Physical activity status and the relationship between non-communicable diseases risk factors in an urban South African teachers' cohort: The SABPA study

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ABSTRACT

Physical activity status and the relationship between non-communicable disease risk factors in an urban South African teachers' cohort: The SABPA study

Keywords: Non-communicable diseases, Physical activity, South Africa, Caucasian, African

Introduction: Non-communicable diseases (NCDs) are chronic diseases caused by unhealthy lifestyle decisions and account for the majority of deaths per year globally. NCD incidence is increasing rapidly and NCDs are becoming an epidemic. The main NCDs include obesity, hypertension, diabetes mellitus (DM) and cancer. The relationship between physical activity (PA), health, and longevity is one that has been recognized by historical figures for centuries. The aim of this study is thus to investigate the prevalence of NCDs in male and female, African and Caucasian teachers and to determine the association between PA and NCD prevalence in African and Caucasian teachers in the North West Province of South Africa.

Method: A total of 216 African and Caucasian South African school teachers were recruited in the North West Province of South Africa (African men n=52; African women n=57; Caucasian men n=52 and Caucasian women n=55). The following measurements were included for the purpose of this study: seven-day objectively measured PA status in PAL 1-5, which is categorized as PAL 1 and 2 (sedentary), PAL 3 (semi active), PAL 4 (Active) and PAL 5 (vigorous active); cardio metabolic risk factors [body mass index (BMI), waist circumference (WC), 24-hour systolic (SBP) and diastolic blood pressure (DBP), fasting lipid profile (total cholesterol (TC), low density lipoprotein (LDL) cholesterol, high density lipoprotein (HDL) cholesterol, triglycerides (TG)] and fasting glucose (FG). Data analyses were performed using SPSS version 20. Interaction on main effects (gender x ethnicity) was tested with a 2 X 2 ANOVA in order to determine significant differences in variables. Departure from normality was evaluated through the Levene test for equality of variances and skewed data was normalised. Forward stepwise regression was undertaken so as to determine associations between the different variables within and between the four groups with adjustments for age, gender, and ethnicity. The Pearson correlation coefficient was used to determine any relationships between variables and different groups. Frequency risk factors were calculated within the different groups as well as within the PA groups and chi-square statistics were used to calculate the frequencies of variables between the groups. The frequency of each risk factor was then calculated to

determine the prevalence within each category of PA status. Statistical significance was set at a two-sided alpha (α) level of 0.05 or less.

Results: The risk factors for NCDs across the entire group were prevalent in the following order: WC (72.22%), hypertension (57.87%), physical inactivity (39.4%), elevated BMI (38.88%), low HDL Cholesterol levels (37.96%), elevated TG (18.98%) and elevated FG (17.13%). The PAL status of the entire group was classified as highly active with the highest PA status profile prevalence in PAL 3-5 (60.7%), and the highest prevalence being found in PAL 4 (21.3%) and PAL 5 (24.1%). 39.3% of participants fell within the sedentary group (PAL 1 and 2). Both male groups (African males and Caucasian males) presented with the lowest PAL, with 50% of the combined male group falling within either PAL 1 or 2, this is followed by Caucasian females, with 34.5% of the group falling within either PAL 1 or 2. African females were seen to be the most active with 75.5% of the group falling within PAL 3 to 5, followed by Caucasian females with 65.5% of the group falling within PAL 3 to 5 (Figures 4.5 A-D). Physical inactive participants presented with a 2.54 times higher probability of an increased WC, a 1.153 times higher probability of an increased FG, a 1.116 times higher probability of an increased TG, a 0.919 times higher probability of a decreased HDL cholesterol value, a 2.338 times higher probability of an elevated SBP and a 1.874 times higher probability of an increased DBP as compared to active participants. Significant differences were noted between the four groups' BMI ($p \leq 0.001$), WC ($p \leq 0.001$), TEE (total energy expenditure) ($p=0.030$), FG ($p \leq 0.001$), TC ($p \leq 0.001$), HDL cholesterol ($p=0.001$), TG ($p \leq 0.001$), SBP ($p \leq 0.001$) and DBP ($p \leq 0.001$). African men were the most vulnerable group as concerns the prevalence of NCD risk factors with participants having three out of six (50%) risk factors.

Discussion: Various researchers have suggested that an increase in PA status can have a positive effect on overall health with a decreased risk for NCDs. However, the current study could not confirm previous research findings. In theory, the risk factors of NCDs decline with an increase in PA, in line with previous research. In the current study, all participants presented with a very high prevalence of inactivity, with the most active groups, African females, Caucasian females, and Caucasian males, showing a higher prevalence of risk factors within the physically inactive subgroup as compared to the physically active subgroup. African males presented with a lower prevalence of risk factors in the active subgroup as compared to the inactive subgroup, even though the prevalence of risk factors overall is the highest within the African males. Reducing the prevalence of NCDs can lead to improved future health, improved life expectancy, and improved productivity on a national scale. It may therefore be beneficial to implement strategies geared at increasing PA in the daily lives of all South African teachers.

Biokineticists and/or exercise therapists may be able to use the information gathered from this study so as to increase awareness regarding PA status and the risks for NCDs engendered by physical inactivity in this population.

Conclusion: An alarmingly high prevalence of NCD risk factors is evident in all four of the groups. While most of these risk factors can be modified, the risk factors seem to be ignored and it is therefore of utmost importance that people be educated as concerns the negative effects of risk factors and how to reduce their risk profile.
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OPSOMMING

Fisieke aktiwiteit status en die verhouding tussen risiko faktore van nie-oordraagbare siektes in ‘n stedelike Suid Afrikaanse kohort studie: die SABPA studie.

Sleutelterme: Nie-oordraagbare siektes, Fisieke aktiwiteit, Suid Afrika, wit, swart

Inleiding: Nie-oordraagbare siektes (NOS) is chroniese kondisies veroorsaak deur ongesonde leefstyl keuses en is die oorsaak van die meeste sterftes per jaar wêreldwyd. Die voorkoms van NOS neem vinnig toe en word 'n epidemie. Die hoof NOS kan gesien word as obesiteit, hipertensie, diabetes mellitus (DM), en kankers. Die verhouding van fisieke aktiwiteit (FA), gesondheid en welstand is reeds eeue tevore geidentifiseer deur historiese figure, met fiksheid as ‘n noodsaaklikheid vir fisieke en geestelike gesondheid. Vervolgens was die doel van die studie om die voorkoms van NOS in mans en vroue in swart en wit onderwysers te bepaal asook om die verhouding tussen fisieke aktiwiteit en die voorkoms van NOS in ‘n kohort studie van stedelike swart en wit onderwysers in die Noord Wes provinsie van Suid Afrika.

Metode: ‘n Totaal van 216 swart en wit Suid Afrikaanse onderwysers (Swart mans n=52, Swart vrouens n=57, Wit mans n=52 en Wit vrouens n=55) is gewerf vanaf die Kenneth Kaunda distrik in die Noord Wes provinsie van Suid Afrika. Die volgende metings is geneem om die doel van die studie te bereik: sewe dag fisieke aktiwiteit status in PAL wat verder verdeel word in PAL 1-5, geklassifiseer as PAL 1 and 2 (sedentêr), PAL 3 (semi aktief), PAL 4 (Aktief) en PAL 5 (hoogs aktief); kardio-metaboliese risiko faktore (Body Mass Index (BMI); middelomtrek, 24 uur sistoliese en diastoliese bloeddruk; vastende lipied profiel (Totale cholesterol (TC), lae digtheid lipoprotein (LDL cholesterol), hoë digtheid lipoprotein en trigliseriedes (TG)) en vastende glukose konsentrasie (VG). Data analise was gedoen met die gebruik van SPSS weergawe 20. Interaksie van hoof effekte (geslag x etnisiteit) is getoets deur ‘n 2x2 ANOVA toets om te bepaal of enige meningsvolle verskille voorkom. Afwyking van normaliteit is bepaal deur die Levene toets vir gelykheid van verskille en skewe data is genormaliseer. Om te bepaal of enige assosiasies met die risiko faktore in en tussen die groepe verskil, is ‘n vorentoe stapsgewyse regressie gedoen met aanpassings vir ouderdom, geslag en etnisiteit. Pearson korrelasie koëffisiënt is gebruik om enige verhoudings tussen die verskillende groepe en risiko faktore te bepaal. Frekwensies is bepaal binne die verskillende groepe en FA groepe en chi-square toetse is gebruik. Statistiese betekenisvolheid is gestel op ‘n tweesydige alpha vlak van 0.05 of minder.

Resultate: Die resultate wys die volgorde van voorkoms van risiko faktore vir NOS as volg: middelomtrek (72.22%), hipertensie (57.87%), fisieke onaktiwiteit (39.4%), BMI (38.88%), HDL cholesterol (37.96%), verhoogde TG (18.98%) en verhoogde VG (17.13%). Die Fisieke Aktiwiteitsvlak van die totale groep was baie hoog met die hoogste voorkoms in FAV 3-5 (60.7%). Die hoogste voorkoms is gevind in FAV 4 (21.3%) en FAV 5 (24.1%). ‘n Voorkoms van 39.3% kon gesien word in die sedentêre groep (FAV 1 and 2). Beide manlike groepe (swart en wit mans) het die laagste FAV voorkoms van 50% in FAV 1 en FAV 2 gehad, gevolg deur ‘n 34.5% voorkoms by wit vrouens. Swart vrouens was die meeste aktief met ‘n voorkoms van 75.5% in FAV 3-5, gevolg deur wit vrouens met ‘n voorkoms van 65.5% in FAV 3-5 (Figure 4.5 A-D). Fisieke onaktiwiteit se voorkoms het ‘n verhoogde waarskynlikheid vir die voorkoms van ‘n te groot middelomtrek (2.54 keer hoër), verhoogde VG (1.153 keer hoër), verhoogde TG (1.116 keer hoër), ‘n verlaagde HDL cholesterol (0.919 keer laer), verhoogde SBP (2.338 keer hoër) en ‘n verhoogde DBD (1.874 keer hoër) in vergelyking met die aktiewe persone. Daarbenewens wys die resultate betekenisvolle verskille tussen die volgende: BMI ($p \leq 0.001$), middelomtrek ($p \leq 0.001$), TEE (Totale energieverbruik) ($p=0.030$), VG ($p \leq 0.001$), TC ($p \leq 0.001$), HDL cholesterol ($p=0.001$), TG ($p \leq 0.001$), SBD ($p \leq 0.001$) en DBD ($p \leq 0.001$). Verder presenteer die swart mans die mees kwesbaar vir die voorkoms van NOS met die hoogste voorkoms van die meeste van die risiko faktore in vergelyking met risiko faktore en deelnemers as met die ander groepe (drie uit ses, 50%).

Bespreking: Verskeie navorsingstudies toon dat die toename in FA ‘n positiewe effek kan hê op algehele gesondheid namate die risiko van NOS afneem. Die huidige studie steun egter nie die vorige navorsing deur geen positiewe effek van FA by die swart vrouens, blanke mans en blanke vrouens te vind nie met die vergelyking van aktief en onaktief. Verder presenteer die swart mans met ‘n laer voorkoms van risiko faktore, selfs al is die hoogste voorkoms van risiko faktore by die swart mans. Deur die teenwoordigheid van NOS’ te verminder kan dit lei tot ‘n verbetering in algehele gesondheid, verhoogde lewensverwagting asook ‘n verhoogde produktiwiteit op ‘n globale skaal. Die verlaging van voorkoms van NOS kan lei tot verbeterde toekomstige gesondheid, verbeterde lewensverwagtinge en produktiwiteit op ‘n nasionale vlak. Daarom kan dit voordelig wees om strategieë te implementeer wat lei tot verhoogde FA onder wit en swart onderwysers. Biokinetikuste en/of oefenterapeute kan die versamelde inligting gebruik om bewustheid te verbeter rakende FA status en die risikos vir NOS wat met fisieke onaktiwiteit saam gaan.

Gevolgtrekking: ‘n Kommerwekkende hoë voorkoms van NOS risiko faktore kan gesien word in die huidige studie met baie ongesonde leefstyle. Alhoewel die meeste van die risiko faktore aangepas kan word, blyk dit of dit geïgnoreer of misverstaan word. Intervensies en opvoeding rakende NOS en die voorkoming daarvan is van noodsaaklike belang en moet in skole aangemoedig word.

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CHAPTER 1 INTRODUCTION

Recently, a number of lifestyle related diseases commonly grouped together as non-communicable diseases (NCDs) have become of great concern globally (Bickler *et al*., 2017:2; Reubi *et al*., 2016:179; Walter *et al.,* 2011:538). NCDs have become a popular topic of research in so far as numerous studies have shown an upswing in unhealthy lifestyle choices including poor dietary patterns and increased physical inactivity (Checkley *et al*., 2014:433; Nugent *et al*., 2018:2029; Roca *et al.,* 2015:258). Despite numerous evidence which have shown the health benefits of physical activity (PA), inactivity and the risk factors that arise out of inactivity remain a global health concern (Andersen *et al*., 2011:871; Armstrong *et al*., 2015:721; Guthold *et al*., 2011:52; Keane *et al*., 2016:21; McKercher *et al*., 2012:51).

1.1 Problem statement

NCDs account for the majority of global deaths (59%) per year and by some measures may even be seen to account for two thirds (67.9%) of annual global deaths (Allen *et al*., 2017:698; Bloom *et al.,* 2011:7; Roca *et al.,* 2015:258; Schwamm, 2018:665 & WEF, 2013:7). The global incidence of NCDs increased from 58% in 2007 to 68% in 2012, increasing to 70% in 2015 (Kroll *et al.,* 2015:1243; Nugent *et al*., 2018:2029). Furthermore, an increase of 16% in the total number of deaths attributable to NCDs can be seen in the period from 2006-2016 (GBD 2016 Causes of Death Collaborators, 2017:1163). NCDs refer to chronic diseases, mainly caused by poor lifestyle choices or, according to Kroll *et al.* (2015:1243), can be defined as chronic conditions with slow progression, but which are rarely completely curable. This term also encompasses what is also known as chronic non-transmissible medical conditions or diseases (Puoane *et al*., 2008:74; WHO, 2010:69).

Historically, NCDs have been problematic in high-income countries due to the behavioural component of the diseases because first world countries have become highly dependent on technology, making the lives of workers and citizens in these countries less physically active (Zhang & Chabaan, 2013:75). Nonetheless, the morbidity attributable to NCDs in low- and middle-income countries is rapidly increasing (Sommer *et al.,* 2015:1; Oni *et al.,* 2014:6; Chaturvedi *et al.,* 2006:833). While Sub-Saharan Africa (which includes South Africa [SA]) has, in the past, predominantly been affected by communicable diseases (Joubert 2015:3; Mensah *et al.,* 2015:7), this region, and SA in particular, is experiencing a NCD epidemic which is coupled with an increase in chronic infectious diseases (Kroll *et al.,* 2015:1243; Mendenhall *et al*., 2017:955; Oni *et al.,* 2015:8; WHO 2010:74). With the exception of Africa, the current mortality

rate of NCDs in low- and middle-income countries is higher than that of communicable diseases (Yach *et al.,* 2004:2; Sommer *et al.,* 2015:1).

According to Walter *et al.* (2011:538), the primary responsibility for the world's current health problems lies with NCDs: eighty per cent of deaths that occur in low- and middle-income countries are due to NCDs (Yach *et al.,* 2004:1; Hallal *et al.,* 2012:248). Yach *et al.* concluded that the increasing burden of NCDs coupled with the existing burden of communicable disease is placing a great degree of strain on the health services of developing countries (Nojilana *et al*., 2016:437; Yach *et al.,* 2004:2). Statistics of a recent study done by Maimela *et al*. (2016:2) found that 37% of deaths in SA are caused by NCDs, a statistic that is confirmed by Nojilana *et al*. (2016:437) in their editorial in the South African Medical Journal which called for strong action given that NCDs accounted for 39% of total deaths in South Africa in 2010. Globally, the four most commonly found NCDs include cardiovascular disease (CVD), cancer, diabetes mellitus (DM) and chronic respiratory disease (Kroll *et al.,* 2015:1243; Sommer *et al.,* 2015:1). Lifestyle and behavioural factors are primarily considered to be the root cause of the development of these diseases and include: alcohol consumption, an unhealthy diet, tobacco intake, and insufficient PA (Kroll *et al.,* 2015:1243). Additional risk factors for NCDs, highlighted by Wu *et al*. (2015:88) include; hypertension, obesity, and inadequate fruit and vegetable intake.

One of the lifestyle and behavioural factors that contributes to the development of NCDs globally is physical inactivity and it is estimated that six to ten percent of deaths from NCDs worldwide may be attributable to physical inactivity (Engelen & Bauman, 2015:1758; Jemmott *et al.,* 2014:114). The increasing prevalence of NCDs could have been attenuated, if not prevented, by increasing PA in so far as mortality risks are closely related to PA status and are immensely reduced with increased PA (Schoenborn & Stommel, 2011:514). It has furthermore been shown that inadequate health related PA could lead to metabolic health risks and chronic diseases (Kemmler *et al.,* 2015:486; Volčanšek & Pheifer, 2014:603; Nozari, 2011:145).

According to the Global Health Observatory (GHO) (cited by Balakumar *et al*., 2016:603), 23% of adults (18 years and older) are classified as physically inactive, not meeting the recommended minimum guidelines for PA. A significant proportion of these individuals (21%) reside within the African region (Balakumar *et al*., 2016:603). In a population-based study by Wu *et al*. (2015:92) in low- and middle-income countries (China, Ghana, Mexico, India, Russia and SA), it is reported that physical inactivity is highest in SA, where the level of physical inactivity is reported to be 59.7%. Moreover, additional studies have highlighted the particularly high levels of physical inactivity, overweight, and obesity among South African females who, as a

consequence, are at great risk of developing NCDs (Adeniyi *et al.,* 2015:5; Bain *et al.,* 2015:2; Okop *et al.,* 2015:3; Walter *et al.,* 2011:538). Effective intervention programs therefore need to be implemented in order to reduce the prevalence of NCDs. One such an intervention should be to increase the PA status of individuals and to improve their overall lifestyle choices (Kolbe-Alexander & Lambert, 2013:142; Schoenborn & Stommel, 2011:515).

The relationship between exercise and PA may be at the origin of several misconceptions in so far as exercise is a type of PA, but not all PAs can be categorized as exercise (Brach *et al.,* 2004:503). For the purpose of this study the focus will be on PA, leisure time, and habitual activity, due to the fact that PA arising out of daily activities could be considered to be sufficient for the enhancement of health (Brach *et al.,* 2004:503). Balducci *et al*. (2014:14) define PA as any bodily movement produced by skeletal muscles that causes an increase in energy expenditure. PA can be categorised into occupational, conditioning, leisure, sport, and household activities. Jemmott *et al.* (2014:114) and Durstine *et al*. (2012:2) identify PA as a powerful tool for the management and/or prevention of NCDs. The American College of Sports Medicine (ACSM) (ACSM, 2014:482) supports Caspersen *et al.* (1985:126) in their definition that explains the difference between PA and exercise. As the main objective of PA is to increase the energy expenditure by any bodily movement, it makes no difference whether it is structured or not (Plasqui *et al.,* 2013:451). It is thus important to regard physical inactivity as an increase in a sedentary lifestyle rather than a result of inadequate exercise.

Occupational, household, and transportation are the most common types of PA in low- and middle-income countries and need to be regarded as daily “exercise” (Bauman *et al.,* 2012:259). In order for health benefits to be obtained, the ACSM (2014:8), Tucker *et al*. (2011:545) and the WHO (2010:69) have agreed that adults (18–64 years) should perform at least 150 minutes of moderate intensity aerobic PA throughout the week or at least 75 minutes of vigorous intensity aerobic PA throughout the week or an equivalent combination of moderate- and vigorous intensity PA.

Blair and Powell (2014:9) recall a seminal action undertaken by the American Heart Association (AHA), wherein discussions concerning physical inactivity, during 1992-2014, lead to the classification of physical inactivity as one of the four major risk factors for heart disease. Over and above physical inactivity, further modifiable behavioural causes of NCDs include tobacco use, an unhealthy diet, and excessive alcohol consumption (Peer *et al.,* 2013:19216; Bradshaw *et al.,* 2011:2). According to the South African Medical Research Council (2011), intermediate risks of NCDs entangled with those related to behaviour include; high blood pressure (BP)

(≥140/90 mmHg), obesity (body mass index (BMI) ≥30 kg.m^{-2} and/or waist girth ≥102 cm for males and ≥88 cm for females) and abnormal blood lipids levels (low density lipoprotein (LDL) cholesterol ≥3.37 mmol.L^{-1} and/or high density lipoprotein (HDL) cholesterol ≤1.04 mmol.L^{-1}). These modifiable risk factors may contribute to the development of what can be understood as the main chronic diseases, e.g. heart disease, stroke, cancer, chronic respiratory disease, and DM (Uthman *et al.,* 2015:7; Peer *et al.,* 2013:19216). Evidence strongly suggests that an increase in PA and following a healthy balanced diet can have a positive influence on several of the NCD risk factors across all populations (Chaput *et al.,* 2011:2; Reiser & Schlenk, 2009:89; Puoane *et al.,* 2008:77; Reddy, 2005:177).

Physical inactivity and obesity are closely related and seen as two of the most common risk factors for the development of NCDs (Durstine *et al.,* 2012:4; Astrand *et al.,* 2003:650). Not only is obesity associated with a decline in physical functioning and a sedentary lifestyle (Aguinaga-Ontoso *et al.,* 2015:200), but it is also related to type two DM, heart disease, hypertension, stroke, and cancer (Kaikonnen *et al.,* 2014:1614). Regarding this statement, Cho *et al.* (2009:786) found that increasing leisure time PA can greatly lower the risk of metabolic syndrome. According to O'Neill and O'Driscoll (2015:2), metabolic syndrome is a clustering of underlying risk factors that, when combined, can lead to CVD.

An intervention study on severely obese adolescents found that cardiovascular fitness and physical capacity as well as individual participation in leisure time PA were significantly improved over a period of nine months (Lazzer *et al.,* 2005:44). This suggests that PA interventions may have a permanent and positive effect on the functionality and lifestyle of obese individuals (Ashworth *et al.,* 2005:14). The most beneficial element of daily PA includes the prevention of many diseases and decreased mortality (Molanorouzi *et al.,* 2015:66), findings that are concurred by a study undertaken by Puett *et al.* (2014:1503). In this study Puett *et al.* (2014:1503) found that daily PA elicited an approximately 12% improvement in physical health. Research by Assah *et al*. (2011:491) suggested that increasing PA status over a long period of time may lead to protection against metabolic diseases. Ketelhut *et al.* (2004:8) stated that chronic aerobic endurance could be regarded as an effective treatment for hypertension.

According to Glanz (as cited by Conlin, 2014:7), Social Cognitive Theory (SCT) implies that human behaviour changes through the observation of actions, thus implying that a strong need exists for a credible role model in order to inspire behavioural changes. Teachers can therefore be seen to have an immense influence on their students as they are often viewed as role models and can increase awareness with regards to health related PA and the importance thereof

(Kaur, 2011:154; Morton *et al*., 2016:150; Natale *et al*., 2014:379). This statement is supported by Donnelly and Lambourne (2011: S40), who found that teachers who engaged in PA had more learners who themselves engaged in PA. Learners spend most of their day at school with the result that the school environment plays an immense role in the promotion of healthy behaviours (Herrera *et al*., 2011:347; Morton *et al*., 2016:142).

Teachers furthermore play a significant role in the community as they work with children of different socio-economic, cultural, religious, and ethnic backgrounds (Engelbrecht *et al*., 2015:1). This occupation should thus be one of the most highly valued positions in civil society; yet teachers work under immense stress and in particularly difficult environments (Dlamini *et al*., 2014:582). Long hours, poor remuneration, and ungrateful students are some of the sad truths that lie behind this profession (George *et al*., 2008:149; Kaur, 2011:152; Maphalala, 2014:78). Biokineticists and/or exercise therapists may be able to use the information gathered in this study in order to increase awareness regarding both PA status and the risks of developing NCDs that arise out of physical inactivity. Therefore, the research questions that arise from the problem statement are: firstly, what is the prevalence of NCDs in male, and female, African, and Caucasian teachers in the North West Province? Secondly, what is the association between PA and NCD occurrence in a cohort of African and Caucasian urban teachers in the North West Province?

1.2 Objectives

The objectives of this study are to:

1.2.1 Investigate the prevalence of NCDs within African and Caucasian male and female teachers in the North West Province of South Africa.

1.2.2 Determine the association between PA status and NCDs in a cohort of urban African and Caucasian male and female teachers in the North West Province of South Africa.

1.3 Hypotheses

The study is based on the following hypotheses:

- Research Hypothesis One:

African males in the North West Province of South Africa will have a significantly higher prevalence of NCD risk factors compared to African females, Caucasian males and Caucasian females of the North West Province in South Africa.

- Research Hypothesis Two:

Physically inactive teachers of the North West Province in South Africa will present with a significantly higher prevalence of NCD risk factors than those that are physically active.

1.4 Structure of the dissertation

This dissertation is presented in the traditional format as approved by the North West University (NWU) of Potchefstroom, consisting of five chapters.

Chapter One: Introduction. This chapter forms the introduction to the study, highlighting the variables investigated in the course of the study. This chapter also details the problem statement, objectives, and hypotheses of this study and concludes with a breakdown of the structure of the dissertation.

Chapter Two: PA status and the relationship between risk factors of NCDs in an urban South African teachers' cohort. A literature review. The chapter begins by offering comprehensive background information regarding NCDs and their prevalence on a global scale. Thereafter, the risk factors for the development of NCDs are detailed, as considered in terms of modifiable and non-modifiable risk factors. The chapter concludes with a consideration of PA as an intervention so as to prevent the development of NCDs.

Chapter Three: Methods. This chapter will include the study design, participants and research methodology of the study.

Chapter Four: Results and discussion. This chapter will report on the results of the study and discuss them in terms of the stated objectives as detailed in Chapter One.

Chapter Five: Summary, conclusion, limitations, and recommendations.

All of the chapters are followed by their references which have been established in accordance with the NWU Harvard style as prescribed by the NWU of Potchefstroom.

CHAPTER 2 LITERATURE REVIEW

PA STATUS AND THE RELATIONSHIP BETWEEN RISK FACTORS OF NCDS IN AN URBAN SOUTH AFRICAN TEACHERS' COHORT.

2.1 Introduction

Non-communicable diseases (NCDs) are currently considered to be the most important health problem globally and are responsible for the greatest share of mortality and premature deaths worldwide at approximately 67% (Bickler *et al*., 2017:2; Kankeu *et al.,* 2013:31; Reubi *et al*., 2016:179). NCDs are furthermore predicted to cause as much as 75% of global deaths by the year 2020 (Sacco *et al.,* 2013:4). NCDs are defined as diseases that are closely connected to lifestyle choices and that have a slow progression (Kroll *et al.,* 2015:1243). These diseases include chronic diseases such as diabetes mellitus (DM), various cancers, chronic respiratory diseases and cardiovascular diseases (CVD) (Schmidt *et al.,* 2011:1949). Risk factors associated with the development of these lifestyle diseases can be divided into modifiable risk factors [physical inactivity, tobacco use, elevated alcohol consumption, dyslipidaemia, fasting glucose (FG) and obesity] and non-modifiable risk factors [age, gender, genetic factors as well as family history, race and gender] (Kolbe-Alexander & Lambert, 2013:141; Wagner & Brath, 2011:39). In order to combat the rising prevalence of NCDs, emphasis should be placed on the cultivation of a healthy lifestyle as early as possible, as the goal should be to prevent rather than to treat the diseases (Balbus *et al.,* 2013:3). A key modifiable risk factor that can be addressed early on is to ensure that physical activity (PA) guidelines are met, as increased PA positively influences various other NCD risk factors and bodily systems (Jelleyman *et al*., 2015:956; Oja *et al*., 2010:11; Timmons *et al.,* 2012:774).

2.2 Non-communicable diseases (NCDS) and NCD risk factors

According to Reddy *et al*. (2015:725), the United Nations called for a global meeting in 2011, in order to address the pressing matter of NCDs and the growing prevalence thereof. The significance of the ever-growing epidemic was also highlighted by *the Lancet* who dedicated a full issue to NCDs (McQueen *et al.,* 2013:93). Figure 2.1 is an illustration detailing what is globally regarded as the four main NCDs and their associated risk factors categorized as modifiable and as non-modifiable risk factors. In examining NCDs in SA, a similar trend can be found where more than half of total deaths in SA during 2015 were due to NCDs (STATS SA,

2017:52). With the increase of multi-morbidity in South Africans, the challenges of NCDs and the adverse effects thereof increase drastically (Alaba & Chola, 2013:63). Multi-morbidity can be defined as "*a person presenting with two or more chronic health conditions simultaneously*" (Barnett *et al*., 2012:37). According to Alaba and Chola (2013:63) multi-morbidity seems to be more prevalent among the South African female population, and is especially prevalent among African females. Additionally, Pieters *et al*. (2014:4) suggest that the increase in the prevalence of NCD risk factors may be ascribed to substantial changes in lifestyle choices with regards to PA status, increased alcohol consumption, and adverse dietary changes.

Some of these unhealthy lifestyle behaviours include a high prevalence of tobacco use, in so far as 29.2% of South African males and 7.3% of South African females (African and Caucasian) smoke tobacco (Reddy *et al*., 2015:649). In addition, South African alcohol consumption was recorded as being the highest in Africa, with an average of 201 alcoholic beverages per capita per year (Ferreira-Borges *et al*., 2016:54). Dietary patterns are also considered to be a risk factor as most of the participants that reported an adequate amount of fruit and vegetable consumption were of high income (Wu *et al*., 2015:92). Moreover, the prevalence of overweight and obesity in SA can be said to be high given a 2016 study which reported that 15% of SA males and 39% of SA females were either overweight or obese in 2016 (WHO, 2018). Although African females presented with the highest obesity rate and the lowest PA status, their perception of risk was not accurate, as most of the participants did not perceive themselves as being overweight or obese, even when confronted with their results (Prioreschi *et al*., 2017:2; Walter *et al*., 2011:5). Wu *et al*. (2015:92), when comparing risk factors in six countries, furthermore noted that the highest rate of physical inactivity (59.7%) was found in South Africans.

Among the SA population, a 78% prevalence of hypertension was reported with higher values among males (51.4%) than females (47.6%) (Peer *et al*., 2015:1039; Wu *et al*., 2015:94). The prevalence of FG was higher than normal (M ≥7.0 $mmol.L^{-1}$) in SA with 9.5% of females and 9.9% of males (for adults older than 25 years) reporting elevated levels (Sliwa *et al*., 2016:1202). Furthermore, DM is seen as one of the most widespread lifestyle diseases in SA with a significantly higher prevalence among females (7.1%) than males (4%). DM is furthermore considered to be the leading NCD attributable cause of death among the female population in SA (STATS SA, 2017:31).

A considerable difference could be noted regarding the prevalence of low concentration HDL cholesterol in the SA population where a 75% prevalence in females (African and Caucasian)

can be compared to a 33.4% prevalence in males (African and Caucasian) (Peer *et al*. 2015:1039). These findings were echoed by Maimela *et al*. (2016:8), who concluded that the prevalence of dyslipidemia is higher among females (20% aged 15-25) than males (15.6% aged 15-25), and even higher with advanced age (females aged 65 and older: 48.4%, and males aged 65 and older: 48.2%). The increased prevalence of TC and low HDL cholesterol concentrations may be attributable to the high obesity rate within the African population, especially among African females (Kaduka *et al*., 2012:4).

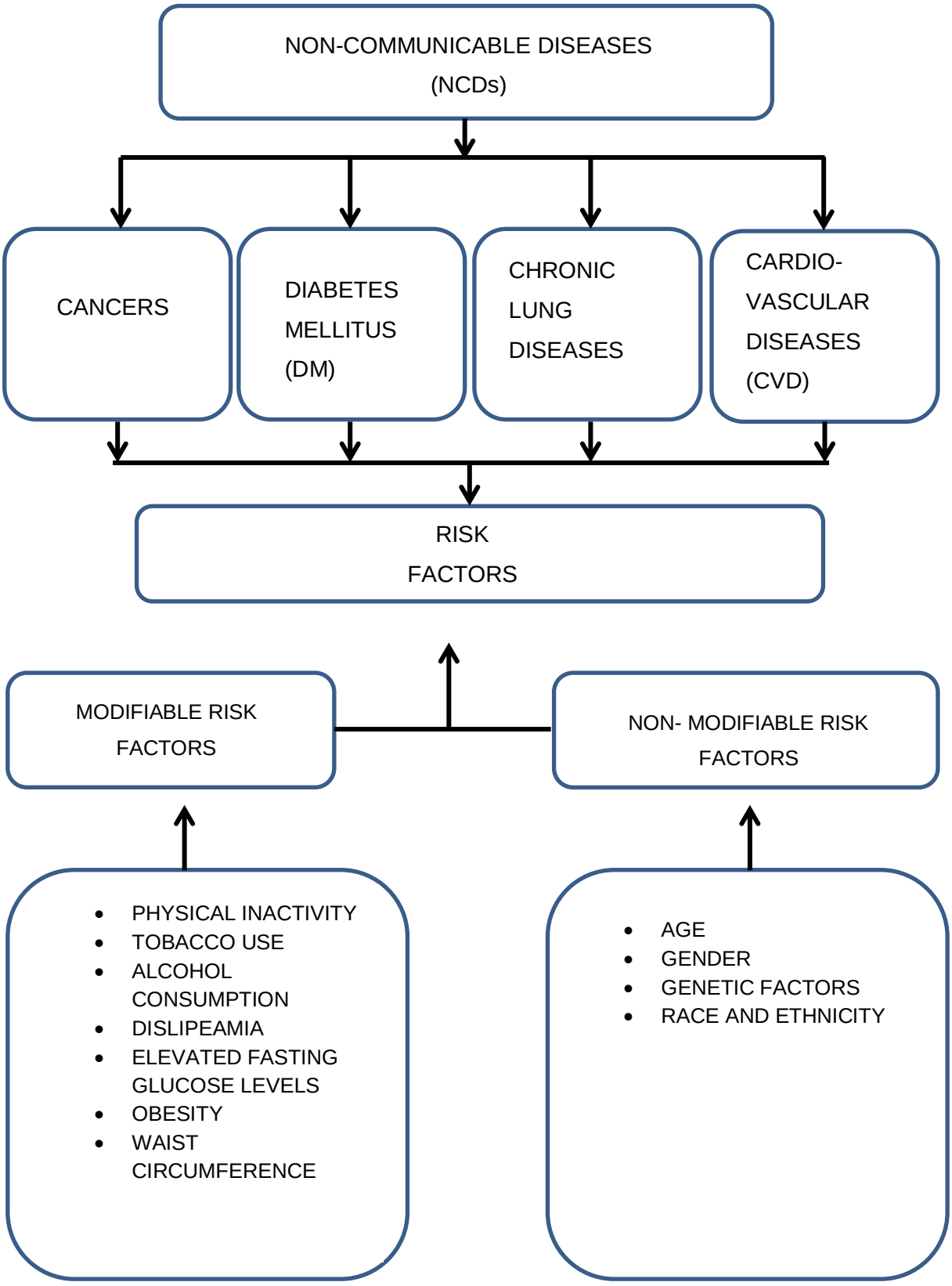


Figure 2-1: A schematic representation of non-communicable diseases (NCDs) and their associated risk factors

2.2.1 Non-modifiable risk factors

Non-modifiable risk factors can be regarded as risk factors that cannot be altered by the individual him-/herself, but which nevertheless increase the risk of developing NCDs and include factors such as age, gender, genetic factors and family history, race and gender (Msyamboza *et al*., 2011:4).

2.2.1.1 Age

Advancement in age is unavoidable and is associated with the deterioration of various bodily systems (Hyman *et al.,* 2010:149). The ageing process leads to adverse changes in body composition such as a decrease in skeletal mass and an increase in fat mass, coupled with a decline in physical function, thereby limiting physical function and eventually increasing the risk of disability and dependency (Brady *et al.,* 2014:441; Lowry *et al.,* 2012:6). According to Stevens *et al*. (2010:9) the amount of abdominal fat increases with age, even though the body mass index (BMI) might remain steady. Furthermore, fat accumulates in muscle, bone marrow, liver and various other areas as the dysfunction of numerous tissues and organs increases with age (Bonomini *et al*., 2015:110). Various studies have found a positive relationship between the increase of waist circumference (WC) or abdominal fat and the increase of cardiovascular risks (Adegbija *et al*., 2015:2, Diabetes Australia, 2013, Freedman & Ford, 2015:425). The accumulation of abdominal fat has furthermore been linked to various other risk factors including; hypertension, dyslipidemia, glucose intolerance, hyperinsulinemia and consequently may result in an increased risk of NCD development (Kaur, 2014:3, Nazare *et al*., 2015:313).

Another phenomenon of ageing is the decrease in the elasticity of arteries as well as of the endothelium cells and a consequent decrease in their ability to regulate the functionality of the cardiovascular system. (Olsen *et al*., 2016:2670). Although these processes occur naturally as part and parcel of the aging process, the risk of hypertension increases in relation to both the decreasing arterial elasticity and to the secondary effects thereof including the increase in endothelial dysfunction, decrease in lumen diameter, decreased oxygen transport and eventual atherosclerotic formation (AlGhatrif & Lakatta, 2015:13; Kaess *et al*., 2012:876). Oni *et al*. (2015:22) noted that the highest prevalence of hypertension in SA was among individuals aged 50 years or older.

An intriguing feature of ageing is that it is often accompanied by the dysregulation of the whole body cholesterol metabolism (McAuley & Mooney, 2014:6). Total cholesterol (TC) levels in both

males and females increase progressively with age, with females TC levels peaking between sixty and seventy years of age, while in males TC levels peak ten years earlier, between fifty and sixty years of age (Pavanello & Mombelli, 2015:499). A clinical manifestation of these processes is an age-related rise in the plasma levels of low-density lipoprotein (LDL) cholesterol (Anagnostis *et al.,* 2015:62; Tchernof & Despres, 2013:366). This rise in LDL cholesterol has a significant impact on CVD risk due to the association of elevated plasma LDL cholesterol with the mechanisms underpinning atherosclerotic plaque formation (Gould *et al.,* 2007:779). Prospective studies have furthermore shown that high-density lipoprotein (HDL) levels diminish with age (Loued *et al.,* 2013:1272). Aging decreases the effectiveness of mediating reverse cholesterol transport (RCT) and the anti-inflammatory response of HDL by increasing the oxidative degradation and resulting in injury to the cell membranes (Ayala *et al*., 2014:2). This is clinically significant in so far as HDLs are central to reverse cholesterol transport (Groen *et al.,* 2004:136; Morgan *et al.,* 2016:108-124). RCT is the process whereby excess cholesterol is transported back to the liver from peripheral tissue in order to prevent the formation of plaque (Morgan *et al*., 2016:109). RCT is mediated by HDL cholesterol and LDL cholesterol, and other harmful lipoproteins are removed by the liver (Hirata *et al*., 2017:29). The risk of developing NCDs also increases dramatically with age, as can be seen in a study by Nichols *et al*. (2013:3023), which underlined the fact that 85% of global deaths from heart disease occur in people older than 65 years.

