

*The relationship between
physical activity and risk
factors for non-communicable
diseases of a population in
transition: The PURE-study*

Tershia van Niekerk

The relationship between physical activity and risk factors for non-communicable diseases of a population in transition: The PURE study

T van Niekerk

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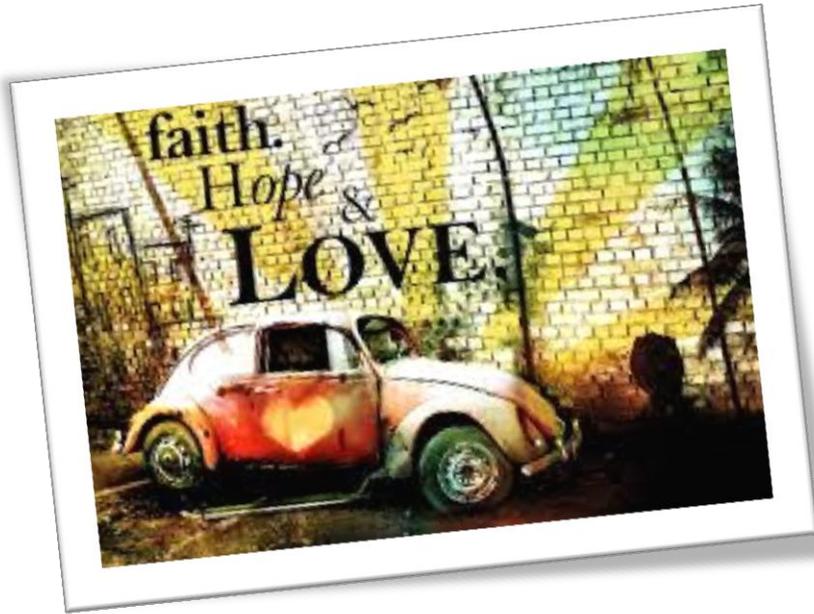
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Promoter: Prof SJ Moss

Co-promoter: Prof A Kruger

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This was one of the toughest challenges in my life, but certainly it will not be my last challenge. The journey has taught me perseverance, patience, character and faith in the Lord Almighty.

Heavenly Father, You said to me once, "I know the plans I have for you" and daily You remind me in Your Word, "My grace is enough for you" and although I do not always understand, You understand me... You are my Saviour and my Compass, without You my Lord, I am lost. Thank you, for being with me on this exciting journey.



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LOVE is patient, love is kind ...

It *ALWAYS* protects, always trusts, always *HOPES*,
always perseveres. *LOVE* bears all things,
BELIEVES all things, hopes all things, *ENDURES* all
things. *LOVE* never ends. Love never fails ...
and now these three remain: *FAITH, HOPE* and *LOVE*
but the *GREATEST* of these is love.

Corinthians 13:4-8, 13

The author

November 2013

*"THE GREATEST SOURCE OF
MOTIVATION COMES FROM YOUR
DEEPEST VALUES"
-ANON-*

THIS THESIS IS A DEDICATION TO MY
BELOVED PARENTS

Dawid Hermanus Botha (1953 - 2002)
Cecília Jacomina Botha (1953 - 2013)

YOU WERE AND FOREVER WILL BE THE DRIVING FORCE BEHIND
ALL MY ACHIEVEMENTS AND SUCCESSES; FROM YOU I SOURCED
THE DEEP MOTIVATION AND COURAGE TO COMPLETE THIS
STUDY SUCCESSFULLY!!!!

Declaration

The co-authors of the articles in this thesis, Prof. S.J. (Hanlie) Moss, Prof. Annamarie Kruger (Co-promoter, and principle investigator for South Africa of the PURE-study), Prof. Andries Monyeki (co-author), and Prof. Salome Kruger (co-author) hereby give permission to the candidate, Ms. Tershia Van Niekerk to include the articles as part of her Ph.D. thesis. The contribution (advisory and supportive) of these co-authors was kept within reasonable limits, thereby enabling the candidate to submit this thesis for examination purposes. This thesis, therefore serves as fulfilment of the requirements for the Ph.D. degree in Human Movement Sciences within the Faculty of Health Sciences at the North-West University, Potchefstroom Campus.

