet the recommended dose of physical activity (15).

Knowledge of healthy lifestyles and factors influencing an individual's health, such as physical activity levels, blood pressure, BMI, waist circumference and blood glucose levels are necessary to intervene effectively in the alarming increase in the prevalence of chronic diseases worldwide (16). By gaining insight into the contributing factors (such as renin) of the development of hypertension among black urban Africans can lead to early detection and preventative measures to be implemented reducing the incidence.

The aim of this study was to determine if low levels of physical activity and renin predicted high blood pressure.

## **Method**

### **Study population**

Two hundred (N=101, male; N=99, female) black urban African teachers, aged between 25 and 65 years (males,  $41.53 \pm 8.13$  years; females,  $44.16 \pm 7.37$  years), from the North West Province (February to May 2008) participated in this study. Participants were all of the same socio-economic status and were screened for eligibility two to three months prior to the study. Pregnancy, lactation, use of hypertension medication,  $\alpha$ - and  $\beta$ -blockers and an ear temperature  $> 37.5^{\circ}\text{C}$  served as exclusion criteria. Persons donating blood and vaccinated in the three months prior to the study were also excluded from the study. Of the 200 subjects, 33 males and 30 females were excluded due to a HIV-positive status (N=19) and anti-hypertensive (N=44) medication use. Our total sample consisted of 68 males and 69 females. Informed consent forms had to be signed by each participant. Ethical approval for the study was obtained from the Ethical Research Committee of the North-West University and conformed to the ethical guidelines of the World Medical Association Declaration of Helsinki of 1975 (as revised in 2008).

### **Clinical Examination**

Data collection involved two days for all participants. On day one (06h00) the physical activity meters (Actical<sup>®</sup> Mini Mitter, Bend OR<sup>®</sup>) were fitted to four participants' hips, whereafter they resumed normal daily activities. Each participant completed a socio-demographic health questionnaire and stayed at the Metabolic Research Facility on the NWU campus. They fasted for eight hours and early on day two, the Actical<sup>®</sup> accelerometers were removed, and the data downloaded. Anthropometric measurements (body mass,

stature, neck, waist and hip circumferences) were taken in triplicate. Sphygmomanometer blood pressure was measured and resting blood samples were taken by a registered nurse in accordance to standardized procedures.

### **Biochemical Measurements**

Fasting blood samples were obtained in order to determine fasting sodium fluoride glucose, serum cotinine (COT), gamma-glutamyl transferase (GGT) and plasma renin levels. Plasma renin concentration was measured using high sensitivity active Renin III IRMA kits (Diagnostic Systems Laboratories, Webster, USA) (Inter-assay 0.09%; Intra-assay 3.6-5.0%). Antibody tests (First Response Kit, Premier Medical Corporation, LTD, Daman, India) supplied by the Health Department of the North West Province were used to determine the participants' HIV/AIDS status. Standardized sampling procedures were maintained using a winged infusion set to obtain blood samples from the brachial vein branches of the dominant arm, by a registered nurse. The samples were centrifuged and stored at -80°C. The analysis involved a measurement of immunoprecipitation, enhanced by polyethylene glycol at 450nm with the Konelab™ 20i Sequential Multiple Analyzer Computer (SMAC), (ThermoScientific, Vantaa, Finland).

### **Lifestyle Factors**

#### **Anthropometric Measurements**

Body mass was determined with the KRUPS scale, to the nearest 0.1 kg, with each participant wearing minimal clothing, and the weight evenly distributed (17).

Stretched stature was measured with a stadiometer (Invicta Stadiometer, IP 1465, U.K) to the nearest 0.1 cm. Accurate measurement required the participant to stand with the heels

together, upper back and buttocks against the stadiometer, and the head in the Frankfort plane (17). Body mass and stature were used to calculate the participants' body mass index (BMI) by dividing body mass (kg) by stature (m<sup>2</sup>) (18).

The waist circumference (WC) was measured at the midpoint between the lower costal border and the iliac crest, perpendicular to the long axis of the trunk (17). WC was measured with a Holtain unstretchable flexible 7 mm wide metal tape, to the nearest 0.1 cm (17).

#### **Physical activity: Objective Measurement (Actical<sup>®</sup> Mini Mitter, Bend OR<sup>®</sup>)**

Each participant's actual energy expenditure was determined by the Actical<sup>®</sup> accelerometers worn on the day the data collection took place. Actical<sup>®</sup> (Mini Mitter, Bend OR<sup>®</sup>) accelerometers were worn around the hip for 24 hours to determine caloric energy expenditure throughout the participant's daily activities. It is an omni-directional accelerometer that measures the participant's physical activity, energy expenditure and step count. By connecting the Acticals<sup>®</sup> to the Actireader<sup>®</sup>, the data were downloaded to a computer, in order to calculate the energy expenditure, presented in kilo Calories (kCal).

#### **Blood Pressure**

After a 10 minute rest period in a semi-recumbent position, a suitable cuff size was applied to the non-dominant arm. Two Riva-Rocci/Korotkoff blood pressure measurements, with a 5 minute rest period between measurements, were taken. The second measurement classified participants as hypertensive according to the cut-off points of the European Society of Hypertension Guidelines (Korotkoff sound I: resting systolic blood pressure  $\geq$  140mmHg and/or Korotkoff sound V: diastolic blood pressure  $\geq$  90mmHg).

## **Statistical Evaluation**

Statistica 10 (StatSoft, Inc. 2011) software was used for statistical analyses. Departure of normality was tested to detect outliers. Chi square statistics calculated proportions. Means were compared by a standard t-test. Variables were compared with ANCOVAS, adjusting for age, BMI, COT and GGT in order to determine significant differences between groups. Multivariate regression analyses were performed, adjusting for age, BMI, COT and GGT. Forward linear stepwise regression analyses models determined associations between dependent variable BP and independent cardiovascular markers in both gender groups. Independent covariates considered for entry into regression models were BMI, age, glucose, METS and renin. A p-value  $\leq 0.05$  was considered significant.

## **Results**

### **Characteristics of the study population**

Table I displays the study population's adjusted and unadjusted baseline characteristics. Females were older ( $44.16 \pm 7.37$  years) and their mean values revealed a more obese state ( $32.00 \pm 7.75$  kg/m<sup>2</sup>) whereas males demonstrated an overweight status ( $27.28 \pm 5.86$  kg/m<sup>2</sup>). Energy expenditure (METS) and renin did not differ significantly between males and females. SBP ( $p < 0.001$ ) and DBP ( $p < 0.001$ ) were significantly higher in males than females. More males (64%) were classified as hypertensive, compared to females (33.33%).

Multivariate regression analyses demonstrated an inverse relationship between BP and renin (Fig. 1, 2; Table 2). Glucose was also associated with DBP in men. No associations existed between renin and physical inactivity (Fig. 2).

## Discussion

The purpose of this study was to determine if low physical activity and low renin levels were associated with blood pressure in an African cohort.

Elevated renin, which is associated with hypertension (8, 10), was not present in this population, but within normal ranges (normal range: 2.4-29pg/mL) (30). It is, however, known that Africans, in particular, display lower levels of plasma renin (11, 12) and it was confirmed by our results where inverse associations were demonstrated between resting renin and blood pressure for the males and the females. Female BP particularly displayed strong inverse associations with renin, which is supported by other studies on black women (31, 38). Low plasma renin, coexistent with high blood pressure in blacks could be a consequence of sodium handling. Africans have increased salt-sensitivity (36, 37) and Sagnella (11) suggests that this phenomenon could be explained by mechanisms responsible for excessive sodium renal reabsorption and genetic abnormalities in the renin-angiotensin-aldosterone system (RAAS) (11). Furthermore, sub-optimal  $\text{Ca}^{2+}$  intake is associated with low plasma renin, suppressing  $\text{Ca}^{2+}$ -ATPases mediated  $\text{Ca}^{2+}$  efflux, which could increase intracellular  $\text{Ca}^{2+}$  ( $\text{Ca}_i$ ), vascular resistance and hypertension (27). Blood pressure and salt sensitivity in Sub-Saharan Africans are most likely related to the genetic polymorphisms that contribute to BP values, but more research is needed to understand fully the genetics of hypertension in sub-Saharan Africa (19).