2.2.1.2 Gender

Numerous gender-based differences exist with regards to NCDs and their risk factors (Muka *et al*., 2016:29). These differences include the influence of sex hormones, body composition differences, physiological and psychological differences, as well as lifestyle behaviours (Harvey *et al*., 2015:239). One of the main gender-based differences to consider is the differing effect of sex hormones on the risk factors of males and females (Harvey *et al*., 2015:239; Kumagai *et al*., 2015:84; Muka *et al*., 2016:39). Oestrogen and testosterone have different effects on the physiology of an individual consequently affecting NCD risk factors: oestrogen, for instance, offers a protective effect against various NCD risk factors (body composition, lipid profile, glucose metabolism and BP regulation) (Kumagai *et al*., 2015:84; Muka *et al*., 2016:39; Murphy, 2011:687; Renehan *et al*., 2008:576; Wu *et al*., 2011:14736). This is in contrast to males who present with a higher probability of developing the vast majority of risk factors including an unfavourable lipid profile, WC, insulin insensitivity, elevated FG and elevated BP (Geer *et al*., 2009:62; Murphy, 2011:688; Palmer & Clegg, 2015:113; Shulman, 2014:1136).

Males and females with similar BMI values present with different patterns of fat distribution in so far as males tend to have higher abdominal fat or a larger WC value as compared to females who generally have a higher fat distribution in the lower body (hips and legs) (Palmer & Clegg, 2015:113). According to Palmer and Clegg (2015:113) these differences in fat distribution occur due to higher oestrogen levels in females and reflect the activation of adipocytes receptors enabling fat deposition. Higher oestrogen levels in females furthermore influence the ability of fat cells to expand and store fat subcutaneously instead of viscerally (as in males), thus functioning as a protective barrier against the consequences of metabolic diseases (Palmer & Clegg, 2015:113). Males present with higher levels of skeletal muscle or fat free mass which might be due to lower oestrogen and higher testosterone concentrations (Bouchard *et al*., 2011:325; Kim *et al*., 2011:288; Lang, 2011:3). Higher levels of skeletal mass serve as a positive protection against the development of NCDs as this increases the basal metabolic rate, oxygen consumption, as well as the metabolic function (especially of carbohydrates) and decreases impaired insulin sensitivity (Kelly & Jones, 2013:35). When comparing males and females of similar age, females tend to present with a higher level of body fat overall (Jankowski *et al.,* 2008:1042; Valentine *et al.,* 2009:519), weaker muscle structure integrity and decreased physical function (the ability of a specific muscle to perform a necessary movement or stabilization) (Brady *et al.,* 2014:442; Millan-Calenti *et al.,* 2010:308).

Peripheral fat distribution (as seen in females) can be linked to increased insulin sensitivity including benefits such as the utilization of glucose, the inhibition of fatty acids, and hepatic glucose release (Bjornstad *et al*., 2015:8; Geer & Shen, 2009:62). Males present with a higher risk of developing an unfavourable lipid profile [TC, LDL cholesterol, HDL cholesterol and triglycerides (TG)], greater insulin sensitivity, FG, inflammatory response and BP regulation as compared to females; it should however be noted that, for post-menopausal females, the risk of developing NCDs presents in a more directly similar fashion to males (Kim & Menon, 2009:279; Murphy, 2011:688).

Measured increases in lipids levels were considerably higher in females than in males in a review of various studies of NCD management (Hendrington & Davis, 2015:2). Mittendorfer *et al*. (2009:1872) noted similar findings with a significantly different effect on the metabolism of lipids during fasting when comparing male and female subjects, a difference which may be due to the concentration and mechanisms of sex hormones (Voss *et al*., 2017:146). Females present with higher levels of HDL cholesterol, responsible for the uptake and the transport of cholesterol (via lipoprotein receptors located in various tissues' cell lining) to the liver, this lipoprotein can be seen as an indicator of a favourable lipid profile (Lee-Reuckert *et al*.,

2016:566). When comparing the lipid profile of females and males, the latter tend to be more vulnerable because of their lower oestrogen levels in so far as oestrogen acts as a protective layer (Choi *et al*., 2015:404). Even though both pre- and postmenopausal females present with a more favourable lipid profile as compared to males of similar age, a significant increase in an atherogenic lipid profile is seen amongst postmenopausal females who present with measures closer to those of their male counterparts (Regitz-Zagrosek & Kararigas, 2017:2). The significant decrease in oestrogen in postmenopausal women has been suggested as both the reason for their generally more atherogenic lipid profile, and for the increase in other risk factors as previously mentioned (Anagnostis *et al.,* 2016:733).

There is a close association between body composition and insulin sensitivity meaning that, in general, females tend to have higher insulin sensitivity than their male counterparts (Geer *et al*., 2009:62). Gender-based differences in glucose metabolism and in the production of glucose can be seen in both a fasting state and during moderate intensity aerobic exercise (Colberg *et al*., 2010:153). Even though some responses, such as an increase in ketones and free fatty acids, are similar across genders during glucose metabolism, females experience a significant decrease in glucose and an increase in lipids during the fasting state (Hendrington & Davis, 2015:2; Maughan *et al*., 2010:491). This can be seen as the result of two key influences regarding insulin regulation, including lower insulin concentrations in females coupled with higher concentrations of adrenalin like hormones (epinephrine) (Hendrington & Davis, 2015:2). This increased concentration of oestrogen results in an increased turnover rate from glycerol to the accumulation of peripheral fat, as well as in higher lipid levels and lower insulin levels (Van Vliet-Ostaptchouk *et al*., 2014:14). Hendrington and Davis (2015:2) reviewed various studies which sought to determine a tool for the management of DM and found that the decrease in glucose concentration and increase in lipid levels were considerably higher in females than in males.

Premenopausal females have a higher ratio of adrenergic receptors than males due to a higher prevalence of subcutaneous fat, consequently increasing their lipolysis rate (Palmer & Clegg, 2015:115). Moreover, FG levels are associated with visceral fat, rather than subcutaneous, which may also explain the differing readings between genders (Shulman, 2014:1136) in so far as a higher ratio of adrenergic receptors in subcutaneous fat and lower ratio of adrenergic receptors in visceral fat creates a favourable environment for lipolysis in females and increases their insulin sensitivity as compared to males (Gavin *et al*., 2013:1185). The increase in adipose tissue around the hips and thighs, as is often prominent in women, results in generally higher TG levels and Free Fatty Acids (FFAs), however, they still present with higher insulin sensitivity

than men (Geer *et al*., 2009:62). In comparing males and females, the higher concentration of oestrogen among females result in increased lipid metabolism, thereby increasing FFA oxidation and decreasing TG storage (Boullart *et al*., 2012:868). Increased skeletal mass can thus be seen to result in lower overall TG values (Gavin *et al*., 2013:1181).

The prevalence of elevated BP was also noted as higher among men (51.4%) than among women (47.6%) in a study which focused on South Africans of African descent (Peer *et al*., 2015:1039). Even though the prevalence of hypertension tends to be higher in males than females, Gu *et al*. (2008:789) suggested that the significance of the disease within the female population had previously been under appreciated in so far as most of the studies were focused on men.

2.2.1.3 Genetics

Genetic predisposition to and a family medical history of the development of various diseases and risk factors are relatively common and lead to an increased risk for the development of NCDs (Elks *et al*., 2012:2; Jha *et al.,* 2013:261; Loveday *et al*., 2018:251). While some studies have argued that in a small portion of the global population, a higher susceptibility to obesity and weight gain may be due to genetic mutations on a specific gene or other genetic abnormalities, rather than the expression of the gene itself (Elks *et al*., 2012:2) this is not a unanimous conclusion. Pigeyre *et al*. (2016:944), for instance, disagree, stating that about 200 different genetic alterations leading to a low risk probability for the development of overweight and obesity have been found. These findings are echoed by other researchers who argue that the majority of the population only present with a small genetic probability for obesity, their weight being the result of lifestyle and behavioural choices (Chung *et al*., 2012:122; Qasim *et al*., 2018:133; Yanovski & Yanovski, 2018:3).

However, much evidence exists which suggests the existence of a relationship between genetics and the distribution of fat, especially as concerns abdominal fat, thereby influencing WC, but not BMI (Lin *et al*., 2015:514; Zahn *et al*., 2018:2; Zain *et al*., 2015:508). In addition, WC can be viewed as a risk factor with a genetic influence of as high as 22% to 61% (Chang *et al*., 2008:3; Heid *et al*., 2010:949). Genetics can furthermore be seen as a risk factor for higher WC in individuals who present with various metabolic diseases and who are unable to maintain a certain WC (Heid *et al*., 2010:949; Pigeyre *et al*., 2016:954). Increased WC may also lead to unfavourable lipid levels and could also be due to genetic predisposition (Willer *et al*., 2015:52).

According to Surakka *et al*. (2016:595) an increased risk of high LDL cholesterol levels was 3.2% higher in European individuals who possessed certain genetic qualities (low-frequency variants) that are linked to lipid levels. These specific genes have also been linked to a higher prevalence of and probability for the development of familial hypercholesterolemia (Thormaehlen *et al*., 2015:3). Conversely, in some individuals, specific loci (the SCARB1 locus) have been reported to result in higher HDL cholesterol concentrations and in a higher rate of HDL cholesterol metabolism, resulting in a decrease in TC (Zanoni *et al*., 2016:1170). Nevertheless Zanoni *et al*. (2016:1170) argue that lipid concentration should be considered as a unit and not as separate values.

The genome-wide association study (GWAS study) is seen as a leading study concerning the determination of the association of DM related loci (Saxena *et al*., 2010:146). The genetic factors related to FG levels and especially to two-hour glucose differences have been found to be inheritable (Saxena *et al*., 2010:146). Rees *et al*. (2011:6) however state that although some of the genetic factors associated with an increased risk in the rise of FG levels exist, their independent responsibility cannot be determined.

Another risk factor that should be taken under consideration is BP in so far as genetics may influence both BP and the probability of developing hypertension (Nyuyki *et al*., 2017:43; Poulter *et al*., 2015:802; Ranasinghe *et al*., 2015:577). Furthermore, a relationship between BP differences in parents and their familial descendants has also been found (Ranasinghe *et al.,* 2015:577). These findings were similar to other studies regarding genetic profiles and BP, strengthening the importance of genetics in the development of hypertension, with frequencies found to be as high as 30% to 40% (Cabo *et al*., 2012:195; Empar *et al*., 2016:1892; Singh *et al*., 2016:268). In addition to the importance of establishing a family history or genetic relationship regarding BP as a risk factor for NCDs, other explanations include a higher sodium absorption rate, a higher counter measure in the sodium-lithium transference mechanism, the storage of fat, higher uric acid levels and higher general levels of sodium intake (Da Silva *et al*., 2013:136; Hedayati *et al*., 2012:315; Kim *et al*., 2014:2; Scholl *et al*., 2015:2).

The prevalence of various diseases has been found to be higher among individuals with a genetic or family history of similar disease (Munoz *et al*., 2016:984). Munoz *et al*. (2016:991) focused on various diseases including cancers (prostate, breast and bowel), DM, stroke and hypertension. According to Couch *et al*. (2014:304) the prevalence of some breast cancers can be attributable to genetics and/or family history. A similar pattern can be seen in other cancers such as colorectal cancer, ovarian cancer, prostate cancer, and lung cancer (Begum *et al*.,

2009:1; Mai *et al*., 2010:496; Robertson *et al*., 2012:1234). Although genetic risk factors are seen to be significant, they are not the only factors that need to be taken into account when considering the prevalence, results, and treatments of these diseases. Genetic factors need to be considered as only playing a small part in the development and progression of the disease itself (Global Burden of Disease Cancer Collaboration, 2017:525; Vineis & Wild, 2014:551).

When considering the relationship between DM and family history, a pattern can be observed where an increased prevalence of abnormally high levels of insulin is seen in individuals without DM (Francis *et al*., 2017:13). Similar links have been found as concerns other risk factors for NCDs. Having a family history of coronary heart disease (CHD) is a recognized independent risk factor for the development of CHD (Van der Saande *et al.,* 2001:321; Veronesi *et al.,* 2014:75). The development of heart disease early in life (younger than 45 years for men, and younger than 55 years for women) by a direct family member (siblings or parents) is reported to increase the risk of developing heart disease (Ripatti *et al.,* 2010:1399). According to Wellens *et al.* (2014:1644), the risk of cardiac death is twice as high when a family history of early onset cardiac death exists.

2.2.1.4 Race and ethnicity

Ethnicity is also considered to be a risk factor for the development of NCDs as some of these diseases are more common in certain populations than in others. Africans, for example, have a higher probability for the development of obesity, DM, hypertension and CVDs (Airhihenbuwa *et al*., 2014:78; Goedecke *et al*., 2017:89; Hilawe *et al*., 2013:671; Tuei *et al*., 2010:434). This may be due to physiological differences within the ethnic group, cultural preferences and/or differences in lifestyle choices (Brown *et al*., 2016:87; Flegal *et al*., 2010:236). According to the Oxford dictionary the difference between race and ethnicity can be explained as the following: *race refers to similar characteristics with regards to physical appearance such as eyes colour, ears, skin, bone structure, etc., whereas ethnicity refers to the differences in nationality, language and cultural influences* (Stevenson, 2010:209,490). The practicality of this statement needs to be kept in mind when considering race and ethnicity as risk factors for the development of NCDs in so far as some risk factors can, to a certain extent, be modified (physical inactivity, diet and smoking) whereas others cannot (age and race) (Ginther *et al*., 2011:1017).

In a country such as SA, there are racial differences, due to ancestral decent of South Africans. (Goedecke *et al*., 2017:88). These differences include skin colour and other physical

characteristics (bone structure, eye colour, hair, body composition) (Ramsay *et al*., 2011:214), whereas differences in ethnicity, amount to cultural and -behavioural differences (such as the perception of a healthy body image, cultural beliefs related to fuller set females within the African population, dietary differences including a higher sodium intake, decreased fruit and vegetable intake, lowered fibre intake, increased alcohol misuse, increased tobacco use and a decrease in PA) (Ramsay *et al*., 2011:215). Furthermore, the link between risk factors for the development of NCDs and race or ethnicity is a two-way street in so far as certain behaviour can positively (increasing healthier behavioural choices) or negatively (making unhealthy behavioural decisions) influence risk factors (Bell *et al*., 2010:534; Mathenge *et al*., 2010:570; Souza *et al*., 2017:2).

The African population presents with a more favourable profile for the development of NCDs and risk factors associated with NCDs such as obesity (Agyemang *et al*., 2009:8; Boateng *et al*., 2017:6; Demerath *et al*., 2015:4465) with the American Cancer Society (ACS) (2017:46) citing a 57% prevalence of obesity in the African American population in 2014. This relatively high level of obesity may be due to various differences in body composition (higher BMI- and WC values leading to a modified ethnic specific WC, rather than an absolute generalized value) between African and Caucasians [higher central adiposity levels, deoxyribonucleic acid (DNA) methylation (with negative effects on central obesity] (Zhang *et al*., 2011:624).

Higher levels of TC and LDL cholesterol coupled with lower levels of HDL cholesterol were found within Caucasians compared to African females making Caucasians more vulnerable for the development of dyslipidemia (Ellman *et al*., 2015:314; Hooper *et al*., 2007:447). Researchers argue that despite the connection between LDL cholesterol levels and an increased risk for cardiovascular and –related diseases (NCDs), more focus should be placed on the quality of the LDL particles (Goedecke *et al*., 2010:1342; Rizzo *et al*., 2009:870). Nishikura *et al*. (2014:755) furthermore note that smaller LDL cholesterol particles are less favourable than bigger, buoyant particles. Although no difference in particle size could be noted when comparing African and Caucasian participants in SA (age between 18 - 45 years), a correlation could be seen in LDL particle size when socioeconomic status (r=0.45) and protein consumption (r=0.16) were taken into account and a significant difference was visible with participants using contraceptives (p=0.046) (Goedecke *et al*., 2010:1347).

Alternative explanations for lipid profile differences may include dietary preference differences such as the consumption of foods with a higher sodium concentration, a higher consumption of processed foods, a lower intake of protein, higher carbohydrate consumption, inadequate fruit

and vegetable intake, lower PA status, and higher sedentary behaviour (Dugas *et al*., 2009:672; Ellman *et al*., 2015:315; Goedecke *et al*., 2010:1342; Joffe *et al*., 2014:2446; Sliwa *et al*., 2012:394).

African females also presented with a higher rate of insulin resistance that might be due to genetics, ethnicity or behavioural factors such as poor dietary habits (the consumption of foods with a higher sodium concentration, a high consumption of processed foods, a lower fibre intake, a higher intake of sugary foods and drinks as well as inadequate fruit and vegetable consumption) (Ellman *et al*., 2015:312; Sumner & Cowie 2008:697). These results support the idea that the relationship between lipid metabolism and insulin resistance differs between African and Caucasian individuals (Kodama *et al*., 2013:1793; Pispraset *et al*., 2013:845). The African population furthermore presented with higher insulin resistance at a given TG concentration (Sumner & Cowie, 2008:701).

A higher probability for the development of hypertension has been linked to the African population (Adeniyi *et al.,* 2015:5; Walter *et al.,* 2011:538; Williams *et al*., 2010:86) and could be attributable to increased sodium sensitivity within the African population (Cappuccio & Miller, 2016:301). Most of the sodium intake within the African population occurs through the increased consumption of processed foods, especially in areas with a lower income bracket (Franciosa *et al*., 2010:29). A higher degree of arterial stiffness has also been linked to individuals within the African population group and even though an increase in arterial stiffness is a common part of ageing, a disconcerting degree of arterial stiffness can be seen amongst individuals in the African population at a young age (Schutte *et al*.*,* 2011:511; Twagirumukiza *et al*.*,* 2011:1250).

2.2.2 Modifiable risk factors

Some of the risk factors in the development of NCDs may be modified and properly implemented interventions and protocols may prevent or even stop the progression of NCDs (Wu *et al*.*,* 2015:91). These risk factors include physical inactivity, tobacco use, excessive alcohol consumption, as well as the individual's lipid profile [TC, LDL cholesterol, HDL cholesterol and TG], FG, obesity and WC. Various adverse health and economic consequences may occur as a result of poor lifestyle choices (Hayman, 2016:134).

2.2.2.1 Physical inactivity

PA is a fundamental component of daily life. Primitive civilizations depended on PA for survival in the natural environment by building, hunting, gathering food as well as engaging in agricultural labour, all of which required large amounts of energy expenditure (O'Keefe *et al.,* 2011:472). The relationship between PA, health and longevity has been recognized by historical figures for centuries, starting with the writings of the Greek physicians Hippocrates, Herodicus and Galen who consider fitness to be a requirement for physical- and mental health (Myers *et al.,* 2015:307).

The Italian physician, Bernardo Ramazzini, who is considered to be the father of occupational medicine and who is celebrated for establishing the association between various occupations and diseases, stated that professional messengers whose occupation required significantly higher levels of PA, presented with a lower prevalence of health risks as compared to sedentary occupations such as tailors and cobblers (Myers *et al.,* 2015:307). A strong positive relationship can be seen between CVDs, responsible for the majority of deaths globally, and decreased PA levels (Pratt *et al.,* 2014:356). Echoing this finding, Morrison (cited by Blair *et al*., 2010:651) concluded that bus conductors whose work requires more physical activity as compared to bus drivers had a significantly lowered risk for the development of CHD.

PA is defined as any movement that increases total energy expenditure and provides health benefits (Guthold *et al.,* 2011:53). The minimal recommendations for health benefits include at least 150 minutes (min) of moderate intensity aerobic exercise [3≤6 metabolic equivalents (METs)] or 75 min of vigorous intensity aerobic exercise (≥6 METs) per week and resistance training at least twice a week (ACSM, 2014:8; Guthold *et al.,* 2011:53). Individuals who are already overweight and/or obese should increase their PA to a minimum of 60 min per day so as to increase their total energy expenditure (TEE) (Oja *et al*., 2010:12; Vasileska & Rechkoska, 2012:368). In addition, Donnelly *et al*. (2009:461) suggest an even more aggressive approach in order to achieve maximum weight loss by increasing PA to 225-420 min per week and participating in ≥250 min per week of moderate intensity activity in order to prevent weight regain. An alternative classification of physical activity status is the use of PAL instead. PAL includes occupational PA (determined by occupation), daily activities (chores at home, tending to family, social and other obligations) and leisure time PA (jogging, hiking, playing tennis, gym). PAL can be categorized into five different levels: PAL 1 equates to a sedentary job with no habitual exercise, general household chores and low activity hobbies such as reading; PAL 2 equates to a sedentary job with no habitual exercise, general household chores, active hobbies such brisk walking, cycling and tennis; PAL 3 equates to a semi-active job (nurse or shop

assistant), household chores, and some active hobbies; PAL 4 equates to an active job (builder or tennis coach) and active lifestyle and lastly PAL 5 equates to an active job (athlete or labourer) with a highly active lifestyle (James & Schofield, 1990).

In order to determine PAL, TEE is divided by resting energy expenditure (REE) (James & Schofield, 1990). REE refers to the energy expenditure while the body is at rest (excluding dietary-induced thermogenesis) and encompasses the energy needs required for body functions essential for life such as: breathing, cardiac function, brain function, enzyme function, hormone function, cell formation and regeneration as well as thermoregulation (Geisler *et al.,* 2016:2; Wiskin *et al.,* 2011:567). REE makes a significant contribution to daily TEE being responsible for approximately 45 to 70% of daily TEE depending on age, gender, body composition and daily activity level (Geisler *et al.,* 2016:2; Wiskin *et al*., 2011:567). REE decreases with age (1-2% per decade) and may be due to a decline in the amount of fat free mass and an increase in visceral fat (Geisler *et al.,* 2016:2). In addition, the higher levels of fat free mass or skeletal muscle found in males as compared to females lead to a generally higher REE in males (Wiskin *et al.,* 2011:567).

Various methods can be used to measure PA including self-reporting [Previous Day Physical Activity Recall (PDPAR), Modifiable Activity Questionnaire (MAQ), 7-day Physical Activity Recall (PAR), Recent Physical Activity Questionnaire (RPAQ), Previous Week Modifiable Activity Questionnaire (PWMAQ), and International Physical Activity Questionnaires (IPAQ)], direct observation by an observer, or the use of numerous devices as accelerometers (activPAL, Tritrac, Tracmor and Actigraph), pedometers (Yamax Digi- Walker and StepWatch), heart rate monitors (Polar andGarmin) and armbands (Sensewear) (Sylvia *et al*., 2014:14). The Actiheart is a popular method used and has the ability to measure the energy expenditure (TEE, AEE and RER) and the PA intensity of the individual and is seen as the gold standard of PA measurement by numerous researchers (Assah *et al*., 2011:112; Brage *et al*., 2005:562; Castello *et al*., 2015:115; Nichols *et al*., 2010:489).

Even though the health benefits of PA are well-known, most people in Europe, Malaysia, and the United States (US) still do not meet the minimum recommendations for health related PA (Molanorouzi *et al*., 2015:66). The health benefits of PA are numerous and studies have shown that PA can be beneficial in managing and even preventing cancer, heart disease, DM, hypertension, stroke, cholesterol, arthritis, sarcopenia, and osteoporosis (Arem *et al*., 2015:966; Sparling *et al*., 2015:1; Veldhuijzen van Zanten *et al*., 2015:1402). Healy *et al*. (2011:590) advocate for a moderate amount of regular physical exercise that would provide health benefits

and protect against the ravages of a sedentary lifestyle. O'Donovan *et al*. (2010:575) recommend that all adults should perform at least 30 min or more of moderate intensity PA on most days of the week either in a single session or through 'accumulated' multiple bouts, where each bout lasts at least ten minutes (O'Donovan *et al*., 2010:575).

Martin *et al*. (2015:1056), highlight concerns related not only to the decrease in PA status, but also regarding the increase in sedentary behaviours. Sedentary behaviour is seen as any wakened activity of low energy expenditure such as lying down or sitting (Sedentary Behaviour Research Network, 2012:540). According to Halloway *et al*. (2017:59) Americans above the age of six years, spend almost eight hours per day in sedentary activities. Anderson *et al*. (2016:238) reported that adults in Canada spent an average of 20-24 hours per week engaged in leisure time sedentary behaviours. Although an individual may meet the recommendations regarding PA, the increased time spent engaged in sedentary behaviours is nevertheless strongly related to increased mortality (Biswas *et al*., 2015:123).

Biswas *et al.* (2015:129) stated that continued sedentary behaviour is autonomously connected to mortality and NCDs. These findings were echoed by Martin *et al.* (2015:1), who reported that interventions focusing on sedentary behaviour reduction tend to be more effective than the promotion of PA. According to Adachi-Mejia and Schifferdecker (2016:212), males tend to be more physically active than females, and this might be explained by the findings of Molanorouzi *et al*. (2015:73) in so far as males tend to react more positively towards competition and challenges than females. Conversely, according to Egli *et al*. (2011:400), females show a markedly positive reaction as concerns PA which improves their physical appearance. These results might help health professionals move their focus onto more sex specific type of PA with more gender-based motivation.

In a study by Wu *et al*. (2015:92) that compared risk factors in six countries, SA scored the highest rate of physical inactivity (59.7%). SA females of African descent scored the lowest in terms of PA status and this can be seen as a significant health risk (Walter *et al*., 2011:9) especially as African females, despite their low PA status and their high obesity rates do not have an accurate perception of their risk. In point of fact, most of the participants did not perceive themselves as being either overweight or obese, even when confronted with their results (Prioreschi *et al*., 2017:2; Walter *et al*., 2011:5). SA is a developing country with an ethnically and culturally diverse population, and which faces various socio-economic challenges (Alaba & Chola, 2013:64). Furthermore, a socio-cultural move to more Westernized behaviours

can be seen which may lead to an increase in adverse health risks and challenges (Micklesfield *et al*., 2013:369; Sartorius *et al*., 2015:2).

2.2.2.2 Tobacco use

Smoking has historically been more prevalent amongst males than among females, but evolving social standards have meant that today there is much greater equality in the numbers of male and female smokers (Secker-Walker *et al.,* 2002:2). Smoking has a number of adverse effects on the human body including damage to the endothelial cells of the vascular system, decreased HDL concentration, an increase in inflammation, the dysfunction of endothelial cells, as well as ventricular arrhythmias due to an increase in sympathetic nerve stimuli and myocardial infarction (MI) (Messner & Bernhard, 2014:513; Middlekauf *et al*., 2014:1741; Morris *et al*., 2015:1381). Smoking causes around 480 000 deaths per year globally (ACS, 2017:40).

A systematic review by Brathwaite *et al*. (2015:7) found that SA adults presented with the highest prevalence of smoking in sub-Saharan Africa, a figure which Alaba and Chola (2013:15) put at 18% of the SA adult population. South African smokers were estimated to have 13% higher medical expenses as compared to than non-smokers (Sturm *et al.,* 2013:842). Smoking leads to adverse health effects including chronic obstructive pulmonary disease (COPD), emphysema, and lung cancer. COPD is a lung disease characterized by constant inflammation and irritation leading to limited airflow, but is treatable and even preventable (Vogelmeier *et al*., 2017:558). The prevalence of cancers is also predicted to rise due to an increase in exposure to risk factors (smoking, poor diet, physical inactivity, alcohol misuse, high BMI and WC) (Bhaskaran *et al*., 2014:755; Wang *et al*., 2018:316). Lung cancer is ranked globally as the most prevalent cancer in men, whereas lung cancer ranks as the second most prevalent cancer in women (Islami *et al*. 2015:327).

2.2.2.3 Alcohol consumption

Alcohol is a relatively easily accessible product globally and is not seen to be as dangerous as other drugs, despite the negative effects that alcohol misuse can have on one's health (Bauer *et al*., 2014:45; Delobelle *et al*., 2016:71; Sewram *et al*., 2016:117). Some of these adverse health issues include; an increased risk of developing atherosclerosis (Shirpoor *et al*., 2012:3), increased inflammation, injury to the endothelial cells (Husain *et al*., 2011:936), an increase in the wall thickness of the aorta (Norouzi *et al*., 2015:23), increased TG concentration, increased LDL cholesterol concentration (Bell *et al*., 2017:2), various diseases of the pancreas (Lugea *et*

al., 2015:1), a decrease in bone density and an increase in chronic liver disease (Ulhoi *et al*., 2017:131).

Alcohol-related problems such as liver disease and liver cancer tend to be noticeably higher in the African population (Obasi *et al.,* 2016:3). This could be explained by the shift from traditional African lifestyles to Westernized behaviour which results in a spike in alcohol intake and in reduced PA (Hamer *et al.,* 2011:237). According to Ferreira-Borges *et al*. (2016:56) the SA population presently carries the highest health burden as a consequence of alcohol abuse in the sub-Saharan region. Alcohol consumption was furthermore seen to be the highest in Africa with an average of 201 alcoholic beverages consumed per capita per year (Ferreira-Borges *et al*., 2016:54) and the second highest worldwide (Ferreira-Borges *et al*., 2016:57). Although the use of alcohol is higher among males (Atkins *et al*., 2013:172), Delobelle *et al*. (2016:71) found a 20% increase in alcohol consumption among females from 2010 to 2013, in SA.

2.2.2.4 Lipid profile

Lipids are biological molecules consisting of fats, oils and some steroids. Lipids are insoluble in water and are formed when FFAs chemically bind with other components dependant on the required function (Ain *et al*., 2016:1057). Within the human body, lipids play an important role as they serve various roles including energy storage, insulation, cellular protection, cellular communication, serving, importantly as the building blocks for cellular membranes (Braverman *et al*., 2012:1445; Pour, 2018:10; Watson, 2015:61). The three most important lipids that can serve as a determinant of NCD risk factors are TG, LDL cholesterol and HDL cholesterol (Ghodsi *et al*., 2017:26; Klug *et al*., 2018:976). In order to determine the risk associated with TG, LDL cholesterol and HDL cholesterol a risk classification based on the following cut-off points was used: TC ≥5.18 $mmol.L^{-1}$, HDL cholesterol of ≤1.04 $mmol.L^{-1}$, LDL cholesterol ≥3.37 $mmol.L^{-1}$ and or TG of ≥1.69 $mmol.L^{-1}$ (ACSM, 2014:46).

Dyslipedemia, the elevated concentration of LDL cholesterol and/or TG, and/or decreased HDL cholesterol concentration (American Diabetes Association, 1998:179; Matsubara *et al*., 2002:2764; Musunura., 2010:907) is as a modifiable risk factor for the development of NCDs (Yuan *et al.,* 2007:1115). Dyslipedemia is considered to be the main cause of atherosclerosis, eventually leading to atherosclerotic CVD (Jacobson *et al*., 2015:2). Balakumar *et al.* (2016:609) further reports that behavioural/modifiable risk factors such as obesity, smoking, hypertension, dyslipidemia, and DM can accelerate the progression of atherosclerosis.

According to Bays *et al*. (2016:6) it is crucial to not only manage dyslipidemia by setting goals for lipid concentrations, but also to prevent the disease from developing. This can be done pharmaceutically, by increasing PA, and by introducing healthy diet behaviour such as increasing fibre intake (McRorie *et al*., 2015:84), while decreasing sugar, sodium and saturated fat intake (Te Morenga *et al*., 2014:76; Wang *et al*., 2015:1).

2.2.2.5 Fasting glucose (FG)

FG is considered to be a modifiable risk factor in so far as positive dietary behaviour changes can lead to health benefits through a decrease in FG levels and FG level related issues (Koniak-Griffin *et al*., 2015:76). Hyperglycaemia is defined by a FG concentration that is chronically (over weeks) ≥10 $mmol.l^{-1}$ and often leads to either impaired insulin mechanisms and/or functioning (Kutyavin & Chawla, 2016:264; Richter *et al*., 2017:1). This failure, when it occurs to a chronic degree, affects overall health negatively by causing damage to both macro- (CHD, cerebrovascular disease, and peripheral arterial disease), and micro vascular structures (retinopathy, nephropathy, and neuropathy) and leads to a host of other health related issues (an increased risk for heart disease, decreased immune system, loss of limbs, to name but a few of the negative effects that may arise) (American Diabetes Association, 2016:6; Colberg *et al*., 2016:2076). Chronic hyperglycemia may furthermore lead to the development of DM, which occurs as a result of the complete failure of insulin secretion (type one DM) or as a result of the failure of the functioning thereof (type two DM) (ADA, 2015:98).

The prevalence of FG as a risk factor for the development of NCDs varies significantly within different regions of the world and this variance is difficult to explain due to various contributing factors such as environmental differences, dietary patterns, accessible food sources and socio-economic differences (Laslett *et al*., 2012:45; McAloon *et al*., 2016:257; Shaw *et al*., 2010:11). A study by Sliwa *et al*. (2016:1202) found the prevalence of FG levels ≥7.0 $mmol.L^{-1}$ in SA to be 9.5% for females and 9.9% for males in adults older than 25 years. Kontis *et al*. (2014:430) predicts that if FG levels can be reduced to healthy targets, the probability of premature mortality can be decreased by 22% in males and 19% in females. These targets may be reached through the adoption of healthier lifestyle choices including the consumption of a healthy, balanced diet and in meeting the recommended PA levels (Christine *et al*., 2015:1312; Ley *et al*., 2016:2011; Nyenwe *et al*., 2011:33; Salas-Salvado *et al*., 2011:33).

2.2.2.6 Obesity

Obesity is normally defined as excess body fat which negatively impacts health and is universally assessed through the use of the BMI as the ratio of weight, measured in kilograms (kg), over height in metres squared (m^{-2}) (Murphy *et al*., 2015:5). According to Jackson *et al.* (2002:789), the World Health Organization (WHO) classifies overweight as a BMI of 25–29.9 kg.m² and obesity as a BMI ≥30 kg.m².

Statistics concerning the global level of obesity prevalence reveal that more than one billion people meet the criteria for excess weight; this number continues to rise in both developed and undeveloped countries (Arroyo-Johnson & Mincey, 2016:572; Mbanya *et al.,* 2015:24; Van Vliet-Ostaptchouk *et al*., 2014:2). According to the WHO (2018) and The Global BMI Mortality Collaboration (2016:776), a steep rise in global overweight and obesity rates have been seen, with an estimated 1.9 billion individuals meeting the criteria of overweight and of these individuals, 600 million are seen to be obese. Global obesity prevalence has increased, almost doubling from 6.4% to 12% during the period from 1980 to 2008 (Stevens *et al*., 2012:23). This increase in global obesity figures can be largely attributed to an increase in obesity levels within the Asian population, especially within China (43.2 million) and India (9.8 million) (Fan *et al*., 2017:863: Kasi *et al*., 2011:52; Ranasinghe *et al*., 2017:108). In addition, the American Cancer Society (ACS) (2017:46) reported that obesity rates among American adults have increased substantially from 15% in the period from 1976 to 1980, reaching a rate of 23% in 2014. A higher prevalence of obesity can be noted in females (40%) as compared to males (35%) and a degree of obesity rate stabilization can be seen in males, whereas obesity rates continue to rise in the female population (ACS, 2017:46).

Phillips *et al*. (2016:751) stated that obesity in SA is a terrifying crisis with SA having the highest reported obesity rates in Africa. In 2012, the South African National Health and Examination Survey (SA-NHANES) found that an astonishing 22.5% of SA adults were overweight, and went on to report an even higher rate of obesity at 25% (HSRC, 2013:2). Obesity rates were furthermore concentrated in the female population (39.2%) as compared to their male counterparts (10.6%) (Alaba & Chola, 2014:66).

As compared to other sub-Saharan countries, rates of overweight and obesity prevalence in SA were found to be the highest, indeed a study conducted by Wollum *et al*. (2018:7) in Umgungundlovu and Pixley ka Seme (South Africa) reported a high prevalence of overweight (55.3%) and obesity (54.8%) among the participants. Despite the overwhelmingly high rates of

obesity and overweight uncovered by the study, 77.9% of the participants did not agree that they would benefit from losing weight and stated that they were happy with their current weight. An increase in the obesity and overweight rate of 2% amongst males (from 9% to 11%) and an increase of 12% amongst females (27% to 39%) could be observed in SA, from 2003 to 2012 (Tugendhaft *et al*., 2015:2296). Agyemang *et al*. (2015:2) reported that the prevalence of overweight within the SA population stood at 41%, with women representing 68.5% of the overweight population. Ajayi *et al.* (2016:1128) reported similar findings, concluding that the prevalence of obesity among SA females and among males stood at 60% and 33% respectively. This may be due to some African cultural practices which see overweight and obesity (especially an increased WC) as a sign of wealth, fertility and overall success, making it particularly difficult to cultivate healthy behaviours (Adeniyi *et al*., 2015:299). Adenyiyi *et al*. (2015:301) went on to report that a strong relationship could be seen between dietary habits and the prevalence of obesity, with 98.2% of obese adults reporting a regular intake of fast foods and no to little vegetable consumption in their diet (Adeniyi *et al*., 2015:301). These results are mirrored in research by Vorster *et al*. (2013:6) who reported that the majority of SA adults consume a high fat, high sugar diet consuming little to no vegetables. Furthermore, the SA-NHANES found that despite evidence of poor dietary choices, most of the participants did not see themselves as being unhealthy and making unhealthy dietary choices (HSCR, 2013:3), a perception which echoes in findings presented by Phillips *et al*. (2016:759).

2.2.2.7 Waist circumference (WC)

Arnold *et al*. (2014:107) and Cameron *et al. (*2013:86) state that both WC and waist to hip ratio (WHR) are relatively easy methods that can be used determine the distribution of visceral fat, where WC is seen to be more reliable in determining health implications than the use of both BMI and WHR (Flint *et al*., 2010:172; Freedman & Ford, 2015:425 & Seidell, 2010:272). A substantial scientific agreement exists regarding the relationship between a larger waist and narrow hips and an increase in the risk of developing DM, CHD and premature death (Lanfer *et al.,* 2014:957; Mbanya *et al.,* 2015:24; Cameron *et al.,* 2013:87). Kihara and Matsuzawa (2015:9) state that the increase of visceral fat may have a negative impact regarding the development of CVD and its risk factors. Lee *et al*. (2011:1565) furthermore found that increased visceral fat was correlated with the prevalence of hypertension and with the ineffective metabolism of lipids and glucose, indicating that WC is an important risk factor not only for body composition, but also for predetermining other risk factors.

An important factor to consider regarding visceral fat is the anatomical location, in so far as this fat is located above the liver moving down to the intestinal tract; an increase in visceral fat thus leads to higher concentrations of free fatty acids (Tsai *et al*., 2015:91). The increased levels of free fatty acids moving into the liver increase the synthesis of lipids, atherosclerosis, gluconeogenesis, hypertension, insulin resistance and glucose intolerance (Kihara & Matsuzawa, 2015:10). According to Rhee *et al*. (2009:166) as well as Yoo and Choi (2014:357), a strong positive correlation between FFA levels and arteries in the cardiovascular system presenting with stenosis, exists. This is important as arterial stenosis leads to the development of CHD and other heart diseases (Davis 2010:71).

2.3 The prevalence of non-communicable diseases (NCDS) globally and in South Africa (SA)

According to Bickler *et al*. (2017:2) NCDs such as stroke, cancer, heart disease, chronic lung diseases, hypertension and DM are responsible for more deaths within the sub-Saharan African and Asian regions than infectious diseases. NCD related deaths were projected to increase globally from 59% in 2002 to 69% in 2030 (Mathers & Loncar, 2006:2011) with ischemic heart disease (IHD) and strokes becoming the primary and secondary causes of death in low- and middle-income countries respectively. According to Bauer *et al*. (2014:45), chronic diseases are the leading cause of premature death in the US with half of the population presenting with at least one chronic condition.