Prof. S.J Moss

Promoter & Co-author

Dr. A. Kruger

Co-Promoter & Co-author

Prof. H.S. Kruger

Co-author

Prof. M.A. Monyeki

Co-author

Ms. Tershia van Niekerk

PhD Student & author

Abstract

THE RELATIONSHIP BETWEEN PHYSICAL ACTIVITY AND RISK FACTORS FOR NON-COMMUNICABLE DISEASES OF A POPULATION IN TRANSITION: THE PURE-STUDY

Non-communicable diseases (NCDs), also known as chronic diseases of lifestyle, cause the greatest burden of disease globally. The major risk factors for NCDs are hypertension, hyperglycaemia, high cholesterol, tobacco smoking, alcohol abuse, overweight/obesity and physical inactivity. NCDs in South Africa are increasing in black South Africans with the transition from rural to urban areas. The transitions have resulted in a change in lifestyle. Regular moderate intensity physical activity (PA) has many health benefits and decreases the risk for NCDs. PA is often determined by means of questionnaires, motion sensors (pedometers and accelerometers), heart rate and accelerometry combined. Within the South African context PA has traditionally been determined with internationally composed questionnaires adapted for South Africa. In South Africa the relationship between PA and risk factors for NCDs has not been investigated in populations in transition, and limited information on the relationship between change in PA and the change in risk factors in a South African population is available.

The objectives of this study was to determine the correlation between the adapted Baecke physical activity questionnaire and the International Physical Activity Questionnaire (short version) (IPAQ-S), the changes in PA and how the changes relate to changes in BMI, and finally the relationship between the changes in PA and the changes in the risk factors for NCDs of black South Africans.

The study forms part of the baseline and five year follow-up of the South African leg of the Prospective Urban and Rural Epidemiological (PURE) study. This study is a longitudinal study of which the baseline data was allocated in 2005 and the five year follow-up allocated in 2010. 2 000 participants aged 30 years and older were recruited for the initial study – 1 000 urbanised (from Ikageng), and 1 000 rural black adults (from Ganyesa, Moswana and Tlakgameng).

Data, including the PA questionnaires (Baecke & IPAQ-S) were collected by a specialised multidisciplinary team. After signing an informed consent form, questionnaires were completed during individual interviews and conducted by extensively trained fieldworkers in the language of the participants' choice. The variables used in this study were anthropometric measurements, blood pressure, serum lipids and fasting blood glucose. BMI was calculated from the body weight divided by the height squared.

Statistical analysis was performed using SPSS for windows (Version 21.0). Descriptive statistics were performed to determine the characteristics of the participants. The relationship between Baecke and IPAQ-S was determined by means of a partial correlation adjusting for age and BMI. Linear regression analyses were used to determine the relationship between the changes in PA (dependent variable) and BMI (predictor variable) and then adjusted for gender and age. Where a significant relationship was observed (in the case of setting, urban versus rural) separate analyses were performed for the rural and urban participants; likewise the relationship between the changes in PAI (dependent variable) and the change in the risk factors for NCDs (predictor variable) was determined by means of linear regression analysis, and also adjusted for gender, change in age and setting (urban/rural).

The results from this study indicated that a weak but significant relationship was found between the Baecke and IPAQ-S (Spearman $r = 0.243$; $p = 0.00$) when adjusted for age and BMI. Significant differences were found between rural and urban participants for age and BMI in 2005, where the urban participants were older and reported a higher BMI compared to the rural participants. Rural women gained significantly more weight than the urban women. The PAI in the urban participants increased from 2005 (6.40 ± 1.84) to 2010 (7.50 ± 1.40), but decreased in rural participants from 2005 (8.21 ± 1.48) to 2010 (5.10 ± 1.54). Change in BMI was significantly inverse associated with change in PA for the urban population after adjusting for gender, setting (rural/urban) and change in age ($\beta = -0.10$; $p = 0.004$).