Interestingly, physical inactivity was not associated with BP or renin. The lack of this association in females may indicate the possible role of estradiol having a vasodilatory and protective cardiovascular effect (28), and could explain the apparent resilience in the African

females who are also still relatively young and/or premenopausal. In males, PA was associated with DBP which is not clear.

Interestingly, physical inactivity was not associated with BP or renin. It has been reported that South Africans generally display high levels of physical inactivity, with a reported 43% of adult men and 49% of adult women not reaching the recommended physical activity dose for health benefits (26). Currently, recommendations regarding the dose of health enhancing physical activity, involve at least three exercise sessions of 30 minutes per week, at a moderate intensity (25). Mechanization and technology reduce the necessity of physical activity in the workplace, further contributing to sedentary lifestyles (14). Olatunbosun (21), however, suggests that a general high level of physical activity in the African population, may explain the absence of effect on the risk of developing high blood pressure and hypertension.

Another explanation of the subjects' elevated blood pressure could be that they are exposed to stress, having debilitating effects on their health (22) that could lead to hypertension, obesity, type-2-diabetes mellitus, the metabolic syndrome and other lifestyle diseases (22). The association between glucose and DBP in males supports this notion. Exposure to mental and chronic stress exacerbate vasoconstriction and increased DBP (27,32). Africans exhibit increased cardiovascular activity and peripheral resistance when exposed to stressful situations (34), predisposing them to develop hypertension (34). Increased BP has been furthermore associated with exposure to psychosocial stress and living in an urban environment (35).

In this study population, males (66%) presented a higher percentage of hypertensive individuals than females (33.33%). Furthermore, more females reported being on anti-

hypertensive medication (23%) compared to males (19.80%), possibly contributing to this difference. Males presented significantly higher levels of alcohol consumption (GGT) and tobacco smoking (COT). High levels of alcohol consumption, as seen in the males in this study, combined with a high-strain occupation such as teaching, could lead to increased BP (29). Physical inactivity in combination with high levels of alcohol consumption, tobacco smoking and a poor diet, is accompanied by a parallel increase in BP (23,24). Lifestyle factors of the males in this population could, therefore, further contribute to the males' vulnerability of developing elevated blood pressure and sub-clinical vascular disease (29,39). It was shown that male gender could be a contributing risk factor for hypertension in black populations (21).

Limitations to this study could be the size of the participant sample, as individuals currently on anti-hypertensive medication were excluded from blood sampling to determine valid renin levels. Energy expenditure was only observed over a 24-hour period, whereas measurement over 7 days might have provided greater insight into their habitual PA. Participants had to wear a Cardiotens apparatus (24-hour ambulatory and electrocardiogram, ECG) in conjunction with the accelerometer, which might have disrupted their normal daily routines, affecting PA levels. Furthermore, diet-recalling could have provided insight into their sodium and  $\text{Ca}^{2+}$  intake.

In conclusion, PA appeared not to buffer high blood pressure in this specific African cohort population, as no significant associations supported this hypothesis. This study furthermore confirms that black Africans display lower renin levels associated with elevated blood pressure (11, 12). The main finding of our study was that low renin and physical inactivity were not related to indicate elevated, especially in females.

Further research is needed to understand mechanisms by which PA or a lack thereof can alter an individual's health, to develop new strategies in the prevention and treatment of cardiovascular disease.

### **Acknowledgements**

The authors would like to thank each member of the SABPA team (North-West University, South Africa) for the collection of data as well as the willing participants for their involvement in this study. This research was partially funded by the National Research Foundation, South Africa; North-West University, Potchefstroom, South Africa; and the Metabolic Syndrome Institute, France.

### **Conflict of interest**

The authors declare no conflicts of commercial interest.

## References

1. Antic V, Dulloo A, Montani J. Multiple mechanisms involved in obesity-induced hypertension. *Heart lung* 2003; 12: 84--94.
2. Kearney PM, Whelton M, Reynolds K, Munter P, Whelton PK, HE J. Global burden of hypertension: analysis of worldwide data. *Lancet* 2005; 365(9455): 217--223.
3. Pescatello LS, Franklin BA, Fagard R, Farquhar WB, Kelley GA, Ray CA. American College of Sports Medicine position stand: exercise and hypertension. *Med Sci Sports Exerc* 2004; 36(3): 533--553.
4. Mathenge W, Foster A, Kuper H. Urbanization, ethnicity and cardiovascular risk in a population in transition in Nakuru, Kenya: a population-based survey. *BMC Public Health* 2010; 10: 569--581.
5. Berra K, Miller NH. Inhibiting the renin-angiotensin system: why and in which patients. *JAANP* 2009; 21: 66--75.
6. Yusuf S, Reddy S, Ôunpuu S, Anand S. Global burden of cardiovascular diseases: Part II: Variations in cardiovascular disease by specific ethnic groups and geographic regions and prevention strategies. *Circulation* 2001; 104: 2855--2864.
7. Mueller PJ. Exercise training and sympathetic nervous system activity: evidence for physical activity dependent neural plasticity. *Clin Exp Pharmacol P* 2007; 34: 377--384.
8. Fisher JP, Young CN, Fadel PJ. Central sympathetic over-activity: maladies and mechanisms. *AutonNeurosci-Basic* 2009; 148: 5--15.
9. Hamer M, Malan L, Schutte AE, Huisman HW, Van Rooyen JM, Schutte R. Plasma renin responses to mental stress and carotid intima-media thickness in black Africans: the SABPA study. *J Hum Hypertens* 2010; 25(7): 437—443.

10. Esler M, Zweifler A, Randal O, Julius S, De Quattro V. The determinants of plasma-renin activity in essential hypertension. *Ann Intern Med* 1978; 88: 746--752.
11. Sagnella GA. Why is plasma renin activity lower in populations of African origin? *J Hum Hypertens* 2001; 15: 17--25.
12. Opie LH, Seedat YK. Hypertension in sub-Saharan African populations. *Circulation* 2005; 112: 3562--3568.
13. Mueller PJ. Influence of sedentary versus physically active conditions on regulation of plasma renin activity and vasopressin. *Am J Physiol-Reg I* 2008; 295: R727--R732.
14. World Health Organization. Preliminary results of the World Health Survey, 2002-2003; International physical activity data, South African results. Geneva: WHO, 2005.
15. Hayward VH. *Advanced Fitness Assessment and Exercise Prescription*. Illinois: Burgess Publishing Company, 2006.
16. Coopoo Y, Constantinou D, Rothberg AD. Energy expenditure in office workers with identified health risks. *SAJSM* 2008; 20(2): 40--44.
17. Marfell-Jones M, Olds T, Steward A, Carter JEL. *International Standards for Anthropometric Assessment*. New Zealand: ISAK. 137p.
18. American College of Sports Medicine. *ACSM's Guidelines for Exercise Testing and Prescription*. Baltimore: Williams & Wilkens. 2006.
19. Kuller LH. Epidemic hypertension in sub-Saharan Africa. *Hypertension* 2007; 50: 1004-1005.
20. Vuori IM. Health benefits of physical activity with special reference to interaction with diet. *Public Health Nutrition* 2001; 4(2B): 517--528.