According to the WHO (2017), the ten leading causes of death globally have remained the same for the previous 15 years (Table 2.1). Numerous studies have concluded that various risk factors leading to cardiovascular conditions such as; age, DM, high cholesterol, gender, smoking tobacco, alcohol consumption physical inactivity, obesity and uncontrolled high BP can be prevented (Boekholdt *et al*., 2014:486; Mahmoodi *et al.,* 2014:43; Mons *et al*., 2015:356; Shah *et al*., 2015:105). In SA, NCDs, including DM, heart disease, hypertension, chronic lower respiratory diseases, and IHD, were all listed as leading causes of death, with STATS SA (2017:30) reporting that the prevalence of each of these NCD's has increased.

Davis (2010:71) reports that these risk factors inevitably lead to the acceleration of the atherosclerotic process by weakening the vascular endothelium and ultimately causing endothelial dysfunction. According to Gaziano (cited by the World Economic Forum; 2011:8) 80% of CVDs can be explained through behavioural risk factors such as tobacco use, physical inactivity and an unhealthy diet. A concerning conclusion regarding mortality rates in the US

was drawn by Malek *et al*. (2015:89) in so far as one in 19 deaths are due to stroke with the African American population presenting with double the risk as compared to the Caucasian population.

Studies focusing on Asia found a 27% prevalence of CVD and a 4% prevalence of DM within South Asia (Misra *et al*., 2017:1). The most common heart diseases include; CHD and MI (Anderson & Taylor, 2014:3). Given that CHD is seen to be the primary cause of death worldwide, being responsible for one third of adult deaths annually (Sanchis-Gomar *et al*., 2016:263), it is a major public health issue. Heart disease more generally is firmly established as one of the major public health issues in so far as it is responsible for 40% of deaths in males and 49% of deaths in females (Keates *et al*., 2017:273; Misra *et al*., 2017:1; Nichols *et al*., 2013:3028; Townsend *et al*., 2016:3233). In Africa, CVD was responsible for 11.3% of all deaths, being responsible for 5% of all deaths within the sub-Saharan region (Keates *et al*., 2017:273).

Kahn *et al*. (2014:1069) assert that DM and DM related issues affect more than 370 million individuals and various other studies suggest that the prevalence of DM lies at between 100 and 246 million globally (Kuwaja *et al*., 2010:72; Sicree *et al*., 2010:3). A growing tendency in the prevalence of DM is also notable with The International Diabetes Federation (IDF), estimating an increase in the prevalence of DM of 246 million individuals in 2007 to 380 million individuals by 2025 globally (Sicree *et al*., 2010:2). Type two DM is responsible for an estimated 90% to 95% of total DM prevalence (in developing countries including Africa and Asia) suggesting that avoidable poor lifestyle choices are in no small part responsible for the prevalence of DM (Whiting *et al*., 2011:318; Unwin *et al*., 2010:3).

The prevalence of DM continues to increase and Tanzania reported an increase from 0.3% to 4.6%, while Cameroon reported an increase from 1.5% to 6.6%, since the 1980's (Peer *et al*., 2012:43336). Various studies found a higher prevalence of DM among females as compared to males (Penno *et al*., 2013:177; Rucci *et al*., 2018:6; Shrivastava *et al*., 2016:67) and a possible explanation for this might be the higher collection of risk factors for atherosclerosis, coagulation differences, unfavourable endothelial function, and an increase in the inflammation process which underlies the increased prevalence of DM in females compared to males (Kautzky-Willer *et al*., 2010:579). This is supported by Ogah *et al.* (2015:483) who reported a higher prevalence of both DM and hypertension within females in sub-Saharan countries. DM is seen as one of the most prevalent lifestyle diseases in the SA population with a significantly higher prevalence among females (7.1%) than males (4%) (STATS SA, 2017:31). STATS SA (2017:32) reported

an increase in the prevalence of DM within the female population in the period from 2013 (6.2%) to 2015 (7.1%), concluding that DM was the leading NCD cause of death among the female population in SA.

Agyemang *et al*. (2015:180) state that the prevalence of hypertension in Europe and North America tends to be the highest in minority ethnic groups, especially amongst males. On a global level the specific reason for the higher prevalence of hypertension in African descendants isn't clear as culture, migration, socio-economic status, healthcare accessibility, psychological and behavioural changes can all contribute to the incidence of hypertension (Batai & Kittles, 2013:82). In research on hypertension, Kearney *et al.* (2005:217) predicted that the global prevalence of hypertension will increase to 60% by 2025 and that about 75% of these individuals will be from developing countries.

In a study by Njelekela *et al*. (2009:34) a considerably high prevalence of hypertension was found in Tanzania (57%), despite the fact that female subjects presented with a 50% lower risk of hypertension. Ogah *et al*. (2015:483) further strengthened this observation in reporting a higher prevalence of hypertension in males of the sub-Saharan region. Various studies concluded that a higher prevalence of hypertension in males as compared to females below the age of 65 years and could be attributable to behavioural and biological influences (Everett & Zajakova, 2015:2; Ong *et al*., 2008:1145; Sandberg & Ji, 2012:8). Nyuyki *et al*. (2017:42) found that behavioural factors affecting the prevalence of, and which have an effect on BP, differ between males and female subjects in so far as the latter have an increased stress reaction due to familial, socio-economic, and educational issues. Other behavioural factors included an increase in sodium and/or sugar intake and a decrease in PA (Siervo *et al*., 2015:4).

Another globally common cluster of NCDs include chronic lung diseases such as asthma and COPD (Duijts *et al*., 2014:871; O'Dwyer *et al*., 2016:4841). Asthma can be defined as a complex disease which involves the irritation, inflammation and remodelling of the airways (Tamm *et al*., 2012:11). Even though asthma is not a prerequisite for the development of COPD, its prevalence is seen as a risk factor (Regnier *et al*., 2013:821). A negative relationship can be seen between quality of life and the ability to not only participate in PA, but also to enjoy the health effects of PA (Duijts *et al*., 2014:872; Welsh *et al*., 2010:166). While some studies argue that the risk of developing these diseases is determined by dietary patterns, smoke exposure and other behavioural and ontogenetic factors, other studies argue that the risk of developing these diseases is due to an increase of the effects of asthma in children, due to their already inhibited lung function (Bisgaard *et al*., 2012:1183; Stocks & Sonnappa, 2013:161).

Worldwide, 8.7 Million deaths can be attributed to cancer which ranks second only to CVD in terms of the mortality attributable to lifestyle diseases (Global Burden of Disease Cancer Collaboration, 2017:525). Torre *et al*. (2015:87) underlines the epidemic nature of the prevalence and burden of cancer on global health. The growing prevalence of cancer can especially be seen in developing countries and may be due to both an ageing population and a higher population density (Torre *et al*., 2015:87). The significantly high number of deaths that can be attributed to different cancers is a worrying source of premature mortality. Unfortunately, treatment for many forms of cancer is not seen as particularly effective and is furthermore limited due to questions of affordability and access, especially within the lower income countries (Vineis & Wild, 2014:550). The prevalence of cancers is predicted to increase as an increase in the prevalence of cancer risk factors (smoking, poor diets, physical inactivity, alcohol misuse, BMI and WC) can be seen (Bhaskaran *et al*., 2014:755; Wang *et al*., 2018:316). Lung cancer is ranked as the most common cancer in men, ranking as the second most common cancer in women (Islami *et al*. (2015:327).

Table 2-1: The ten leading causes of death globally (WHO, 2017)

1	Ischemic Heart Disease (IHD)	8.76 million
2	Stroke	6.24 million
3	Lower respiratory infections	3.19 million
4	Chronic Obstructive Pulmonary Disease (COPD)	3.17 million
5	Trachea, bronchus, lung cancers	1.69 million
6	Diabetes Mellitus (DM)	1.59 million
7	Alzheimer's and other dementias	1.54 million
8	Diarrhoeal diseases	1.39 million
9	Tuberculosis	1.37 million
10	Road injury	1.34 million

Table 2-2: The ten leading causes of death in SA (STATS SA, 2017:31)

1	Tuberculosis (TB)	33 063	7.2%
2	Diabetes Mellitus (DM)	25 070	5.4%
3	Cerebrovascular diseases	22 879	5.0%
4	Other forms of heart disease	22 215	4.8%
5	Human Immunodeficiency disease (HIV)	21 926	4.8%
6	Influenza and pneumonia	20 570	4.5%
7	Hypertensive diseases	19 443	4.2%
8	Other viral diseases	16 097	3.5%
9	Chronic lower respiratory diseases	12 667	2.8%
10	Ischaemic heart diseases (IHD)	12 239	2.7%

2.4 Physical activity (PA) and non-communicable diseases (NCDS)

Various studies (Artinian *et al.,* 2010:431; Ebrahim *et al.,* 2013:3; Goldstein *et al.,* 2006:1605) found that a significant positive relationship exists between physical inactivity and CVD risk factors (obesity, DM and hypertension). Myers *et al*. (2015:307) date the first study connecting chronic diseases to physical inactivity to a 1961 publication by Kraus and Raab, (Myers *et al.,* 2015:307). In accordance with the American College of Sports Medicine (ACSM), Guidelines for Exercise Testing and Prescription were published, consisting of evidence-based recommendations for the promotion of health through PA (ACSM, 2014:114). According to Anderson and Taylor (2014:4), PA has not only direct but also indirect benefits. The direct benefits include the improvement of autonomic tone, inflammatory markers, myocardial oxygen demand, development of coronary collateral vessels, coagulation and clotting factors and endothelial function of the cardiovascular system (Anderson & Taylor 2014:4; Hambrecht *et al.,* 2004:1377), while the indirect benefits of PA are the amelioration of risk factors for atherosclerosis (smoking, BP, and lipid levels) leading to a decline in mortality (Taylor *et al.,* 2006:370).

According to Sallis *et al*. (2015:375) physically active individuals, across gender, age and ethnicity enjoy healthier lives and live longer lending credence to the phrase: "*exercise is medicine."* Yet, this statement nevertheless fails to receive the attention it deserves, even though numerous studies have shown strong supporting evidence (Pedersen & Saltin, 2015:2;

Lobelo *et al.,* 2014:1; Coombes *et al.,* 2013:3; Sallis, 2009:3). Being physically inactive is socially accepted and exercise is not sufficiently encouraged (Wen & Wu, 2012:192). Numerous studies identified barriers for not meeting the PA recommendations and these barriers include self-efficacy, physical environment, low income, social support and a lack of time (Adachi-Mejia & Schifferdecker, 2016:213; Pekmezi *et al*., 2013:301-302; Schoeny *et al*., 2017:57). Limited organized efforts to increase PA levels, moving the populace from largely sedentary to active have been undertaken globally and therefore the constant increase of physical inactivity can be seen in both developing and developed (Wen & Wu, 2012:192).

Increased PA has a positive correlation with cardiorespiratory fitness and with other health benefits which include: improved cardiac health, BP, lipid profile, glucose levels, overall health and wellbeing (Sallis *et al.,* 2015:376; Sardinha, 2007:491).

2.5 Global trends in physical activity (PA) levels

Wilmot *et al*. (2012:2896) state that the majority of people spend their time being sedentary, either at home, at work, or during leisure time activities. Data from the US and Australia suggests that 83% of adults are seated for about 35 hours per week, where this measure takes only workplace behaviour into account (Van Uffelen *et al.,* 2010:380). A sedentary lifestyle often leads to the development of chronic lifestyle diseases (Saleh *et al.,* 2015:382). The movement to a service-based economy on a global scale has led to an increase in sedentary lifestyles, where technology makes it easy to remain physically inactive (Lewis *et al*., 2017:113). In the US, the Centre for Disease Control (CDC) (2015), found that only 25% of all Americans could be categorised as exclusively sedentary, with only 49.2% of the population meeting PA guidelines. According to Sallis *et al.* (2016:1327), 23.3% of the worldwide population do not meet the minimal recommendations for health related PA, this is however an improvement in so far as in 2012 31.1% of the population did not meet these recommendations.

Numerous clinical and observational studies suggest that moderate exercise can prevent the development of atherosclerosis and other chronic diseases (Durstine *et al.,* 2012:4,6; Ignarro *et al.,* 2007:237; Thompson *et al.,* 2003:3112; Warburton *et al.,* 2013:759). The focus on combatting morbidity and mortality should be placed on programmes to increase PA (Haskell *et al.,* 2007:1438). Unfortunately, global urbanization further development is counter to this goal (Henderson, 2010:515) leading to a global decrease in PA and an increase in sedentary behaviour (Attard *et al.,* 2015:153).

Urbanisation causes lifestyle changes that often result in an increase in risk factors such as obesity, FG, TG, HDL cholesterol and decreased PA (Gong *et al.,* 2012:844). This is supported by Abubakari *et al.* (2009:602) who state that the migration from rural to urban surroundings in African countries has contributed to the decline in PA. The increase in urbanisation results in health issues that require urgent attention in order to prevent an epidemic of chronic issues (Hallal *et al.,* 2012:247). Tremblay *et al*. (2010:727) illustrated the typical working day of adults globally so as to distinguish between time spent in sedentary activities and time spent active (Figure 2.2). This illustration is indicative of an immense problem concerning declining PA, as the vast majority of time is spent in sedentary activities. Only a few organised efforts exist to address physical inactivity. In both developed and developing countries programs concerning the improvement of PA status are limited and not seen as crucial (Kohl *et al.,* 2012:295).

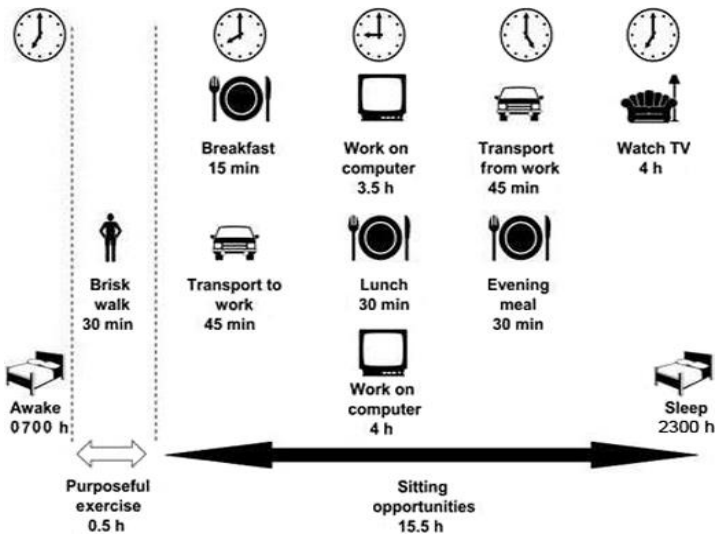


Figure 2-2: General distribution of sedentary behaviour of a typical adults' working day (From Dunstan et al., 2010a, reproduced with permission of Touch Briefings, European Endocrinology, Vol. 6, p. 20, # 2010)

2.6 The general public's knowledge of risk factors for the development of NDCS

Makamu (2014:60) and Puoane *et al.* (2006:59) conducted research in order to determine the prevalence of NCD risk factors and the corresponding perception of the participants in SA. The research showed that SA is in line with global trends where individuals have very limited knowledge, not only of NCDs, but also of the risk factors for developing NCDs (Makamu, 2014:60; Puoane *et al*., 2006:59). According to Kaba *et al*. (2017:801), younger individuals in SA consider health check-ups to be a waste of time and in the absence of trusted medical advice lose what could act as an impetus for the modification of unhealthy choices. The differences of perception regarding NCD risk factors show that younger individuals are more inclined to view risk factors negatively than older individuals are, as the study in Diepsloot with

2135 participants older than 20 years of age, SA shows (Kaba *et al*. 2017:803). This negative perception is especially marked as concerning as the perception of risk varies with 24% amongst the younger participants, irrespective of smoking (Kaba *et al*. 2017:803). Laurence *et al*. (2016:998) found similar findings with a 48.5% prevalence of hypertension, among the male and female participants older than 18 years, even though only 48.2% of these diagnosed participants reported to be on antihypertensive medication. Wu *et al*. (2015:92) noted a prevalence of hypertension (78%), obesity (45.2%), WC (63.9%) and coupled with a 59.7% incidence of physical inactivity among SA adults older than 18 years after multistage clustering were used. The SA participants in the study undertaken by Wu *et al*. (2015:91) represented a group of uneducated individuals of low incomeand lived in a rural setting, all of which are important factors as regards access to information and care. Another barrier to the awareness of NCDs and their risk factors is a high degree of illiteracy and unemployment (Hosseinpoor *et al*., 2012:913). The study by Wu *et al.* (2015:89) included teachers from different countries (China, Ghana, Mexico, India, Russia, and SA) and found the majority of participants lacking the knowledge or understanding of risk factors. This is significant in so far as teachers play an important role in the modification of learners' lifestyle behaviours and/or lifestyle choices through both education and example.

According to Glanz (as refered to by Conlin, 2014:7), Social Cognitive Theory (SCT) implies that human behaviour changes through the observation of other human actions, thus implying that a strong need for a credible role model for behaviour change exists. Teachers can therefore be seen to have an important degree of influence on their students as they are often viewed as role models and can increase awareness with regards to health-related PA and the importance thereof (Kaur, 2011:154; Morton *et al*., 2016:150; Natale *et al*., 2014:379). This statement is supported by Donnelly and Lambourne (2011: S40), who found that teachers engaging in PA had more learners who themselves engaged in PA. Learners spend most of their day at school and imitate their teachers' habits, thus plays an immense role in the promotion of healthy behaviours (Herrera *et al*., 2011:347; Morton *et al*., 2016:142).

Teachers have an important role in the broader community as well given that they work with children of different socio-economic, cultural, religious, and ethnic backgrounds (Engelbrecht *et al*., 2015:1). Teachers should therefore be among the most highly valued positions and yet they work under immense stress and in difficult environments (Dlamini *et al*., 2014:582). Long hours, poor remuneration and ungrateful students are some of the realities behind this profession (George *et al*., 2008:149; Kaur, 2011:152; Maphalala, 2014:78).

2.7 Summary

Combatting NCDs is a constantly growing battle affecting the health and well-being of individuals across social strata, across the globe (Alwan *et al.,* 2010:1861). Population trends in SA show evidence of unhealthy lifestyle choices with the consequences of these choices being exposure to risk factors which lead to the development of NCDs (Wagner & Brath, 2011:39).

Numerous risk factors for the development of NCDs can be modified by increasing PA and this can also offer a more accessible approach to improved health and overall well-being (Balboa-Castillo *et al.,* 2011:47). Teachers spend more than half their day in the presence of students whose lifestyle choices are still in the process of being defined. Students can thus be educated and taught at an early age about the risk factors for NCDs which may prevent the development of NCDs. Prevention is better than a cure and this is where the phrase: *"Exercise is medicine"* can be particularly instructive (Abegunde *et al.,* 2007:1935).

Global and SA statistics form an alarming picture that should motivate academia and policy-makers to formulate a plan of action combatting NCDs. The plan should not only include the identifying of barriers and the development of guidelines, but should also be cultural specific (Guthold *et al*., 2008:491). Physical inactivity, one of the risk factors of NCDs, is a common issue as the research and practice rarely align (Matheson *et al*., 2011:1276). The accurate measurement of PA is difficult to do in a developing country as SA (Warren *et al*., 2010b:131). SA has vast differences regarding culture, ethnicity, income levels and education levels proving a questionnaire difficult and inaccurate for the objective measurement of PA (Matheson *et al*., 2011:1276). Other barriers include eleven different languages making the interpretation of information challenging, activity differences from on the questionnaire and limitations in occupational and leisure time activities (Clark *et al*., 2009:13). Self-reported questionnaires have mainly been used by SA researchers as this method is simple and cost-effective, yet not as accurate. The ability to modify health behaviours, hopefully decreasing the prevalence of NCDs and risk factors is dependent on determining objective PAL. Using a direct approach as the Actiheart, the bias of selfreporting is eliminated. The Actiheart also provides both occupational and leisure time activity data (Barreira *et al*., 2009:69). SA is also diverse with various ethnicities; therefore a single set of recommended guidelines for behaviour modification is not sufficient (Alaba & Chola, 2013:64; Assah *et al*., 2011b:118). The current PA guidelines are based mainly on Caucasian individuals from developed countries. Moreover, improved results may be seen if intervention strategies can be derived from objectively measured PA and ethnic-specific risk factors or cut points.

CHAPTER 3 METHOD

3.1 Introduction

A concerning increase in the prevalence of non-communicable diseases (NCDs) and underlying unhealthy lifestyle choices remains a severe threat to health and well-being in developing countries (Nugent, 2016:371). Samb *et al*. (2010:1785) predict that NCDs will be responsible for 69% of global deaths by 2030. Diseases that can be classified as NCDs include: stroke, diabetes mellitus (DM), heart disease, obesity, cancer and mental disorders (Simpson & Camorlinga, 2017:117). According to the World Health Organisation (WHO), the most common risk factors for the development of NCDs are obesity (5%), elevated blood glucose concentration (6%), physical inactivity (6%), tobacco use (9%) and elevated blood pressure (BP) (13%) (WHO, 2018). Bauer *et al.* (2014:46), state that healthy behaviour and an active, healthy lifestyle can improve future health prospects, improve life expectancy and productivity, as well as decrease the risks of the development of NCDs. Most of the risks for the development of these NCDs can be limited by healthy behaviours and/or lifestyle changes (Saranummi *et al.,* 2013:21). The objectives of this study are, firstly, to investigate the occurrence of NCDs in African and Caucasian males and females in the North West Province of South Africa (SA) and, secondly, to determine the relationship between PA and NCDs in a cohort of urban African and Caucasian teachers in the North West Province of South Africa.

A strong positive relationship between physical inactivity and increased health risks has been found (Biswas *et al.,* 2015:123; Buckley *et al.,* 2015:4 & Dunstan *et al.,* 2010:389). Evidently, SA researchers agree on the increasing necessity for research on the occurrence of NCDs (Ibanez-Gonzalez *et al*., 2014:529; Nojilana *et al*., 2016:477; Puoane *et al*., 2012:115). Moreover, given South Africa's large ethnic diversity (Sliwa *et al.,* 2008:915), research should necessarily take the different risk factors for the development of NCDs among different ethnic and cultural groups into account. As previous research has shown, some risk factors for the development of NCDs differ between various ethnic groups, WC and sodium sensitivity being two such examples. The focus of this chapter is to elaborate/explain the method used to conduct the study that directs the research outcomes of this dissertation. This chapter presents the methodology for the study design conducted and the research that was performed. The study's limitations and ethical considerations are also included. All participants met the inclusion criteria [Phase I: 200 African teachers aged 25-60 years (male=100, female =100) and Phase II: 200 Caucasian teachers (n = male, 100 = female) aged 25-60 years] and all data used are complete. Data collection was done in 2011 and 2012, where data regarding the African teachers was collected in 2011 and the data regarding the Caucasian teachers during 2012.

3.2 Empirical research

3.2.1 Study design

This study forms part of the Sympathetic activity and Ambulatory Blood Pressure in Africans (SABPA II) prospective cohort study. The aim of the SABPA umbrella study was to identify the relationship between increased sympathetic nervous system activity and stress hormones, cardiovascular activity, metabolic syndrome indicators, and the renin-angiotensin-aldosterone system in African and Caucasian teachers of both genders (Malan *et al*., 2015:1815). Only the data gathered in 2011 and 2012 (SABPA II) was used for the purpose of this research. The data was gathered as part of a follow up of the first phase of the SABPA study. The first phase of the SABPA (SABPA I) study was conducted in 2008-2009. Participants were excluded from the umbrella study (SABPA II), if they: were pregnant or lactating; used alpha or beta blocker medication; self-reported abuse of psychotropic substances and/or had been vaccinated; or donated blood within three months prior to participation.

Data collection for SABPA II occurred in two separate phases in order to avoid seasonal influences, between February and May 2011 for the African participants (n=173) and between February and May 2012 for the Caucasian participants (n=186). For the SABPA II sub study, 143 participants were excluded for not wearing the Actiheart device for the full seven days as recommended by the study design. It is a cohort study where both phases followed a cross-sectional study design. The sub-study will investigate relevant data from the second phase as a longitudinal, observational research design; entirely dependent on data already obtained in the SABPA II study.

3.2.2 Participants

All participants of the SABPA I study were, three months before the start of SABPA II, invited to participate in the SABPA II study. Eighty-seven per cent of all participants in SABPA I was included in the SABPA II study. African and Caucasian South African school teachers (N=216), consisting of African males (n=52), African females (n=57), Caucasian males (n=52) and Caucasian females (n=55) with similar socio-economic status, were recruited from the Kenneth Kaunda district in the North West Province of SA. Participants (25-60 years) were invited to participate voluntarily.The participants' age groups were represented as follow: African males (25-30 years: n=0; 30-40 years: n=7; 40-50 years: n=27; 50-60 years: n=15 and older than 60 years: n=3); African females (25-30 years: n=1; 30-40 years: n=8; 40-50 years: n=22; 50-60 years: n=21 and older than 60 years: n=5); Caucasian males (25-30 years: n=2; 30-40 years:

n=3; 40-50 years: n=13; 50-60 years: n=25 and older than 60 years: n=9) and Caucasian females (25-30 years: n=1; 30-40 years: n=5; 40-50 years: n=20; 50-60 years: n=21 and older than 60 years: n=8). All participants were within similar socio-economic status, differences in culture and background can explain varying nutritional and lifestyle choices. Participants were informed of the process two months before the start of the study and assistance was provided in their home language in order to obtain informed consent for the study which participants signed. Approval for the SABPA I and II study was obtained from the North West Department of Education, as well as the South African Democratic Teachers Union and the Human Research Ethics Committee of the North West University (0003607S6).

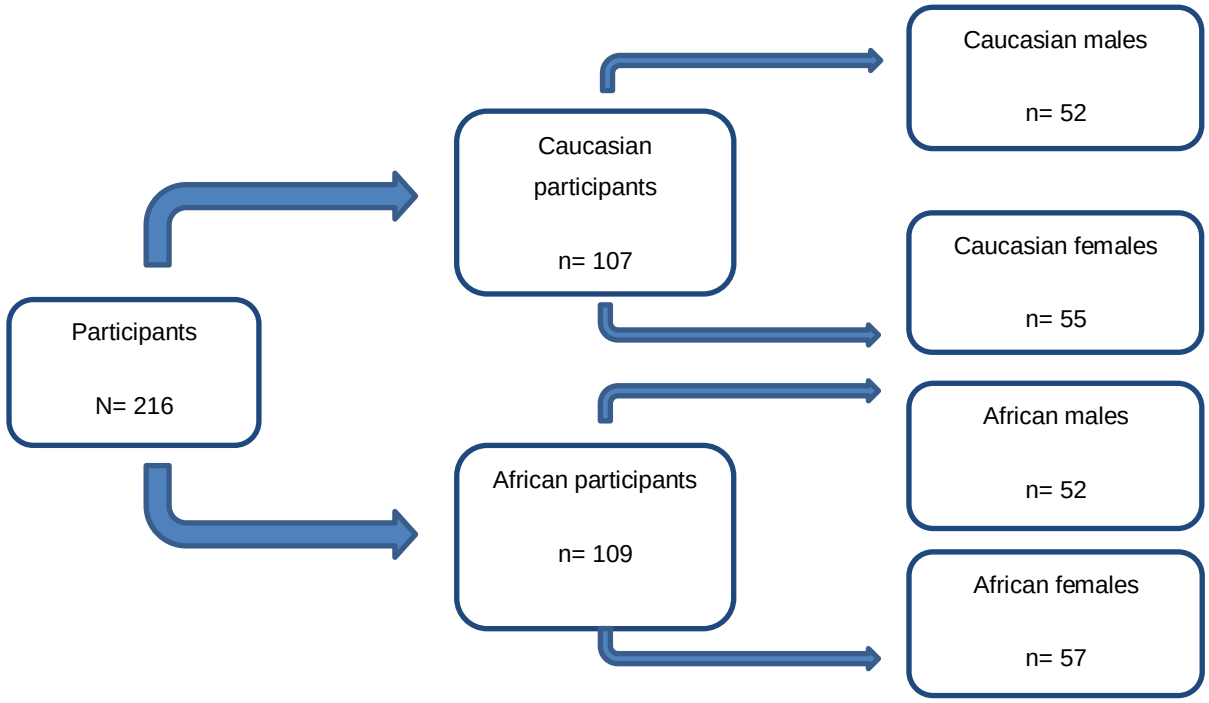


Figure 3-1: Flow diagram of participants in the SABPA II

3.2.3 Ethical considerations

This study required no interaction with the participants was needed. All participants signed an informed consent form that had been approved by the HREC of the NWU and complies with the World Medical Association Declaration of Helsinki (Ethical principles for medical research involving human subjects) (Appendix B). A letter granting consent for the use of statistical data was received from the principal investigator of the SABPA study, Professor Leone Malan (Appendix D).

Confidentiality was guaranteed by performing all the tests in a private room and data was password protected. The data is highly confidential as no identifiable markers are visible and no additional interaction with participants was required. A registered nurse collected all blood samples with sterilized equipment. Surgical masks and gloves were worn while handling and testing the blood samples and standardized procedures and methods were used. Disposal of bio hazardous waste was done using the approved and needed procedures according to good laboratory practices. A medical doctor was available at all times in case of an emergency. The anthropometric measurements were performed by level two qualified anthropometrists in a private closed room.

3.2.4 Measurements and apparatus

The following measurements were included in this study: seven-day objectively measured PA status, anthropometric measurements [body mass index (BMI) and waist circumference (WC) in centimetres (cm)] and cardio metabolic risk factors (24-hour ambulatory blood pressure (AMBP) in mmHg, fasting lipid profile [triglycerides (TC), high density lipoprotein (HDL) cholesterol, low density lipoprotein (LDL) cholesterol, triglycerides (TG)], liver enzymes (γ-GT) (alcohol misuse) and serum cotinine (smoking) and fasting glucose (FG) levels in ($mmol.L^{-1}$).

3.2.4.1 Physical activity (PA) measurement

The PA status of participants was measured with an ActiHeart (GB0/67703, CamNtech Ltd., Cambrigeshire, UK) device over a period of seven consecutive days. The ActiHeart objectively measures energy expenditure and has been validated against the doubly labelled water method (Brage *et al*., 2005:562). Assah *et al.* (2011:112) stated that the ActiHeart is a valid method for estimating daily free-living PA energy expenditure in Sub-Saharan Africa. This is a compact, chest-worn device consisting of a combined heart rate (HR) and accelerometer. Participants were asked to continue with their usual lifestyle, carrying the monitor at all times – even when showering/bathing/swimming. If the Actiheart became detached over the seven day period, they could reattach it with the two extra electrodes, as well as an extra plaster that they received. Following the recording session, data were transferred to the computer for analysis. Total energy expenditure (TEE), resting energy expenditure (REE) and active energy expenditure (AEE) were expressed in kcal/week as well as in metabolic equivalents (METs) for each participant over the seven day data recording period. In order to determine the different physical activity levels (PAL), TEE was divided by REE (James & Schofield, 1990) and participants were classified according to their PAL.

Table 3-1: The Physical Activity Level index (James & Schofield, 1990)

Physical Activity Level (PAL)		Day activity
PAL 1	1.2 – 1.4	Sedentary job, no habitual exercise, general household chores, low activity hobbies such as reading.
PAL 2	1.5 – 1.7	Sedentary job, no habitual exercise, general household chores, active hobbies such brisk walking, cycling and tennis.
PAL 3	1.8 – 2.0	Semi-active job (nurse, shop assistant), household chores, and some active hobbies.
PAL 4	2.1 – 2.3	Active job (builder, tennis coach, and reasonably active lifestyle.
PAL 5	2.4 – 2.6	Highly Active job (athlete, labourer), active lifestyle.

3.2.4.2 Anthropometric measurements

The anthropometric measurements were measured in triplicate by level II Anthropometrists and the median was used as the final score. Participants were requested to be in minimal clothing wearing neither shoes nor socks (Marfell-Jones *et al*., 2006:62). The measurements were taken using calibrated instruments.

3.2.4.2.1 Stature

The stature was measured with a stadiometer (Invicta Stadiometer, IP 1465; Invicta, London, UK) to the nearest 0.1cm. Participants were asked to remove their shoes and socks and their head was placed in the Frankfort plain before a measurement was taken (Marfell-Jones *et al*., 2006:58-89).

3.2.4.2.2 Body mass

Body mass was measured three times (Precision Health Scale; A&D company, Tokoyo, Japan) using the KRUPS scale to the nearest 0.1kg. The participants had minimal clothing on for this measurement and the average of the three measurements were used (Marfell-Jones *et al*., 2006:57).

3.2.4.2.3 Body mass index (BMI)

The BMI ($kg.m^{-2}$) was calculated by dividing body weight in kilograms by height in metres squared (ACSM, 2014:63). The use of BMI as a measurement for the risk of overweight and obesity has been validated and deemed to represent a reliable statistic variable (Dobbins *et al*., 2013:17; Waters *et al*., 2011:3). The cut-off points used to determine whether an individual was at risk were as follows: for an underweight BMI a cut-off of BMI ≤18.5 $kg.m^{-2}$, for a healthy BMI a cut-off of 18.5–24.9 $kg.m^{-2}$,for overweight a cut-off of 25–29.9 $kg.m^{-2}$ BMI was used, whereas obesity was set at a BMI ≥ 30 $kg.m^{-2}$ (Bakir *et al*., 2016:3).

3.2.4.2.4 Girths

Girths were measured by making use of the cross-hand technique. Constant tension was applied with no indentation of the skin when the tape surrounded a segment (Marfell-Jones *et al.,* 2006:79). Girths were measured in cm. The waist circumference (WC) was taken at the midpoint between the lower costal border and the iliac crest perpendicular to the long axis of the trunk (Marfell-Jones *et al.,* 2006:87). A waist girth ≥102 cm for males and $\geq$88 cm for females is seen as a cut-off points which is used to determine whether WC is a risk factor (Uthman *et al.,* 2015:7).

3.2.4.3 Cardio metabolic risk factors

3.2.4.3.1 Blood pressure (BP)

A 24-hour AMBP was obtained during the working week with the Cardiotens apparatus (Meditech CEO120®, Budapest, Hungary, British Hypertension Society (BHS) validated) with the appropriate cuff size being used for each participant. The measurements were taken each morning at 08:00 and the apparatus measured blood pressure every 30 minutes on the non-dominant arm throughout the day up to 22:00. From 22:00 to 06:00 it was set to measure blood pressure every 60 minutes. Participants were woken at 06:00 and the ABPM device was removed for analysis. The data from BP testing was downloaded into a database using the CardioVisions 1.9.0 Personal Edition (Meditech). The ABPM was repeated the following day for participants who had completed <75% of the 24-hour ABPM (seen as an incomplete measurement). BP (mmHg) was also measured with a sphygmomanometer and stethoscope (1.3M ™ Littman® II S.E. Stethoscope 2205, Riester CE 0124, No. 1010-108 Diplomat-presameter®, Germany) on the left arm at rest and again after five minutes using the Riva-Rocci/Korotkoff method (Verrij *et al*., 2008:481). Participants rested for ten minutes in a semi-

recumbent position before the first measurement was taken. The second measurement was used for analyses. The cut-off points used to analyse BP data were the following: a mean daytime measurement from 130-139 and/or 80-89 mmHg (ACSM, 2014:46) was seen as pre-hypertensive whereas a reading ≥140 and/or 90mmHg was seen as hypertensive (ACSM, 2014:296).

3.2.4.3.2 Lipid profile

Participants rested in a semi-recumbent position for one hour before blood sampling began. A fasting blood sample of 65ml was obtained from the dominant arm by a registered nurse from the brachial vein branches using a winged infusion set with syringes for the preparation of serum, in sodium fluoride tubes. The serum samples for TC were analysed with the sequential multiple analyser computer (Konelab 20i; Thermo Scientific, Vantaa, Finland). The cut-off points that were used for the lipid profile are as follow: TC ≥5.18 $mmol.L^{-1}$, HDL cholesterol of ≤1.04 $mmol.L^{-1}$, LDL cholesterol ≥3.37 $mmol.L^{-1}$ and or TG of ≥1.69 $mmol.L^{-1}$ (ACSM, 2014:46).

3.2.4.3.3 Fasting glucose

A fasting blood sample of 65ml was obtained from the dominant arm by a registered nurse from the brachial vein branches using a winged infusion set with syringes for preparation of serum and NAF glucose. The Olympus AU 2700 analyser (Olympus UK, London, UK) was used to determine serum glucose. All samples were handled by a registered nurse and sent to an independent laboratory with a runner immediately after sampling for later biochemical analyses. The samples were blinded as concerns the participant. Independent laboratories were used for the analysis of the data with no pre-existing knowledge of the cardiovascular profile of each participant in order to ensure confidentiality and accuracy. A fasting glucose level of ≥5.55 $mmol.L^{-1}$ is used as the cut-off point for determining whether a risk factor exists (ACSM, 2014:48).

3.2.4.3.4 Tobacco and Alcohol use

A fasting blood sample of 65ml was obtained from the dominant arm by a registered nurse from the brachial vein branches using a winged infusion set with syringes for preparation of serum and NAF glucose. Liver enzymes (γ-GT) (alcohol misuse) and serum cotinine (smoking) were analysed by the Konelab™ 20I Sequential Multiple Analyzer Computer, ThermoScientific, Vantaa, Finland.

3.3 Procedures

Data of the African and Caucasian teachers participating in the SABPA II were collected from February 2011 until to May 2012. The data were collected in two separate time frames; from February to May 2011, as concerns the African participants and from February to May 2012, for the Caucasian participants. Four participants were tested on each day of the time frame with the clinical tests taking place over two days. Data collection continued over an eight-day period.

DAY ONE:

On day one, at 07:00, the Cardiotens apparatus (24-hour ambulatory and electrocardiogram [ECG]) was fitted to four participants (this process was performed on four participants every day of the week from February to May). An explanation of the 24-hour controlled diet and urine sampling was given in order to ensure a better understanding of the procedures. Containers and a cooler box were given to each participant and the use thereof explained. The participants were told to resume their normal daily activities.

At approximately 17:00 to 18:00 participants were transported from the physiology department to the Metabolic Unit Research Facility of the NWU. Participants stayed overnight in private rooms and the protocol that would be followed during the second day of testing was explained. After completing a psychosocial battery questionnaire, the participants enjoyed a standardised dinner. Participants were asked to restrain from consuming any food or drink after 22h00 as measurements should be taken after fasting for accuracy.

DAY TWO:

Participants woke at 07:00 after which the Cardiotens apparatus was disconnected. The resting cortisol saliva sampling and the last 24-hour urine sample were taken. The anthropometric measurements were taken by the anthropometrists. After these measurements were taken, participants were instructed to rest for 60 minutes in the semi-recumbent position as to evade the cortisol awakening response, before the initiating the blood sampling. Samples were obtained from the dominant arm by a registered nurse from the brachial vein branches using a winged infusion set with syringes for preparation of serum, NaF glucose and EDTA plasma. A 65ml resting blood sample was taken between 08:30 and 09:30. All blood samples were immediately sent to the laboratory with a runner.

The Actiheart device was fitted and set to measure the seven-day PA status of each participant. The device was set to start collecting data at 11:00. Participants were shown the instructions of

the device in order to reattach it if necessary. They were also given two extra electrodes and plaster if needed. The participants were also instructed to secure the device immediately if it detached during the seven days of normal daily activity. Participants had breakfast after the completion of all data collection and were transported back to their separate schools at 11:00.

After seven days (day eight of data collection), PhD students returned to the schools in order to disconnect the Actiheart devices and to ensure that the data was transferred to the computer for storage, viewing, and analysis.

3.4 Statistical analysis

Data analyses were performed by using SPSS version 20 (IBM Corp. Released 2011. IBM SPSS Statistics for Windows, Version 20.0. Armonk, NY: IBM Corp). Participants were grouped into four different groups: African males, African females, Caucasian males, and Caucasian females. Descriptive statistics were calculated using a one-way analysis of variance and were expressed as mean (M), standard deviations (SD), as well as 95% confidence intervals (CI). Departure from normality was evaluated using the Levene test for equality of variances and skewed data was normalised.