Significant differences were found for resting systolic blood pressure (SBP) for the rural (129.72 ± 23.30) and urban (137.33 ± 25.14) participants as well as the diastolic blood pressure (DBP) of rural (86.16 ± 14.48) and urban (89.28 ± 14.46), fasting glucose of rural (4.88 ± 1.23) and urban (5.10 ± 1.86), triglycerides of rural (1.21 ± 0.64) and urban (1.38 ± 0.92) and physical activity index (PAI) of rural (8.21 ± 1.48) and urban (6.40 ± 1.84) in 2005. There were significant changes in the high density lipoprotein cholesterol (HDL-C) and in the low density lipoprotein cholesterol (LDL-C). Although the overall PAI decreased from 2005 (7.30 ± 1.90) to 2010 (6.46 ± 1.85), it increased in urban participants ($6.40 \pm 1.84 - 7.50 \pm 1.40$) and decreased in rural participants ($8.21 \pm 1.48 - 5.10$

± 1.54). A significant negative relationship between changes in PAI and changes in blood pressure (systolic and diastolic), total cholesterol and LDL-cholesterol was found when adjusted for gender. When changes in PA and changes in risk factors were separated according to gender, a significant negative relationship was found between PA and diastolic blood pressure ($\beta -0.63$; $p 0.02$) in the male population, and a significant negative relationship for females between PA and systolic blood pressure ($\beta -1.05$; $p 0.002$), diastolic blood pressure ($\beta -0.59$; $p 0.003$), total cholesterol ($\beta -0.05$; $p 0.01$) and LDL-cholesterol ($\beta -0.07$; $p 0.00$).

In conclusion, the study found that the low but significant correlation between PAI assessed with the Baeck questionnaire and IPAQ-S makes both questionnaires applicable for the South African context, however the Baecke questionnaire is based on various domains for PA, while the IPAQ-S report on time spent in physical activity. Over the 5-year period PA decreased in this black South African population with a concomitant increase in BMI. Biological risk factors for NCDs increased from 2005 to 2010. The change in PA was inversely related to changes in total blood pressure. Future in PA interventions would be beneficial in the management of hypertension in the at risk South African black population.

KEY WORDS: Non-communicable diseases, abdominal obesity, hypertension, black Africans, ethnicity, anthropometry, urbanisation.

Opsomming

DIE VERHOUDING TUSSEN FISIEKE AKTIWITEIT EN RISIKOFAKTORE VIR NIE-OORDRAAGBARE SIEKTES VAN 'N POPULASIE IN OORGANGSTADIUM: DIE *PURE*-STUDIE

Nie- oordraagbare siektes (NOS'e), ook bekend as chroniese leefstylsiektes, veroorsaak wêreldwyd die grootste siektelas. Die primêre risikofaktore vir NOS'e is hoë bloeddruk, hiperglukemie, hoë cholesterol, tabakrook, alkoholmisbruik, oorgewig/vetsug en fisieke onaktiwiteit. NOS'e in Suid-Afrika is besig om toe te neem onder swart Suid-Afrikaners, met die verskuiwing van landelike na stedelike gebiede. Hierdie verskuiwings het gelei tot 'n leefstylverandering. Gereelde fisieke aktiwiteit (FA) van matige intensiteit het baie gesondheidsvoordele en dit verminder die risiko vir NOS'e. FA word dikwels gemeet deur middel van vraelyste, bewegingsensors (pedometers en versnellingsmeters), en 'n kombinasie van hartklop- en versnellingsmetings. In die Suid-Afrikaanse konteks word FA tradisioneel bepaal met internasionaal saamgestelde vraelyste wat aangepas is vir Suid-Afrika. In Suid-Afrika is die verhouding tussen FA en risikofaktore vir NOS'e nog nie ondersoek in verskuiwende populasies nie, en daar is beperkte inligting beskikbaar oor die verhouding tussen die verandering in FA en die verandering in die risikofaktore in 'n Suid - Afrikaanse populasie.

Die doelwitte van hierdie studie was om die verband te bepaal tussen die aangepaste Baecke-Fisieke-Aktiwiteitvraelys en die Internasionale-Fisieke-Aktiwiteitvraelys (kort weergawe) (IPAQ-S), die veranderinge in FA en die wyse waarop die veranderinge verband hou met veranderinge in liggaamsmassa-indeks (LMI), en laastens die verhouding tussen die veranderinge in FA en die veranderinge in die risikofaktore vir NOS'e by swart Suid-Afrikaners.