21. Olatunbosun ST, Kaufman JS, Cooper RS, Bella AF. Hypertension in black population prevalence and biosocial determinants of high blood pressure in a group of urban Nigerians. *Journal of Human Hypertension* 2000; 14:249--257.
22. Chrousos GP. Stress and disorders of the stress system. *Nature Reviews Endocrinology* 2009; 5:374--381.
23. Geleijnse JM, Grobbee DE, Kok FJ. Impact of dietary and lifestyle factors on the prevalence of hypertension in Western populations. *J Hum Hypertens* 2005; 19: S1--S4.
24. Reid CM, Thrift AG. Hypertension 2020: confronting tomorrow's problem today. *Clin Exp Pharmacol P* 2005; 32: 374--376.
25. Choudhury A, Lip GYH. Exercise and hypertension. *J Hum Hypertens* 2005; 19: 585--587.
26. Joubert J, Norman, R, Lambert EV, Groenewald P, Schneider M, Bull F, Bradshaw D. Estimating the burden of disease attributable to physical inactivity in South Africa in 2000. *S Afr Med J* 2007; 97(8): 725--731.
27. Cooper RS, Borke JL. Intracellular ions and hypertension in blacks. In: *Pathophysiology of Hypertension in Blacks*. New York, NY: Oxford University Press, 1993: 181--213.
28. De Bold, MLK. Estrogen, natriuretic peptides and the renin-angiotensin system. *Cardiovasc Res* 1999; 41: 524--531.
29. Theorell T, Westerlund H, Alfredsson L, Oxenstierna G. Coping with critical life events and lack of control-the exertion of control. *Psychoneuroendocrinology* 2005; 30:1027--1032.
30. Karabinos I, Papageorgiou G, Papadopoulos A. A Renin-dependent hypertension due to renal angiodyplasia. *Clin Res Cardiol* 2008; 97: 782--783.
31. Opie, L.H. 2004. *Heart Physiology: From Cell to Circulation*. 4th ed. Philadelphia: Lippincott Williams & Wilkins. 648 pp.

32. Gottdiener JS, Kop WJ, Hausner E, McCeney M, Herrington D, Krantz DS. Effects of mental stress on flow-mediated brachial arterial dilation and influence of behavioral factors and hypercholesterolemia in subjects without cardiovascular disease. *Am J Cardiol* 2003; 92(6): 687--691.
33. Van Rooyen JM, Kruger HS, Huisman HH, Wissing MP, Margetts BM, Venter CS, Vorster HH. An epidemiological study of hypertension and its determinants in a population in transition: the THUSA study. *J Hum Hypertens* 2000; 14: 779--787.
34. Hinderliter AL, Blumenthal JA, Waugh R, Chilukuri M, Sherwood A. Ethnic differences in left ventricular structure: relations to hemodynamics and diurnal blood pressure variation. *Am J Hypertens* 2004; 17: 43--49.
35. Malan L, Malan NT, Wissing MP, Seedat YK. Coping with urbanization: A cardiometabolic risk? The THUSA study. *BiolPsychol* 2008; 79: 323--328.
36. Mufunda J, Somova L, Chifamba J. Pathophysiological mechanisms of urbanization-related hypertension and the sodium stressor response in black Zimbabweans. *S Afr Med J* 1994; 83: 507--510.
37. Wright Jr JT, Rahman M, Scarpa A, Fatholahi M, Griffin V, Jean-Baptiste R, Islam M, Eissa M, White S, Douglas JG. Determinants of salt sensitivity in black and white normotensive and hypertensive women. *Hypertension* 2003; 42: 1087--1093.
38. Holland OB, Gomez-Sanchez C, Fairchild C, Kaplan NM. Role of renin classification for diuretic treatment of black hypertensive patients. *Arch Intern Med* 1979; 139(12): 1365-1370.
39. Hamer M, Malan L, Schutte AE, Huisman HW, Van Rooyen JM, Schutte R, Fourie CMT, Malan NT, Seedat YK. Conventional and behavioral risk factors explain differences in

sub-clinical vascular disease between black and Caucasian South Africans: The SABPA study. *Atherosclerosis* 2011; 215: 237--242.

**Table 1: Baseline characteristics of the study population**

	<b>MALES (N=68)</b>	<b>FEMALES (N=69)</b>	<b>P</b>
<b><i>Unadjusted Lifestyle Factors (mean±SD)</i></b>			
Age (years)*	<b>41.53 ± 8.13</b>	<b>44.16 ± 7.37</b>	<b>0.05</b>
Body mass index (kg/m <sup>2</sup> )*	<b>27.28 ± 5.86</b>	<b>32.00 ± 7.75</b>	<b>&lt;0.001</b>
Metabolic equivalents (kCal)	2680.78 ± 728.64	2570.99 ± 807.84	0.40
Cotinine (ng/mL)*	<b>25.62 ± 47.73</b>	<b>11.88 ± 32.58</b>	<b>0.05</b>
Gamma-glutamyl transferase (u/L)*	<b>69.41 ± 57.23</b>	<b>39.53 ± 32.77</b>	<b>&lt;0.001</b>
<b><i>Adjusted Physiological Factors (±95% CI)</i></b>			
Fasting blood glucose (mmol/L)	<b>5.95 (5.57;6.33)</b>	<b>4.72 (4.34;5.10)</b>	<b>&lt; 0.001</b>
Waist circumference (cm)	<b>96.99 (95.18;98.79)</b>	<b>86.48 (84.67;88.28)</b>	<b>&lt; 0.001</b>
Renin (pg/mL)	4.63 (3.86;5.41)	4.07 (3.29;4.84)	0.33
SBP (mmHg)	<b>140 (136;144)</b>	<b>125 (120;129)</b>	<b>&lt;0.001</b>
DBP (mmHg)	<b>93 (90;96)</b>	<b>81 (78.84)</b>	<b>&lt;0.001</b>
<b><i>Clinically diagnosed</i></b>			
Hypertensive N (%)	<b>64 (64)</b>	<b>33 (33.33)</b>	<b>&lt; 0.001</b>

N, number of participants, Mean ± SD; p < 0.05 considered significant, printed in bold; \*, confounding factors adjusted for

**Table 2: Forward stepwise regression analyses predicting associations with systolic blood pressure (SBP) and diastolic blood pressure (DBP) in urban Africans ( $\pm 95\%$  CI).**

	<b>Males (N=67)</b>		<b>Females (N=67)</b>	
<b>Dependent Variable</b>	<b>Systolic Blood Pressure (mmHg)</b>			
<b>Adjusted R<sup>2</sup></b>	0.27		0.30	
<b>Variables</b>	<b><math>\beta</math> (95% CI)</b>	<b>P values</b>	<b><math>\beta</math> (95% CI)</b>	<b>P values</b>
<b>Renin (pg/mL)</b>	-0.27 (-0.48;-0.07)	0.01	-0.29 (-0.49;-0.08)	0.007
<b>Dependent Variable</b>	<b>Diastolic Blood Pressure (mmHg)</b>			
<b>Adjusted R<sup>2</sup></b>	0.19		0.23	
<b>Variables</b>	<b><math>\beta</math> (95% CI)</b>	<b>P values</b>	<b><math>\beta</math> (95% CI)</b>	<b>P values</b>
<b>Renin (pg/mL)</b>	-0.24 (-0.46;-0.02)	0.04	-0.43 (-0.64;-0.22)	0.0001
<b>METS (kCal)</b>	0.22 (0.004;0.44)	0.05		
<b>Glucose (mmol/L)</b>	0.27 (0.05;0.48)	0.02		

N, number of participants; METS, metabolic equivalents; CI, confidence interval; Adjusted for age, BMI, smoking (COT), alcohol intake (GGT);