Interaction on main effects (gender and ethnicity) was tested with a two-by-two ANOVA to determine significant differences in variables (anthropometric, cardio metabolic risk factors and the PA status) which were also adjusted for age differences.

Next, the prevalence of NCD risk factors was calculated and reported as frequencies using chi-square statistics for each group (African males, African females, Caucasian males and Caucasian females) within the sub-classification of the non-active group (PAL 1 & 2) and the active (PAL 3-5) group. The frequency of PAL in each different category (PAL 1 and 2: sedentary, PAL 3: semi active, PAL 4: moderate active and PAL 5: vigorous active) among the different groups was then presented. The prevalence of NCD risk factors in the non-active (PAL 1 and 2) and active (PAL 3-5). Covariates that were considered included: cardiovascular risk confounders such as age, gender and smoking. Values were seen as statistically significant if $p \leq 0.05$ and considered as a two sided hypotheses.

Lastly, multivariable logistic regression models were used on the group as a whole so as to determine the influence of PA status (being non-active, PAL 1&2 as the independent variable) on the NCD risk factors (dependent variables individually modelled: WC, FG, TG, HCL, SBP and

DBP as the independent variables). Adjustments were made for the following covariates: race, gender, smoking, alcohol consumption, age and BMI (Landau & Everitt, 2004:123; SPPS instruction manual).

3.5 Summary

The sub-study will investigate relevant data from the second phase of the SABPA II study as a longitudinal, observational research design; entirely dependent on data already obtained in the SABPA II study. African and Caucasian teachers (N=216), consisting of African males (n=52), African females (n=57), Caucasian males (n=52) and Caucasian females (n=55) with the same socio-economic status, were recruited in the Kenneth Kaunda District in the North West Province of South Africa. The following measurements were included for the purpose of this study: 7-day PA; cardio metabolic risk factors [BMI, WC, 24-hour SBP and DBP, lipid profile and FG, liver enzymes (γ-GT) (alcohol misuse) and serum cotinine (smoking)]. The methods were chosen to investigate the prevalence of NCDs and determine the association between PA status and NCDs in a cohort of urban African and Caucasian male and female teachers in the North West Province of South Africa.

CHAPTER 4 RESULTS AND DISCUSSION

4.1 Introduction

The primary aim of the current study is to investigate the prevalence of NCD risk factors within a cohort of African and Caucasian male and female teachers of the North West Province and secondly, to determine the association between PA status and NCD risk factors in the above mentioned group.

4.2 Results

The results are reported and discussed in accordance with the objectives provided in Chapter one. Firstly, the descriptive statistics are reported (Figures 4.1 and Tables 4.1), categorized into the four different groups (African males, African females, Caucasian males and Caucasian females). Thereafter the prevalence of NCD risk factors is presented in terms of both the group (Figure 4.2) and the different subgroups (Figures 4.3 A-D). The frequency of PAL in each different category (PAL 1 and 2: sedentary, PAL 3: semi active, PAL 4: moderate active and PAL 5: vigorous active) among the different groups is then presented in Figures 4.4 A-D. The prevalence of NCD risk factors in the non-active (PAL 1 and 2) and active (PAL 3-5), categorized in terms of the four subgroups are reported in Figures 4.5 A-D. The results conclude with the logistic regressions of the variables [waist circumference (WC), high density lipoprotein (HDL) cholesterol, triglycerides (TG), fasting glucose (FG), systolic blood pressure (SBP), diastolic blood pressure (DBP), total energy expenditure (TEE), resting energy expenditure (REE) and active energy expenditure (AEE)] among the total group with PAL (inactive), where Race, Gender, Smoking, Alcohol consumption, Age and BMI considered as covariates (Table 4.2).

4.2.1 Participants

The Dr Kenneth Kuanda Education district, North West Province of SA, consists of forty three schools. For the original SABPA study, all teachers of the schools were invited to participate (N=2170). The volunteers complying with the inclusion and exclusion criteria were then enrolled in the SABPA I study (n=409). Two hundred and sixteen (N=216) African and Caucasian teachers (112 females and 104 males) participated in the SABPA II follow-up study. Participants were teachers recruited from the Dr Kenneth Kaunda district in the North West Province of SA. The participants represented a similar socio-economic status with both genders residing in an

urban area. Participants were further categorized into four subgroups: African males (n=52), African females (n=57), Caucasian males (n=52) and Caucasian females (n=55). Figure 4.1 represents the ethnic and gender dispersion of the participants.

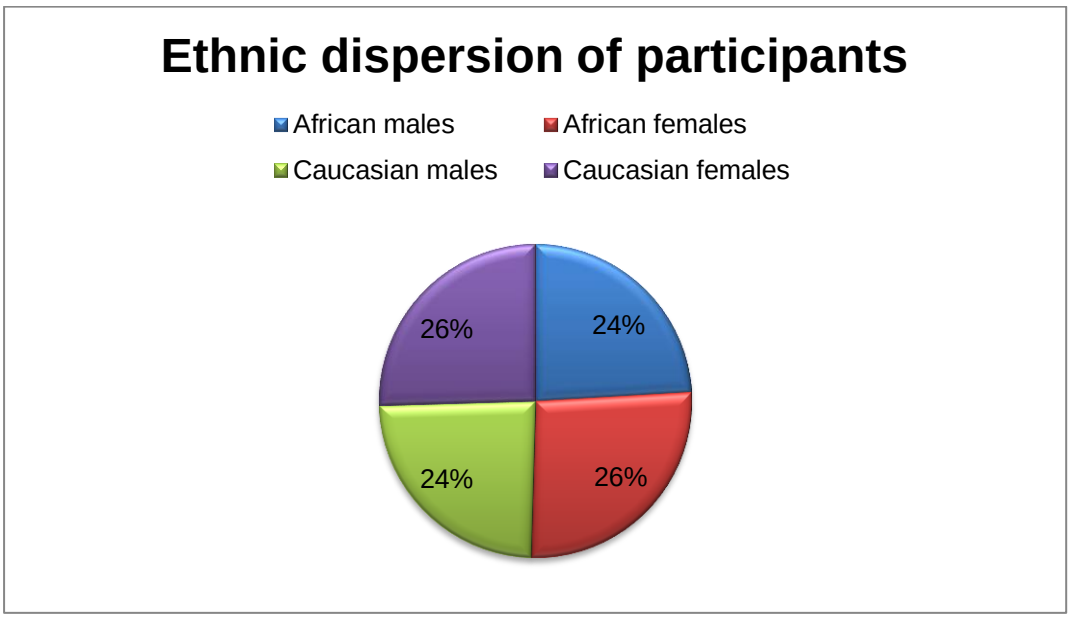


Figure 4-1: Ethnic dispersion of participants in the SABPA II

4.2.2 Descriptive statistics

The descriptive characteristics of the participants are presented in Table 4.1. The mean age of the group (N=216) was 49 years (±8.6). Caucasian males (n=54; 51.58 years ±8.91) were the eldest, followed by Caucasian females (n=50; 50.57 years ±8.47), African females (n=47; 47.79 years ±8.54) and African males (n=48; 43 years ±7.98). Age did not however differ significantly (p=0.86) between the groups. Statistical differences were determined by the use of ANOVA analysis. Waist circumference (WC) values also indicated statistically significant differences (p≤0.001) between the groups, with the highest value found among Caucasian males (104.0 ±10.44 cm) followed by African males (100.91±14.75 cm), African females (96.58±15.85 cm) and Caucasian females (84.22 ±12.65 cm). Only Caucasian males had a WC value above the cut-off point (≥102cm) which indicates a heightened risk for the development of cardiometabolic diseases.

BMI values indicated statistically significant differences between the groups ($p \leq 0.001$) with African females having the highest BMI (32.44±6.49 $kg.m^{-2}$), followed by Caucasian males (29.29±3.89 $kg.m^{-2}$), African males (28.84±5.45 $kg.m^{-2}$) and Caucasian females with the lowest BMI value (26.13±6.30 $kg.m^{-2}$). All four groups presented with a heightened health risk in terms of BMI values and three of the four groups were classified as overweight (25–29.9 $kg.m^{-2}$) while one group (African females) was classified as obese (≥30 $kg.m^{-2}$) (ACSM, 2014:318).

With regards to the lipid profile of the participants, statistically significant differences in total cholesterol (TC) values ($p \leq 0.001$), high-density lipoprotein (HDL) cholesterol ($p = 0.001$) and triglyceride (TG) ($p \leq 0.001$) values were found between all four groups. African males had the highest TC value (4.96±1.06 $mmol.L^{-1}$), followed by African females (4.48± 0.98 $mmol.L^{-1}$), Caucasian females (4.35±1.11 $mmol.L^{-1}$) and Caucasian males (4.17 $mmol.L^{-1}$± 0.84). All of the groups were however within the recommended ranges for TC. Considering HDL-C values, both male groups presented with a more vulnerable value for HDL cholesterol as compared to their female counterparts and can be classified as being within the increased risk profile for developing CVD, in so far as their HDL cholesterol values are ≤1.04 $mmol.L^{-1}$. The lowest value was recorded in Caucasian males (0.86±0.23 $mmol.L^{-1}$), followed by African males (0.92± 0.27 $mmol.L^{-1}$), African females (1.07± 0.31 $mmol.L^{-1}$) and Caucasian females (1.29±0.35 $mmol.L^{-1}$).

Only African males (1.78±1.12 $mmol.L^{-1}$) fell within the risk category for TG having values that were ≥1.69 $mmol.L^{-1}$ (ACSM, 2014:46). African males presented with the highest TG value (1.78±1.12 $mmol.L^{-1}$) followed by Caucasian males (1.34±0.66 $mmol.L^{-1}$), African females (1.07±0.60 $mmol.L^{-1}$) and Caucasian females with the lowest (0.83±0.43 $mmol.L^{-1}$) value.

Table 4-1: Descriptive Statistics

	African males (n=52)		African females (n =57)		Caucasian males (n=52)		Caucasian females (n=55)		p-value
Variables	**Mean ± SD**	**Median[25%; 75%]**	**Mean ± SD**	**Median [25%; 75%]**	**Mean ± SD**	**Median[25%; 75%]**	**Mean ± SD**	**Median[25%; 75%]**	
Age (years)	43 (± 7.98)	48 [45.87;50.72]	47.79 (± 8.54)	47 [45.28;50.30]	51.58 (± 8.91)	54.0 [49.10;54.06]	50.57 (± 8.47)	50.0 [48.26;52.89]	0.86
Body Mass (kg)	85.82 (±17.53)	83.45 [80.49; 91.15]	79.98 (±18.28)	79.80 [74.51; 85.24]	95.94 (±13.45)	95 [92.20; 99.69]	71.58 (±17.23)	68.40 [66.87; 76.28]	**≤0.001***
Stature (m)	172.47 (±6.73)	171.75 [170.42; 174.51]	158.21 (±4.99)	157.10 [156.75; 159.68]	181.11 (±6.07)	181.10 [179.42; 182.80]	165.51 (±5.41)	165.70 [164.03; 166.99]	**≤0.001***
BMI ($kg.m^{-2}$)	28.84 (± 5.45)	28.83 [27.18;30.50]	32.44 (± 6.49)	31.29 [30.53;34.34]	29.29 (± 3.89)	29.16 [28.21;30.38]	26.13 (± 6.30)	25.11 [24.41;27.85]	**≤0.001***
WC (cm)	100.91 (± 14.75)	99.05 [96.42;105.39]	96.58 (± 15.85)	97.80 [91.93;101.24]	104.0 (± 10.44)	102.87 [101.10;106.91]	84.22 (± 12.65)	82.94 [80.76;87.67]	**≤0.001***
HDL ($mmol/L^{-1}$)	0.92 (± 0.27)	0.91 [0.84;1.0]	1.07 (± 0.31)	1.00 [0.98;1.17]	0.86 (± 0.23)	0.85 [0.80;0.93]	1.29 (± 0.35)	1.23 [1.20;1.39]	**0.001***
TG ($mmol/L^{-1}$)	1.78 (± 1.12)	1.41 [1.44;2.12]	1.07 (± 0.60)	0.97 [0.90;1.25]	1.34 (± 0.66)	1.22 [1.16;1.53]	0.83 (± 0.43)	0.78 [0.72;0.95]	**≤0.001***
FG ($mmol/L^{-1}$)	6.26 (± 2.99)	5.52 [5.35;7.17]	5.01 (± 0.88)	4.87 [4.75;5.27]	4.75 (± 1.20)	4.66 [4.42;5.09]	4.18 (± 1.44)	4.12 [3.78;4.57]	**≤0.001***
AMPB SBP (mmHg)	140.9 (± 17.12)	141.04 [135.71;146.11]	129.13 (± 21.08)	122.0 [122.94;135.32]	127.98 (± 13.58)	128.0 [124.20;131.76]	117.48 (± 10.97)	114.50 [114.49;120.48]	**≤0.001***

AMBP DBP (mmHg)	94.50 (± 10.30)	93.0 [91.37;97.63]	84.40 (± 10.37)	85.00 [81.36;87.45]	86.94 (± 9.17)	88.0 [84.39;89.50]	78.33 (± 8.89)	80.0 [75.91;80.76]	**≤0.001***
PAL	2.02 (±0.70)	1.70 [1.34;4.13]	2.17 (± 0.56)	2.03 [1.48;3.65]	2.03 (± 0.83)	1.69 [1.24;5.15]	2.01 (± 0.48)	1.98 [1.30;3.13]	**≤0.001***
TEE (kCal/week)	3183.90 (± 1262.48)	2781.14 [1718.29;7376.14]	3139.30 (± 1371.89)	2681.43 [1814.57; 10657]	3925.29 (±1614.49)	3228.64 [2244.57;10152.29]	2838.96 (±772.98)	2809.86 [1643.86;4937]	**≤0.001***
REE (kCal/week)	1692.71 (±229,34)	1671.36 [1279.29;2245.50]	1677.53 (±571.23)	1630.29 [291.21;5296.14]	1938.72 (±181.96)	1939.07 [1437.43;2667.29]	1411.47 (±153.56)	1361.0 [1162.43;2037.43]	**≤0.001***
AEE (kCal/week)	1172.77 (± 1082.80)	802.07 [91.14; 4636.71]	1122.24 (±897.80)	819.43 [64.21;4295.57]	1593.99 (± 1444.97)	1059.36 [228.29;7149.86]	1143.59 (±626.15)	1140.71 [227.29;2491.00]	**≤0.001***

BMI= Body Mass Index; WC= Waist Circumference; FG= Fasting Glucose; TC= Total Cholesterol; HDL= High-Density Lipoprotein; TG= Triglycerides; AMPB SBP= Ambulatory Monitoring of Systolic Blood Pressure; AMPB DBP= Ambulatory Monitoring of Diastolic Blood Pressure; TEE= Total Energy Expenditure; REE= Resting Energy Expenditure; AEE= Active Energy Expenditure; PAL= Physical Activity Level; kCal= Kilocalories. *Significant p value at a level 0.05 level

Statistical significance in the differing FG values between the groups ($p \leq 0.001$) was also shown. African males were recorded as having the highest values (6.26±2.99 $mmol.L^{-1}$), followed by African females (5.01±0.88 $mmol.L^{-1}$), Caucasian males (4.75±1.20 $mmol.L^{-1}$) and Caucasian females (4.18±1.44 $mmol.L^{-1}$). Both African groups were seen to have significantly higher FG values as compared to their Caucasian counterparts, nevertheless only African males (6.26±2.99 $mmol.L^{-1}$) fell within the risk category for FG with values ≥5.55$mmol.L^{-1}$ (ACSM, 2014:48).

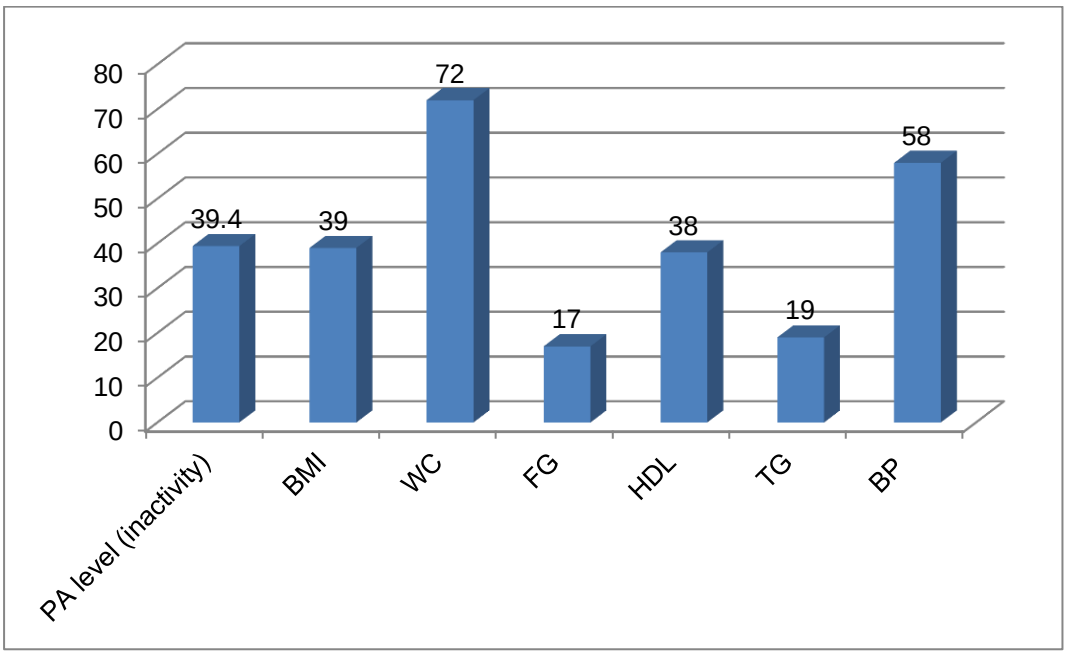
Statistically significant differences were found between the various groups with regards to both SBP ($p \leq 0.001$) and DBP ($p \leq 0.001$). African males had the highest SBP values (140.9±17.12 mmHg) followed by African females (129.13± 21.08 mmHg), Caucasian males (129.13±21.08 mmHg) and Caucasian females (117.48±10.97 mmHg). DBP values showed similar trends in so far as African males were recorded as having the highest DBP values (94.50±10.30 mmHg) followed by Caucasian males (86.94 ±9.17 mmHg), African females (84.40±10.37 mmHg) and Caucasian females (78.33±8.89 mmHg). African males can be classified as hypertensive (SBP≥140 and/or DBP≥90mmHg) in so far as both their SBP (140.9 mmHg) and DBP (94.50 mmHg) mean values exceed the recommended values; African females (129.13 mmHg; 84.40 mmHg) and Caucasian males (127.98 mmHg; 86.94 mmHg) can be considered as pre-hypertensive (SBP 130-139 and/or DBP 80-89 mmHg) (ACSM, 2014:44).

Differences in PAL also showed statistical significant differences ($p \leq 0.001$): African females had the highest PAL value (2.17 ±0.56) with a PAL classification of 4 (active), followed by Caucasian males (2.03 ±0.83, PAL of 3 = semi-active), African males (2.02 ±0.70, PAL of 3 = semi-active) and Caucasian females (2.01 ±0.48, PAL of 3 = semi-active).

Statistically significant differences ($p \leq 0.001$) in total energy expenditure (TEE) values, resting energy expenditure (REE) and active energy expenditure (AEE) were recorded. Caucasian males were recorded as having the highest TEE value (3925.29 ±1614.49 kCal/week), followed by African males (3183.90±1262.48 kCal/week), African females (3139.30±1371.89 kCal/week) and Caucasian females (2838.96±772.98 kCal/week). Concerning REE, Caucasian males had the highest value (1938.72 ±181.96 kCal/week), followed by African males (1692.71 ±229.34 kCal/week), African females (1677.53 ±571.23 kCal/week) and Caucasian females (1411.47 ±153.56 kCal/week). Caucasian males had the highest AEE value among the groups (1593.99 ±1444.97 kCal/week), followed by African males (1172.77 ±1082.80 kCal/week), Caucasian females (1143.59 ±626.15 kCal/week) and African females (1122.24 ±897.80 kCal/week).

4.2.3 Prevalence of NCD risk factors among participants

NCD risk factor prevalence for the total group is presented in Figure 4.2 and is broken down in terms of the four different ethnic and gender groups in Figures 4.3 A-D.



BMI= Body Mass Index; WC= Waist Circumference; FG= Fasting Glucose; HDL= High Density Lipoprotein; TG= Triglycerides; BP= Blood Pressure (SBP≥140 and/or DBP≥90 mmHg); PA inactivity (PAL level 1 and 2)

Figure 4-2: The prevalence of NCD risk factors in the total group of participants

Figure 4.2 illustrates the prevalence of the various risk factors (using the cut-off points indicated in chapter 3) for the development of NCDs for the total participant group. WC (72.2%) is the risk factor with the highest prevalence (Figure 4.2) followed by elevated BP (57.9%) and physical inactivity (39.4%). A third of the participants also had BMI (38.9%) and HDL-C (38%) values falling within their respective risk categories.

Figure 4.3 – 4.6: NCD risk factor % prevalence in the different groups

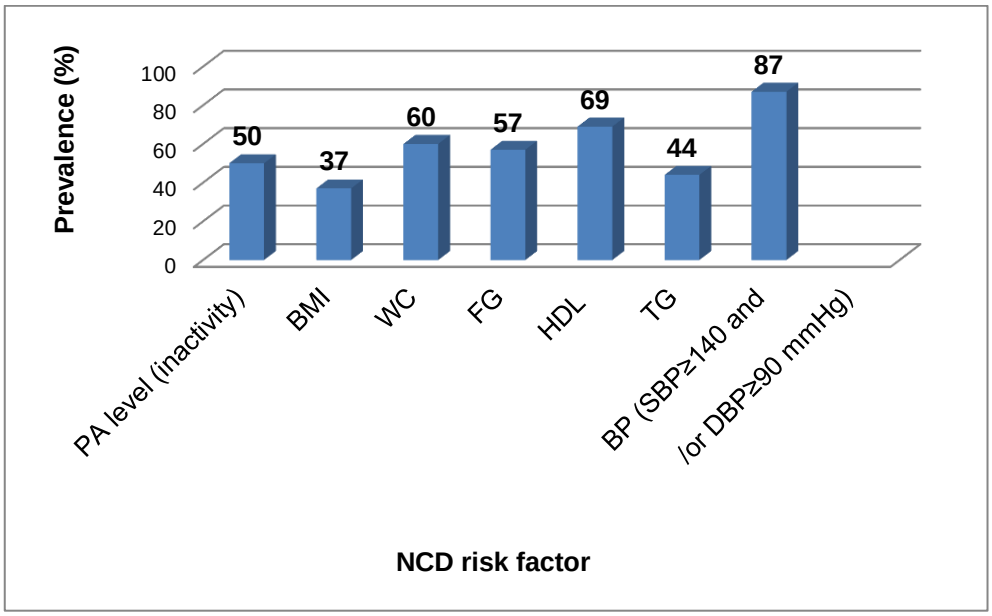


Figure 4-3: NCD risk factor % prevalence in African males

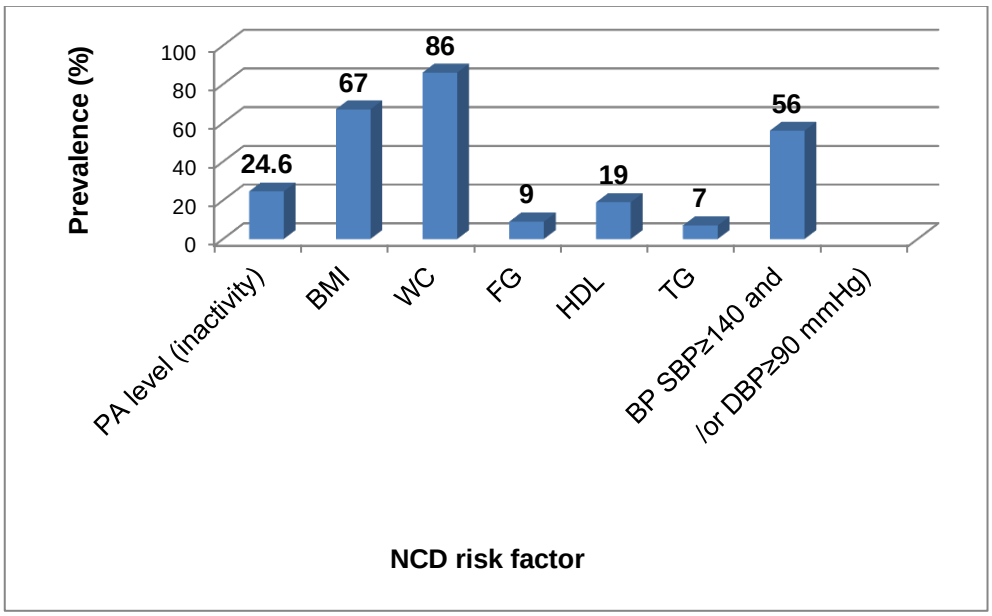


Figure 4-4: NCD risk factor % prevalence in African females

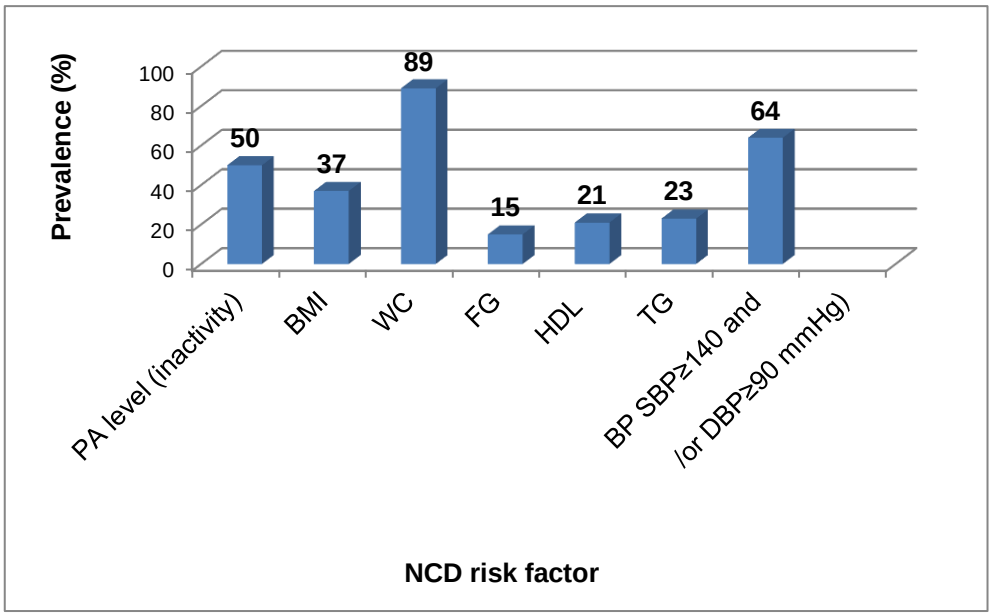


Figure 4-5: NCD risk factor % prevalence in Caucasian males

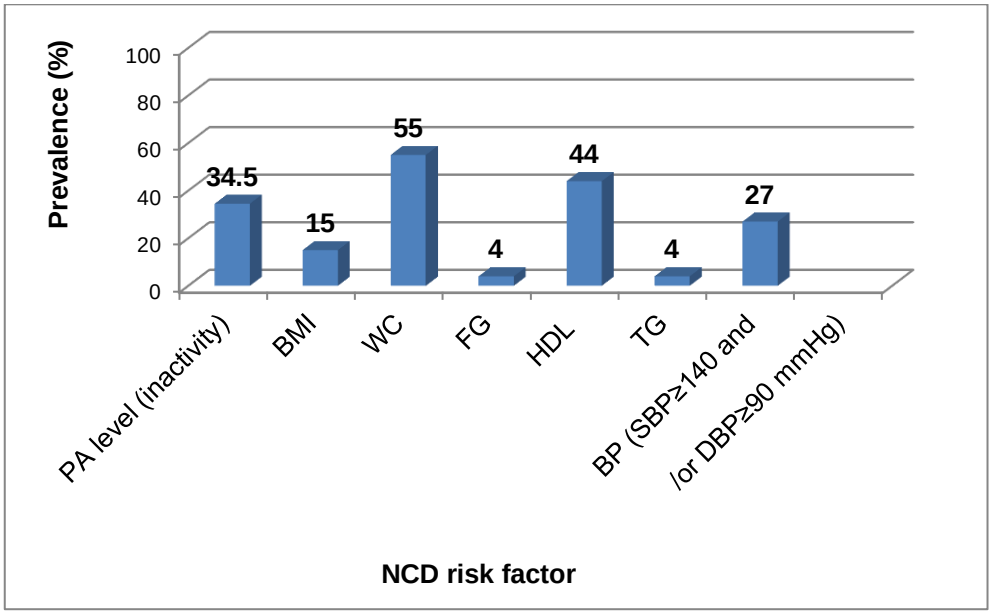


Figure 4-6: NCD risk factor % prevalence in Caucasian females

NCD risk factor prevalence was highest among African males (five of the variables show a prevalence of more than 50%), followed by African females and Caucasian males (three of the risk factors at a higher than 50% prevalence), and Caucasian females (one risk factor with a prevalence of above 50%).

Physical inactivity was highest in both African males (50%) and Caucasian males (50%), followed by Caucasian females (34.5%) and African females (24.6%). African females had the highest BMI value (67%), followed by African males (37%), Caucasian males (37%) and Caucasian females (15%). Caucasian males were recorded as having the highest incidence of elevated WC (89%), followed by African females (86%), African males (60%), and Caucasian females (55%). FG risk factors were much higher in African males (57%), followed by Caucasian males (15%), African females (9%) and Caucasian females (4%). African males were also recorded as having the highest HDL risk factor values (69%) followed by Caucasian females (44%), Caucasian males (21%) and African females (19%). TG risk factors were also significantly higher in African males (44%), followed by Caucasian males (23%) while African females (7%) and Caucasian females (4%) had a substantially lower incidence of TG risk factors. Lastly, the incidence of BP as a risk factor was highest in African males (87%), followed by Caucasian males (64%), African females (56%) and Caucasian females (27%).

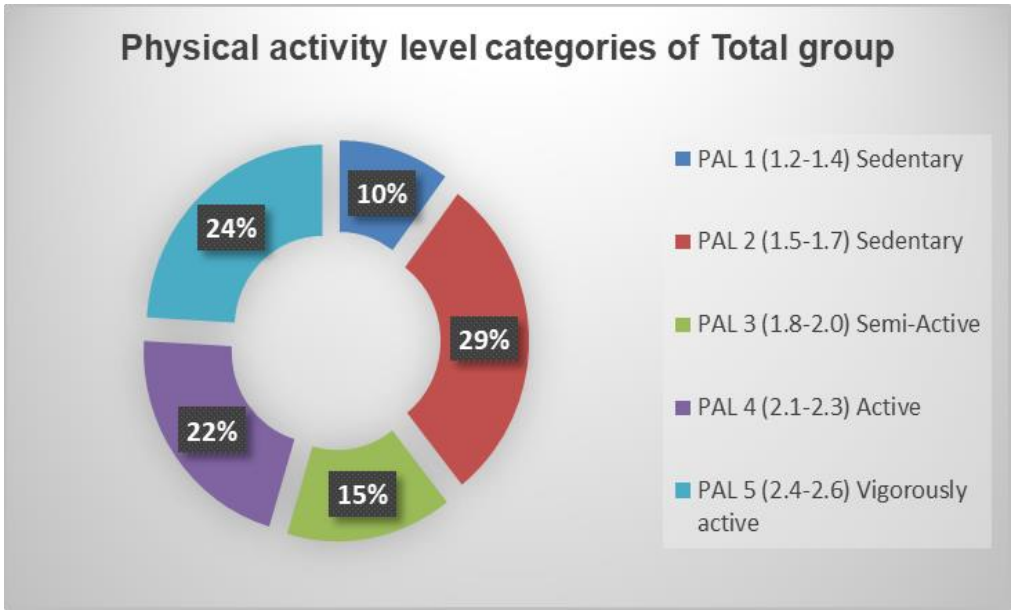


Figure 4-7: Physical activity level (PAL) categories of the total group

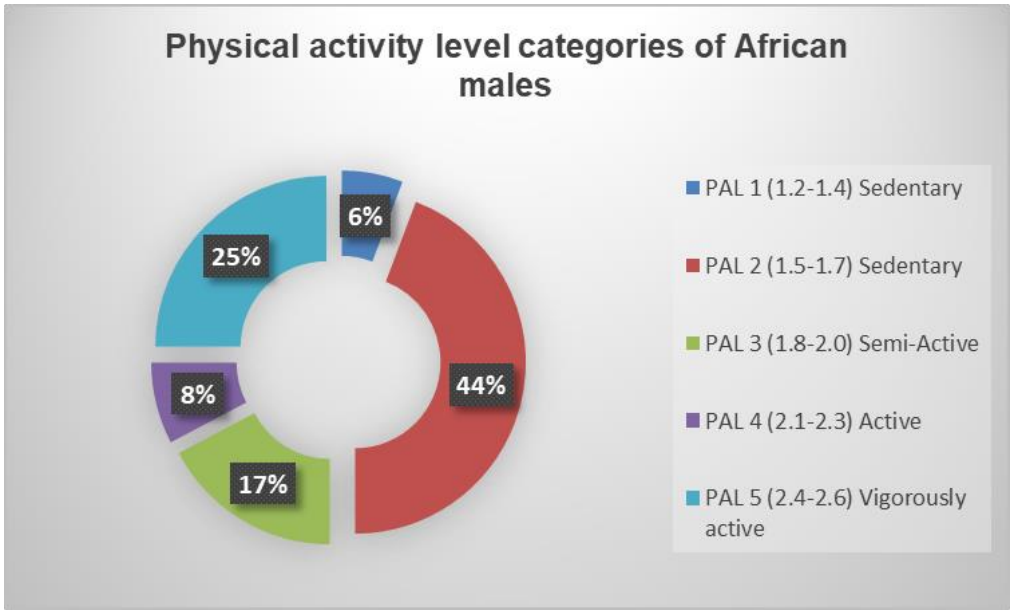


Figure 4-8: Physical activity level categories of African males

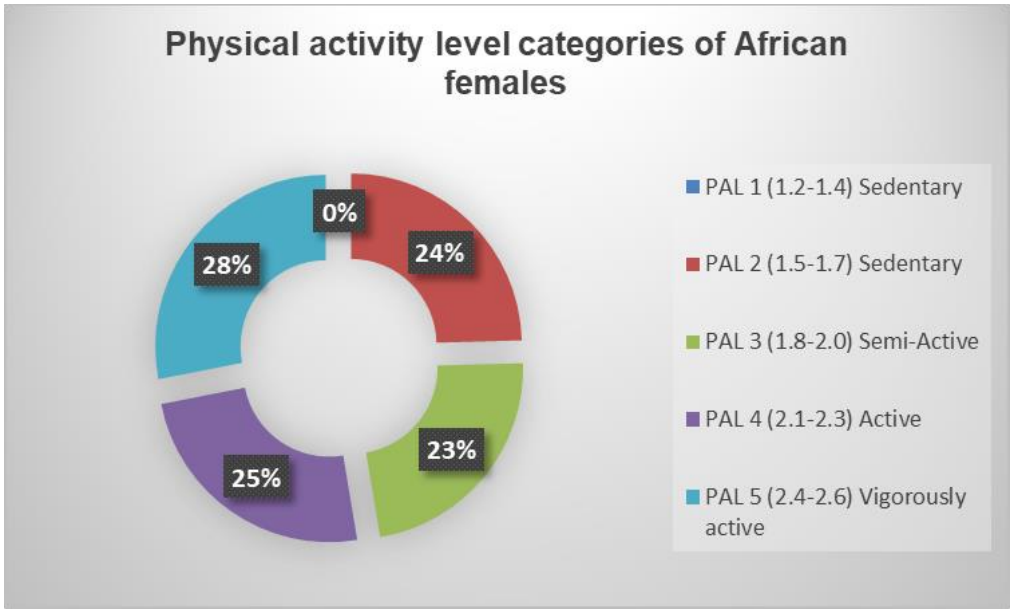


Figure 4-9: Physical activity level categories of African females

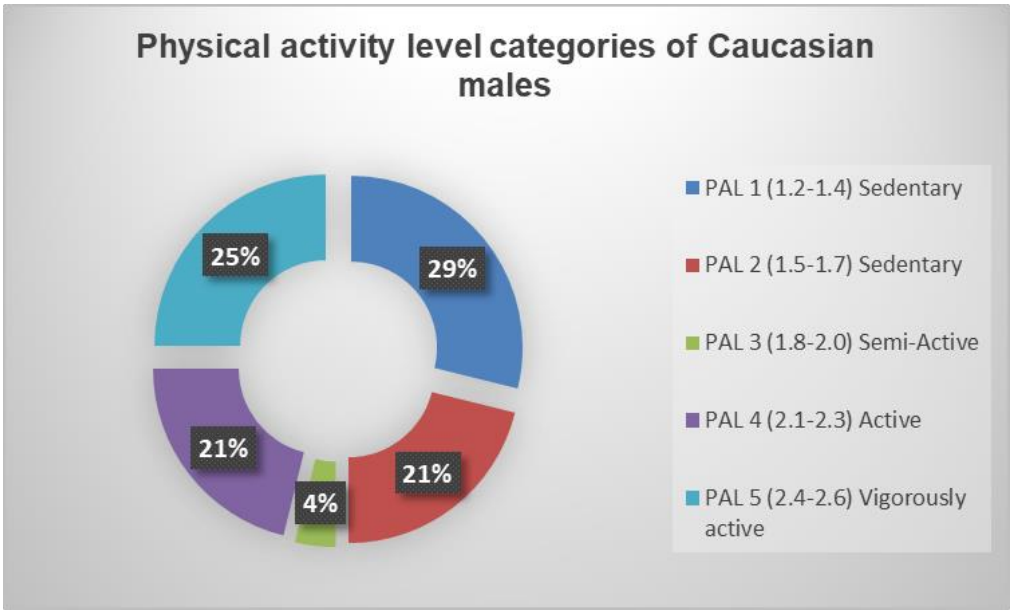


Figure 4-10: Physical activity level categories of Caucasian males

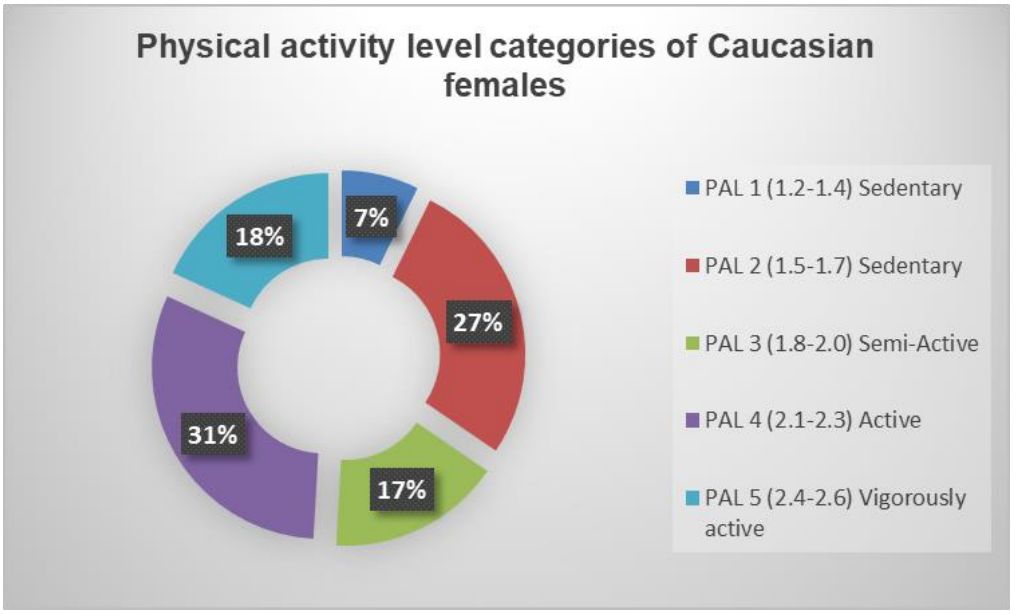
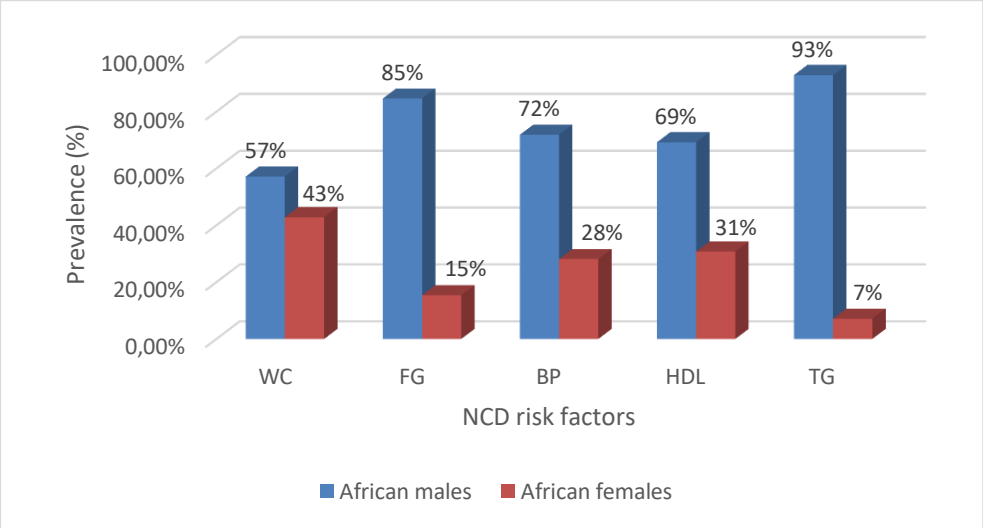


Figure 4-11: Physical activity level categories of Caucasian females

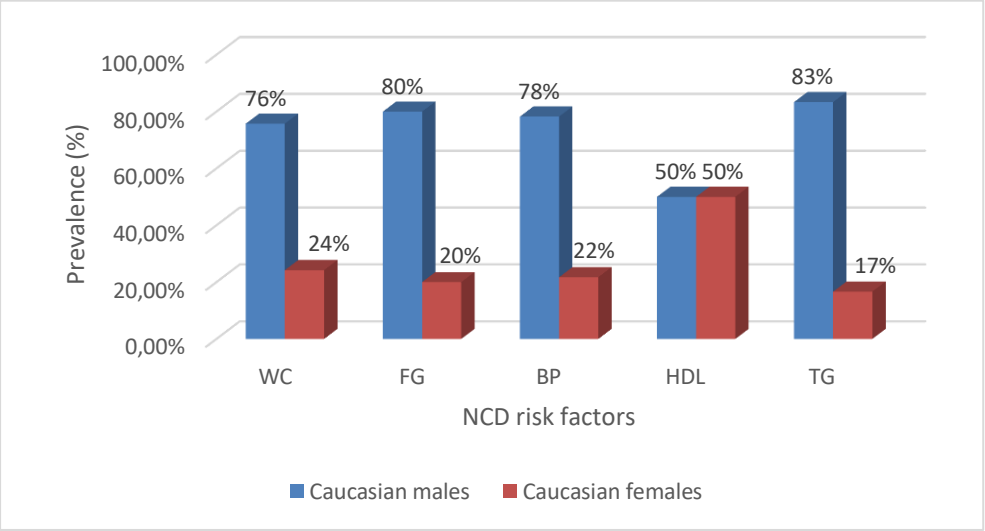
Figure 4.7 illustrates the physical activity status of the total group of participants as concerns the PAL categories. The majority of the total group was recorded as having a PAL status profile of 3-5 (60.7%), with the highest prevalence in PAL 4 (21.3%) and PAL 5 (24.1%). The remainder of the group (39.3%) was classified as sedentary. Figures 4.8-4.11 show the breakdown of the PAL categories within the four subgroups. Both male groups (African males and Caucasian males) had the lowest PAL score with a 50% of participants being classified as PAL 1 (sedentary job, no habitual exercise, general household chores, low activity hobbies such as reading) and 2 (sedentary job, no habitual exercise, general household chores, active hobbies such brisk walking, cycling and tennis). This was followed by Caucasian females, who had 34.5% prevalence in PAL 1 and 2. African females were the most active with 75.5% of the group falling within PAL 3-5 [PAL 3: Semi-active job (nurse, shop assistant), household chores, and some active hobbies; PAL 4: Active job (builder, tennis coach, and reasonably active lifestyle; PAL 5: Highly active job (athlete, labourer), active lifestyle], whereas 65.5% of the Caucasian female group had a score within the PAL 3-5 range.