Die studie vorm deel van die basislyn en vyfjaar-opvolg van die Suid-Afrikaanse been van die *Prospective Urban and Rural Epidemiological (PURE)* - studie. Hierdie studie is 'n longitudinale studie waarvan die basislyn data ingesamel is in 2005 en die vyfjaar-opvolg in 2010 uitgevoer is. 2 000 deelnemers van 30 jaar en ouer is gewerf vir die aanvanklike studie – 1 000 verstedelike swart volwassenes (van Ikageng) en 1 000 landelike swart volwassenes (van Ganyesa, Moswana en Tlakgameng).

Data, insluitend die FA-vraelyste (Baecke & IPAQ-S), is ingesamel deur 'n gespesialiseerde multi-dissiplinêre span. Na die ondertekening van 'n ingeligte toestemmingsvorm, is vraelyste voltooi tydens individuele onderhoude en wat behartig is deur omvattend opgeleide veldwerkers, in die taal van keuse van die deelnemers. Die veranderlikes wat gebruik is in hierdie studie, was antropometriese metings, bloeddruk, serumlipiede en vastende bloedglukose. LMI is bereken op grond van liggaamsgewig gedeel deur die kwadraat van lengte.

Statistiese analise is uitgevoer met behulp van SPSS vir Windows (weergawe 21.0). Beskrywende statistieke is uitgevoer om die kenmerke van die deelnemers te bepaal. Die verhouding tussen Baecke en IPAQ-S is bepaal deur middel van 'n gedeeltelike korrelasie wat aanpas vir ouderdom en LMI. Lineêre regressie-ontledings is gebruik om die verhouding te bepaal tussen die veranderinge in fisieke-aktiwiteitindeks (FAI; afhanklike veranderlike) en LMI (voorspeller-veranderlike) en dit is dan aangepas vir geslag en ouderdom. Waar 'n beduidende verhouding waargeneem is (in die geval van die omgewing, stedelik teenoor landelik), is afsonderlike ontledings uitgevoer vir die landelike en stedelike deelnemers; en die verhouding tussen die veranderinge in FAI (afhanklike veranderlike) en die verandering in die risikofaktore vir NOS'e (voorspeller-veranderlike) is bepaal deur middel van lineêre regressie-analise, en ook aangepas vir geslag, verandering in ouderdom en omgewing (stedelik/landelik).

Die resultate van hierdie studie het aangedui dat daar 'n swak maar beduidende verhouding bestaan tussen die Baecke en IPAQ-S (Spearman $r = 0.243$; $p = 0.00$) wanneer dit aangepas word vir ouderdom en LMI. Beduidende verskille is gevind tussen landelike en stedelike deelnemers vir ouderdom en LMI in 2005, waar die stedelike deelnemers ouer was en 'n hoër LMI gerapporteer het as die landelike deelnemers. Landelike vroue het aansienlik meer gewig aangesit as die stedelike vroue. Die FAI het toegeneem onder die stedelike deelnemers, vanaf 2005 ($6,40 \pm 1,84$) tot 2010 ($7,50 \pm 1,40$), maar dit het afgeneem onder landelike deelnemers vanaf 2005 ($8,21 \pm 1,48$) tot 2010 ($5,10 \pm 1,54$). Verandering in LMI is beduidend omgekeerd geassosieer met FA vir die stedelike populasie na aanpassing vir geslag, omgewing (landelik/stedelik) en verandering in ouderdom ($\beta = -0,10$; $p = 0,004$).