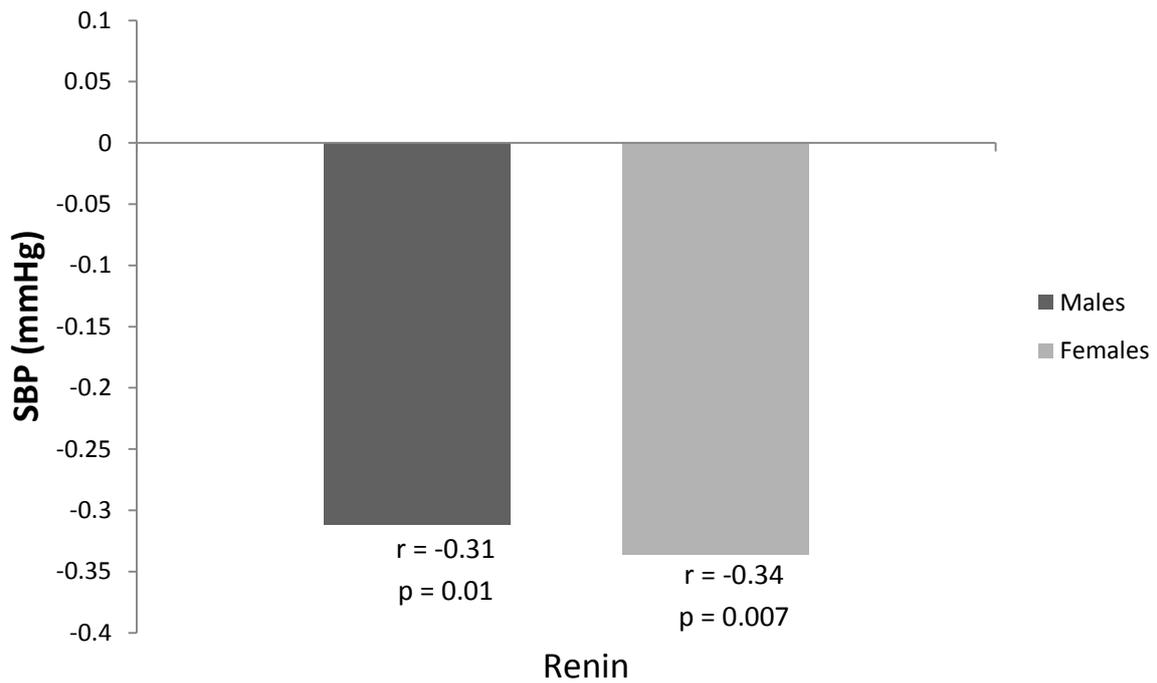


Figure 1a: Associations between renin and SBP in African males (n=67) and females (n=67). Data is presented as r values, adjusted for age, BMI, COT and GGT.

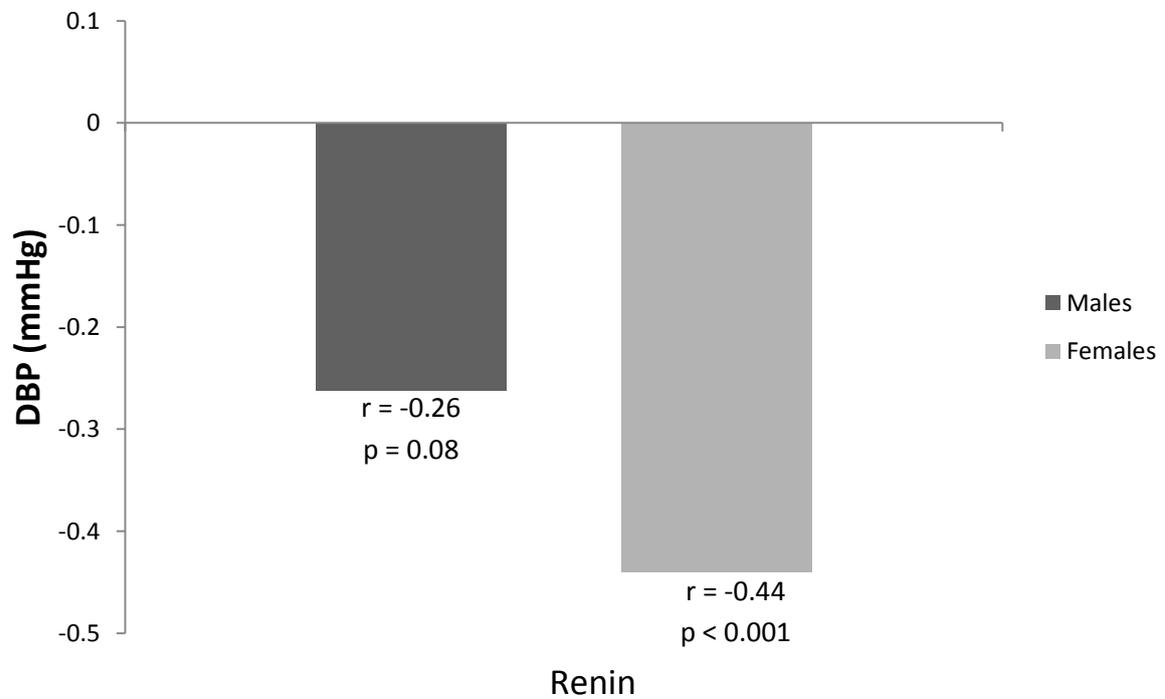


Figure 1b: Associations between renin and DBP in African males (n=67) and females (n=67). Data is presented as r values, adjusted for age, BMI, COT and GGT.

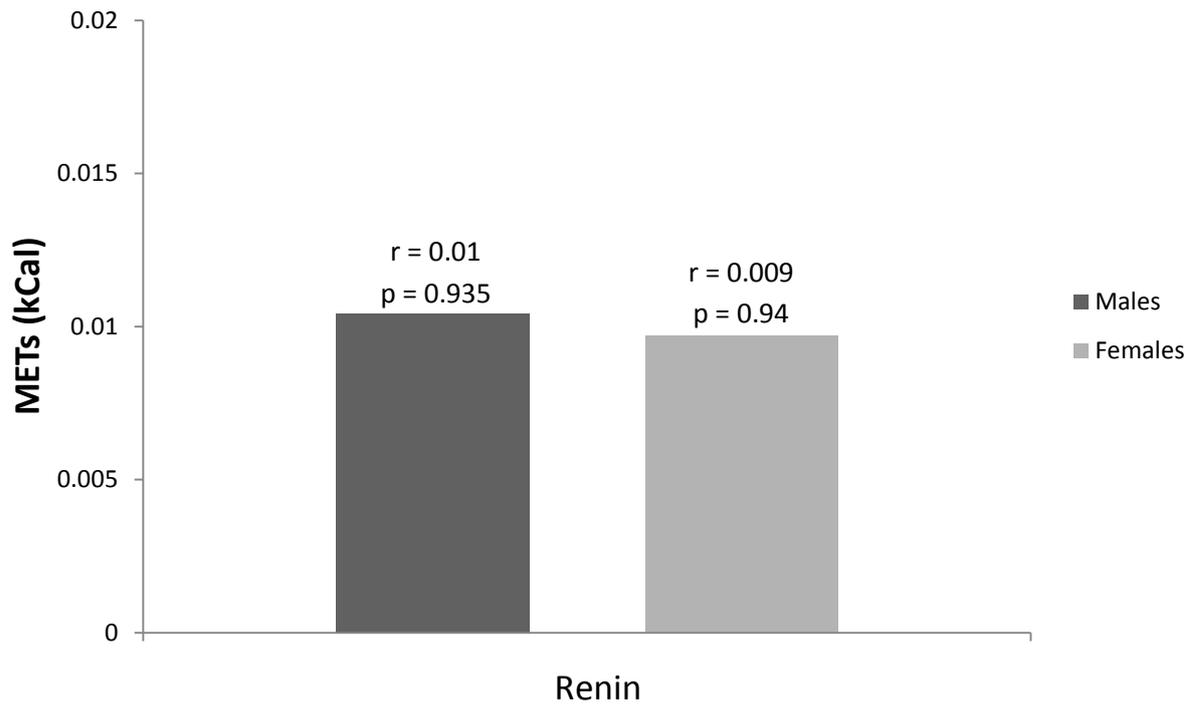


Figure 2: Associations between renin and METs in African males (n=67) and females (n=67). Data is presented as r values, adjusted for age, BMI, COT and GGT.