NCD risk factor comparison of active and non-active participants within the four groups



Active (PAL 3-5); non-active (PAL 1-2); BMI= Body Mass Index; WC= Waist Circumference; FG= Fasting Glucose; HDL= High Density Lipoprotein; TG= Triglycerides; BP= Blood Pressure (SBP≥130 and/or DBP≥80 mmHg

Figure 4-12: NCD risk factor comparison of active and non-active participants within the African participants



Active (PAL 3-5); non-active (PAL 1-2); BMI= Body Mass Index; WC= Waist Circumference; FG= Fasting Glucose; HDL= High Density Lipoprotein; TG= Triglycerides; BP= Blood Pressure (SBP≥130 and/or DBP≥80 mmHg

Figure 4-13: NCD risk factor comparison of active and non-active participants within the Caucasian participants

All four groups were categorized as either active (PAL 3-5) or non-active (PAL 1-2). The prevalence of risk factors within each group was then reported separately.

Within the African male group, the NCD risk factor prevalence of the active group (PAL 3-5) was lower than the inactive group (Pal 1 and 2). WC (48.4%), BP (48.9%), HDL cholesterol (43.8%) and TG (43.5%) were found to be lower within the active group, whereas FG risk factor levels were identical, measuring 50% irrespective of categorization. As concerns the African female group, a much higher prevalence of all of the NCD risk factors was recorded within the active subgroup (PAL 3-5) as compared to the inactive group (PAL 1 and 2). WC (75.5%), FG (60%), BP (71.9%), HDL cholesterol (63.6%) and TG (75%) were all found to be higher within the active group. Within the Caucasian male group, the NCD risk factor prevalence was lower among the active group (PAL 3-5) than the inactive group (PAL 1 and 2) in so far as WC (45.7%), BP (45.5%) and HDL cholesterol (45.5%) were found to be lower within the active group. Despite this, FG risk factor levels were identical in both the active and inactive group, with a prevalence of 50%, and TG risk factor levels were more prevalent within the active group (58.3%). Regarding Caucasian females, a much higher prevalence of most NCD risk factors in the active group (PAL 3-5) was observed with risk factor prevalence concerning WC (73.3%), BP (66.7%) and HDL cholesterol (75%) being particularly high in the active group whereas the prevalence of FG and TG were similar in both the active and inactive group (50%).

Logistic regression analyses (Table 4.2) were performed so as to assess the impact of being non-active (PAL 1 & 2) on the prediction of different variables (WC, FG, TG, HDL-C, SBP and DBP). In order to strengthen the accuracy of the results, the total group (as opposed to the four participant subgroups) was used for the logistical regression model. The covariates that were taken into consideration for this model were PAL (inactive), race, gender, smoking, alcohol consumption, age, and BMI. Statistical significance was set at P≤0.05.

Table 4-2: Logistic regression of WC for the total group

		B	S.E.	p-value	Odds Ratio (OR)	95% C.I. for OR	
						Lower	Upper
WC	PAL (inactive)	0.934	0.597	0.118	2.546	0.790	8.206
	Race	-0.807	0.640	0.208	0.446	0.127	1.565
	Gender	-0.725	0.606	0.231	0.484	0.148	1.588
	Smoking	0.241	0.911	0.792	1.272	0.213	7.592
	Alcohol consumption	-0.508	0.753	0.500	0.602	0.138	2.633
	Age	0.077	0.034	0.023	1.080	1.011	1.154
	BMI	0.910	0.142	0.000	2.485	1.881	3.282
	Constant	-26.459	4.374	0.000	0.000		

Statistical significance was set at P≤0.05. Covariates taken into consideration for the model: PAL (inactive), Race, Gender, Smoking, Alcohol consumption, Age, BMI

Table 4.2 presents the output of the logistic regression model, where we investigate the relationship between physical activity status and WC, adjusted for various covariates. Physically inactive participants displayed 2.54 (CI: 0.79;8.21, p=0.118) times higher odds of having an increased WC (waist girth ≥102 cm for males and ≥88 cm for females) value as compared to physically active participants.

Table 4-3: Logistic regression of FG for the total group

		B	S.E.	p-value	Odds Ratio (OR)	95% C.I. for OR	
						Lower	Upper
FG	PAL (inactive)	0.142	0.435	0.744	1.153	0.491	2.705
	Race	1.236	0.526	0.019	3.443	1.228	9.652
	Gender	1.945	0.573	0.001	6.994	2.274	21.510
	Smoking	-0.720	0.567	0.204	0.487	0.160	1.479
	Alcohol consumption	0.693	0.494	0.161	1.999	0.759	5.264
	Age	0.084	0.029	0.004	1.088	1.027	1.152
	BMI	0.064	0.037	0.080	1.066	0.992	1.145
	Constant	-9.490	2.247	0.000	0.000		

Statistical significance was set at P≤0.05. Covariates taken into consideration for the model: PAL (inactive), Race, Gender, Smoking, Alcohol consumption, Age, BMI

Even though physical inactivity is positively associated with FG related to the log of odds of physical inactivity (B=0.142), the results are not statistically significant (p=0.74). Physically inactive participants presented with a 1.153 (CI: 0.49;2.71, p=0.74) times higher probability of having an increased FG (FG of ≥5.55 mmol.L^{-1}) value as compared to physically active participants.

Table 4-4: Logistic regression of TG for the total group

		B	S.E.	p-value	Odds Ratio (OR)	95% C.I. for OR	
						Lower	Upper
TG	PAL (inactive)	0.110	0.426	0.796	1.116	0.484	2.575
	Race	0.158	0.476	0.740	1.171	0.461	2.975
	Gender	1.947	0.544	0.000	7.005	2.413	20.333
	Smoking	-1.219	0.539	0.024	0.296	0.103	0.850
	Alcohol consumption	1.163	0.473	0.014	3.200	1.267	8.083
	Age	-0.016	0.024	0.500	0.984	0.939	1.031
	BMI	0.065	0.034	0.060	1.067	0.997	1.141
	Constant	-3.488	1.712	0.042	0.031		

Statistical significance was set at P≤0.05. Covariates taken into consideration for the model: PAL (inactive), Race, Gender, Smoking, Alcohol consumption, Age, BMI.

Table 4.4 presents the output of the logistic regression model, where we investigate the relationship between physical activity status and TG, adjusted for various covariates. Physically inactive participants displayed 1.116 (CI: 0.48;2,58, p=0.80) times higher odds of having an increased TG (TG of ≥1.69 mmol.L^{-1}) value as compared to physically active participants.

Table 4-5: Logistic regression of HDL cholesterol for the total group

		B	S.E.	p-value	Odds Ratio (OR)	95% C.I. for OR	
						Lower	Upper
HDL-C	PAL (inactive)	-0.084	0.343	0.807	0.919	0.470	1.800
	Race	-0.178	0.378	0.637	0.837	0.399	1.756
	Gender	-0.469	0.363	0.197	0.625	0.307	1.275
	Smoking	0.860	0.601	0.152	2.362	0.728	7.668
	Alcohol consumption	0.653	0.424	0.123	1.922	0.837	4.410
	Age	0.072	0.022	0.001	1.075	1.029	1.122
	BMI	-0.093	0.033	0.005	0.911	0.854	0.972
	Constant	-2.549	1.476	0.084	0.078		

Statistical significance was set at P≤0.05. Covariates taken into consideration for the model: PAL (inactive), Race, Gender, Smoking, Alcohol consumption, Age, BMI.

While physical inactivity is negatively associated with HDL cholesterol related to the log of odds of physical inactivity (B=-0.084), the results are not statistically significant (p=0.81). Physically inactive participants presented with a 0.919 (CI: 0.47;1.80, p=0.81) times higher probability of having a decreased HDL cholesterol (HDL cholesterol of ≤1.04 mmol.L^{-1}) value as compared to physically active participants.

Table 4-6: Logistic regression of SBP for the total group

		B	S.E.	p-value	Odds Ratio (OR)	95% C.I. for OR	
						Lower	Upper
SBP	PAL (inactive)	0.849	0.362	**0.019**	2.338	1.150	4.752
	Race	1.217	0.384	0.002	3.376	1.591	7.163
	Gender	1.056	0.378	0.005	2.874	1.371	6.028
	Smoking	-1.167	0.538	0.030	0.311	0.108	0.893
	Alcohol consumption	0.923	0.400	0.021	2.517	1.149	5.512
	Age	0.038	0.021	0.072	1.039	0.997	1.083
	BMI	0.140	0.032	0.000	1.151	1.080	1.226
	Constant	-7.146	1.629	0.000	0.001		

Statistical significance was set at P≤0.05. Covariates taken into consideration for the model: PAL (inactive), Race, Gender, Smoking, Alcohol consumption, Age, BMI.

Table 4.6 presents the output of the logistic regression model, where we investigate the relationship between physcial activity status and SBP, adjusted for various covariates. Physically inactive participants displayed 2.338 (CI: 1.15;4.75, p=0.019) times higher odds of having an elevated SBP (SBP≥ 140 mmHg) value as compared to physically active participants. The relationship between SBP and physical inactivity is the only variable presenting with a statistical dignificant difference (p=0.019). Therefore physical inactivity has a significant effect on SBP strengthening the notion of an increased PA lowering the risk of an elevated SBP as seen in various studies (Artinian *et al.,* 2010:431; Anderson & Taylor 2014:4; Ebrahim *et al.,* 2013:3; Taylor *et al.,* 2006:370).

Table 4-7: Logistic regression of DBP for the total group

		B	S.E.	p-value	Odds Ratio (OR)	95% C.I. for OR	
						Lower	Upper
DBP	PAL (inactive)	0.628	0.347	0.070	1.874	0.950	3.696
	Race	1.641	0.372	0.000	5.158	2.490	10.686
	Gender	1.193	0.359	0.001	3.297	1.631	6.665
	Smoking	-1.322	0.561	0.018	0.267	0.089	0.801
	Alcohol consumption	0.358	0.394	0.363	1.430	0.661	3.094
	Age	0.032	0.020	0.118	1.032	0.992	1.074
	BMI	0.073	0.028	0.010	1.075	1.018	1.136
	Constant	-4.459	1.429	0.002	0.012		

Statistical significance was set at P≤0.05. Covariates taken into consideration for the model: PAL (inactive), Race, Gender, Smoking, Alcohol consumption, Age, BMI.

Physical inactivity is positively associated with DBP related to the log of odds (B=0.628), the results are not statistically significant (p=0.07). Physically inactive participants presented with a 1.874 (CI: 0.95;3.70, p=0.07) times higher probability of having an increased DBP (DBP≥ 90 mmHg) value as compared to physically active participants.

4.3 Discussion

The WHO reported that 43% of total deaths in SA in 2012 were caused by NCDs (WHO, 2014). CVD (18%) was the most prevalent NCD cause of death, followed by cancer (7%) and DM (6%) (WHO, 2014). Lifestyle choices that play an enormous part in the development of NCDs include smoking, elevated BP, chronic stress, cholesterol, overweight and obesity, physical inactivity, and alcohol abuse (Hancock *et al.,* 2011:24; Mayige *et al.,* 2012:1; Stoner *et al.,* 2014:128).

In this study, a larger than WC (72.22%), hypertension (57.87%) and physical inactivity (39.4%) were shown to be the most prevalent NCD risk factors for the development of NCDs within the total group of participants (Figure 4.3-4.6). In comparing physical inactivity between groups, and taking into consideration that it is a lifestyle choice and modifiable risk,

we see a high prevalence of physical inactivity in African males (50%), and Caucasian males (50%), whereas African females (24.6%) and Caucasian females (34.5%) have a comparatively reduced prevalence of physical inactivity (Figures 4.3-4.6). These findings echo numerous studies concerning NCDs (Rosen, 2015:34; Stoner *et al.,* 2014:26; Waxman, 2004:59). A review by Kelishadi *et al*. (2014:54) concluded that CVD risk factors might be recognized and treated as early as adolescence. Kelishadi *et al.* (2014:60) also suggested that increasing PA would decrease these risk factors. This conclusion is further supported by various other studies (Bentley, 2013:26; Jimenez-Pavon *et al.,* 2013:178; Kelishadi *et al.,* 2007:47; Magnussen *et al.,* 2013:562; Subramanian *et al.,* 2013:1880). Global trends have shown that PA seems to have severely decreased over the last century (Vineis *et al.,* 2014:425). Evans *et al*. (2016:85) further state that 50% of South Africans are physically inactive, and do not even meet the minimum PA requirements. Recent studies agree with earlier research which concluded that a strong, positive relationship between physical inactivity and increased health risk factors exists (Biswas *et al.,* 2015:127; Buckley *et al.,* 2015:1; Rosique-Esteban *et al*., 2017; Warburton & Brendin, 2016:495). These trends may be due to a shift in the nature of labour which is no longer manual but dominated by machines (Ng & Popkin, 2012:660). Substantial evidence in studies illustrated that a minimum of 10 000 steps a day is required in order to achieve minimal health benefits, at least 5 000 of these steps should furthermore be at a brisk walking pace (Antonacopoulos, 2016:45; Bentley, 2013:26; Nogic *et al*., 2017:304; Tudor-Locke *et al.,* 2008:541). The average energy requirements (TEE) for males range from 1503 kCal to 4330 kCal, while females' average energy requirements (TEE) are lower, ranging from 1100 kCal/day to 3431 kCal/day. The average RER for females is approximately 1550 kCal/day, while males' RER is higher ranging from 1600 kCal/day to 1800 kcal/day (Farinatti *et al*., 2016:80).

Physical inactivity is a risk factor that is relatively easy to track. Nevertheless, males seem to be at higher risk than females, and males, on average, have a higher risk for mortality. This higher mortality rate may be due to poor lifestyle choices, a tendency to engage in risky behaviours, are less likely to acknowledge health issues and are more reluctant to consult with a medical professional (Singleton, 2008:44). Males also tend to be more stubborn as regarding the tracking of their activity than females (Burton *et al.,* 2008:57). People that are more likely to participate in PA intervention studies tend to be Caucasian and of the average, to above average, income group (Cooke & Jones, 2017:2; Noble *et al*., 2015:16; Waters *et al.,* 2011:100). At all ages worldwide, the minimum recommendations for PA are not being met (Egli *et al*., 2011:399; Lee *et al.,* 2009:504; Troiano *et al.,* 2008:185) and these findings echo the results of the current study. The findings regarding the highest levels of inactivity (Figures 4.3-4.6), which are to be found in both male subgroups (African males: 50% and

Caucasian males: 50%), agree with research from the WHO (2011). These findings are furthermore supported by research that has shown that females are more willing to participate in PA than males (Aittasalo *et al*., 2006:193; Pinto *et al*., 2005:248; Waters *et al*., 2011:85). As previously mentioned, the minimum recommended PA participation level required in order to enjoy health benefits is 150 min of moderate activity (3-6 METs) or an average PAL of 1.75 . Figures 4.7-4.11 illustrate that only 60.7% of participants achieved the minimum recommended PA participation level of 1.75 PAL. Due to the sedentary nature of teachers' occupation they should focus on achieving the minimum recommended PA during their leisure time.

NCD risk factors have been studied both within the various groups and as categorized into active (PAL 3-5) and non-active (PAL 1 and 2) groups. Despite the high risk factor that physical inactivity presents for all the participants (Figure 4.7-4.11), the results in Figures 4.8-4.11 differ from other research (Liu *et al*., 2017:816; Loo *et al*., 2017:5; Rhodes *et al*., 2017:946). While results drawn from the African male group showed a higher prevalence of most risk factors in the participants that did not meet the PA recommendations, results drawn from the other ethnic and gender subgroups suggest a completely different trend in so far as most of the physically active participants were found to have higher risk factors than those that are inactive. Results from the African female, Caucasian male and Caucasian female subgroups illustrate a higher prevalence of most of the risk factors within the active group as compared to the non-active group. Theoretically, the level of PA should have moderate to strong negative correlations compared to various risk factors for NCDs, and yet the participants in this study only show weak correlations in this regard across all groups. This may be due to the high amount of time that participants in the study spend in sedentary and low PA level activities. Furthermore, the amount of time spent engaged in vigorous activities is also very low across all four groups (Figure 4.7-4.11), with African females spending the most time engaged in vigorous activities with 28% of the group being categorised as vigorously active. Univariate analyses were used in order to calculate the differences between the risk factors within the active and inactive PA category of each subgroup.

The highest risk factor is WC, which is highly modifiable through better lifestyle choices (Du *et al*., 2013:487; Hill & Wyatt, 2005:768). In so far as African females were shown to have the biggest risk profile (as compared to both African males and to the other subroups as a whole), this evidence is contradicted by Du *et al*. (2013:490) and Morgan *et al*. (2011:240), who found males with a mean WC of 81.9 cm presented with a higher risk for abdominal obesity than females with a mean WC of 78.8 cm. This may be due to the fact that males are

not likely to see themselves as overweight and are thus less likely to diligently follow a weight loss programme (Lemon *et al.*, 2009:90). Obesity is a widespread problem in South Africa, (Pouane *et al*., 2008:1026) and BMI is seen as a meaningful risk factor (Feng *et al*., 2012:318). However this study found a bigger issue with WC than with BMI, where the highest prevalence of WC as a NCD risk factor can be seen in the Caucasian male group (Figure 4.3 C). Ekoru *et al.* (2018:491) note that CVD risk due to elevated WC among Africans, especially among African males, is extremely high, and this at lower cut-off values such as WC ≥81.20 cm. The high prevalence of WC may be explained by the the participants PAL. In the current study both male groups (African males and Caucasian males) presented with the lowest PAL having a 50% PAL 1 (sedentary job, no habitual exercise, general household chores, low activity hobbies such as reading) and 2 (sedentary job, no habitual exercise, general household chores, active hobbies such brisk walking, cycling and tennis) PA status profile prevalence.

A comparison of the two male subgroups shows that while both ethnic groups have the same prevalence for BMI as a NCD risk factor at 36.5%, the African males only have a 59.6% prevalence of WC as a NCD risk factor, a level that is substantially lower than that of the Caucasian male group. African females were found to have a much higher prevalence of WC than Caucasian females, which is suggestive of a lack of correlation between both gender and ethnicity as concerns WC. Other studies have shown a higher prevalence of WC in Caucasian males than in Caucasian females (Beltran-Sanchez *et al*., 2013:701; Katzmarzyk *et al*., 2004:201), and the findings of this study echoed those results. Even though Ekoru *et al.* (2018:491) clearly state that CVD risk due to WC among Africans, especially among African males to be extremely high, at cut-off values as low as WC ≥81.20 cm, studies by Freedman and Ford (2015:427) as well as by Mendoza-Nunen *et al*. (2002:257) report a higher mean WC value in females than in males. Further studies have found a strong association between BMI and mortality in the Caucasian population and WC can be seen as a better indicator for health risk factors, especially as concerns CVD risk factors, than BMI (Cornier *et al*., 2011:1998). A possible reason for this might be due to the fact that BMI only takes an individual's height and weight into account, and does not include muscle mass or any skeletal weight (Lam *et al*., 2015:2). WC is also seen as a better predictor, because it identifies the distribution of fat as opposed to considering total fat (Cornier *et al*., 2011:1998). Lee *et al*. (2015:326) notes a higher prevalence of increased WC amongst postmenopausal females, suggesting that sex hormones might explain the variations found in studies done on females. Lee *et al*. (2015:37) also state that due to the significant differences regarding WC, more attention should be paid to the distribution of body fat and its contribution to the risk of developing NCDs. However, females still show a

lower risk of NCDs due to elevated WC in so far as they generally have a higher hip circumference which might be due to the protective function of gluteal fat as concerns glucose and lipid levels (Lim & Meigs, 2013:166; Manolopoulos *et al*., 2010:949). The importance and benefit of such diets have been seen when following a Mediterranean diet, which is associated with numerous health benefits such as a reduction in TG, TC, and LDL cholesterol, as well as lower BP values and improved BP responses (Bellisle, 2009:1646; Paoli *et al*., 2011:117; Sofi *et al*., 2013:2769).

Hypertension is among the top three risk factors across all participant groups (Figure 4.3). Similar findings by Husaini *et al*. (2016:347) support the findings of higher BP values in those of African descent than in those from Caucasian descent; it also suggested that high BP has an earlier onset in those of African descent than in Caucasians. These results are supported by a number of studies (Abu-Saad *et al.,* 2014:1511; Aoki *et al*., 2014:5; Hicken *et al*., 2014:119; Espeland *et al.,* 2015:99). Economically disadvantaged countries tend to present with higher prevalence of hypertension, because of the inability to pursue healthier behaviour and receive treatment due to financial constraints and the lack of availability of treatment in these areas (Jan *et al*., 2018:2048; Legido-Quigley *et al*., 2015:2).

A recent study in rural Northern Ghana showed a lower prevalence of hypertension (Addo *et al.,* 2012:8). These results can be due to the area being even more economically disadvantaged than other rural areas in the same country (Abegunde *et al.,* 2007:1929) and reflect similar results to studies undertaken in North America and in Europe (Addo *et al.,* 2012:8; Kearney *et al.,* 2005:220; Wolf-Maier *et al.,* 2003:2368).

Hypertension as a risk factor for the development of NCDs is seen as one of the top three risk factors in three of the four groups that participated in this study. In most studies the prevalence of hypertension increased with age (Lewington *et al.,* 2002:1903; Wirth *et al.,* 2016:133) and Addo *et al*. (2012:8) furthermore concluded that a positive association between hypertension and WC, HR, BMI, salt consumption, a family history of hypertension and alcohol intake exists. Elevated BP is present in any population that has a higher prevalence of obesity, but this may rather be due to lower PA and more sedentary time than to physiology (Addo *et al*., 2012:8). Hmar and Purkayastha (2018:4) however found similar BMI values in both males and females even though higher BP was recorded amongst males. An increase in BP has been associated with an increased risk in the development of NCDs, where the risk can be as much as twice as high (Yoon *et al*., 2014:54). Moreover an increase in fat, especially abdominal fat, is associated with an increased risk of developing hypertension or elevated BP, but can be modified by healthier choices such as consuming

less salt and salty foods, reducing alcohol intake, reducing tobacco intake and increasing PA (Kearns *et al*., 2014:1411; Niroumand *et al*., 2015:3). The association between PA and the prevalence of hypertension are not reported in most studies (Hofman, 2014:647). Both SBP and DBP values are considerably higher amongst males as compared to females (Hmar & Purkayastha, 2018:4) and echo the results of a number of other studies (Emdin *et al*., 2015:1556; Hendriks *et al*., 2012:5; Varshitha, 2015:849). Hendriks *et al*. (2012:5) and Ong *et al*. (2008:69), also report a higher prevalence of increased BP amongst females as compared to males. This may be due to sex hormone differences influencing BP and the differences in SBP and DBP which are present within the different groups (Daugherty *et al.,* 2011:1009).

The African males can be classified as hypertensive as concerns both their SBP (140.9 mmHg) and DBP (94.50 mmHg) BP values (Table 4.2) (Kearney *et al*., 2005:217; Sawicka *et al.,* 2011:43), whereas the Caucasian males, Caucasian females and African females can be classified as pre-hypertensive (SBP 130-139 and/or DBP 80-89 mmHg) (ACSM, 2014).

According to Lundsgaard and Kiens (2014:2), glucose concentration tends to be higher in males than females and may be due to a higher glucose clearance rate in females. Kanaya *et al*. (2014:1623) also report a higher prevalence of high concentrations of blood glucose and impaired FG levels in African than in Caucasian participants. Motala *et al*. (2011:1034) also noted a higher prevalence of elevated FG concentrations (≥5.6 $mmol.L^{-1}$) among males when comparing males and females, older than 15 years, without MS (males: 9.0%; $p \leq 0.001$ & females: 3.4%; $p \leq 0.001$) and an even higher prevalence among males with MS (males: 50.0%; $p \leq 0.001$ & females: 27.1%; $p \leq 0.001$). Crowther and Norris (2012:4) argue that more research should be spent on the African population as certain risk factors may not be interpreted as being significant due to cultural differences seen among African countries (culturally, bigger females are seen as fertile and beautiful while bigger males are seen as being wealthy and prosperous). Dyslipidaemia is regarded to be higher in African females (52.3%) as compared to Caucasian females (50.9%) in different regions within the United States (Newby *et al*., 2012:30). Barkas *et al*. (2016:62) suggest a positive correlation in the comparison between FG and TG, especially among individuals with DM and/or MS. Barkas *et al*. (2016:62) as well as Taskinen and Boren (2015:489) conclude that this is due to a higher prevalence of free fatty acids among individuals with an already higher FG or TG level and who may also suffer from insulin resistance.

Perez-Lopez *et al*. (2010:512) concluded that the lipid profile is more favourable to females; their conclusions are supported by Cooney *et al*. (2009:612), who state that females have a

higher risk of developing HDL cholesterol than males. This may be due to the higher testostreone concentration seen in males, leading to a higher TG level and a decrease in HDL cholesterol, all of which are independent risk factors for CVD (Haring *et al.,* 2010:2). In addition Perez-Lopez *et al*. (2010:513) note a higher prevalence of TG and a lower prevalence of HDL cholesterol, suggesting a negative correlation. However, Chandra *et al*. (2015:892) and Walker *et al*. (2012:144) found higher values of HDL cholesterol concentration among African than among Caucasians. This could be due to different dietary choices.

Even though physical inactivity is a high risk factor among all participants, the results of this study (Figures 4.7-4.11) differ from other research (Hallal *et al*., 2010:254; Reiner *et al*., 2013:1). Within the African male group, the results found a higher prevalence of most of the risk factors in the participants that did not meet the PA recommendations. These results agree with research done by Pengpid *et al*. (2015:540) underlining a higher prevalence of risk factors within African males. Yet, the remaining three subgroups suggest a completely different trend in so far as most of the physically active participants were seen to have higher risk factors than those that are inactive. African females, Caucasian males and Caucasian females have a higher prevalence of all the risk factors within the active group as compared to the non-active group. These results conflict with most other research done on the effect of PA on the risk factors for NCD development (Hallal *et al*., 2010:254; Reiner *et al*., 2013:1). Furthermore, the conflicting results may have been due to participants not fully understanding the study and what was expected of them, and therefore changing their habits for the duration of the study, and thus skewing the results. In addition, the high levels of sedentary time may also affect the results as sedentary time can play a detrimental role with regard to people's NCD risk factors, even if they meet the requirements for PA as mentioned earlier. Another explanation could be that the equipment (Actiheart) was too difficult for participants to use. Joy *et al*. (2012:49) suggest that death rates due to physical inactivity seem to be even higher than expected; estimating that by increasing PA, 1.3 million deaths globally could have been prevented. Moreover Joy *et al*. (2012:49) found that the mortality risk in a group with self-reported PA levels was 24% lower in females and 27% lower in males than those that did not meet the minimum PA requirements. Furthermore Lee *et al.* (2012:508) also found that for objectively measured PA levels females and males in the active group had a 44% and a 45% lower mortality rate (respectively) than members of their non-active group.

In this study physical inactivity was associated with a higher prevalence of WC [2.54 times higher probability of an increased WC (waist girth ≥102 cm for males and $\underline{\geq}$88 cm for

females)], FG [1.153 times higher probability of an increased FG (FG of ≥5.55 mmol.L^{-1})], and TG [1.116 times higher probability of an increased TG (TG of ≥1.69 mmol.L^{-1})]. HDL cholesterol is negatively related with a 0.919 times higher probability of a decreased HDL cholesterol value (HDL cholesterol of ≤1.04 mmol.L^{-1}). SBP is positively related to and presented with a 2.338 times higher probability of elevated SBP (SBP≥ 140 mmHg) than physically active participants.

In this study the DBP is positively related to PA and inactive participants had a 1.874 times higher probability of an increased DBP (DBP≥ 90 mmHg) than physically active participants. These results are consistent with those of Thankappan *et al*. (2010:61) who found a positive association between physical inactivity and an elevated BMI (2.51 times higher), WC (2.79 times higher) and an elevated BP (1.64 times higher); no association could be found between physical inactivity and an increased FG and TG. Peer *et al*. (2013:7) also found a higher probability of elevated BP when correalated to physical inactivity. In addition, Oommen *et al*. (2016:468) in a study done in the rural and urban Vellore district also found physically inactive participants had higher odds of presenting with increased WC, BMI, BP, FG, TG and decreased HDL.

4.6 Summary

NCDs account for the majority of global deaths (59%) per year with almost 43% of deaths in SA due to NCDs (Allen *et al*., 2017:698; Bloom *et al.,* 2011:7; Roca *et al.,* 2015:258; Schwamm, 2018:665 & WEF, 2013:7). It is estimated that these statistics will continue increase due to the rise in unhealthy lifestyle behaviours. Lifestyle choices play an enormous part in the development of NCDs and a strong positive relationship between PA and decreased risk factors has been established by numerous studies (Biswas *et al.,* 2015:127; Buckley *et al.,* 2015:1; Dunstan *et al.,* 2010:384; Hancock *et al.,* 2011:24; Mayige *et al.,* 2012:1; Stoner *et al.,* 2014:128). The leading risk factors in the development of NCDs include increased WC, hypertension and physical inactivity, all of which concur with the results found in this study. Modifying lifestyle behaviours, such as improving dietary patterns (reduced sodium intake, an increased intake of fibre, fruits and vegetables) and increasing the level of PA, will result in more favourable risk factor profiles, therefore leading to a reduced WC and decreased BP (Peer & Kengne, 2016:433). The global trends in PA seem to show a severe decrease in the level of PA (Vineis *et al.,* 2014:425). Evans *et al*. (2016:85) further state that 50% of South Africans are physically inactive, not even meeting minimum requirements of PA. Unfortunately, most PA intervention studies have focused on a

Caucasian population and a greater need for research among the African population therefore exists. African males have the highest risk for the development of NCDs. Within this study the high occurrence of risk factors within the population that participated in the study is alarming and needs to be further investigated. The results show that physical inactivity, WC and hypertension were the highest risk factors across all four groups. These risk factors can all be modified by increasing PA and by improving lifestyle choices (Peer & Kengne, 2016:433), underlining the need for an intervention relating to better lifestyle choices and improved PA.

CHAPTER 5 SUMMARY, CONCLUSIONS, LIMITATIONS AND RECOMMENDATIONS

5.1 Summary

Non-communicable diseases (NCDs) are a serious problem which is responsible for a decline in quality of life and overall health, decreased productivity and increased medical costs (Alwan *et al.,* 2010:1861; Farmer *et al.,* 2010:1187; Sacco *et al.,* 2013:4). The consequences of poor lifestyle choices which contribute to the rise of NCDs include a decrease in the performance and the productivity of individuals in their workplace (Hayman, 2016:134). Negative lifestyle choices such as being overweight due to bad dietary habits, smoking and stress (Nyberg *et al.,* 2011:66) are reported by Freak-Poli *et al*. (2013:7) to have an immense impact, negatively influencing the productivity of an individual. Furthermore, Freak-Poli *et al.* (2013:7) found that individuals who are more physically active in their spare time have a smaller likeliness to suffer from the short-term effects of these choices. Statistics surrounding these lifestyle diseases and the contributing risk factors are quite troubling and do not show improvement with increased knowledge and education (McDonnel *et al.,* 2014:828).

It has already been stated that the number of deaths worldwide is increasing and that South Africa is experiencing the repercussions of the constant increase, as reflected in South African statistics (Bradshaw *et al.,* 2003:683). South Africans can be seen to have a particularly destructive lifestyle as seen by the South African Demographic data with about 39.2% of South African females and 10.2% of South African males being overweight, whilst 18% South African adults smoke (Alaba & Chola, 2013:15). According to Sallis *et al*. (2015:375) physically active individuals, across gender, age and ethnicity, lead healthier lives and live longer, supporting the phrase: exercise is medicine. Yet, this statement fails to receive the veneration it seems to deserve, even though numerous studies have proven it to be true (MacAuley *et al*., 2015:350; Pedersen & Saltin, 2015:2; Lobelo *et al*., 2014:1; Coombes *et al*., 2013:3; Paternostro-Bayles, 2009:36; Sallis, 2009:3). Being physically inactive is socially accepted as a custom and exercise encouragement is often ineffective (Wen & Wu, 2012:192). Incorporating PA into everyday life can be introduced from an early age via schools (Engelbrecht *et al*., 2015:1). As children spent most of their day in school, they can look to a teacher for guidance (Engelbrecht *et al*., 2015:1).Yet teachers are highly inactive, therefore creating a need to incorporate PA in both teachers and students day (Dlamini *et al*., 2014:582). Organized efforts to increase PA within the population, attempting to move general PAL from sedentary to active are available, but are limited, in both developing and developed countries worldwide (Wen & Wu, 2012:192).

The first aim of this study was to investigate the prevalence of NCDs in African and Caucasian teachers of the North West Province of South Africa. The second aim of this study was to determine the association between PA and NCDs in African and Caucasian teachers in the North West Province of South Africa.

Chapter One includes a short introduction of the problem statement. NCDs account for the majority of global deaths (59%) per year and by some measures may even be seen to account for two thirds (67.9%) of annual global deaths (Allen *et al*., 2017:698; Bloom *et al.,* 2011:7; Roca *et al.,* 2015:258; Schwamm, 2018:665 & WEF, 2013:7). One of the lifestyle and behavioural factors that contributes to the development of NCDs globally is physical inactivity and it is estimated that six to ten percent of deaths from NCDs worldwide may be attributable to physical inactivity (Engelen & Bauman, 2015:1758; Jemmott *et al.,* 2014:114). The increasing prevalence of NCDs could have been attenuated, if not prevented, by increasing PA (Schoenborn & Stommel, 2011:514). Teachers play a significant role in the community as they work with children of different socio-economic, cultural, religious, and ethnic backgrounds (Engelbrecht *et al*., 2015:1). Biokineticists and/or exercise therapists may be able to use the information gathered in this study in order to increase awareness regarding both PA status and the risks of developing NCDs that arise out of physical inactivity. Therefore, the research questions that arise from the problem statement are: firstly, what is the prevalence of NCDs in male, and female, African, and Caucasian teachers in the North West Province? Secondly, what is the association between PA and NCD occurrence in a cohort of African and Caucasian urban teachers in the North West Province?