Beduidende verskille is gevind vir rustende sistoliese bloeddruk (SBD) vir die landelike ($129,72 \pm 23,30$) en stedelike ($137,33 \pm 25,14$) deelnemers sowel as die diastoliese bloeddruk (DBD) vir landelike ($86,16 \pm 14,48$) en stedelike ($89,28 \pm 14,46$) deelnemers, vastende glukose vir landelike ($4,88 \pm 1,23$) en stedelike ($5,10 \pm 1,86$) deelnemers, trigliseriede vir landelike ($1,21 \pm 0,64$) en stedelike ($1,38 \pm 0,92$) deelnemers en fisieke-aktiwiteitindeks (FAI) vir landelike ($8,21 \pm 1,48$) en stedelik ($6,40 \pm 1,84$) deelnemers in 2005. Daar was beduidende veranderinge in die hoë-digtheid-

lipoproteïen-cholesterol (HDL-C) en in die lae-digtheid-lipoproteïen-cholesterol (LDL-C). Hoewel die algehele FAI afgeneem het vanaf 2005 ($7,30 \pm 1,90$) tot 2010 ($6,46 \pm 1,85$), het dit toegeneem onder stedelike deelnemers ($6,40 \pm 1,84 - 7,50 \pm 1,40$) en afgeneem onder landelike deelnemers ($8,21 \pm 1,48 - 5,10 \pm 1,54$). 'n Beduidend negatiewe verhouding is gevind tussen veranderinge in FAI en veranderinge in bloeddruk (sistolies en diastolies), totale cholesterol en LDL-cholesterol wanneer dit aangepas is vir geslag. Wanneer veranderinge in FA en veranderinge in risikofaktore geskei volgens geslag, is 'n beduidend negatiewe verhouding gevind tussen FA en diastoliese bloeddruk ($\beta -0,63$; $p 0,02$) vir die manlike bevolking; en vir vroue is 'n beduidend negatiewe verhouding gevind tussen FA en sistoliese bloeddruk ($\beta -1,05$; $p 0,002$), diastoliese bloeddruk ($\beta -0,59$; $p 0,003$), totale cholesterol ($\beta -0,05$; $p 0,01$) en LDL-cholesterol ($\beta -0,07$; $p 0,00$).

Ten slotte het die studie bevind dat die lae maar beduidende korrelasie tussen FAI wanneer dit beoordeel word met die Baeck-vraelys en IPAQ-S, aandui dat beide vraelyste geskik is vir die Suid-Afrikaanse konteks. Die Baecke-vraelys is egter gebaseer op verskeie gebiede vir FA, terwyl die IPAQ-S rapporteer oor die tyd wat bestee is aan fisiese aktiwiteit. Oor die vyfjaartydperk het FA afgeneem onder hierdie swart Suid-Afrikaanse populasie, met 'n gepaardgaande toename in LMI. Biologiese risikofaktore vir NOS'e het toegeneem vanaf 2005 tot 2010. Die verandering in FA is omgekeerd verwant aan veranderinge in totale bloeddruk. Toekomstige studies in intervensie ten opsigte van FA sal voordelig wees vir die bestuur van hoë bloeddruk in die risiko- Suid-Afrikaanse swart populasie.

TREFWOORDE: Nie-oordraagbare siektes, abdominale vetsug, hoë bloeddruk, swart Afrikane, etnisiteit, antropometrie, verstedeliking.

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List of Abbreviations

A

ACC	accelerometry
ACSM	American College of Sports Medicine
AEE	activity energy expenditure
AIDS	acquired immunodeficiency syndrome
AIHW	Australian Institute of Health and Welfare

B

BC	Before Christ
BMI	Body mass index
BP	Blood pressure
BQ	Baecke questionnaire

C

°C	Degree Celsius
CAL	Chronic airflow limitation
CDC	Centre for disease control
CHD	Chronic Heart Disease
CHNS	China Health and Nutrition Survey
Chol	Cholesterol
cm	centimeter
COAD	Chronic obstructive airway disease
COLD	Chronic obstructive lung disease
COPD	Chronic obstructive pulmonary disease
CORD	Chronic obstructive respiratory disease
cpm	counts per min

cts·min	physical activity counts per minute
CVD	Cardiovascular disease
D	
DALY	disability-adjusted life year
DLW	Doubly labeled water
DM	Diabetes Mellitus
E	
ECG	Electrocardiography
EE	Energy expenditure
EDTA	Etylenediaminetetra-acetic acid
<i>et al</i>	and others
F	
FA	fisieke aktiwiteit
FAS	Fetal alcohol syndrome
FEV 1	Forced expiratory volume in 1 second
FG	fasting glucose
G	
g	gram
GOD-POD	glucose oxidase-peroxidase
GPAQ	Global physical activity questionnaire
H	
HDL	High-density lipoprotein
HDL-C	High-density lipoprotein-cholesterol
HIV	Human immunodeficiency virus
HR	Heart rate
Hz	hertz