## **CHAPTER 4: GENERAL FINDINGS AND CONCLUSIONS**

4.1 Summary	50
4.2 Discussion of main findings	51
4.3 Conclusions	52
4.4 Recommendations	52
4.5 Shortcomings	53
4.6 References	54

## 4.1 SUMMARY

In this chapter of the dissertation a summary of the main findings is given. Results will be discussed, interpreted and compared to the relevant literature. Conclusions are drawn from the results as well as recommendations made to future research investigating the association of physical activity with blood pressure in Africans. The main aim of this study was to determine the association between physical inactivity, high blood pressure and low renin levels in urban Africans.

Significant findings of this study were:

The results confirmed that black urban Africans display an inverse relationship with BP. Low renin and physical inactivity ( $p > 0.05$ ) were not related to indicate elevated BP through elevated SNS activity. PA ( $p = 0.05$ ) was positively associated with DBP in males only but did not have a buffering effect on the low renin-high BP profile of Africans. Results confirmed and contradicted certain findings in existing literature.

Low levels of plasma renin found in black Africans (Sagnella, 2001:19; Opie & Seedat, 2005:3564) was confirmed by this study as both gender groups displayed inverse associations with SBP and DBP. Females in particular displayed strong inverse associations between plasma renin and BP (SBP,  $p = 0.007$ ; DBP,  $p = 0.0001$ ). This phenomenon has also been reported by Opie (2004:458) and Holland *et al.* (1979:1365). Furthermore, the prevalence of hypertension was significantly higher in the male group ( $p \leq 0.001$ ). Male gender has been found to be a risk factor for hypertension in Africans (De Ramirez *et al.*, 2010:792).

Considering the benefits that PA has to offer, inverse associations were expected between PA and BP (Warburton *et al.*, 2006:809; ACSM, 2006:3), as well as positive associations between PA and renin. This was however not the case in this study, except for a positive association with DBP in males.

Confounding factors (age, body mass index, smoking, alcohol intake) were adjusted for analyses. HIV positive status and anti-hypertensive medication could have affected results and were, therefore, excluded from all analyses.

## 4.2 DISCUSSION OF MAIN FINDINGS

Africans, in particular, display lower levels of plasma renin (Sagnella, 2001:19; Opie & Seedat, 2005:3564) and it was confirmed by the results in this study as negative associations existed between resting renin and blood pressure among the males and females. Black African females in particular display a strong inverse association between renin and BP (Holland *et al.*, 1979:1365; Opie, 2004:458), which has been confirmed in this study. Low plasma renin, coexistent with high blood pressure in blacks could be a consequence of sodium handling, which could be explained by mechanisms responsible for excessive sodium renal reabsorption and genetic abnormalities in the renin-angiotensin-aldosterone system (RAAS) (Sagnella, 2001:23). Sub-optimal  $\text{Ca}^{2+}$  intake is, furthermore, associated with low plasma renin, that suppresses  $\text{Ca}^{2+}$ -ATPases mediated  $\text{Ca}^{2+}$  efflux, increasing intracellular  $\text{Ca}^{2+}$  ( $\text{Ca}_i$ ), vascular resistance and hypertension (Cooper & Borke, 1993:181). Further research is needed to understand fully the genetics of hypertension in sub-Saharan Africa (Kuller, 2007:1004).

Physical inactivity was not associated with BP or renin. The lack of this association in females may indicate the possible role of estradiol having a vasodilatory and protective cardiovascular effect (De Bold, 1999:524), and could explain the apparent resilience in the African females who are also still relatively young and premenopausal. In males, PA was associated with DBP which is not clear. Physical inactivity in combination with low renin could indicate elevated SNS, but not here.

Lifestyle factors of the males in this population could contribute to the males' vulnerability of developing elevated blood pressure and sub-clinical vascular disease (Hamer *et al.*, 2011:239). It has, however, been found that male gender could be a contributing risk factor for hypertension in black populations (Olatunbosun *et al.*, 2000:254). High levels of alcohol consumption, as seen in the males in this study, combined with a high-strain occupation such as teaching, could furthermore explain their increased BP (Theorell *et al.*, 2005:1031). It is known that Africans exhibit increased cardiovascular activity and peripheral resistance when exposed to stressful situations (Van Rooyen *et al.*, 2000:785), predisposing them to develop hypertension (Hinderliter *et al.*, 2004:47). Increased BP has been associated with residing in an urban environment (Malan *et al.*, 2008:327).

In this study population, males presented a higher percentage of hypertensive individuals than females. More females reported being on anti-hypertensive medication, possibly contributing to this difference.

In conclusion, PA appeared not to buffer high blood pressure in this specific African cohort population, as no significant associations supported this hypothesis. This study also confirms that black Africans display lower renin levels associated with elevated blood pressure (Sagnella, 2001:19; Opie & Seedat, 2005:3564). The main finding of our study was that low renin predicted BP, especially in females.

### **4.3 CONCLUSIONS**

Hypothesis: Low renin and physical activity will be associated with elevated SBP and DBP in Africans.

The hypothesis was partially accepted as renin was negatively associated with SBP and DBP, but no significant associations existed between low PA and BP and/or renin.

PA appeared not to buffer high blood pressure in this specific African cohort population, as no significant associations supported this hypothesis. This study furthermore confirms that black Africans display lower renin levels associated with elevated blood pressure. The main finding of our study was, therefore, that low renin but not low PA was associated with BP, especially in females.

### **4.4 RECOMMENDATIONS**

Results from this study provided some insight into physical activity levels of urban Africans, adding to data currently available. Little is known about their physical activity habits, and further in-depth research is needed to determine to what extent physical activity can contribute to a reduced cardiovascular risk profile in Africans.

It is a known fact that Africans display low levels of renin coexistent with elevated blood pressure. These results add to the available data regarding this phenomenon in Africans. Considering the higher prevalence of obesity and elevated blood pressure among the female groups, as well as increased salt sensitivity of Africans, further investigation into their

nutritional status could provide insight into the strong inverse associations between renin and blood pressure in this population.

#### **4.5 SHORTCOMINGS**

Some methodological weaknesses of this study deserve to be mentioned:

The sample size was reduced by the exclusion criteria set. Individuals currently on anti-hypertensive medication were excluded from blood sampling to determine plasma renin levels, resulting in smaller gender groups.

Furthermore, physical activity was observed over a 24-hour period, not reflecting typical daily activities, as participants had to wear a Cardiotens apparatus (24-hour ambulatory and electrocardiogram, ECG) in conjunction with the accelerometer. Observation over a period of 7 days might have given a better reflection regarding their physical activity levels.

Further research is needed to understand mechanisms by which PA or a lack thereof can alter an individual's health, to develop new strategies in the prevention and treatment of cardiovascular disease.

#### 4.6 REFERENCES

AMERICAN COLLEGE OF SPORTS MEDICINE. 2006. ACSM's guidelines for exercise testing and prescription. 7<sup>th</sup> ed. Baltimore: Williams & Wilkens. 366 p.

COOPER, R.S. & BORKE, J.L. 1993. Intracellular ions and hypertension in blacks. (*In* Fray, J.C.S. & Douglas, J.G., eds. Pathophysiology of hypertension in blacks. New York: Oxford University Press. p. 181-213.)

DEBOLD, M.L.K. 1999. Estrogen, natriuretic peptides and the renin-angiotensin system. *Cardiovascular research*, 41:524-531.