In Chapter Two the literature of physical activity (PA), NCDs and the relationship between the two is reviewed. Risk factors for the development of NCDs are a global problem and have been thoroughly reviewed, focusing on gender and ethnicity differences. In this chapter, a strong relationship between PA and NCD risk factors is seen in both African and Caucasian population groups, in males and females. The presence of NCD risk factors increases the risk of mortality two-fold (Wagner & Brath, 2012:39). Even though NCDs can be seen as increasing worldwide, low- to middle income countries are particularly hard hit (Di Cesare *et al.,* 2013:585) in so far as NCDs are responsible for 29% of deaths under the age of 60 (Wagner & Brath, 2012:38) and the high costs of treatment cannot always be afforded (Balbus *et al.,* 2013:3). Although numerous risk factors are modifiable, the prevalence of these risk factors is such that the rise in NCDs can be seen as an epidemic (Lee *et al.,* 2012:219).

An increased PA has numerous health benefits including the decrease of other risk factors such as obesity, diabetes mellitus (DM) and hypertension (Brown *et al.,* 2013:1005; Lee *et al.,* 2012:219 & Warburton *et al.,* 2010:39). Chapter Two further focuses on PA as intervention in order to reduce the risk of NCDs, contributing to the knowledge of professionals in this field, as well as to that of the general public for whom the perception of the importance of a healthy lifestyle might be increased through better knowledge surrounding NCD risk factors.

Chapter Three reports the research methods. This study forms part of the Sympathetic activity and Ambulatory Blood Pressure in Africans (SABPA II) prospective cohort study. Only the 2011 and 2012 data (SABPA II) was used for the purpose of this research. African and Caucasian South African school teachers (N=216), consisting of African males (n=52), African females (n=57), Caucasian males (n=52) and Caucasian females (n=55) with similar socio-economic status, were recruited from the Kenneth Kaunda district in the North West Province of SA. SABPA II is a follow up of the first phase of the SABPA study and interventions had already taken place. The following objective measurements were taken: seven-day objectively measured PA status, anthropometric measurements [body mass index (BMI) and waist circumference (WC) in centimetres (cm)], and cardio metabolic risk factors (24-hour ambulatory blood pressure (AMBP) in mmHg, fasting lipid profile [triglycerides (TC), high density lipoprotein (HDL) cholesterol, low density lipoprotein (LDL) cholesterol, triglycerides (TG)] and fasting glucose (FG) levels in $mmol.L^{-1}$). Data analyses were performed by using SPSS version 20 (IBM Corp. Released 2011. IBM SPSS Statistics for Windows, Version 20.0. Armonk, NY: IBM Corp). Participants were grouped into four different groups: African males, African females, Caucasian males, and Caucasian females. Descriptive statistics were calculated using a one-way analysis of variance and were expressed as mean (M), standard deviations (SD), as well as 95% confidence intervals (CI). ANOVA was used to determine to determine significant differences in variables (anthropometric, cardio metabolic risk factors and the PA status) which were also adjusted for age differences. The prevalence of NCD risk factors was calculated and reported as frequencies using chi-square statistics for each group (African males, African females, Caucasian males and Caucasian females) within the sub-classification of the non-active group (PAL 1 & 2) and the active (PAL 3-5) group. The frequency of PAL in each different category (PAL 1 and 2: sedentary, PAL 3: semi active, PAL 4: moderate active and PAL 5: vigorous active) among the different groups was then presented. The prevalence of NCD risk factors in the non-active (PAL 1 and 2) and active (PAL 3-5). Covariates included: age, gender, smoking and alcohol consumption. Lastly, multivariable logistic regression models were used on the group as a whole so as to determine the influence of PA status (being non-active, PAL 1&2 as the independent variable) on the NCD risk factors (dependent variables individually

modelled: WC, FG, TG, HCL, SBP and DBP as the independent variables). Adjustments were made for the following covariates: race, gender, smoking, alcohol consumption, age and BMI.

Chapter Four consists of the detailed results found in this study. The core findings included statistically significant differences in BMI (p≤0.001), waist circumference (WC) (p≤0.001), total cholesterol (TC) (p≤0.001), high density lipoprotein (HDL) cholesterol (p=0.001) and triglycerides (TG) (p≤0.001), fasting glucose (FG) (p≤0.001), systolic blood pressure (SBP) (p≤0.001), diastolic blood pressure (DBP) (p≤0.001), and physical activity level (PAL) (p≤0.001), total energy expenditure (TEE) (p≤0.001), resting energy expenditure (REE) (p≤0.001) and active energy expenditure (AEE) (p≤0.001) were found when the four groups were compared. The leading three risk factors were WC (72.22%), elevated BP (57.87%) and physical inactivity (39.4%) with the highest prevalence of risk factors being found among African males (five of the variables show a prevalence of more than 50%). Logistic regression analyses (Table 4.2) were performed to assess the probability by which being non-active (PAL 1 & 2) could predict different variables (WC, FG, TG, HDL-C, SBP and DBP). To strengthen the accuracy of the results, the total group was used in the logistical regression model. The Covariates considered for in this model were PAL (inactive), race, gender, smoking, alcohol consumption, age and BMI. All of the risk factors showed a positive relationship with physical inactivity, with participants having a higher probability of the development of an unfavourable risk factor when inactive, although SBP presented with the only statistical significant difference (p=0.019).

Chapter Five includes a summary of the study including the hypothesis and whether they are accepted or rejected, conclusions, limitations and recommendations, concluding with the references.

5.2 Conclusions

The conclusions drawn from this study are based on the hypotheses set out in Chapter 1.

Hypothesis 1:

African males in the North West Province of South Africa will have a significantly higher prevalence of NCD risk factors compared to African females, Caucasian males and Caucasian females of the North West Province in South Africa.

Although a higher prevalence of some risk factors is evident in African females as compared to the Caucasian groups, African males present the highest prevalence of NCD risk factors with

most of the risk factors exceeding the cut-off points, including BMI, glucose, WC, HDL-C, SBP and DBP. NCD risk factor prevalence was highest among African males (five of the variables show a prevalence of more than 50%) with the remaining two risk factors (BMI 33%, TG 44%) more than 30%. Significant differences are seen between the groups as concerns BMI ($p \leq 0.001$); African females are the only group that can be classified as obese (≥ 30 $kg.m^{-2}$) according to the ACSM (2014:63) whereas the remaining three groups can be classified as overweight (25–29.9 $kg.m^{-2}$) in terms of the definitions laid out by the ACSM (2014:63). WC also shows significant differences between the groups ($p \leq 0.001$). However, the male groups had a higher prevalence of WC than the female groups. With regards to the lipid profile of the participants, statistically significant differences in total cholesterol (TC) values ($p \leq 0.001$), high-density lipoprotein (HDL) cholesterol ($p = 0.001$) and triglyceride (TG) ($p \leq 0.001$) values were found between all four groups. African males had the highest TC value (4.96±1.06 $mmol.L^{-1}$), even though all of the groups were in recommended range. , both male groups presented with a more vulnerable value for HDL cholesterol as compared to their female counterparts and can be classified as being within the increased risk profile for developing CVD, in so far as their HDL cholesterol values are ≤1.04 $mmol.L^{-1}$. The lowest value was recorded in Caucasian males (0.86±0.23 $mmol.L^{-1}$), followed by African males (0.92± 0.27 $mmol.L^{-1}$). Only African males (1.78±1.12 $mmol.L^{-1}$) fell within the risk category for TG having values that were ≥1.69 $mmol.L^{-1}$ and presented with the highest value compared to the other three groups (ACSM, 2014:46). FG also presented with a significant difference ($p \leq 0.001$), with African males (6.26±2.99 $mmol.L^{-1}$) presenting with the highest value between the groups. Both African groups were seen to have significantly higher FG values as compared to their Caucasian counterparts, nevertheless only African males (6.26±2.99 $mmol.L^{-1}$) fell within the risk category for FG with values ≥5.55$mmol.L^{-1}$ (ACSM, 2014:48). Statistically significant differences were found between the various groups with regards to both SBP ($p \leq 0.001$) and DBP ($p \leq 0.001$). African males had the highest SBP values (140.9±17.12 mmHg) and DBP values (94.50±10.30 mmHg). African males can therefore also be classified as hypertensive (SBP≥140 and/or DBP≥90mmHg) in so far as both their SBP (140.9 mmHg) and DBP (94.50 mmHg) mean values exceed the recommended values; African females (129.13 mmHg; 84.40 mmHg) and Caucasian males (127.98 mmHg; 86.94 mmHg) can be considered as pre-hypertensive (SBP 130-139 and/or DBP 80-89 mmHg) (ACSM, 2014:44).

Differences in PAL also showed statistical significant differences ($p \leq 0.001$): African females had the highest PAL value (2.17 ±0.56) with a PAL classification of 4 (active), followed by Caucasian males (2.03 ±0.83, PAL of 3 = semi-active), African males (2.02 ±0.70, PAL of 3 = semi-active) and Caucasian females (2.01 ±0.48, PAL of 3 = semi-active).

Physical inactivity was highest in both African males (50%) and Caucasian males (50%). Figures 4.5 A-D show the breakdown of the PAL categories within the four subgroups. Both male groups (African males and Caucasian males) had the lowest PAL score with a 50% of participants being classified as PAL 1 (sedentary job, no habitual exercise, general household chores, low activity hobbies such as reading) and 2 (sedentary job, no habitual exercise, general household chores, active hobbies such brisk walking, cycling and tennis).

Hypothesis one is therefore accepted.

Hypothesis 2:

Physically inactive teachers of the North West Province in South Africa will present with a significantly higher prevalence of NCD risk factors than those that are physically active.

Based on the results, the hypothesis can only be partially accepted, as the only the results of the African male group align with the hypothesis. Even though physical inactivity is the risk factor of greatest prevalence across participant groups, the results in Figures 4.5 A-D show a higher prevalence of most of the risk factors within the physically active participant groups as compared to the inactive groups, with only the African male group being in line with the hypothesis. Within the African male group, the results showed a higher prevalence of most of the risk factors in the participants that did not meet the PA requirements than those who did with only TG as risk factor not following this trend. The other groups however suggest a completely different trend with most of the physically active participants being shown to have a higher risk factor prevalence than those that are inactive. African females present within the active group showed a higher prevalence of all risk factors as compared to the inactive group. The same can be seen within the Caucasian male group, with only HDL cholesterol concentration presenting a higher value in the inactive group. The Caucasian female group also shared this trend with all risk factors measuring higher in the active group. Physical inactivity was nevertheless associated with a higher prevalence of WC (OR = 2.54), FG (OR = 1.153), TG (OR = 1.116) TG, HDL cholesterol (OR = 0.919), SBP (OR = 2.338) and DBP (OR = 1.874). Considering the results of this study, hypothesis two is only partially accepted.

The aim of the current study was to investigate PA and NCD risk factors in African and Caucasian teachers. Most of the participants spent their time in the sedentary and semi active

category. This study showed high amounts of daily time spent sedentary, as well as in light and moderate intensity activity for all groups. A study done by Assah et al. (2011:495) in Cameroon on participants of both rural and urban areas, produced similar results as the current study if TEE is measured in KJ/kg/day (African males: 49.84 KJ/kg/day, African females: 51.15 KJ/kg/day, Caucasian males: 66.03 KJ/kg/day and Caucasian females: 64.75 KJ/kg/day). Therefore the high prevalence of active (PAL 4) may be attributed to a high level of occupational activity as teachers walk very often during a school day and also during the after school activities, sport practice, etc. Earlier research suggested Actihearts to be worn for a maximum of fourteen hours to decrease the hours spent sedentary due to sleep and relaxing as seen as very high in the current study due to seventeen hours of awake time (Herrmann et al., 2013:745). The protective effect of PA is difficult to quantify as studies vary significantly on the methods used to determine PA. Another limitation is that the research done on the African population regarding PA is very limited and proves difficult to compare to the Caucasian counterparts (Shimora & Lee, 2010:746). Even though no differences could be noted between the PAL comparing African and Caucasian males, the African males presented with a much higher prevalence of NCD risk factors. Therefore it is evident that the African males tend to be more vulnerable to NCD risk factors than their Caucasian counterparts. A strong positive relationship can be seen between CVDs, responsible for the majority of deaths globally, and decreased PA levels (Pratt *et al.,* 2014:356). The health benefits of PA are numerous and studies have shown that PA can be beneficial in managing and even preventing cancer, heart disease, DM, hypertension, stroke, cholesterol, arthritis, sarcopenia, and osteoporosis (Arem *et al*., 2015:966; Sparling *et al*., 2015:1; Veldhuijzen van Zanten *et al*., 2015:1402).

Numerous gender-based differences exist with regards to NCDs and their risk factors (Muka *et al*., 2016:29). These differences include the influence of sex hormones, body composition differences, physiological and psychological differences, as well as lifestyle behaviours (Harvey *et al*., 2015:239). The current study presented with the highest BMI prevalence amongst the African females (67%), followed by both male groups (37%). Caucasian males also presented with the highest WC prevalence (89%) among the groups. Males and females with similar BMI values present with different patterns of fat distribution in so far as males tend to have higher abdominal fat or a larger WC value as compared to females who generally have a higher fat distribution in the lower body (hips and legs) (Palmer & Clegg, 2015:113). Higher oestrogen levels in females furthermore influence the ability of fat cells to expand and store fat subcutaneously instead of viscerally (as in males), thus functioning as a protective barrier against the consequences of metabolic diseases (Palmer & Clegg, 2015:113). This is in contrast to males who present with a higher probability of developing the vast majority of risk

factors including an unfavourable lipid profile, WC, insulin insensitivity, elevated FG and elevated BP (Geer *et al*., 2009:62; Murphy, 2011:688; Palmer & Clegg, 2015:113; Shulman, 2014:1136). Peripheral fat distribution (as seen in females) can be linked to increased insulin sensitivity including benefits such as the utilization of glucose, the inhibition of fatty acids, and hepatic glucose release (Bjornstad *et al*., 2015:8; Geer & Shen, 2009:62). Males present with a higher risk of developing an unfavourable lipid profile [TC, LDL cholesterol, HDL cholesterol and triglycerides (TG)], greater insulin sensitivity, FG, inflammatory response and BP regulation as compared to females. When comparing the lipid profile of females and males, the latter tend to be more vulnerable because of their lower oestrogen levels in so far as oestrogen acts as a protective layer (Choi *et al*., 2015:404). Females present with higher levels of HDL cholesterol, responsible for the uptake and the transport of cholesterol, this lipoprotein can be seen as an indicator of a favourable lipid profile (Lee-Reuckert *et al*., 2016:566). Ellman *et al*. (2015:312) and Sumner & Cowie, 2008:697) found that African females presented with a higher rate of insulin resistance that might be due to genetics, ethnicity or behavioural factors such as poor dietary habits. These results support the idea that the relationship between lipid metabolism and insulin resistance differs between African and Caucasian individuals (Pispraset *et al*., 2013:845). Similar to other research the current study presents FG (57%), too low values of HDL cholesterol (69%) and TG (44%) as the highest prevalence among the African males (Choi *et al*., 2015:404; Lee-Reuckert *et al*., 2016:566). Both the male groups presented with the highest prevalence of BP with African males as the highest (87%), followed by the Caucasian males (64%). The prevalence of elevated BP was also noted as higher among men (51.4%) than among women (47.6%) in a study which focused on South Africans of African descent (Peer *et al*., 2015:1039). Adeniyi et al. (2015:5) and Walter *et al*. (2011:538) also noted a higher probability for an elevated BP has been linked to the African population. The higher probability in developing hypertension may be due to increased sodium sensitivity within the African population (Cappuccio & Miller, 2016:301). Another reason may be a higher degree of arterial stiffness that has also been linked to individuals within the African population group and even though an increase in arterial stiffness is a common part of ageing, a disconcerting degree of arterial stiffness can be seen amongst individuals in the African population at a young age (Schutte *et al.,* 2011:511; Twagirumukiza *et al.,* 2011:1250). According to a study done by Cherkas *et al*. (2008:155) individuals participating in more than 199 minutes per week of PA were showing similar stress on their cardiovascular system than sedentary individuals of ten years younger, after covariates as smoking, alcohol use, age, sex, BMI and socio economic status were used.

Adopting a healthy lifestyle, and making healthy decisions, can play a significant role in the decrease of NCDs on a global scale (Mbanya *et al*., 2010:536). One of these healthy decisions, PA, is easier to improve than others. PA is an essential part of an individual's life and can improve well being as well as increase life expectancy (Lewis & Hennekens, 2016:137). The implementation thereof is furthermore relatively easy and cost effective. (Allotey *et al.,* 2010:1689). PA can be done anywhere, and over-all health can be improved, not only by increasing the participation of PA, but also by decreasing sedentary time throughout the day (Owen *et al*., 2010:107). In the cuurent study, the sample size was limited and may be due to the high amount of participants being excluded due to not wearing the Actiheart for the full seven consecutive days. As the knowledge of NCDs and risk factors are limited in most countries, a global plan of action needs to be implemented in order to reduce mortality and improve quality of life and life expectancy. Teachers can have a positive impact on students from a very early age, educating them about the importance of a healthy lifestyle. Teachers have an important part to play in the implementing of healthy living as they are often viewed as role models.

5.3 Limitations

All statistically significant results were construed from a physiological perspective and do not automatically indicate a physiological significance. The results reported in Chapter four should be interpreted against the background of some limitations experienced including a small study size due to the comprehensive exclusion criteria used in the study, (especially concerning the participants who did not wear the Actiheart for the full seven days). A fitness level was determined by self-report of PA to determine the programme on the Actiheart, which was used to gather the PA data and by questions designed to determine the PA status, rather than through individual calibration. The reason for this approach was due to the increased CVD risk of participants and the time limits that were imposed on data collection. This specific design may have had a negative effect on the statistical strength of the effects of PA.

5.4 Recommendations

The following recommendations are made in order to attain a better understanding of PA status and other NCD risk factors.

It is apparent that further research is required on the prevalence of NCD risk factors as these risk factors continue to evolve and affect individuals of all genders, ethnicity and socio-economic

backgrounds. Further research should therefore, be conducted using larger sample sizes, representative of both genders and ethnicities. Data gathering should include both comprehensive questionnaires and PA data gathered after the Actiheart monitor has been worn for a full 24 hours.

Longitudinal results are needed in order to establish the true relationship between PA and other behaviours. Intervention programs should also be based on the results of different ethnicities and genders. In addition, it is recommended that future studies measure the sedentary time together with PA levels to form a better understanding of physical inactivity and the risk thereof.

5.5 Future research

Research noted that PA can lead to decreased risks for NCDs, which can lead to improved future health, life expectancy and productivity as wel as to decreased medical costs and should thus be implemented in the daily lives of African and Caucasian teachers of the North West Province of South Africa. Biokineticists and/or exercise therapists may be able to use the information gathered in this study so as to increase awareness and in order to develop intervention programmes regarding the PA status and the NCD risks involved with physical inactivity. This study shows a positive relationship between NCD risk factors and different ethnicities and genders within the North West Province of South Africa. Future research within this area of study could be useful for the education of the people of South Africa concerning the prevention and treatment of lifestyle diseases and their risk factors. Research is also needed to investigate the reasons why the findings were different from what is seen in other populations and how ethnic differences influence the data. South Africa is an ethnically rich country with immense problems related to preventable diseases; future research may aid in the development of interventions focusing on gender and ethnic specific approaches.

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ANNEXURES

Appendix A: Informed consent form

Appendix B: Ethical certificate

Appendix C: Consent to use data

Appendix D: Approved protocol of phase I of the SABPA study

Appendix E: Approved protocol of phase II of the SABPA study

Appendix F: Plagarism

Appendix G: Turnitin report

Appendix H: Acknowledgement of language review

Appendix I: Permission to use Figure 4.2

Appendix A: Informed consent form

NORTH WEST UNIVERSITY

POTCHEFSTROOM CAMPUS

SCHOOL FOR PHYSIOLOGY, NUTRITION AND CONSUMER SCIENCES

PARTICIPANT INFORMATION AND CONSENT FORM

PART 1

PRINCIPAL RESEARCHER: Dr. Leoné Malan, Subject Group Physiology

PROJECT LEADER: Dr. Leoné Malan, Subject Group Physiology

Associate Researcher(s): The postdoctoral fellow involved in this trial is Dr. Szabolcs Péter. Other persons assisting in the study are Dr. Hugo W. Huisman, Prof. Johannes M. van Rooyen, Prof. Nico T. Malan, Dr R Schutte, 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).

This Participant Information and Consent Form is 7 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 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, screeening 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

o 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.

o 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 willl be you 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 1st 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 2nd 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 3rd 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 contributres 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.

1. All teachers will receive feedback on their health profile and if necessary references will be given to physicians/clinics/hospitals.
2. Printout feedback on 24 hour blood pressure monitoring report (normally costing R637.60), sonar of the artery (R1200.00), resting ECG (R600.00) and other variables (R500.00). 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 (± R55.00).
4. Dinner and breakfast (± R24.00).
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.

   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 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. 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 the North West University.

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.

Dr Leoné Malan (018-299 2438) Signature:

Sr. Chrissie Lessing (018-299 2480) Project Leader: Dr Leoné Malan

PART 2

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: Participation in this project is voluntary.

1. 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.

2. 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.

3. 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.

4. 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.

5. 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. 6. 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 BLOOD 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 ……2008/9

Witnesses

1. .....

2. . .....

Signed at ..... on ……2008/9

Appendix B: Ethical certificate

Private Bag X6001, Potchefstroom

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

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Faculty of Health Sciences Ethics Office for Research,

Training and Support Health Research

Ethics Committee (HREC)

Tel: 018-285 2291

Email: Wayne.Towers@nwu.ac.za

4 December 2017

Dr H Hammill Biokinetics

PhASRec

Dear Dr Hammill

APPROVAL OF YOUR APPLICATION BY THE HEALTH RESEARCH ETHICS COMMITTEE (HREC) OF THE FACULTY OF HEALTH SCIENCES

Ethics number: NWU-00003-17-S1

Kindly use the ethics reference number provided above in all future correspondence or documents submitted to the administrative assistant of the Health Research Ethics Committee (HREC) secretariat.

Study title: Physical activity status and the relationship between risk factors of non-communicable disease risk factors in an urban South African teachers' cohort: The SABPA study

Study leader/supervisor: Dr H Hammill

Student: B Erwee

Application type: Single study

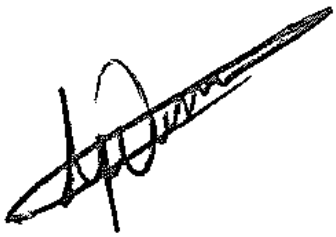
Risk level: Minimal (monitoring report required annually)

You are kindly informed that your ethics approval application has been successful and fulfilsall requirements for approval. Your study is approved for a year and may commence from 16/02/2017. Continuation of the study is dependent on receipt of the annual (or as otherwise stipulated) monitoring report and the concomitant issuing of a letter of continuation. A monitoring report should be submitted two months prior to the reporting dates as indicated i.e. annually for minimal risk studies, six-monthly for medium risk studies and three-monthly for high risk studies, to ensure timely renewal of the study. A final report must be provided at completion of the study or the HREC, Faculty of Health Sciences must be notified if the study is temporarily suspended or terminated. The monitoring report template is obtainable from the Faculty of Health Sciences Ethics Office for Research, Training and Support at Ethics-HRECMonitoring@nwu.ac.za. Annually, a number of studies may be randomly selected for an internal audit. The HREC, Faculty of Health Sciences requires immediate reporting of any aspects that warrants a change of ethical approval. Any amendments, extensions or other modifications to the proposal or other associated documentation must be submitted to the HREC, Faculty of Health Sciences prior to implementing these changes. These requests should be submitted to Ethics-HRECApply@nwu.ac.za with a cover letter with a specific subject title indicating,“Amendment request: NWU-XXX-XXX”. The letter should include the title of the approved study, the names of the researchers involved, the nature of the amendment/s being made (indicating what changes have been made as well as where they have been made), which documents have been attached and any further explanation to clarify the amendment request being submitted. The amendments made should be indicated in yellow highlight in the amended documents. The e-mail, to which you attach the documents that you send, should have a specific subject line indicating that it is an amendment request as well as the nature of the amendment e.g. “Amendment request: NWU-XXX-XXX”. This submission will be handled via the expedited process.

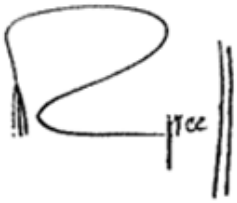
Any adverse/unexpected/unforeseen events or incidents must be reported on either an adverse event report form or incident report form to Ethics-HRECIncident-SAE@nwu.ac.za.The e-mail, to which you attach the documents that you send, should have a specific subjectline indicating that it is a notification of a serious adverse event or incident in a specific project e.g. “SAE/Incident notification: NWU-XXX-XXX”. Please note that the HREC, Faculty of Health Sciences has the prerogative and authority to ask further questions, seek additional information, require further modification or monitor the conduct of your research or the informed consent process.The HREC, Faculty of Health Sciences complies with the South African National Health Act 61 (2003), the Regulations on Research with Human Participants (2014), the Ethics in Health Research: Principles, Structures and Processes (2015), the Belmont Report and the

Declaration of Helsinki (2013).We wish you the best as you conduct your research. If you have any questions or need further assistance, please contact the Faculty of Health Sciences Ethics Office for Research, Training and Support at Ethics-HRECApply@nwu.ac.za.

Yours sincerely



Prof Wayne Towers
HREC Chairperson



Prof Minrie Greeff
Ethics Office Head

Appendix C: Consent to use data



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South Africa 2520
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Web: http://www.nwu.ac.za
Hypertension in Africa Research Team (HART)
Tel: +2718 299 2438
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Web: http://www.nwu.ac.za/hart

4th May 2016

Miss Bianca Erwee
Hypertension in Africa Research Team (HART)
Faculty of Health Sciences

Dear Miss Erwee

LETTER OF CONSENT FOR USE OF DATA
MSc. (Curriculum G885P), student number 20673914
Supervisor: Dr. H. Hammill

Permission is hereby granted by the undersigned principal investigator, Prof Leoné Malan, to conduct the following study: Physical Activity Status and the Relationship between Risk Factors of Non-Communicable Disease Risk Factors in an Urban South African Teachers' Cohort: The SABPA study. The study is to be undertaken within the scope of the **S**ympathetic activity and **A**mbulatory **B**lood **P**ressure in **A**fricans (SABPA) prospective cohort study.

To address main objectives of the SABPA study, the sub study will refine these objectives by assessing lifestyle behaviour (alcohol consumption) and DNA damage (telomere length) [Annexure A: page 3: Objectives 2, 7 and 8]:

You, therefore have permission to use the following data from phases I of the SABPA study:

1. Anonymised demographics of the participants.

2. Diseases applicable to the scope of your study (cardiovascular disease, diabetes, HIV status).

3. Medication use.

4. Results of the Patient Health Questionnaire: Depression symptoms (PQH) as well as the General Heath Questionnaire (GHQ).

5. Anthropometric measurements of the participants.

6. Cardiovascular measures (blood pressure and heart rate),

7. Renal impairment marker (estimated glomerular filtration rate).

8. The following fasting biochemical measures, if applicable (in no particular order): Gamma glutamyl transferase, cotinine, glucose and glycosylated haemoglobin A1C, triglycerides cholesterol, serum C-reactive protein, renin levels, aldosterone levels. If any other variables may add value to your research (confounding variables or other biochemical/cardiovascular measures), please consult with me.

Success with your research.

Yours sincerely



Prof L Malan (SABPA Study, Principal Investigator)

(RN, HED, PhD)

Annexure A: Main hypothesis to be examined in the SABPA Study:

Increased sympathetic nervous system activity as reflected by the renin-angiotensin II-aldosterone system (RAAS), stress profile, catecholamine metabolites, obesity, inflammatory markers and certain coping styles will enhance vascular dysfunction, hypertension and metabolic syndrome prevalence in urbanised Africans. To test the main hypothesis, the following main objectives have been formulated: To assess the relationship between lifestyle changes and increased sympathetic nervous system activity as well as vascular dysfunction in white and black urbanised South African teachers with specific attention to the link between coping and renin-angiotensin-aldosterone system, stress profile, catecholamine metabolites,

obesity and inflammatory markers, cardiovascular and metabolic syndrome indicators.Sub-hypotheses include:

1. A relationship exists between sympathetic nervous system activity and vascular dysfunction in Africans [as reflected by a dysfunction in catecholamine metabolism (metabolites, thyrosine hydroxilase polymorphism, phenylalanine levels), renin-angiotensin II-aldosterone system (RAAS), arterial stiffness, non-dipping blood pressure, hyperreactivity to stressors, ST-segment deviation, left ventricular hypertrophy].

2. There is a relationship between specific psychological variables (or the lack thereof) and the development of vascular dysfunction, type 2 diabetes and hypertension in black and white Africans.

3. Obesity is related to poorer psychological well-being.

4. There is a predisposition for a genetic susceptibility for metabolic polymorphism as well as hypertension polymorphism on the gene encoding thyrosine hydroxilase in participants with a coping disability.

5. Blacks are prone to hemodynamic abnormalities characterized by increases in arterial stiffness in response to external stimuli.

6. Sympathetic nervous system reactivity in blacks is greater in response to stressors (mental and physical).

7. Sympathetic overactivity increases inflammation which contributes to vascular endothelium growth, hypertension prevalence and type 2 diabetes in blacks.

8. Lifestyle changes induce: habituation/dissociation of physiological coping styles, prolonged/chronic stress through altered stress hormone levels, pre-diabetic conditions, increases in obesity and cardiovascular risk factors (more smoking and alcohol consumption, less physical activity).

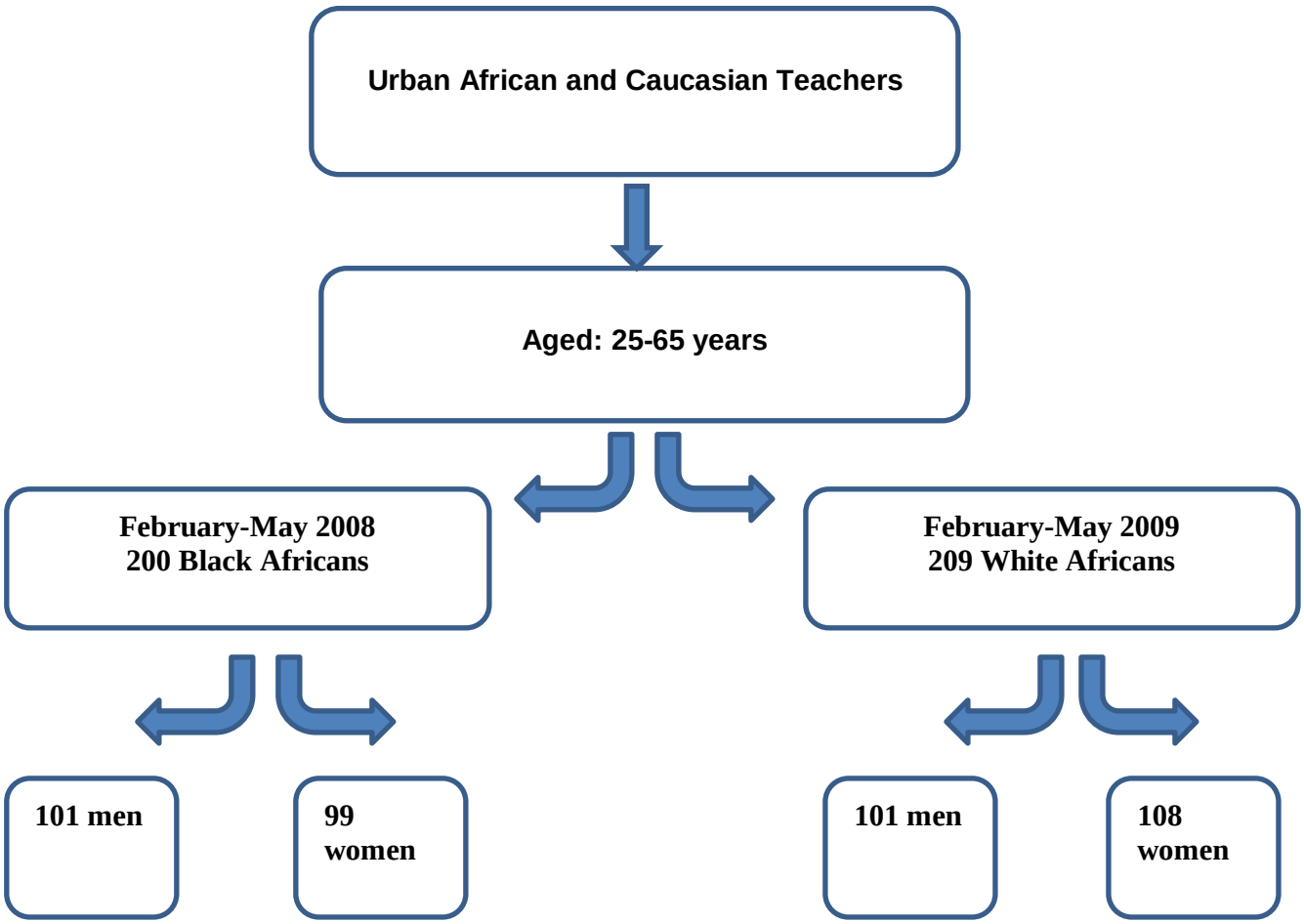
9. Disability in coping styles and experiencing of more stress is associated with right brain hemispheric thinking processes.

Appendix D: Approved protocol of phase I of the SABPA study

The SABPA Study

SABPA (**S**ympathetic activity and **A**mbulatory **B**lood **P**ressure in **A**fricans).

A PROSPECTIVE COHORT STUDY



The participants complied to the following criteria:

* Not being pregnant or lactating
* Not using α & ß blockers
* No blood donors/been vaccinated in previous 3 months
* Ear temperature > 37◦C

Schematic presentation of procedures during data observations

RECRUITMENT (*2 researchers*) 2007

45min/day (14 days)

PRE-DAY I: batteries

Check Cardiotens batteries, charge

9hours

A TRANSPORT TO SCHOOL (*2 researcher*)
- ID, Check consent, apply & program Cardiotens (AMBP&ECG)
- Actical meter
- NBI questionnaire complete after school

Reseacher transport to school : **15min**

ID, consent, apply & program

Cardiotens: +-**15min**
SCHOOL 07:30 – 08:30
Actical meter: +-**2min**

B TRANSPORT (*1 researcher*)
- Metabolic Unit (MU) 16:30

C WELCOMING: Sitting room (*2 researchers*)
- Demographic & Health questionnaire
- Baecke Physical activity questionnaire
- Pre-counselling HIV/AIDS

Researcher to school + Participants to MU schooltransport: +-**30min**

METABOLIC UNIT 17:00 –

D BEDROOM
- Freshen up and 30 min psychosoc quest

Dinner: +-**60min**

E DINING ROOM (*1 researcher*)
- Dinner 18:00
- Completion - Psychosocial battery 19:00 – 20:00 with break (coffee/tea & cookie)

Psychosocial battery:
+-**40 + 20min**
(2 X 20 min with break of 20 min)

PROJECTED TIME from 17:00:
180 min or +- 3 hours

SUMMARY OF PROCEDURES FOR DAY I:

 Pre-requisites for saliva sampling*: Participants are staying overnight and therefore will refrain from consuming alcohol, caffeine, smoking, exercising 12 hours prior to data sampling. They must be careful with their dental hygiene the previous night preventing bleeding gums for sampling on Day II. They will be requested not to brush their teeth before data collection (Earle et al., 2000; Sarstedt Cortisol-Salivette, 2007).*

 Numbers/ID for 4 participants (all women /men) will be given and every day the informed consent forms will be checked at the schools and the Cardiotens and Actical apparatus will be fitted and programmed. They will then continue with normal daily activities. After school the Neethling Brain Instrument (NBI) questionnaire must be completed.

 At 16.30 they will be transported to the MU which is well ventilated with a comfortable temperature and they will receive their own private bedroom. Two participants will share a bathroom.

 They will complete the following questionnaires:

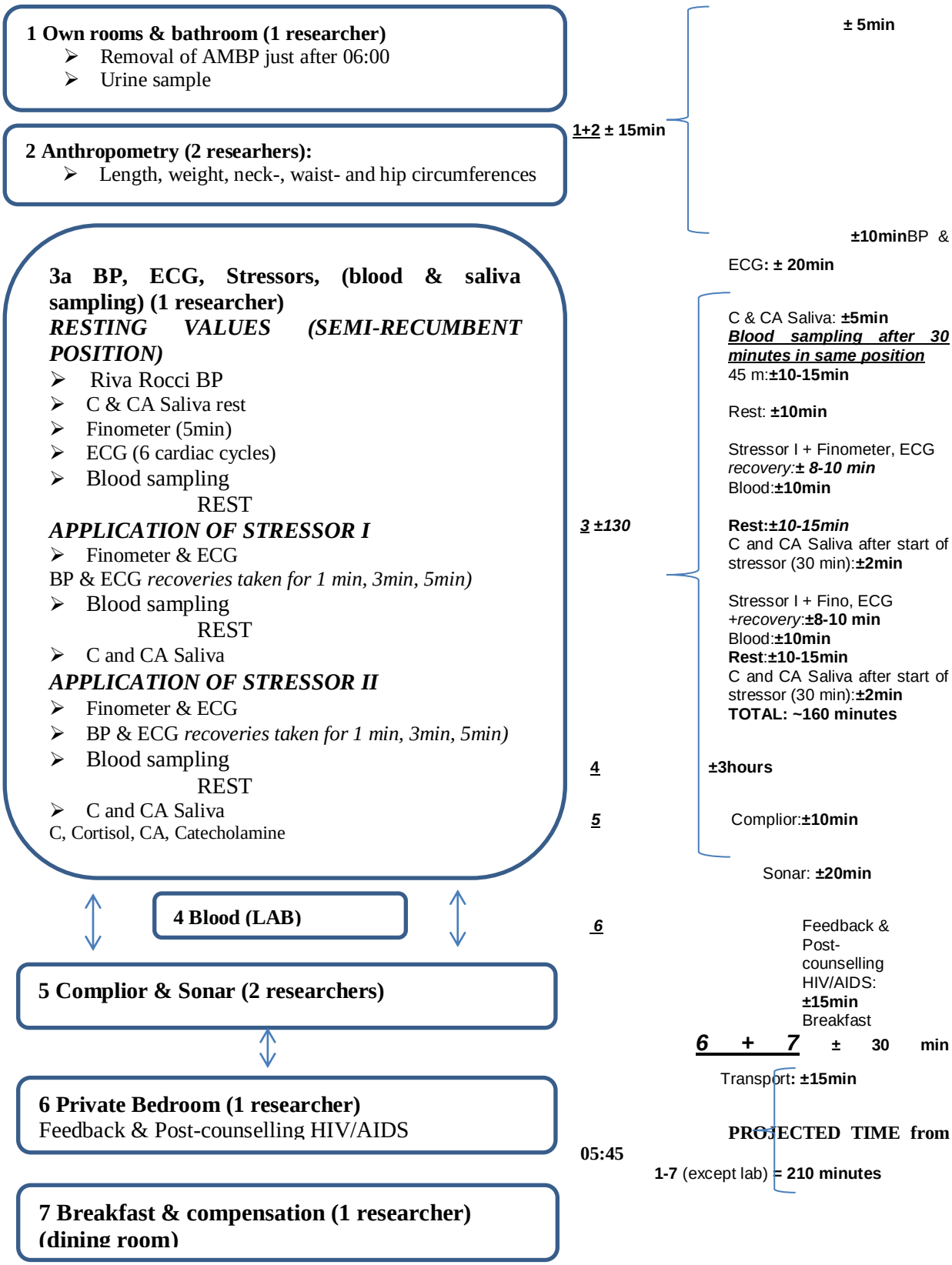
o Demographic & General Health Questionnaire

o Ambulatory blood pressure diary chart

 Pre-counselling for HIV/AIDS will be done whereafter they receive a standardized dinner. Before and after dinner, they will complete the psychological questionnaires whereafter last beverages can be taken (coffee/tea & cookie), socializing and bedtime.