I

IDL	Intermediate density lipoprotein
IPAQ	Physical Activity Questionnaire
IPAQ-S	International Physical Activity Questionnaire (IPAQ) - Short version
ISAK	International Society for the Advancement of Kinanthropometry

K

kCal/kg/d	kilocalorie per kilogram per day
kCal/kg/h	kilocalorie per kilogram per hour
kg	kilogram
kg/m ²	kilogram per square meter

L

LDL	Low-density lipoprotein
LMI	liggaamsmassa indeks

M

MET	Metalbolic equivalent (energy expenditure measured in units of resting energy expenditure)
mg/dL	milligrams per decilitre
minutes/week	minutes per week
mmHg	millimetres of mercury
mmol/l	milli-molarities per liter
MOD 1	moderate
MOD 2 VG	moderate-2 to vigorous
MRC	Medical Research Council
MS	Metabolic syndrome
MVPA	moderate-to-vigorous physical activity

N

NCD	Non-Communicable Disease
-----	--------------------------

NCDs	Non-Communicable Diseases
NHANES	National Health and Nutrition Examination Survey
NHIS	National Health Interview Survey
NOSs	Nie-oordraagbare siektes
P	
P	significance
PA	Physical activity
PAI	physical activity index
PAEE	physical activity energy expenditure
PAL	physical activity level
PURE	Prospective Urban and Rural Epidemiological
PURE-SA	Prospective Urban and Rural Epidemiological in South Africa
R	
Rpm	rates per minute
S	
SANHANES	South African Health and Nutrition Examination Survey
Sed	sedentary
T	
TEE	Total energy expenditure
TG	Triglycerides
THUSA	Transition in health during Urbanisation in South Africa
V	
VLDL	Very-low density lipoprotein
W	
WC	waist circumference/waist girth

WHO

World Health Organization

WHtR

Waist-to-height ratio

Chapter 1

Introduction



Introduction

- 1.1 INTRODUCTION
 - 1.2 PROBLEM STATEMENT
 - 1.3 OBJECTIVES
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 - 1.5 CONTEXTUALISATION WITHIN THE PURE-STUDY
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-

1.1 INTRODUCTION

With rapid economic growth and globalization, people's lifestyles have been changing dramatically; they have become more physically inactive, eat more fast foods and in general are more stressed in comparison to their old lifestyles (Shi *et al.*, 2008:277). The rapid change in lifestyle due to the transition from rural to urban areas has led to the health of the population quickly shifting from a high mortality rate due to infectious and domestic disease in 1980, to a currently greater life expectancy and higher prevalence of risk factors for chronic diseases brought on by affluence and changes in lifestyle and diet (Cook & Dummer, 2004:329; Shi *et al.*, 2008:278).

Rapid urbanisation is a global trend (Malan *et al.*, 2008:323). In 1994 it was estimated that 44.5% of all people were urbanised. It is projected that this figure will increase to 61.1% by 2025 (Seedat, 2007:2; Malan *et al.*, 2008:323). The impact of urbanisation in Africans has been associated with an elevated risk of chronic diseases, for example essential hypertension (Malan *et al.*, 2008:323), increased obesity in women (Schutte & Olckers, 2007:653), higher levels of stress (Malan *et al.*, 2008:323), diabetes, hyperlipidaemia, and physical inactivity (Malan *et al.*, 2008:323). The South African National Health and Nutrition Examination Survey (SANHANES-1, 2013:71) reported that cardiovascular diseases, cancers, chronic respiratory diseases and diabetes are the four diseases which are the world's biggest killers, causing an estimated 35 million deaths each year, 60% of all deaths globally, with 80% in low- and middle-income countries. The epidemic of non-communicable diseases (NCDs) also known as chronic diseases of lifestyle has shifted from high-

income countries to developing countries as industrialization occurred. NCDs is the leading cause of morbidity and premature mortality world-wide and it is expected that by 2020, more than 80% of persons with NCDs will be in low- and middle-income countries, with the bulk being in high-income countries. Therefore the control of NCDs is an important goal for the prevention of premature death in all countries (Teo *et al.*, 2009:1; Mash, 2010:438).