DE RAMIREZ, S.S., ENQUOBAHRIE, D.A., NYADZI, G., MJUNGU, D., MAGOMBO, F., RAMIREZ, M., SACHS, S.E. & WILLET, W. 2010. Prevalence and correlates of hypertension: a cross-sectional study among rural populations in sub-Saharan Africa. *Journal of human hypertension*, 24:786-795.

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

HINDERLITER, A.L., BLUMENTHAL, J.A., WAUGH, R. & CHILUKURI, M. 2004. Ethnic differences in left ventricular structure: relations to hemodynamics and diurnal blood pressure variation. *American journal of hypertension*, 17:43-49.

HOLLAND, O.B., GOMEZ-SANCHEZ, C., FAIRCHILD, C. & KAPLAN, N.M. 1979. Role of renin classification for diuretic treatment of black hypertensive patients. *Archives of internal medicine*, 139(12):1365-1370.

KULLER, L.H. 2007. Epidemic hypertension in sub-Saharan Africa. *Hypertension*, 50:1004-1005.

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

OLATUNBOSUN, S.T., KAUFMAN, J.S., COOPER, R.S. & BELLA, A.F. 2000. Hypertension in black population prevalence and biosocial determinants of high blood pressure in a group of urban Nigerians. *Journal of human hypertension*, 14:249-257.

OPIE, L.H. 2004. Heart physiology: from cell to circulation. 4th ed. Philadelphia: Lippincott Williams & Wilkins. 648 p.

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

SAGNELLA, G.A. 2001. Why is plasma renin activity lower in populations of African origin? *Journal of human hypertension*, 15:17-25.

THEORELL, T., WESTERLUND, H., ALFREDSON, L. & OXENSTIERNA, G. 2005. Coping with critical life events and lack of control-the exertion of control. *Psychoneuroendocrinology*, 30:1027-1032.

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.

WARBURTON, D.E.R., NICOL, C.W. & BREDIN, S.S.D. 2006. Health benefits of physical activity: the evidence. *Canadian medical association journal*, 174(6):801-809.

## **APPENDICES**

1. References according to the guidelines of the North-West University
2. Guidelines for authors
3. Anthropometric and blood pressure proforma
4. Informed consent

## 1. REFERENCES ACCORDING TO THE GUIDELINES OF THE NORTH-WEST UNIVERSITY

### JOURNALS

- (Van Rooyen *et al.*, \*2000:779)
- 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.

### BOOKS

- (Guyton & Hall, \*2006:200)
- GUYTON,\*A.C.\*&\*HALL, J.E.\*\*2006.\*\*Textbook of medical physiology.\*\*11<sup>th</sup> ed. Philadelphia,\*Penn.:\*Elsevier/Saunders.\*\*1116\*p.

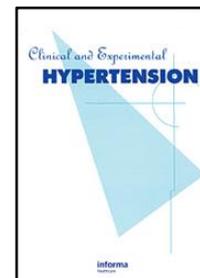
### INTERNET: DOCUMENTS

- AUTHOR.\*Year\*- when information was created or revised.\*Title.\*Address/ URL\*Date of access.
- (INFORMAHEALTHCARE, 2011)
- (IHC) INFORMAHEALTHCARE.\*2011.\*Instructions for Authors\*  
<http://informahealthcare.com/page/Description?journalCode=ceh#instructions>\*Date of access:24 September 2011.

VAN DER WALT, E.J. 2006. Quoting sources. Potchefstroom . Ferdinand Postma Library. 75 p.

## 2. GUIDELINES FOR AUTHORS

### Instructions for authors: Clinical and Experimental Hypertension



- The title page must include the title, authors' names and addresses, phone and fax numbers and e-mail address of the corresponding author.
- Authors should also supply a shortened version of the title, suitable for the running head, not exceeding 50 character spaces.
- An abstract of not more than 100 words should be included as well as 3-6 keywords.
- The manuscript should be prepared using MS Word or WordPerfect
- All parts of the manuscript should be typewritten, double-spaced, with margins of at least one inch on all sides and numbered consecutively throughout the paper.
- Acknowledgments should be gathered into a brief statement at the end of the text and should include sources of financial sponsorship, including the names of private and public sector sponsors. This includes government grants, corporate funding, trade associations and contracts.
- References should be cited in text by reference number in parentheses. Multiple references within one set of parentheses should be set off by comma, but no space.
- A short descriptive title should appear above each table with a clear legend and any footnotes suitable identified below. All units must be included. Figures should be completely labelled.
- Submissions to the journal 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.

### 3. ANTHROPOMETRIC AND BLOOD PRESSURE PROFORMA

#### PARTICIPANT SHEET: The SABPA Study

Subject no.				Date			2009
-------------	--	--	--	------	--	--	------

#### Checklist

**1. Consent form completed**

#### 2. Anthropometry

Date of birth (yyyy/mm/dd)		Gender		Age	
Height (cm)		}	<b>BMI (kg/m<sup>2</sup>):</b>		
Weight (kg)					
Waist circumference (cm)	1.				
Hip circumference (cm)	1.	2.	3.		
Neck circumference (cm)	1.	2.	3.		

SBP		DBP	
SBP		DBP	

**Resting:** 5 min BP + ECG .  
Filename:

**Ice:** 1 min BP & ECG  
+ 1,3,5 min recovery. Filename:

**Col/Colour word conflict:** 1 min BP & ECG  
+ 1,3,5 min recovery. Filename:

#### 5. COL chart, columns read

D. body (cm)		Minus D.neck (cm)		= D.complior (cm)	
--------------	--	-------------------	--	-------------------	--

#### Pulse Wave Velocity (m/s)

<b>SONAR</b>	<b>OPTIMAL</b>		<b>PLAQUE SCORE</b>	
<b>Right</b>				
<b>Left</b>				

Value for fasting **Blood glucose** (mmol/L)

**Urine**

**Urine**

**Guthry cards**

**Guthry cards**

**Ear temperature**

**Blood: Resting**

<input type="text"/>	ICE	<input type="text"/>	Colour word conflict	<input type="text"/>
<input type="text"/>	ICE	<input type="text"/>	Colour word conflict	<input type="text"/>

**Saliva: Resting**

**13. HIV/AIDS**

Precounselling

Postcounselling

**14. Short Report Feedback given**

**15. Breakfast**

**16 Referred to doctor / clinic**

**Y/N (Y, Yes; N, No)**

## 4. INFORMED CONSENT

**NORTH-WEST UNIVERSITY  
POTCHEFSTROOM CAMPUS  
SCHOOL FOR PHYSIOLOGY, NUTRITION AND CONSUMER SCIENCES  
PARTICIPANT INFORMATION AND CONSENT FORM**

### PART 1

**PRINCIPAL RESEARCHER:** Prof Leoné Malan, Subject Group Physiology

**PROJECT LEADERS:** Prof Leoné Malan, Subject Group Physiology

**Associate Researcher(s):** The postdoctoral fellow involved in this trial is Dr. P Szabolcs. Other persons assisting in the study are Dr. Hugo W. Huisman, Prof. Johannes M. van Rooyen, Prof. Nico T. Malan, Mrs. Carla M.T. Fourie, Mrs. Tina Scholtz (Cardiovascular research group, Physiology), Prof. Salomé Kruger & Dr. Ramoteme Mamabolo, (Physical activity), Proff. Hans de Ridder (Anthropometry), Marié Wissing (Psychology), Linda Brand & Brian Harvey (Pharmacology), Kobus Mentz (Education), Francois van der Westhuizen (Biochemistry), Hester Klopper (Nursing), Nancy Frasure-Smith & Francois Lespérance (Psychology, Canada), Alaa Alkerwi (Epidemiology, Luxembourg), Yackoob Seedat (ECG, Kwazulu Natal), Paul Rheeder (Sonar, Pretoria Univeristy), Drs. Johan Potgieter & Michael Temane & Mr Thumi Khumalo (Psychology), Mrs Gedina de Wet (Nursing), Drs T Ziemssen & M Reimann (Autonomic function, Dresden).