All resting sampling (blood and saliva) after being in a semi-recumbent position for 30 minutes, were done at:

1. Time 1: 06:30 - 0:700
2. Time 2: 08:30 – 09:00
DAY II (05:45) (Stations are marked: 1 - 7)



Transport back to school **(1 researcher)**

SUMMARY OF PROCEDURES FOR DAY II:

 Participant confidentiality will be maintained under all circumstances.

 Early on Day II (05:45am) the Cardiotens will be removed and an overnight 8h fasting urine sample collected.

 Anthropometric measurements will be taken by level II anthropometrists. The ECG electrodes will be applied and Riva/Rocci Korotkoff blood pressure taken in duplicate. Fasting resting saliva samples as well as venous blood samples of *48 ml with a winged infusion set* will be obtained. A small amount of anti-clotting solution (0.5ml heparin:9ml normal saline solution) was left in the infusion set to prevent blood clotting after application of each stressor. It was thoroughly flushed and pro-thrombic markers samples taken after serum, EDTA plasma, NaF sampling were done. Resting and stressor cardiovascular & ECG values at baseline and after application of each stressor will be obtained.

 In between the cardiovascular, saliva and blood sampling measurements the other participants will have their arterial stiffness and sonar indices measured. If all these measurements have been done participants will receive post-counselling for HIV/AIDS and an immediate feedback on their health and compensation for their Strooop test whereafter they can take a shower and have breakfast.

 They will be transported back to school and will receive feedback reports on the Cardiotens measurements and NBI questionnaire within one week.

STATIONS

A list of the stations that are needed for the project and tentatively the person/s appointed to specific stations is given below. In the table a description follows of each stations' activities but we will appreciate it if the persons appointed for each station will also take responsibility for the order of data sampling as we won't always be able to think about everything and to control it.

Stations		**Persons responsible**
	Recruitment & informed consent	L Malan & G Colane/L Mamabolo/T Khumalo
DAY I A	*Transport to school: ID, consent, Cardiotens* Actical *NBI questionnaire*	L Palmer/H Malan/H Huisman/N Mashele/JM van Rooyen/NT Malan/P Szabolcs* S Kruger/L Mamabolo Participants
B	*Transport to MU*	Postgraduate student/s

		(collaborators)
C	Welcoming *Health & Physical activity questionanaires* *Pre-counselling AIDS*	LMalan LMalan & S Kruger/L Mamabolo L Malan
D	Freshen up	
E	Dinner Psychosocial battery	J Potgieter/T Khumalo/M Temane
DAY II 1	*Removal Cardiotens & Urine sample*	L Malan
2	Antropometry	H De Ridder & students
3	Finometer & ECG & Stressor *Blood & saliva sampling*	L Malan & P Szabolcs C Lessing/RN
4	Blood handling(LAB)	P Venter/C van Deventer (Runners: postgraduate students) collection: ***liquid nitrogen, ice for blood and CPT***
5	Complior & SonociteMaxx	A Schutte/C Fourie
6	Feedback *Post-counselling*	G de Wet L Malan
7	Breakfast & Compensation	T Scholtz (Support L Palmer)

1We want to ensure continuity by placing specific researchers at the same station each day. The contact numbers of students involved in the data sampling of the study will be announced early mid-January 2008/9. [*Postdoctoral fellow (MD): Peter Szabolcs, MSc students: Claire Tolmay (0833879871), Paul Venter (0834713986), Nyiko Mashele (0835080234), Hons students: Danelle Meyburg, Lisa van Lill].

DESCRIPTION OF PRE-DAY I

School principal: Phone principal at specific school to remind participants that they must wear cotton shirts before undergoing the AMBP, shower/bath early on DAY I as they can't do it at the end of DAY I).

Batteries: Every day, before DAY, I the responsible researcher must check if batteries for Cardiotens (AMBP & ECG) are fully charged (4 batteries/Cardiotens), i.e. 4 X 4 = 16. Each set of batteries must be charged for 9 hours.

DESCRIPTION OF DAY I

Recruitment, screeening and informed sessions with the human participants have been done at 7 secondary schools in Potchefstroom and informed consent forms signed. All participants are urbanized with the same socio-economic status & in posession of a medical aid. *ALL questionnaires are completed once only.*

NB Checklist of particulars that must go to school on DAY I:

o ***Consent forms(plus participants copy) for specific school.***

o ***Participant sheets for specific school: participant numbers will be given and indicated on the participant sheets. Participant sheets must NOT be given to participants but be taken back to the Metabolic Unit (MU) at the North-West University (NWU).***

o ***Cardiotens (additional batteries, Laptop & USB serial port, protocol for programming, ECG electrodes, cotton disposable towel, extra obese and normal cuffs, diary, pen).***

o ***4 X Actical physical activity apparatus***

o ***4 X NBI questionnaires***

A SCHOOLS (TWO teachers/day from 2 schools involved independent of gender)

Transport*:* A North-West University (NWU) vehicle which can accommodate all passengers will be used (kombi). The drivers must obtain and deliver the keys at the car park of the NWU, beginning and end of the week, respectively.

Cardiotens, Actical The Cardiotens and Actical will be fitted to participants (N = 4). The Cardiotens will be programmed for daily (every 30 min) and nightly (every 60min) measurements (Kohara K, Nishida W, Maguchi M, Hiwida K. Autonomic Nervous Function in Non-dipper Essential Hypertensive Subjects: Evaluation by Power Spectral Analysis of Heart Rate Variability. *Hypertension.* 1995;26:808).

The following must be explained to participants regarding the Cardiotens: diary recording of daily activities and access to contact numbers of researchers whereafter they can resume their normal daily activities.

NBI questionnaire No supervision needed and must be completed in the afternoon before 16:30.

B TRANSPORT FROM SCHOOL TO MU AT 16:30

Every day from Monday – Thursday participants will be transported to the MU for observations.

C WELCOMING

o Each participant will be welcomed and receive their own room. Protocol will be explained again and questions answered regarding DAY I and/or DAY II (*including the incentives: benefit of chronic medication prescriptions, brain preferences report, feedback report on general health, free dinner and breakfast, monetary incentive on completion of a stressor).*

o ***Questionnaires:*** All questionnaires will be completed on DAY I in a comfortable relaxing environment (MU), which is well ventilated with mild temperatures day and night.

Before dinner:

o Demographic and General Health: marital status, education, employment status, family history, diseases affecting: heart / blood vessels / kidney / kidney stones / diabetes / hypertension / current health /medications / medications / menstrual cycle / parity and related surgery or diseases/ smoking and alcohol consumption.

o Baecke Physical Activity.

o Teacher Stress Inventory (Job stress). *Indicate on participant sheet.*

o ***HIV/AIDS pre- and post-counselling*** on DAY I and post-counselling DAY II, according to the guidelines from the Dept. of Health will be perfomed (School for Nursing Sciences). The procedures of the initial sifting tests, confirmation tests and CD-4 counts as well as applying for chronic medication benefit, will be explained. *Indicate on participant sheet*.

D FRESHEN UP FOR DINNER

E DINNER & PSYCHOSOCIAL BATTERY

o ***Standardized dinner***: (according to fat, carbohydrates and protein content) supplied by De Jonge Akker Restaurant, NWU.

o ***The psychosocial battery*** *has been completed prior to the study by 2 researchers (a registered psychologist and a physiologist*). Questionnaires under supervision of a registered education specialist and psychologists will be completed within approximately 1 hour, break with coffee/tea and biscuits included (sponsored by Turkstra Bakery).

o The questionnaires chosen (validated and internationally peer-reviewed) are measures which are associated with predictors/worsening of hypertension, with known heritability & which could moderate the environment: *Marital status, job strain, coping styles, African cultural support system, perception of health, personality inventory, life orientation, perceived social support from family and friends, emotional and personal psychological and social well-being, selfregulation of emotions (2).* Questionnaires included are therefore:

A. PREDICTORS OF DEVELOPMENT/WORSENING OF HYPERTENSION

1) Dyadic Adjustment Scale (Marital) (Spanier, 1976) – 32 items (5-10 minutes).

2) Karasek Job Strain Questionnaire (Karasek et al., 1998) – 18 items (5 minutes).

3) General Health Questionnaire (GHQ). Perception of own health) (Goldberg & Hiller, 1979) – 28 items (10 minutes).

4) The Coping Strategy Indicator (Amirkhan, 1994) AND the ACSI (Africultural Coping Systems inventory) (Utsey et al., 2000) – 30 items (15 minutes).

5) Patient Health Questionnaire: Depression symptoms (PQH) (Kroenke et al., 2001) – 9 items (3-5 minutes).

6) Teacher Stress Inventory (TSI) (Boyle et al., 1995) measures the amount of stress experienced by teachers, and that are caused by different work-related factors – 20 items (5 minutes)

B. MEASURES WITH KNOWN HERITABILITY

1) BTI-S (Basic Traits Inventory – Short form) measures 'big five' personality traits as found for instance in the NEO-PIR personality inventory – 77 items (15 minutes). This questionnaire is in a developmental process, and is currently validated for the South African context.

2) Life orientation Questionnaire (LOT) (Scheier & Carver (1987) – measures optimism – 12 items (5 minutes).

C. MEASURES WHICH COULD MODERATE THE EFFECTS OF ENVIRONMENT

1) Short Self-regulation Questionnaire (SSRQ) (Carey, Neill & Collins, 2004) – 31 items (5 minutes)

2) Mental Health Continuum – emotional and personal psychological and social well-being (MHC-SF) (Keyes, 2006a) – 14 items (5-8 minutes).

3) Selfregulation Scale (Schwarzer et al., 1999) – 7 items (3-5 minutes).

DESCRIPTION OF STATIONS OF DAY II (06:45)

1 Own rooms & bathroom

Removal of Cardiotens by supervisors and obtaining an urine sample for pre-screening tests for microalbuminuria (If values of 10-15mg/l are found follow-up 24hour urine samples will be obtained (Gansevoort *et al*., 2007). Samples will be analyzed within 2 weeks – 2 months after sampling to avoid sedimentation (Elving *et al*., 1989).

2 Anthropometry

The following basic anthropometric measurements will be done in triplicate by Biokinetic postgraduate students (Supervisor: Prof H de Ridder, +27 18 2991791; Cell, 0825773171):

- Height
- Weight
- Waist circumference
- Hip circumference
- Neck circumference (NC)

[NC is measured at mid-neck height, between the mid-cervical spine to mid-anterior neck, to within 1 mm. In men with a laryngeal prominence (Adam's apple), it is measured just below the prominence. Ben-Noun & Laor, 2003]

Participant sheet will accompany participants during DAY and DAY II in between stations. On this form their is a place to indicate measurements.

3 BLOOD PRESSURE, ECG, BLOOD AND SALIVA SAMPLING, STRESSOR EXPOSURE

NB Two identical set-ups for the blood pressure, ECG, blood and saliva sampling exists at station 3 (in separate rooms).

Participant position*: All participants must lie on the bed in a comfortable semi-Fowlers position for the whole procedure (i.e. upper part of body and head 45 degrees elevated).* ***NB. They must be in this position for 30 minutes before blood sampling (renin-angiotensin-aldosterone system requirements (Diagnostic Systems Laboratories, 2005).***

o ***The 12 ECG electrodes***: 12 electrodes applied and 6 cardiac cycles taken (programmed strip lead: II).

o ***Sphygmomanometer***: The blood pressure (BP) normal/obese cuff of the spygmomanometer is applied to the ***left arm.*** After 5 minutes of rest the first BP measurement will be taken and the second after another 5 minutes of resting. *Indicate on participant sheet*.

o ***Saliva sampling:*** Place the cotton roll from the salivette in the mouth and ask the participant to chew the cotton swab and remove it after saturation (Helhammer et al., 2004). After collection the saturated cotton swab is returned to the vial (Sarstedt). The vial is placed in a plastic adapter that allowes it to fit into a standard centrifuge test-tube holder.

o ***For Catecholamines (CA) and Cortisol (C) sampling:*** place samples immediately into flask with liquid nitrogen, later after all participants samples have been obtained it will be stored at at -80°C. Before analysis, centrifuge at 1000 x g for 2 minutes. ***Follow the same procedure for saliva sampling throughout the data collection period****. Indicate on participant sheet.*

o ***Blood sampling***: A resting blood sample of 47.5 ml must be obtained from the ***right arm*** where possible as cardiovascular measurements are done on the left arm. The arm will be supported by a splint for the rest of the procedure to keep it immobile. The winged infusion set is left in situ with a diluted heparin block (0.5ml heparin:9ml normal saline). *Cover the arm with a towel to lessen perception of stress on viewing the intact needle*. Fresh resting blood (2ml) will be used for genetic (Guthrie cards) and blood glucose screening (One sure step kit). Serum (200µl) will be used for the HIV/AIDS screening (First Response Kit test and if positive, the Pareekshak test).

o ***At BP stations: Resting 2 ml blood must be used for Guthrie cards and glucose screening. Done once only. Indicate on participant sheet****.* (Blood glucose with the One Touch Sure StepTM Glucose meter (Life Scan, Johnson& Johnson, California, USA®).

o ***Blood sample handling (SEE BLOOD HANDLING of STATION 4* AFTER *STATION 5* s' description)**.

o Blood sample handling implies 3 X 10 ml tubes (2 serum [red plug] and 1 EDTA plasma [purple plug]); 1 X 5 ml serum tube [red plug], 1 X 5 ml EDTA plasma [purple plug], 1 X 1 ml NaF plasma [grey plug] and 1 X 5 ml citrate plasma [light blue plug] *It is VERY important that the citrate plasma sample tube [light blue plug] must be filled entirely (4.5 - 5 ml) otherwise the ratio of anti-clotting substance to clotting factors in blood is not reliable.* All samples are immediately sent to the lab with a runner. The same procedure for handling must be followed after each stressor was applied.

o ***The Finometer*** cuffs must be fitted and necessary anthropometric and age information can be obtained form the participant sheet. In total an **one minute ECG** and **five minutes Finometer** recording is obtained (including a RTF-calibration after 2 minutes). *Please indicate the filename of the recording on the participant sheet and in the Finometer book.*

o ***Stressor application (repeated)***: Stressors are applied in a counterbalanced way (Steptoe et al., 2005) for **one minute** whilst recording the BP & ECG including recoveries. *Indicate the filenames of the recordings on the participant sheet and in the Finometer book at the station.*

o A blood sample of 47.5 ml was obtained after exposure of each stressor and followed by a rest period of 15 minutes. CA and C saliva samples are obtained 20 minutes after stressor applications. Thus 30 minutes since application of stressor.

Renumeration for completion of the Colour Word Conflict Test/Stroop Test (MOTIVATION):

During the Stroop test (10 columns) they can money for successfully completing the whole test without any faults within the time frame allowed (1 euro per column).

SEVERITY OF STRESSORS QUESTIONNAIRE (Steptoe *et al*., 2005)

Participants will report the severity of the stressors by indicating their perception of the stressors as:

1, *not at all stressful and 7*, *very stressful.* Additional form will be supplied at station.

HANDLING of URINE, FRESH BLOOD (GLUCOSE, GUTHRIE CARDS), SALIVA

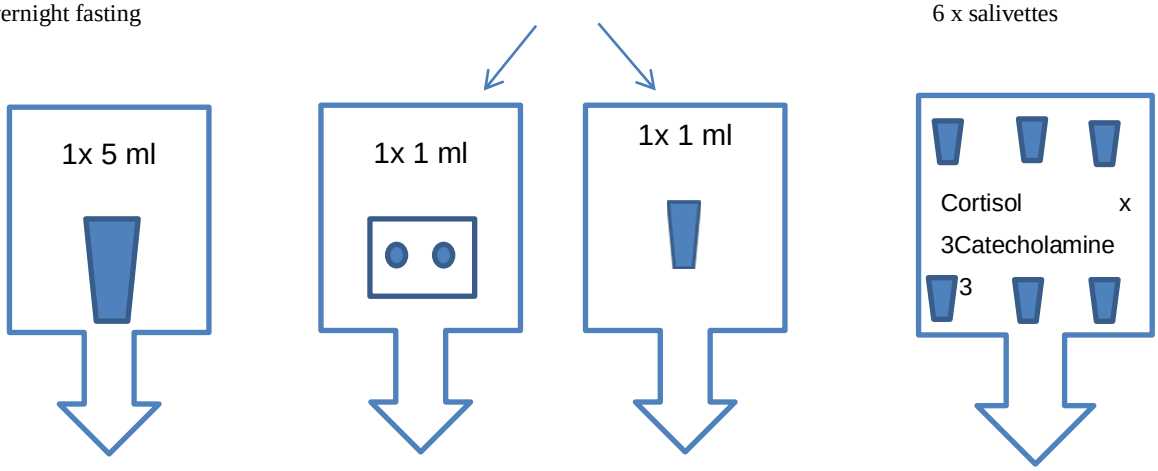
Urine ± 5ml

Overnight fasting

Fresh Blood

Saliva ±

6 x salivettes



Immediately on ice

Pipet into 0.5 ml eppendorf. Freezer (-80°C)
Total: **1 Eppi** marked:
SAB PPNR. 2008/9 U

Fill 3 circles (14mm diameter)

Room temperature

1 drop: glucose meter.

1. Cortisol (C)
✓ Liquid nitrogen flask immediately
✓ Freezer (-80°C)

2. Catecholamine (CA)
✓ Liquid nitrogen flask immediately
✓ Freezer (-80°C)

Total: **6 Salivettes** marked:
SAB PPNR.
2008/9 C/CA r/s1/s2

Total urine eppi's: x1 (fasting)/participant
Total saliva salivette's: C: x3; CA: x3 (resting and stress I, II)/ participant

SAB: SABPA
PPNR: participant number (1 – 200)
U: urine sample
Yellow eppendorf: Urine sample
C: cortisol resting/stress 1/stress2
CA : catecholamine resting/stress1/stress2

5 COMPLIOR AND SONAR

Before participants go to the Complior and Sonar station, it is expected that they must have been resting in a sitting/lying position for at least 10 minutes. The 2 participants at the Finometer station will later defnitely comply to this criteria but the first 2 participants must be made comfortable and left to lie down for 10 minutes prior to testing. Measurements for the Complior are taken in the left foot.

- *Remove all pillows form the bed and assure the participant is in a supine position*.

COMPLIOR

- Measure the participant's carotis-pedalis distance whilst he/she is lying on the bed and document it on the participant sheet. A direct measurement is taken with the tape from the carotis to the pedalis by asking the patient to straighten his/her leg in line with the longitudinal axis of the body.
- The participant has to lie flat on the bed with his/her eyes closed.
- Duplicate measurements of the carotis-pedalis with the Complior and store data. *Both values must be indicated on the participant sheet*. *Export all measurements each day to an Excel file. Do back-up on USB flash.*

SONAR

Scanning-and-reading protocols were developed and standardized in collaboration with experts from the Vascular Imaging Centre, Utrecht University, The Netherlands and Chalmers University, Gothenburg, Sweden. Using the Sonocite® portable ultrasound system, a total bilaterally, of 8 end-diastolic (on R-wave) B-mode images will be acquired and stored for off-line analysis of the near and far walls of the distal Common Carotid Artery (CCA) – with 30 degree-increments, at 4 different angles both left and right, using the Meijers Carotid Arc.

4 BLOOD LAB: Handling of Resting & Stressor blood samples:

Preparation by the lab technician:

Prepare the workstation by setting right 3 separate trays, each containing the following allotted number of Eppendorf tubes:

One tray with white eppendorf tubes for resting blood samples:

- ✓ 20 x for Serum from Red plug vaccutainers
- ✓ 1 x for NaF from Grey plug vaccutainer
- ✓ 4 x for Citrate from Light blue plug vaccutainers

- ✓ 12 x for EDTA from Purple plug vaccutainers
- ✓ 1 x for EDTA from Purple plug vaccutainer (for Biochemistry)

One tray with pink eppendorf tubes for Colour-word-conflict blood stressor samples:

- ✓ 20 x for Serum from Red plug vaccutainers
- ✓ 1 x for NaF from Grey plug vaccutainer
- ✓ 4 x for Citrate from Light blue plug vaccutainers
- ✓ 12 x for EDTA from Purple plug vaccutainers

One tray with blue eppendorf tubes for Cold presser blood stressor samples:

- ✓ 20 x for Serum from Red plug vaccutainers
- ✓ 1 x for NaF from Grey plug vaccutainer
- ✓ 4 x for Citrate from Light blue plug vaccutainers
- ✓ 12 x for EDTA from Purple plug vaccutainers

Also add the following in a tray:

Tubes needed for urine samples:

- ✓ 1 x Yellow eppendorf tube (For Physiology)
- ✓ 1 x Brown eppendorf tube (For Biochemistry)

Utensils and apparatus needed for sampling:

- ✓ 4 x Centrifuges (Centrifuge 1, 2, 3 and 4)
- ✓ Eppendorf micro pipettes
- ✓ Eppendorf pipette tips (Blue)
- ✓ First response HIV card test 1-2.0 & One step HIV-1/2 Whole blood / Serum / plasma test (2 lines)
- ✓ Gloves

Blood samples from nurses will be received in 3 batches, each consisting of:

3 x Red plug vaccutainers [CAT] labeled SAB _ _ _ r / s1 / s2

- ✓ 2 x 10.0 ml
- ✓ 1 x 6.0 ml

1 x Grey plug vaccutainer [NaF] labeled SAB _ _ _ r / s1 / s2

- ✓ 1 x 2.0 ml

1 x Light blue plug vaccutainer [Citrate] labeled SAB _ _ _ r / s1 / s2

✓ 1 x 2.7 ml

2 x Purple plug vaccutainers [EDTA] labeled SAB _ _ _ r / s1 / s2

✓ 1 x 10.0 ml

✓ 1 x 6.0 ml

Urine samples received from nurses:

✓ 1 x Urine sample (Clear container with green screw top).

Remember

Each batch of samples received must be treated in unison manner.

The HIV test however, must only be done on the RESTING blood samples.

All tests are performed at room temperature.

PROCEDURE

HIV test

First HIV test procedure performed using the FIRST RESPONSE HIV CARD TEST 1-2.0:

From the EDTA (Purple top) vaccutainer, which is homogenised beforehand, remove whole blood for the following test procedure:

1. Remove the Test Device and the dropper from the foil pouch, and place it on a flat, dry surface.

2. Slowly add 20 µL (two drop) of whole blood to the sample wells and then add 35 µL (one drop) of the Assay Diluent.

3. As the test begins to work, you will see purple colour move across the Result Window in the center of the Test Device.

4. Interpret test results at 5 – 15 minutes.

5. Do not interpret after 15 minutes.

6. For interpretation of result refer to test SOP / insert of product.

If **POSITIVE**, perform Pareekshak test (next procedure) to confirm the positive result (Indicate the HIV test result in the results book (on table) in the laboratory).

To be performed using the One Step HIV-1/2 Whole Blood / Serum / Plasma Test (2 lines)

From the EDTA (Purple top) vaccutainer, which is homogenised beforehand, remove whole blood for the following test procedure:

1. Remove a testing device from the foil pouch by tearing at the notch and place it on a level surface.

2. For Whole blood testing: Holding a sample dropper vertically, add one drop (approx 40µL) of specimen to the sample well. Add 2 drops of buffer (provided) from the bottle directly onto the well.

3. Wait for 15 minutes and read the results. Do not read results after 30 minutes.

4. For interpretation of result refer to test SOP / insert of product.

Blood sample preparation

For each of the following batches of vaccutainers received, follow the steps in chronological order:

SERUM (Procedure done at / in Centrifuge 1)

1. Leave 3 x red plug blood sample vaccutainer tubes at room temperature for 20 – 45 min (max 45 min) to coagulate;

2. Centrifuge the rest of the samples using the bench top centrifuge (program 1) at 4700 rpm for 15 minutes at room temperature. There is space for 24 tubes in the centrifuge (rotor radius = 12 cm);

3. If necessary odd numbered tubes must be counterbalanced with water filled tubes;

4. Aspirate the serum (top aqueous layer) into the prepared *20 labelled eppendorfs* tubes for serum, marked with an “S”.

NaF PLASMA (Procedure done at room temperature in Centrifuge 1)

1. Centrifuge the Grey plug vaccutainers in the bench top centrifuge for 10 minutes at 3700 rpm (using program 1);

2. There is space for 24 tubes in the centrifuge (rotor radius = 12 cm);

3. Aspirate the plasma into *1 labeled eppendorf* tube for NaF plasma, label marked with an “F“.

CITRATE PLASMA (Procedure done at room temperature in Centrifuge 2)

1. Centrifuge the Light blue vaccutainers in the bench top centrifuge at 1500 rpm (2000g) for 15 minutes at room temperature (using program 1);

2. There is space for 24 tubes in the centrifuge (radius=12 cm);

3. Aspirate the plasma into *4 labelled eppendorfs* tubes for citrate plasma, label marked with a “C”.

EDTA PLASMA (Procedure done at 20°C Centrifuge)

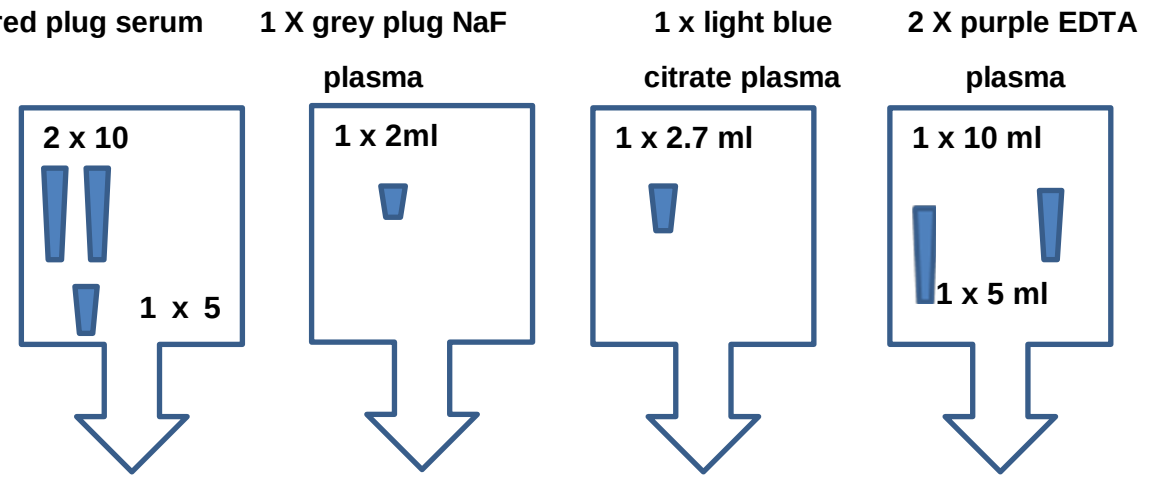
1. For resting blood samples alone: Homogenise the vaccutainered blood and remove 1 ml of the whole blood and pipette into 1.5 µL eppendorf tube (For biochemical analysis purposes).

2. Use the cold centrifuge and centrifuge the Purple plug vaccutainers (20°C) for 10 minutes at 3700 rpm (using program 1);

3. There is space for 24 tubes in the centrifuge (rotor radius=12 cm);

4. Aspirate the plasma into *12 labelled eppendorfs* tubes for EDTA plasma, label marked with an “E”.

BLOOD LAB: HANDLING of RESTING / STRESSOR I / STRESSOR II samples



Stand: 20-45 min. Room temp to clot.

⇩

Centrifuge in general centrifuge for 15 min at 4700 rpm (3000g) Centrifuge 1

⇩

Pipet into 0.5 ml eppendorfs. Total: **20 Eppi's marked:**

Centrifuge in general centrifuge for 10 min at 3700 rpm (2000g) Centrifuge 1 Program 1/

⇩

Pipet into 0.5 ml eppendorf. Total: **1 Eppi** marked: **SAB PPNR. 2008/9 F**

Centrifuge general centrifuge for 15 min at 1500 rpm (2000g) Centrifuge 2

⇩

Pipet 0.3ml into 0.5 ml eppendorfs. Total: **4 Eppi's** marked: **SAB PPNR. 2008/9 C**

One drop for HIV test, if positive also one drop for

⇩

Centrifuge in cold centrifuge for 10 min at 4000 rpm (1600g) at 20₀C Cent 3 Prog 1

⇩

Pipet 1.5 ml whole blood into white eppendorfs marked on top

⇩

Pipet into 0.5 ml eppendorfs Total: **12 Eppi's** marked: **SAB PPNR. 2008/9 E**

Total eppi's: 37

SAB: SABPA
PPNR: participant number (1 – 200)
S/F/C/E: serum/fluoride/citrate/EDTA samples
Clear eppendorf: resting samples
Blue eppendorf: cold pressor test samples
Orange eppendorf: Stroop test samples

Big centrifuges have space for 24 tubes.

Urine processing

Procedure done for urine sample:

1. Pipette 1.0 ml of urine sample into the Yellow eppendorf tube, set aside according to the preparation instructions.

2. Pipette 0.5 ml / 500 µL of urine sample into the Brown eppendorf tube, as set aside according to the preparation instructions (For Biochemical analysis).

6 FEEDBACK AND POST-COUNSELLING

- Their feedback form must be completed at Station 5.
- In the privacy of their own room they will receive feedback by a registerd nurse and their own feedback form with anthropometry, blood pressure, glucose and HIV/AIDS results. *If they do not want to know their HIV/AIDS sitfting test status it must be respected.* However, all participants will receive post-counselling for HIV/AIDS.Their data must be discussed (e.g. within normal ranges etc.) and if there are any concerns regarding their values they will be referred to their doctors.

7 BREAKFAST & COMPENSATION

- *Incentive*: They will be thanked for their participation and receive their incentive for the completion of the Stroop test. They must sign on the participation sheet that the money was received.
- *Breakfast:* They can take a shower and receive a takeaway breakfast. Every evening Mr Bertus Els from De Jonge Akker must be informed about how many dinners and breakfasts must be delivered (De Jonge Akker Restaurant, Tel: +27 18 299 4125). All dinners and breakfasts will be delivered at the MU. Coffee/Tea/Cookies are sponsored by Turkstra bakery.
- With dinner each plate can be warmed in the microwave oven. In the dining room everything needed for making coffee/tea will be available (cups and saucers, teaspoons, milk, sugar, boiling water).
- *Transport:* Hereafter, they will be transported back to school.

Appendix E: Approved protocol of phase II of the SABPA study

The SABPA II Study

Follow-up of SABPA I (Sympathetic activity and Ambulatory Blood Pressure in Africans).

MAIN OBJECTIVE AND FRAMEWORK OF SABPA II We will repeat cutting edge novel psychophysiological measurements, the first in Sub- Saharan Africans, namely:

1) A follow-up of SABPA I with SABPA II in 2011/2012. According to the knowledge of the authors, this is the first 24h ambulatory blood pressure, 24h ECG and psychophysiological follow-up study in South Africa). Assessing blood pressure and ECG and silent ischemia.

The SABPA I study (2008/2009) received an award for excellence from 938 entries, as one of three international projects in the fight against the metabolic syndrome (Metabolic Syndrome Institute Scientific Committee, France). We will therefore strive to repeat the level of excellence in the follow-up SABPA II study. Extreme quality control was important in conducting our research in SABPA I and we will repeat the exact quality control in a homogenous population from South Africa (e.g., teachers with the same socio-economic status, avoiding seasonal changes and specific sampling times avoiding circadian rhythm bias).

We will attempt to assess the main outcomes of SABPA I. In SABPA I we assessed the link between psychological stress, sympathetic nervous system activity and vascular dysfunction in a cohort of urban South African teachers. Specific attention was given to the link between coping and: renin-system, stress profile, catecholamine metabolites, oxidative stress, obesity, prothrombotic and proinflammatory markers, cardiovascular-, metabolic syndrome indicators and target end-organ damage.

Exclusion criteria: pregnancy, lactation, temperature >37ºC, users of alpha and beta blockers, blood donors and/or vaccinated in the previous 3 months.

DATES OF SABPA II PROJECT 2011

February				**March**				**April**				**May**			
M	D	W	D	M	D	W	D	M	D	W	D	M	D	W	D
V				V				V				V			
	1	2	3		1	2	3	11	12	13	14	2	3	4	5
4				4				15				6			
7	8	9	10	7	8	9	10	18	19	20	21	9	10	11	12
11				11				22				13			
14	15	16	17	14	15	16	17	25	26	27	28	16	17	18	19
18				18				29				20			
21	22	23	24	21	22	23	24					23	24	25	26
25				25								27			
28				28	29	30	31								
	Total: 12x4 N=48			Total: 16X4 N=64				Total: 7X4 N=28				Total: 13x4 N=52			

Starting date, 8th February: Shaded areas: Day II measurements

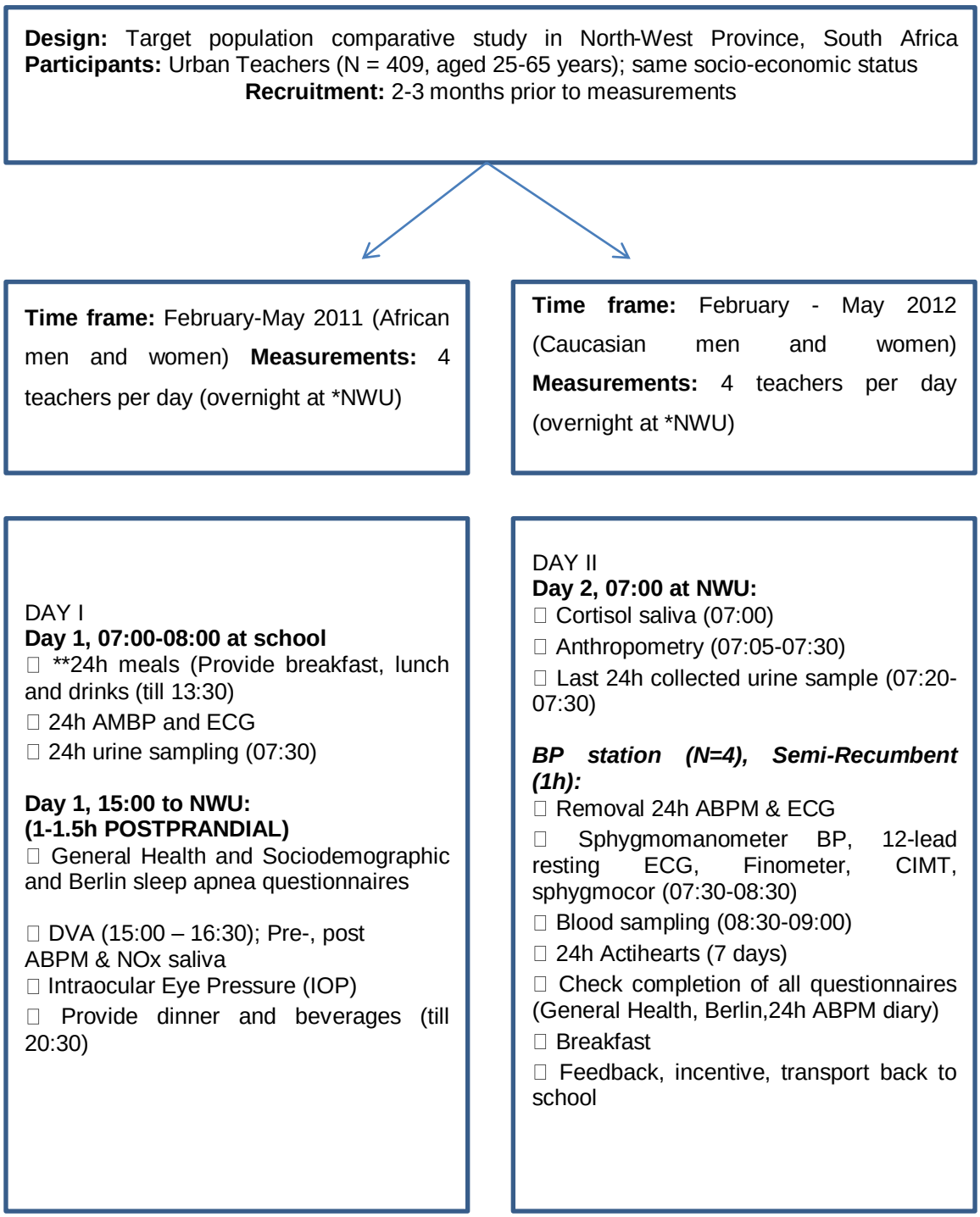
DATES OF SABPA II PROJECT 2012

February				**March**				**April**				**May**			
M	D	W	D	M	D	W	D	M	D	W	D	M	D	W	D
V				V				V				V			
6	7	8	9				1		10	11	12			2	3
10				2				13				4			
13	14	15	16	5	6	7	8	16	17	18	19	7	8	9	10
17				9				20				11			
20	21	22	23	12	13	14	15	23	24	25	26	14	15	16	17
24				16								18			
27	28	29		19	20		22					21	22	23	24
				23								25			
				26	27	28	29					28	29	30	31
				30											
14 days				16 days				10 days				12 days			

Starting date, 7 February

Theoretical: Overnight per day (N=4) for observations on DAY I and DAY II. From previous experience we know it is possible that more days are necessary but we want to complete all observations to avoid seasonal change.

SABPA II DESIGN



*NWU: North-West University; **24h meals: 2 x Breakfasts, 1x Lunch, 1x dinner, tea time refreshments.

The SABPA I comparative population study was successfully completed in 2008-2009. The SABPA II study is the 3 year follow-up which will commence in 2011 (Black African teachers) and in 2012 (Caucasian teachers). To minimize bias when comparing data, the exact well-controlled protocol will be followed. The volunteering teachers were contacted again at their schools four months prior to the data collection phase of SABPA II. Teachers are working in the Dr Kenneth Kaunda Education District, North-West Province, South Africa. Informed consent (2008) was confirmed again in 2010 after explaining the exact protocol. Permission to participate in the follow-up study has been granted by the North-West Education Department and support ensured from the South African Democratic Teachers Union.

Schematic presentation of procedures during data observations

RECRUITMENT (PI, Mr GJ Motlhasedi)

90 min/day (20 days)

Check: 24hCardiotens batteries, stickers, meals, urine, 7day actiheart

DAY I (07:00)

A TRANSPORT TO SCHOOL (*2 researchers*)

- ID, Check consent, apply & program Cardiotens (24h ABPM & -ECG)
- 24h meals
- 24h urine sampling (07:30)

Reseacher transport to school : **±20min**

ID, apply & program Cardiotens: **±15min**

SCHOOL 07:00 – 08:00

24h meals and -urine: **±10min**

B TRANSPORT (1 researcher)

- NWU (15.00)

15:00: Researcher to school + Participants to NWU transport: **±30min**

C WELCOMING: (4 researchers)

- General Health and Berlin sleep apnea quest.
- DVA (Pre-, post-ABPM, Saliva NOx)
- Pre-counselling HIV/AIDS (RN)
- Psychosocial battery 17:30

PHYSIOLOGY (F12)

IOP: 30 minutes Precounselling HIV/AIDS: **±10min** Psychosocial battery: **±45min**

DVA+ NO+Hair**: ±120 min**

D DINING ROOM (*1 researcher*)

- Freshen up
- Dinner 18:30
- Last beverages: 20:00-21:30 (coffee/tea & cookie)

  Bed 22:00

PROJECTED TIME from 15:45 till bedtime:

SUMMARY OF PROCEDURES FOR DAY I:

Numbers/ID for 4 participants (all women/men) will be given and every day the informed consent forms will be checked at the schools and the Cardiotens apparatus will be fitted and programmed. ABPM diary charts will be explained and contact numbers given if problems are experienced.