---

This Participant Information and Consent Form is **8** pages long. Please make sure you have all the pages.

### **Your Consent**

You are invited to take part voluntarily in this research project.

This participant information document contains detailed information about the research project which has been explained to you verbally. Its purpose is to explain to you as openly and clearly as possible all the procedures involved in this project before you decide whether or not to take part.

Please read this *Participant Information Form* carefully. Feel free to ask questions about any information in the document. You may also wish to discuss the project with a relative or friend or your local health worker. Feel free to do this.

Once you understand what the project is about and if you agree to take part in it, you will be asked to sign the Consent Form. By signing the Consent Form, you indicate that you understand the information and that you give your consent to participate in the research project.

You will be given a copy of the Participant Information and Consent Form to keep as a record.

### **What is the study about?**

The aim of this project is to have an impact on the eventual prevention and treatment of lifestyle diseases in Africans from South Africa. New knowledge regarding the relationship between higher nervous system activity implicating cardiovascular, metabolic and psychological well-being will improve understanding and change strategies at the roots of treatment and prevention of lifestyle diseases.

Our research has shown that lifestyle diseases in urbanised Africans present higher obesity levels, high blood pressure or hypertension prevalence rates and the experiencing of more stress. This pattern is enhanced during psychosocial stress/urbanisation in participants with a specific coping style. Hence the planned SABPA project, which is the first study in South Africa where coping and direct markers of nervous system activity in Africans will be measured.

### **Purpose of study**

The purpose of this study is to investigate biological markers associated with higher sympathetic nervous system activity in urbanised teachers with a specific coping style.

To investigate the relationship between blood pressure, inflammation, obesity, stress and coping in more detail we are going to perform this study in 400 men and women from the North-West province, aged 25-60 years. A comprehensive assessment of the cardiovascular and nervous systems by means of non-invasive painless techniques will be performed and a blood sample will be taken by an experienced research doctor and nurse to determine your blood sugar, cardiovascular, inflammation and stress hormone levels amongst other health markers.

### **Procedures**

All measurements are performed in the Metabolic Unit (lipid clinic) of the University. A researcher has explained the entire procedure in detail and while you are reading this information document you have time to ask questions and to have clarified matters. If you are fine with the explained procedure you are requested to sign a \*consent form (at the end of this document). Remember all personal data will be handled with care and remain confidential.

*\*By consenting to participate in this study, you consent to the storage and later analysis and testing of your stored blood samples for the purposes noted above. Your blood will also be tested for preliminary results on HIV status, since your HIV status may directly influence the main purposes of this study. If you would like to know what your HIV-status is, we will provide it. If tested positive we will refer you to your doctor and he/she will perform the necessary tests which will allow you to apply for chronic medication benefit. Also, the blood cells from your donated blood sample will be used to investigate the molecular genetics of higher nervous system activity and type 2 diabetes in order to enable pre-symptomatic diagnosis of hypertension and diabetes in the long term.*

**Why was I chosen?** Teachers are exposed to changing curricula and disciplinary problems whilst living in an urbanised environment adding to higher stress experiencing and nervous system activity.

## **How was I chosen?**

### **Inclusion criteria:**

*Phase I: 200 black Africans aged 25-60 years (male=100, female = 100)*

*Phase II: 200 white Africans (n = male, 100 = female) aged 25-60 years.*

**Exclusion criteria:** *pregnancy, lactation, any acute/chronic medication (e.g. high blood pressure, TB/tuberculosis, high sugar/diabetes, arthritis, anti-clotting/stroke factors, epilepsy/mental diseases or being treated for it as well being addicted to the medicine). You can not be included if you have been vaccinated in the previous 3 months and if you are a regular blood donor.*

## **What will be expected of me?**

You, as participant will be screened once by a registered nurse to be eligible complying to the inclusion criteria. The following procedures will be followed:

- Recruitment, screening and informed sessions with all participants will be done two months prior to the study (October - November 2007, Phase I, and November, 2008, Phase II) and informed consent forms will be signed.
- After selection of all participants, the details of the project will be discussed with you in English or your home language, i.e. what the exact objectives of the study are, what procedures will be taken and what will be expected from each of you (e.g. overnight stay, resting blood pressure procedures and fasting urine and blood samples are required, importance of complying with the correct sampling methods, incentives). You will be given the opportunity to ask questions.
- Data collection for each participant will involve two days (15min in the morning and 2½ hours in the evening) on Day I; and 2 hours on Day II):

### **DAY I**

- On day I at 07:00, the blood pressure apparatus, which will measure your blood pressure and heart function as well as a physical activity meter will be applied to your arm and waist at your school and you can then resume your normal daily activities. In the afternoon you must complete the Neethling Brain Instrument questionnaire which measures thought processes of the brain.
- At the end of Day I (± 16:30) you will be transported from your schools to overnight in the Metabolic Unit Research Facility of the North-West University. This unit is a research unit for human studies and equipped with 10 well furnished bedrooms, a kitchen, two bathrooms and a television room. Each of you will be subjected to the following procedures:
  - At the end of Day I between ± 17:15 and 18:00 you will be welcomed and each of you will receive your own private bedroom.
  - The procedures, which will be done, will be explained again and each of you will then complete a general socio-demographic health questionnaire. Afterwards you will receive dinner.

- After dinner, psychological questionnaires will be completed under supervision of registered education specialists and psychologists. Completion of questionnaires will take approximately 40 min, including a break of 20 minutes with coffee/tea and biscuits. This will be your last meal for Day I as you must be fasting on Day II for obtaining good results.
- Thereafter, you can relax and watch television or socialise with your c-participants. It will be wise to go to bed not later than 22:00 as the blood pressure apparatus will take measurements every hour during the night and it can be tiring.

## DAY II

- At 06:45 on Day II the AMBP will be removed and an urine sample collected. Once this has been done you will be directed to the anthropometric station where your weight, height and body circumferences will be measured.
- The next station involves the blood pressure measurement station. Whilst in a sitting position your blood pressure will be taken in duplicate with the sphygmomanometer (the same as used at clinics) with a resting period of 5 minutes in between. Our registered research doctor/nurse will take a fasting saliva sample as well as a blood sample of 45ml from a vein in your dominant arm. The infusion set will be left in your arm to lessen the effect of inserting a needle again for blood sampling after exposure to the two stressors. A small amount of diluted heparin will be left in the infusion set in your arm to prevent clotting.

Next the cardiovascular measurements will follow consisting of three separate procedures:

- The 1<sup>st</sup> measurement involves an ECG apparatus, which measures heart function, with 12 leads, which will be placed into position on your rib cage/front part of the body.
- The 2<sup>nd</sup> measurements are non-invasive and will be done by means of the Finometer device which also involves the assessment of heart functioning such as pulse (beats per minute), stroke volume (blood volume ejected by the heart per beat), cardiac output (blood volume ejected by the heart per minute), total peripheral resistance (resistance against the blood flow created by small arteries), central resistance (resistance against which the heart has to work while ejecting the blood into the aorta) as well as the elasticity of your large arteries (compliance). For this procedure a blood pressure cuff will be placed around your left arm and middle finger which will be inflated and stepwise deflated. You will not have more discomfort than during a common blood pressure measurement. This will take about 5 minutes.
- The stressor application procedure follows: You will now be exposed to a stressor for 1 minute whilst your blood pressure and ECG will still be taken. After exposure a saliva and blood sample (45ml) will be taken. After 10 minutes another saliva sample will be taken. Then the stressor application procedure will be repeated with the second stressor.
- At another station your 3<sup>rd</sup> measurement includes the assessment of pulse wave velocity, i.e. how fast your blood travels through your arteries. This measurement gives us an indication about how stiff your vessel walls are. The stiffer your vessel wall is the faster the blood travels from one point of your body to another. These painless measurements will require two technicians using blunt probes (tonometer) putting light pressure on the neck and on the foot to measure the velocity of the pulse waves. This takes only a few minutes. An ultrasound device will be taken of your arteries in the neck with a blunt probe to indicate the intrinsic thickness of your arteries which contributes to high blood pressure.

The two stressors you will be exposed to for one minute include:

1. The *Colour-Word-Conflict Chart (applied for 1 minute)* is written in various colours. You must say or select the ink colour rather than the name of the colour spelled out by the word. A sliding scale with monetary incentives (maximum of R55.00) will be given if you can complete reading the chart.
  2. *The Cold Pressor Test (Foot) (applied for 1 minute)*: Immersion of your foot up to the wrist in ice water (4 degrees Celcius). As the cold can make you hold your breath you must quietly count to yourself during cold exposure to breath more rythmic.
- You have reached the end of the sampling phase.
  - **Thank you for your participation! You now will have the opportunity to shower and a take away breakfast will be given.**
  - Immediate feedback on your HIV/AIDS status, obesity, blood pressure and blood glucose/sugar values will be given. *HIV/AIDS post-test counselling will be arranged if you are tested positive.*
  - You are now transported back to your school and after one week you will receive your Neethling Brain Instrument and 24-hour blood pressure reports.

### **Possible Risks**

The measurements performed in our study will include only non-invasive techniques that are not expected to reveal any risks but might cause little discomfort. The taking of blood samples is an invasive procedure with a minimal risk of bleeding. Thus the procedure may cause only a few seconds of light discomfort. All tests will be performed by experienced research nurses of our department. There may be additional unforeseen or unknown risks.

### **Precautions to protect the participant**

The Metabolic Unit facility of the NWU is fully equipped, and in case of an emergency which could not be handled by the registered nurse, the supervising medical doctor Emile Kotzé will be contacted. Dr. Kotzé was notified before the study commenced that this study will be taking place, and that there is a slight possibility that he may be contacted. Supporting medical treatment care facilities will be at hand anytime if needed.

### **Other Treatments Whilst on Study**

It is important to tell the research staff about any treatments or medications you may be taking, including non-prescription medications, vitamins or herbal remedies during your participation in the study.

## **Incentives**

1. All teachers will receive feedback on their health profile and if necessary references will be given to physicians/clinics/hospitals.
2. Blood pressure and ECG monitoring report (normally costing R637.60). Your benefit of participation is a comprehensive assessment of the cardiovascular and metabolic condition including investigation of blood pressure, inflammatory status and psychological well-being. These examinations will help us to assess the degree of vascular impairment of the arteries and to predict your risk of possible cardiovascular events such as heart attacks and stroke. The results may assist your doctor in decision making for further treatment or for instituting preventive measures. Our study will also contribute to the identification of possible factors leading to high blood pressure. As 24 hour ambulatory blood pressure monitoring is required for the diagnosis of hypertension, medical aids insist on this method of diagnosis to qualify for chronic medication. Additional testing could also reveal illnesses of a chronic nature and would serve as a motivation to qualify for chronic medication, such as metabolic syndrome, anti-inflammatory and cholesterol-lowering drugs.
3. Monetary incentive on completion of the colour word conflict chart.
4. Dinner and breakfast.
5. Neethling Brain Instrument profiles done by registered user of the Whole Brain (normally costing ± R350.00).
6. Coping skills workshop will be arranged on request.

## **Privacy, Confidentiality and Disclosure of Information**

By consenting to participate in this study, you consent to the storage and later analysis and testing of your stored blood samples for purposes noted above. Your blood samples will be discarded immediately after analysis. All information provided by you and the results of tests will be treated in the strictest confidence, and will only be used for the purpose of this research project. It will only be disclosed with your permission, except as required by law. The results of your medical tests will be labelled only with a code number, and will be stored separately from any identifying information. When the results are analysed we will be looking for differences between groups of people, not at the results of individuals. No information that could identify any person taking part in the study will be revealed when the results are reported.

## **Participation is Voluntary**

Participation in any research project is voluntary. If you do not wish to take part you are not obliged to. If you decide to take part and later change your mind, you are free to withdraw from the project at any stage.

Your decision whether to take part or not to take part, or to take part and then withdraw, will not affect your routine treatment, your relationship with those treating you or your relationship with the North-West University.

Before you make your decision, a member of the research team will be available so that you can ask any questions you have about the research project. You can ask for any information you want. Sign the Consent Form only after you have had a chance to ask your questions and have received satisfactory answers.

If you decide to withdraw from this project, please notify a member of the research team before you withdraw.

### **Ethical Guidelines**

This project will be carried out according to Ethical Guidelines of the Helsinki declaration from 2000, with additional notes in 2002. This statement has been developed to protect the interests of people who agree to participate in human research studies.

The ethical aspects of this research project have been approved by the Human Research Ethics Committee of ***North-West University Potchefstroom***.

### **Further Information or Any Problems**

If you require further information or if you have any problems concerning this project, you can contact the principal researcher or *the other* researchers responsible for this project.

Prof Leoné Malan (018-299 2438)

Sr. Chrissie Lessing (018-299 2480)

## PART 2

### **To the subject signing the consent as in part 3 of this document**

You are invited to participate in a research project as described in paragraph 2 of Part 1 of this document. It is important that you read/listen to and understand the following general principles, which apply to all participants in our research project:

1. **Participation in this project is voluntary.**
2. **It is possible that you personally will not derive any benefit from participation in this project, although the knowledge obtained from the results may be beneficial to other people.**
3. **You will be free to withdraw from the project at any stage without having to explain the reasons for your withdrawal. However, we would like to request that you would rather not withdraw without a thorough consideration of your decision, since it may have an effect on the statistical reliability of the results of the project.**
4. **The nature of the project, possible risk factors, factors which may cause discomfort, the expected benefits to the subjects and the known and the most probable permanent consequences which may follow from your participation in this project, are discussed in Part 1 of this document.**
5. **We encourage you to ask questions at any stage about the project and procedures to the project leader or the personnel, who will readily give more information. They will discuss all procedures with you.**
6. **We require that you indemnify the University from any liability due to detrimental effects of treatment by University staff or students or other subjects to yourself or anybody else. We also require indemnity from liability of the University regarding any treatment to yourself or another person due to participation in this project, as explained in Part 1. Lastly it is required to abandon any claim against the University regarding treatment of yourself or another person due to participation in this project as described in Part 1.**
7. **If you are married, it is required that your spouse abandon any claims that he/she could have against the University regarding treatment or death of yourself due to the project explained in Part 1.**

**PART 3**

**Consent**

Title of the project:

“THE SABPA STUDY (SYMPATHETIC ACTIVITY AND AMBULATORY BBLOOD PRESSURE IN AFRICANS)”.

I, the undersigned ..... (full names)

read/listened to the information on the project in PART 1 and PART 2 of this document and I declare that I understand the information. I had the opportunity to discuss aspects of the project with the project leader and I declare that I participate in the project as a volunteer. I hereby give my consent to be a subject in this project.

(Signature of the subject)

Signed at ..... on .....2008

**Witnesses**

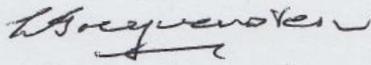
1. ....

2. ....

Signed at ..... on .....2008

This is to certify that the language editing of this dissertation by Ms J Bower was done by Prof L A Greyvenstein.

Prof L A Greyvenstein was a member of the South African Translators' Institute, membership number: 1001691. She completed her primary, secondary and tertiary education, including a doctoral thesis, in English. She has done the English language editing of many proposals, dissertations, theses and scientific articles.



Lesley Ann Greyvenstein (Prof)

(South African Translators' Institute: membership no. 1001691)