1. 24h Urine sampling and 24h controlled diet procedures will be explained and demonstrated. Ice containers for urine sampling will be available at their schools. They will then continue with normal daily activities.
2. Participants will overnight and will not have access to alcohol. They will also refrain from caffeine, smoking, exercising 12 hours prior to data sampling.
3. At 15:00 they will be transported to the NWU. They will be welcomed and receive precounselling for HIV.
4. General Health and Berlin sleep apnea Questionnaires will be completed.
5. DVA measurements. Salivary NO and AMBP will be taken at rest and directly after flicker responses.
6. Afterwards (~ 17:00) they will be transported to the MU to overnight. Each teacher will have their own private bedroom and two bathrooms are available. Protocol for measurements on DAY II will be explained to lessen anticipation stress (Obrist *et al.,* 1997).
7. At 17:30 they commenced with the psychosocial battery (45 minutes).
8. At 18:30 – 19:00 they will enjoy dinner and lastly, receive their last beverages for the night (coffee/tea & cookie), socialize and prepare for bedtime ±22:00).

DAY II (07:00) (~3 hours) (Stations are marked: 1 - 6)

1 Anthropometry (2 researhers):
Length, weight, neck-, waist- and hip circumferences

1+2 **± 30min**

2 Urine sampling (07:15)

3 1 x Room/teacher (semi-recumbent)
(4 researchers)
RESTING: 07:20 – 09:30

- Removal ABPM (07:30)
  Sphygmomanometer BP
- 12 lead ECG
- Finometer, Sphygmocor
- Blood sampling 08:30-
- Sonar CIMT
  Actihearts

1 x Room/teacher (semi-recumbent) (4 researchers)
RESTING: 07:20 – 09:30

- Removal ABPM (07:30)
  Sphygmomanometer BP
- 12 lead ECG
- Finometer, Sphygmocor
- Blood sampling 08:30-
- Sonar CIMT
  Actihearts

1 x Room/teacher (semi-Fowler)
(4 researchers)
RESTING: 07:20 – 09:30

- Removal ABPM (07:30)
- Sphygmomanometer BP
- 12 lead ECG
- Finometer, Sphygmocor
- Blood sampling 08:30-
- Sonar CIMT
- Actihearts

3 1 x Room/teacher (semi-recumbent)
(4 researchers)
RESTING: 07:20 – 09:30

- Removal ABPM (07:30)
  Sphygmomanometer BP
- 12 lead ECG
- Finometer, Sphygmocor
- Blood sampling 08:30-
- Sonar CIMT
  Actihearts

3 BP**: ± 10min/teacher**
ECG: **±10 min/teacher**
Finometer: **±15 min/teacher**
Sphygmocor: **±20-min/teacher**
Sonar: **±25 min/teacher**

Blood:**±10-15 min/teacher**

Actiheart: ±15min

4 Blood lab:±2hours

4 Blood (LAB)

5 Private Bedroom (1 researcher)
Feedback & Post-counselling HIV/AIDS

6 Breakfast & compensation (1 researcher) (dining room)

5 Feedback & post- counselling (HIV) **±15min**
6 Breakfast**±30min** Back to school (transport)**: ±30min**

PROJECTED TIME from 07:00:
1+2 +3 = ~185 minutes

SUMMARY OF PROCEDURES FOR DAY II:

- Participant confidentiality will be maintained under all circumstances.
- Anthropometric measurements will be taken..
- Last 24h urine sampling at 07:20-07:30.
- Four identical BP stations:

  Participants in semi-recumbent position for procedures (07:30). Their positions must be maintained for 1 hour before venous blood samplings with a winged infusion set at 08:30 (*requirements for renin-angiotensin system*).
- All cardiovascular apparatus will be on mobile trolleys and move in between rooms to collect data.
- Riva/Rocci Korotkoff blood pressure will be taken after a resting period of 5 min in duplicate with a 5 min rest period in between.
- The Finometer beat-to-beat BP (3 min) and 12 lead ECG will be taken for 6 cardiac cycles.
- The Actiheart apparatus will be fitted to participants.
- If all these measurements have been done they can get up, take a shower and have breakfast.
- Participants will receive post-counselling for HIV/AIDS and an immediate feedback on their health and incentive as token of appreciation (R100.00 / US$ ± 14.5 / 10 euro).
- They will be transported back to school and will receive feedback reports on their Cardiovascular health within one week.

STATIONS

A list of the stations that are needed for the project and tentatively the person/s appointed to specific stations is given below. In the table a description follows of each stations' activities but we will appreciate it if the persons appointed for each station will also take responsibility for the order of data sampling as we won't always be able to think about everything and to control it.

Stations		**Persons responsible1**
	Recruitment & informed consent	**L Malan & GJ Motlhasedi**
DAY I A	*Transport to school and NWU: ID, consent,* Cardiotens 24h urine *24 h diet (collect previous day & handout on Day I)*	NWU BRS/Pharmacology/Education **L van Lill/A Burger** & students **L Venter/A Pretorius** **S Botha** & Hons student
B	*Transport to NWU*	BRS/Pharmacology/Education
C	Welcoming *Psychosocial battery* *Pre-counselling AIDS*	L Malan **JC Potgieter and students** L Malan

	□ *DVA, NO, ABPM & download, reports* □ *Cortisol hair sampling*	□ **NT Malan/W Smith/L Malan** □ **L Malan and postgraduate students**
E	□ *24h diet packages for DAY I & quest, data download*	De Jonge Akker caterers, Postgraduate students
DAY II 1	□ Anthropometry,	□ **S Hoebel & students**
2	□ *24 h urine & data download*	□ **L Venter/A Pretorius, A Smith**
3	□ *Sphygmomanometer BP, ECG and download*	□ L Malan
	□ *Finometer & download*	□ **H Huisman, senior researchers** & postgraduate students
4	□ *24h Cardiotens removal, download and reports (08:30)*	□ **A Burger/L Malan**
5	□ *Sphygmocor (+ download)*	□ **R Schutte, senior researchers** & postgraduate students
6	□ *Sonar SonociteMaxx + (download)*	□ **AE Schutte//R Kruger**
	□ *General Health Quest .& download)* □ *24 ABPM diary download*	□ **N Mashele/Y van Rooyen/S Koegelenberg & trained postgraduate students**
7	□ *Vaccutainer organization* □ Blood sampling □ *Blood handling(LAB)* □ Telomere	□ **C Mels/W Smith/T Scholtz/M Glynn &** students □ C Lessing □ **C Mels/M Glynn** & runners □ **W Smith/L Lammertyn/M Glyn**
8	□ 7 day Actiheart	□ **S. Hoebel, J. Botha, E. Bruwer**
8	□ Immediate feedback □ *Post-counselling HIV*	□ **A Burger/L Malan** □ **G deWet / A Burger**
9	□ *Breakfast & Compensation*	□ A Burger
10	□ *Download of data into Statistica*	□ **W Smith (Participant sheet); AS van Lill (ABPM); ECG (C Botha), R v Staden, Y v Rooyen/S Koegelenberg (General Health Quest), DVA (W Smith); Sphygmocor (R Schutte); 24h urine (L Venter / A Pretorius); Sonar (R Kruger)**
11	□ *ABPM & Sonar reports on*	□ AS Uys/S Hoebel

	Fridays/Mondays (schools)	
12	□ *Emergency power supply*	□ JM van Rooyen
13	□ *Questionnaire prints & packing*	□ **Tina Scholtz** & students

We want to ensure continuity by placing specific researchers (in bold) at the same station each day. These researchers are responsible for organizing the station, equipment and students involved. The PI will coordinate everything (L Malan) 0733765321.

DESCRIPTION OF PRE-DAY I

School principal: Phone principal at specific school to remind participants that they must wear cotton shirts before undergoing the AMBP, shower/bath early on DAY I as they can't do it at the end of DAY I).

Batteries: Every day, before DAY, I the responsible researcher must check if batteries for Cardiotens (AMBP & ECG) are charged, ***not less than 5.4V*** (4 batteries/Cardiotens), i.e. 4 X 4 = 16.

DESCRIPTION OF DAY I

Recruitment and informed sessions with the human participants have been done at schools in Potchefstroom. *ALL questionnaires are completed once only.*

NB Checklist of particulars that must go to school on DAY I:

o ***Cardiotens (additional batteries, Laptop & USB serial port, protocol for programming, ECG electrodes, cotton disposable towel, extra obese and normal cuffs, diary, pen).***

o ***4 X Actical physical activity apparatus SCHOOL***

Transport*:* A North-West University (NWU) vehicle which can accommodate all passengers will be arranged (Condor). The drivers must obtain and deliver the keys at the car park of the NWU, beginning and end of each day, respectively.

Participation of gender groups: Gender groups will not be done separately.

Indicate gender on participant sheet.

Cardiotens: On day I, between 07:00 – 08:00 at their respective schools, 4 teachers will each be fitted with a 24h ambulatory blood pressure and ECG apparatus (Cardiotens®, CE0120, Meditech, Budapest, Hungary, BHS validated) with appropriate cuff sizes and instructions to comply with successful inflation rates. The software programs for the Cardiotens (Cardiovisions version 1.15) will be activated. The Cardiotens will be programmed for daily (every 30 min) and nightly (every 60min) measurements (Kohara *et al*., 1995). *Indicate on participant sheet*.

They will be requested to complete a 24h ABPM diary card on any related cardiovascular disturbances (visual, headaches, light physical activity, stress, syncope, palpitations etc). They will have access to contact numbers of researchers whereafter they can resume their normal daily activities. *Indicate on participant sheet*.

24h DIET

Proposed menu: sufficient for males ans females (± additional sandwich). Teachers will tick off on a list what they ate at the end of the 24h observation period.

Breakfast # 1 at school (DAY I): for fasting teachers at (07:00): Fruit juice, joghurt, sandwich, apple/other fruit

Lunch : to school at 07:00:

Assorted cold meat, 3 salads (eg.pasta/potato , carrot, 3-bean), fruit juice

Dinner at NWU:

Mealie meal, Sausage (+-150g), tamato and onion mix chakalaka.

- Last beverages before bedtime: Tea/coffee plus biscuit (sponsored by Turkstra Bakery, Potchefstroom).

Breakfast #2 at NWU (DAY II):

-2 x sausages (without pork)

- 2 x scrambled eggs

- fresh green salad and tamato

- 2 slices of fresh bread/toast, butter, jam.

All teachers will receive the same 24h standardized diet (2 x breakfasts, 1 x lunch, 1 x dinner with drinks and fruit as snacks). A 24h diary of all food ingested will be completed. *Lunch must be taken not later than 14:30 to comply with prerequisites for DVA measurements at 16:00*. *Indicate on participant sheet*.

Urine sampling: Methodology for 24h urine sampling will be explained at school and commence from 07:30. Each teacher will receive containers for urine sampling and a cool box with crashed ice for storage purposes. ***Sampling time must be indicated on the container by the teacher.***

The teachers can then resume their normal daily activities. *Indicate on participant sheet*.

TRANSPORT FROM SCHOOL TO NWU AT 15:00

B

Every day from Monday – Thursday participants will be transported to the MU for observations. Teachers can use their own transport if preferred.

WELCOMING, GENERAL HEALTH QUESTIONNAIRE

- Participants will be welcomed and informed about proposed measurements. Procedures will be done in a quiet relaxing environment. Postgraduate students assisted trachers on completion of questionnaires.

ON DAY I, between **15:00-17:30:**

HIV/AIDS pre- and post-counselling: On DAY I (precounselling) and post- counselling on DAY II, will be perfomed by Prof L Malan/RN and A Burger (RN, Manager of the HART clinic) according to the guidelines

from the Department of Health, South Africa. The procedures of the initial screening, confirmation tests and CD-4 counts as well as applying for chronic medication benefit, will be explained. *Indicate on participant sheet*.

 Resting and immediate poststress measures will be obtained **for ABPM.**

 After measures at ~17:00 they will be transported to the Metabolic Unit (MU) and each participant will receive their own room. Protocol for DAY II will be explained again and questions answered. *Water/tee/ coffee were given.*

The psychosocial battery at 17:30-18:30: Questionnaires will be completed on DAY I in a comfortable relaxing environment, which is well ventilated with mild temperatures day/night. *Indicate on participant sheet*. It will be possible to complete it within approximately 45 minutes under supervision of a registered teaching specialist and psychologists

The questionnaires chosen (validated and internationally peer-reviewed) are measures which are associated with predictors/worsening of hypertension, with known heritability & which could moderate the environment: *Marital status, job strain, coping styles, African cultural support system, perception of health, personality inventory, life orientation, perceived social support from family and friends, emotional and personal psychological and social well-being, selfregulation of emotions.*

Questionnaires included are therefore:

PREDICTORS OF DEVELOPMENT/WORSENING OF HYPERTENSION

1) The Coping Strategy Indicator (Amirkhan, 1990) 30 *items (10 minutes)*

2) Africultural Coping Systems Inventory (Utsey et al., 2000) – *30 items (10 minutes).*

3) General Health Questionnaire (Goldberg & Hiller, 1979) – *28 items (8 minutes)*

4) Patient Health Questionnaire: Depression symptoms (PQH) (Kroenke et al., 2001) – 9 items (3-5 minutes).

MEASURES WHICH COULD MODERATE THE EFFECTS OF ENVIRONMENT

5) Mental Health Continuum – emotional and personal psychological and social well-being (MHC-SF) (Keyes, 2006a) – *14 items (5-8 minutes).*

6) Teachers Stress Inventory (Boyle et al., 1995) – *20 items (5-8 minutes).*

7) Selfregulation Questionnaire (Carey et al., 2004) – 31 items (8-10 *minutes*)

8) Selfregulation Questionnaire (Schwarzer et al., 1999) – 7 items (*3 minutes*)

DINNER

STANDARDIZED DINNER (18:30): According to fat, carbohydrates and protein content, supplied by De Jonge Akker Restaurant: Bertus Els, +27 18 2994125, NWU).

DESCRIPTION OF STATIONS OF DAY II (07:00)

Participant sheet will accompany participants during DAY and DAY II in between stations. On this form there is a place to indicate measurements.

1 ***Anthropometry***

The following basic anthropometric measurements will be done in triplicate by Biokinetic postgraduate students (Invicta Stadiometer, IP 1465, U.K.; Precision Health Scale, A & D Company, Japan; Holtain unstretchable flexible 7 mm wide metal tape) (Supervisor: Prof H de Ridder, +27 18 2991791; Cell: 0825773171):

- Height
- Weight
- Waist circumference
- Hip circumference
- Neck circumference (NC)

[NC is measured at mid-neck height, between the mid-cervical spine to mid- anterior neck, to within 1 mm. In men with a laryngeal prominence (Adam's apple), it is measured just below the prominence. Ben-Noun & Laor, 2003].

2 ***Own rooms & bathrooms***

At 07:30 the ***Cardiotens*®** will be disconnected and the last ***24h urine*** sample obtained.

3 BLOOD PRESSURE, FINOMETER, ECG, SPHYGMOCOR, SONAR CIMT AND BLOOD SAMPLING

NB*. They must be in semi-recumbent position for one hour before blood sampling (renin-angiotensin-aldosterone system requirements (Diagnostic Systems Laboratories, 2005). Identical set-ups in separate rooms for these measuemrents will be available in four rooms at station*

3. Spygmomanometer blood pressure (BP): normal/obese cuff of the spygmomanometer is applied to the ***left arm (***1.3M TM Littman® II S.E. Stethoscope 2205, Riester CE 0124, No. 1010-108 Diplomat-presameter®, Germany). After 5 minutes of rest the first BP measurement will be taken and the second after another 5 minutes of resting. *Indicate on participant sheet*.

o ***The Finometer*** cuffs must be fitted and necessary anthropometric and age information can be obtained form the participant sheet. In total **a five minutes Finometer** recording will be obtained (including a RTF-calibration after the first 2 minutes). *Please indicate the filename of the recording on the participant sheet and in the Finometer book.*

o ***The 12 ECG electrodes*** will be attached and the patient detail must be filled in on the PC system. A 12-lead ECG of 6 cardiac cycles will follow (NORAV PC-ECG 1200, Israel)

o ***Blood sampling***: A resting blood sample of 65 ml will be obtained between 08:30 – 09:00 to correspond with sampling times from SABPA I. Blood will be obtained from the dominant (mostly **right**) arm by a registered nurse from the antebrachial vein branches using a winged infusion set with syringes

for preparation of serum, citrate, NAF glucose, EDTA plasma and telomerase activity. Fresh resting blood (2ml) will be used for essential amino acid screening (Guthrie cards) and blood glucose screening. Serum (200µl) will be used for the HIV/AIDS screening (First Response Kit test and the confirmatory Pareekshak test).

o **Actiheart (7 day).** Actiheart activity monitors will be fitted to participants and activated

***Blood sample handling (SEE BLOOD HANDLING IN LAB: STATION 4* AFTER *STATION 5* s' description)**.

o Blood sample handling implies (2 X 10 ml tubes (2 serum [red plug] and 1 EDTA plasma [purple plug]); 1 X 6 ml serum tube [red plug], 1 X 6 ml EDTA plasma [purple plug], 1 X 4.5 ml citrate plasma [light blue plug] and 1 X 2 ml NaF plasma [grey plug]. *It is VERY important that the citrate plasma sample [light blue plug] must fill the tube entirely (4.5 ml) otherwise the ratio of anti- clotting substance to clotting factors in blood is not reliable.*

o All samples are immediately sent to the lab with a runner. The same procedure for handling must be followed after each stressor was applied.

o Subsequently, ultrasound scanning of the carotid intima media thickness will follow for detection of sub-clinical atherosclerosis progression.

o ***Sphygmocor:*** Person lies in the supine position and personal info is filled in on the PC. Brachial BP is determined with a sphygmomanometer entered into the PC. Wait 2 minutes before taking the measurement. For central blood pressure, place the pressure transducer over the strongest pulse of the radial artery. After a stable 11 second waveform is achieved, the data will be automatically captured. To determine arterial stiffness enter systolic and diastolic BP (sphygmomanometer), measure and enter distal and proximal distances and connect ECG leads. Place the pressure transducer over the carotid artery and obtain a quality reading (11 seconds). Place the pressure transducer over the femoral artery and obtain a quality reading. Analyze data [SphygmoCor (AtCor Medical Pty. Ltd., Sydney Australia) and the SphygmoCor Software version 9.0]

o ***Ultrasound Sonar CIMT:*** *Remove all pillows form the bed and assure the participant is in a* ***supine position***. ***Darken the room and place a pillow underneath the knees to support the lower back ensuring a comfortable relaxed position for the participant.*** The ***exact optimal angles obtained during SABPA I will be screened again** of the carotid intima media for detection of sub-clinical atherosclerosis progression. Scanning-and-reading protocols were developed and standardized in collaboration with experts from the Vascular Imaging Centre, Utrecht University, The Netherlands and Chalmers University, Gothenburg, Sweden. Using the Sonocite® portable ultrasound system, a total bilaterally, of 8 end-diastolic (on R-wave) B-mode images will be acquired and stored for off-line analysis of the Carotid intima media thickness (CIMT) for near and far walls of the distal **Common Carotid Artery (CCA) –** at 2 different angles both left and right, using the Meijers Carotid Arc. Plague scores will be obtained in the bifurcation (Sonocite Micro- maxx high resolution ultrasound system) using the Rudy Meijer protocol (Developed by the Vascular Unit Imaging Centre, University Medical Centre Utrecht, Netherlands). Interpretation will be done with a semi-automated program, namely the Artery Measurement Systems (AMS) II v1.139 (Gothenburg, Sweden).

See SONAR book for angles scanned in SABPA I.

4 BLOOD LAB: HANDLING FOR RESTING BLOOD SAMPLES

o ***Resting 2 ml blood must be used for Guthrie cards and glucose screening. Done once only. Indicate on participant sheet***. (Blood glucose with the One Touch Sure StepTM Glucose meter (Life Scan, Johnson& Johnson, California, USA®).

Preparation by the lab technician:

Prepare the workstation by setting right 1 tray for every participant, each containing the following allotted number of Eppendorf tubes**:**

Aliquots/Eppendorf tubes for blood samples:

- 20 x for Serum from Red plug vaccutainers
- 1 x for NaF from Grey plug vaccutainer
- 4 x for Citrate from Light blue plug vaccutainers
- 12 x for EDTA from Purple plug vaccutainers

Also add the following in a tray: Tubes needed for urine samples:

- x 1.5 ml & 2 x 0.5 ml white eppendorf tubes (For Physiology)
- 1 x 20 ml container (For Biochemistry) Utensils and apparatus needed for sampling:
- x Centrifuges (Centrifuge 1, 2, 3 and 4)
- Eppendorf micro pipettes
- Eppendorf pipette tips in boxes (Blue)
- Antibody First response HIV card test 1-2.0 & One step HIV-1/2 Whole blood / serum / plasma test (2 lines)
- Gloves
- Medical waiste bins
- Stopwatch

Blood samples will be received from nurses consisting of:

- x Red plug vaccutainers [CAT] labeled **2 SAB PPNR**
- x 10.0 ml
- 1 x 6.0 ml
- 1 x 2.0 ml Grey plug vaccutainer [NaF] labeled **2 SAB PPNR**
- 1 x 4.5 ml Light blue plug vaccutainer [Citrate] labeled **2 SAB PPNR**
- 2 x Purple plug vaccutainers [EDTA] labeled **2 SAB PPNR**
- 1 x 10.0 ml

- 1 x 6.0 ml

Urine samples received from nurses:

- 1 x 3litre Urine sample (Amber container with green screw top).

Remember

Each batch of samples received must be treated in unison manner. The HIV test must be done on the EDTA wholeblood samples.

All tests are performed at room temperature.

PROCEDURE

HIV test

HIV test procedure performed using the SD BIOLINE HIV-1/2 3.0 (3rd generation of ONE STEP) HIV CARD TEST:

From the EDTA (Purple top) vaccutainer, which is homogenised beforehand, remove whole blood for the following test procedure:

1. Remove the Test Device from the foil pouch, and place it on a flat, dry surface.
2. Slowly add 20 µL of whole blood with a pipette to the sample well and then add 120 µL (four drops) of the assay diluent into the sample well.
3. As the test begins to work, you will see purple colour move across the Result Window in the centre of the Test Device.
4. Interpret test results at 5 – 20 minutes.

5. **Do not interpret after 20 minutes.**
6. For interpretation of result refer to test SOP / insert of product.

If **POSITIVE**, perform Determine® test (next procedure) to confirm the positive result (Indicate the HIV test result in the results book (on table) in the laboratory).

To be performed using the Determine® HIV-1/2 Serum/Plasma/Whole Blood Assay, 100 Tests (List No. 7D23-43.). The kit contains 10 HIV-1/2 recombinant antigen and synthetic peptide coated test cards with 10 test units on each card. 1 Bottle (2.5 ml) Chase buffer (List No.7D22-43)

The desired number of test units form the 10-test card can be removed by bending and tearing at the perforation.

Note: Removal of the test units should start from the right side of the test card to preserve the lot number which appears on the left side of the test card.

From the EDTA (Purple top) vaccutainer which is homogenised beforehand, remove plasma for the following test procedure:

1. Remove the protective foil cover from each test.

2. **For Whole blood testing:** Apply 50 µL of sample (precision pipette) to the sample pad (marked by the arrow symbol). Wait one minute, then apply 1 drop of Chase Buffer (provided) from the bottle directly onto the sample pad.

3. Wait for a minimum of 15 minutes and read the result.

4. **Do not read results after 60 minutes.**

5. For interpretation of result refer to test SOP / insert of product.

BLOOD SAMPLE PREPARATION

For each of the following batches of vaccutainers received, follow the steps in chronological order:

SERUM (Procedure done at room temperature in Centrifuge 1)

1. Leave 3 x red plug blood sample vaccutainer tubes at room temperature for 20 – 45 min (max 45 min) to coagulate;

2. Centrifuge the coagulated samples using the bench top centrifuge at 4700 rpm for 15 minutes at room temperature. There is space for 24 tubes in the centrifuge (rotor radius = 12 cm);

3. If necessary odd numbered tubes must be counterbalanced with water filled tubes;

4. Aspirate the serum (top aqueous layer) into the prepared ***20 labelled eppendorf*** tubes for serum, marked with an "**S"**.

NaF PLASMA (Procedure done at room temperature.)

1. Centrifuge the Grey plug vaccutainers in the bench top centrifuge for 10 minutes at 3700 rpm.

2. There is space for 24 tubes in the centrifuge (rotor radius = 12 cm);

3. Aspirate the plasma into ***1 labeled eppendorf*** tube for NaF plasma, label marked with an **"F**".

CITRATE PLASMA (Procedure done at room temperature.)

1. Centrifuge the Light blue vaccutainers in the bench top centrifuge at 1500 rpm (2000g) for 15 minutes at room temperature;

2. There is space for 24 tubes in the centrifuge (radius=12 cm);

3. Aspirate the plasma into ***4 labelled eppendorf*** tubes for citrate plasma, label marked with a **"C".**

EDTA PLASMA (Procedure done at 20°C Centrifuge)

1. Homogenise the vaccutainered blood and remove 1 ml of the whole blood and pipette into 1.5 µL eppendorf tube (For biochemical analysis purposes).

2. Use the cold centrifuge and centrifuge the Purple plug vaccutainers (20°C) for 10 minutes at 3700 rpm.

3. There is space for 24 tubes in the centrifuge (rotor radius=12 cm);

4. Aspirate the plasma into ***12 labelled eppendorf*** tubes for EDTA plasma, label marked with an "**E**".

NOTES/PREPARATION

For all lab work, especially since the samples will be used for RNA and DNA analysis, wear gloves at all times. Change gloves before dipping into stocks of tips/ tubes etc. Keep all tips and tubes etc in sealed

bags, when not using. When removing lids from tubes, try to place the lid upside down on the bench (inside facing up). Avoid leaving buffers/samples uncovered when not using; the lid can be placed on top to keep sterile without necessarily screwing on tightly.

References

Pfaffl MW, Horgan GW and Dempfle L. Relative Expression Software Tool (REST©) for group wise comparison and statistical analysis of relative expression results in real- time PCR. Nucleic Acids Research 2002 May 1; 30(9): E36

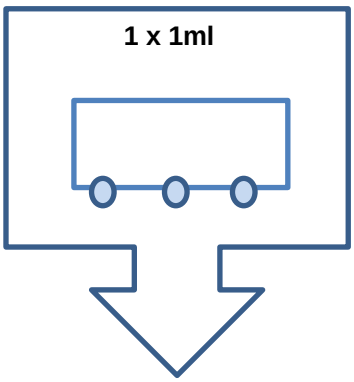
URINE PROCESSING

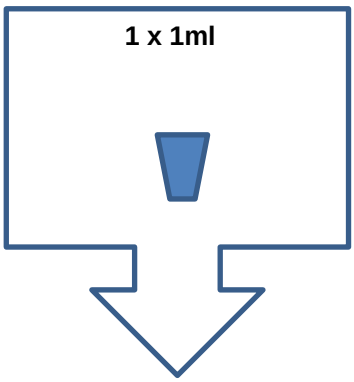
Procedure done for urine sample:

1. Pipette 1.5 ml of urine sample into 3 x 1.5ml eppendorf tube, set aside according to the preparation instructions.
2. Pipette 0.5 ml / 500 µL of urine sample into 2 x 2 eppendorf tubes, as set aside according to the preparation instructions.
3. Pour 20ml in urine containers supplied by Biochemistry. (For Biochemical analysis).

HANDLING of FRESH BLOOD (GUTHRIE CARDS, GLUCOSE)

Fresh Blood





Fill 3 circles (14mm diameter) completely with blood.

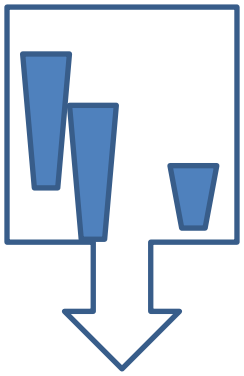
1 drop: glucose (One-Rure step).

Room temperature

SAB: SABPA
PPNR: participant number (1 – 200)

BLOOD LAB: HANDLING of samples

3 X red plug serum plasma



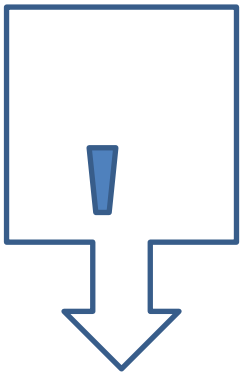
Stand: 20-45 min. Room temp to clot.

Centrifuge in general centrifuge for 15 min at 4700 rpm (3000g) **Centrifuge 1**

Centrifuge in general centrifuge for 15 min at 4700 rpm (3000g) **Centrifuge 1**

Big centrifuges have space for 24 tubes.

1 X grey plug NaF

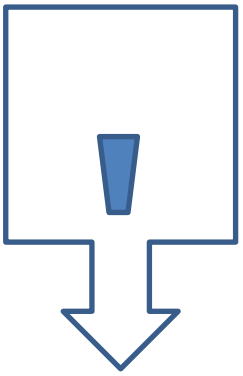


Centrifuge in cold centrifuge for 10 min at 3700 rpm (2000g) at 20oC **Centrifuge 4**

Pipet into 0.5 ml eppendorf. Total: **1 Eppi** marked: **2SAB PPNR F**

Total eppi's: 37

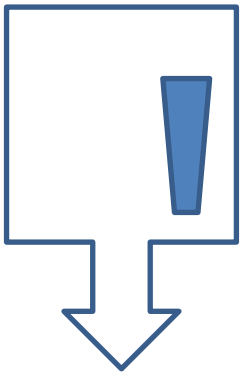
1 x light blue citrate plasma



Centrifuge general centrifuge for 15 min at 1500 rpm (2000g) **Centrifuge 2**

Pipet 0.5ml into eppendorf. Total: **4 Eppi's** marked: **2SAB PPNR**

2 X purple EDTA plasma



One drop for One Step HIV test, also one drop for Pareekshak HIV test.

Pipet 1 ml whole blood into white eppendorf marked on top

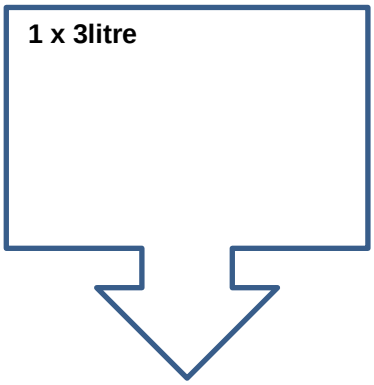
Centrifuge in cold centrifuge for 10 min at 4000 rpm (1600g) at 20oC **Centrifuge 3**

Pipet into 0.5 ml eppendorfs Total: **12 Eppi's** marked: **2 SAB PPNR**

SAB: SABPA
PPNR: participant number (1 – 200)
S/F/C/E: serum/fluoride/citrate/EDTA samples

HANDLING of URINE

24H urine collection ± 3litre



After voiding:
Immediately in cooler box with ice

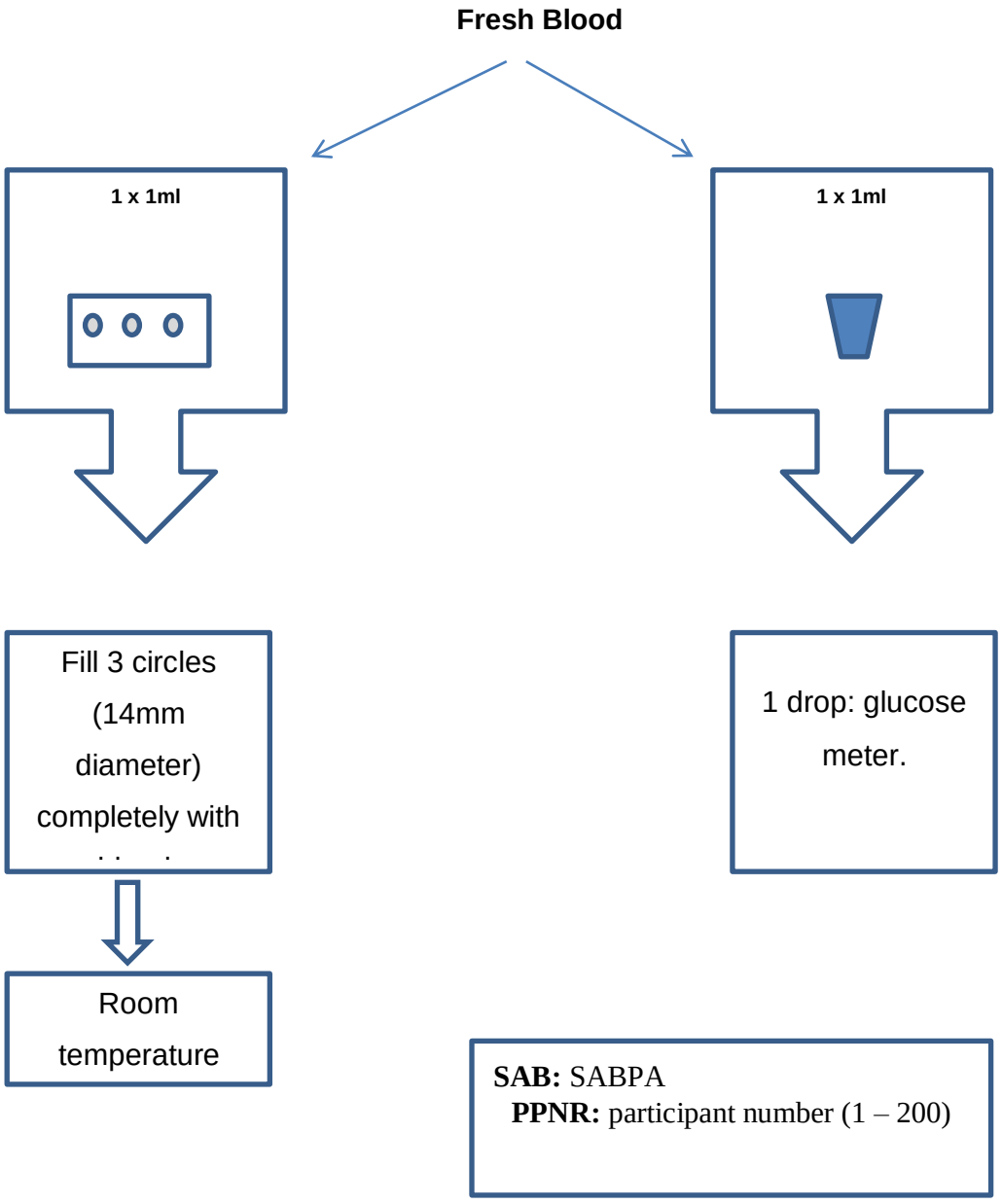
Pipet into 2 x 0.5ml & 3 x 1.5 ml eppendorfs. 1 x 20 ml container Freezer (-80°C) Total: **5 Eppi's** marked:
2 SAB PPNR U
And one container marked
2 SAB PPNR U

NB.Before processing:Gently swirl the bottle rather than vigorous shaking

Total urine eppi's: x 5 (24 h collection)/participant 1 x 20 ml container/participant

SAB: SABPA
PPNR: participant number (1 – 200)
U: urine sample

HANDLING of FRESH BLOOD (GLUCOSE, GUTHRIE CARDS),



6 FEEDBACK AND POST-COUNSELLING

o Their feedback form must be completed at **Station 5**.

o In the privacy of their own room they will receive a feedback form with their anthropometry, blood pressure and glucose values. Feedback will be given to the participants as well as post-counselling for HIV/AIDS individually (registerd nurse). Their data must be discussed (e.g. within normal ranges etc.) and if there are any concerns regarding their values they will be referred to their doctors.

7 BREAKFAST & COMPENSATION

o ***Incentive***: They will be thanked for their participation and receive their incentive. *They must sign on a NWU form that the money was received.*

o ***Breakfast:*** They can take a shower and receive breakfast. Every day Mr Bertus Els from De Jonge Akker must be informed about how many dinners, lunches and breakfasts must be delivered (De Jonge Akker Restaurant, Tel: +27 18 299 4125).

o All dinners and DAY II breakfasts will be delivered at the MU. Coffee/Tea/Cookies are sponsored by Turkstra bakery.

o With dinner each plate can be warmed in the microwave oven. In the dining room everything needed for making coffee/tea will be available (cups and saucers, teaspoons, milk, sugar, boiling water).

o ***Transport:*** Hereafter, they will be transported back to school.

ADDENDUM A:

SAMPLE COLLECTION GUIDELINES FOR TRACE ELEMENTS IN BLOOD AND URINE. *Pure* & ***Appl.*** *Chem.,* Vol. **67, Nos 8/9, pp. 1575-1608, 1995.**

24-hour (or timed) specimen: To obtain an accurately timed specimen, it is necessary to begin and end the collection period with an **empty bladder**. The following instructions for collecting a 24-hour specimen can be applied *to any timed collection*

Day 1 - *7 AM*: Patient voids and ***discards*** specimen. Do not save this urine. Patient ***collects*** all urine for the next 24 hours.

Day 2 - *7 AM*: Patient voids and ***adds*** this urine to the previously collected urine.

Dust falling into the container is a potential hazard, **as** the cover must be removed for collection several times during the day. This is especially problematic for **24** h urine samples, because the collection vessel will be opened (usually in room air). Voiding of urine from the body into the vessel again introduces a major risk of contamination, from clothes and the skin.

Procedure:

1. For the **next 24 hours**, **urinate first into a collection container**, then **pour ALL** the **urine into your storage container**. Keep the container refrigerated or on ice/in cooler between additions.

2. **It may also be recommended to collect each void in separate containers**. For woman and young children the container-neck should have a diameter of about **12** cm. Timing of spot urines must be recorded and standardized within the study, e.g. first void of the day, pre-prandial, etc..

3. **Urine should be added into an acid-washed polyethylene container that can be closed with an airtight lid.** The subject should be instructed to minimize contamination **of** the sample by avoiding contact with the inside of the container or lid, and to refrain from leaving the container open to the air longer than necessary. In between sampling sessions, the container is wrapped in a clean polyethylene bag**.**

Appendix F: Plagarism

PLAGIARISM DECLARATION

Bianca Henning (née Erwee)

(full name and surname and student number) hereby declare that this assignment / paper / project / portfolio is my own work.

I further declare that:

1. the text and bibliography reflect the sources I have consulted. and
2. where I have made reproductions of any literary or graphic work(s) from someone else, I have obtained the necessary prior written approval of the relevant author(s)/publisher(s)/creator(s) of such works and/or, where applicable, from the Dramatic, Artistic and Literary Rights Organisation (DALRO).
3. sections with no source referrals are my own ideas, arguments and/or conclusions.

Signature: BHenning Student number: 21757429

Date: 20/11/2019

NWU®

Appendix G: TURNITIN report

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Appendix H: Acknowledgement of language review

Brendon John Wocke

Brendon.wocke@gmail.com

P.O .Box 1150 Knysna

6570

I, the undersigned, Brendon Wocke, hereby confirm that I have proofread and edited the academic thesis entitled

Physical activity status and the relationship between non-communicable diseases risk factors in an urban South African teachers' cohort: The SABPA study

B. Henning (nee Erwee) (BSc. Hons)

Please do not hesitate to contact me should you have any questions.

Sincerely,

Brendon Wocke



Appendix I: Permission to use figure 4.2