1.2 PROBLEM STATEMENT

The prevention and management of preventable chronic diseases of lifestyle poses challenging problems for many countries due to aging populations. There are many factors associated with the development of chronic diseases of lifestyle, for example, lack of physical activity and exercise (Peltzer & Phaswana-Mafuya, 2012:447). Physical inactivity has been associated with obesity, and obesity in turn with cardiovascular disease, diabetes and osteoarthritis (Sui *et al.*, 2007:2507).

Chronic diseases of lifestyle, also called non-communicable diseases, are a group of diseases causing millions of deaths globally each year (Teo *et al.*, 2009:1; Van Zyl *et al.*, 2010:72). National cause-of-death statistics released by Statistics South Africa in 2005 revealed that 20% of deaths in the 35 to 64 year age group in the years 1997-2003 were as a result of chronic diseases of lifestyle. Chronic diseases of lifestyle have similar modifiable risk factors, which include hypertension, tobacco smoking, diabetes, obesity, hyperlipidaemia and physical inactivity (Van Zyl *et al.*, 2010:72). According to the SANHANES-1 (2013:70) 30.9% of South Africans reported a family history of high blood pressure and that females had a significantly higher rate of high blood pressure than males (20.6% and 12%). SANHANES-1 (2013:70) also reported that 20.7% of South Africans reported a family history of high blood sugar. Currently 72.5% of South Africans smoke daily (SANHANES-1, 2013:96) and 31% of males and 9.3% of females reported alcohol consumption. In South Africa 59% of African women and 49% of white women are overweight or obese (SANHANES-1, 2013:136). Deaths from risk factors for cardiovascular disease are on the rise globally and are projected to be responsible for 69% of all deaths by 2030 (Mathers & Loncar, 2006:442; Teo *et al.*, 2009:1; Fleischer *et al.*, 2011:294). Nearly 80% of these deaths already occur in low and middle-income countries (Reddy, 2002:232; Fleischer *et al.*, 2011:294). Also troubling is that deaths from chronic diseases of lifestyle usually occur at younger ages in developing countries than they do in developed countries (Abegunde *et al.*, 2007:1930; Fleischer *et al.*, 2011:294).

Fleischer and associates (2011:294) report that urbanisation is associated with an adoption of high-energy, high-fat, Westernised diets, and that the types of jobs available in urban areas are often more sedentary than those in rural areas, causing changes in physical activity levels. Likewise, changes in leisure-time activities and the different types of transportation available result in more sedentary lifestyles (Popkin, 2006:289; Mash, 2010:440). Fleischer *et al.* (2011:294) also report that persons living in urban areas in most developing countries have higher levels of chronic disease risk factors such as overweight, hypertension and diabetes than do their rural counterparts. According to the Rural Healthy People 2010 survey, of the top ten health concerns (cancer; diabetes; heart disease; stroke; maternal, infant and child health; mental health and mental disorders; nutrition; overweight; substance abuse and tobacco use) five are chronic conditions (cancer; diabetes, heart disease, stroke and overweight) that can be prevented or ameliorated with adequate physical activity (Gamm *et al.*, 2002:10; Mash, 2010:439).

Risk factors for chronic diseases of lifestyle have become an increasing global concern (Draper *et al.*, 2010:398). The burden of these chronic diseases of lifestyle is growing in South Africa in both urban and rural low income communities. (Steyn *et al.*, 2004:233; Tollman *et al.*, 2008:893; Mayosi *et al.*, 2009:934; Fernstrom *et al.*, 2012:301). The World Health Organization has projected an increase in people with diabetes from 347 million in 2008 to 366 million by 2030 (Wild *et al.*, 2004:1048; Allender *et al.*, 2010:297; Mash, 2010:438). Hypertension is also a major public health concern in the urbanised black population of South Africa (Van Rooyen *et al.*, 2000:779; SANHANES-1, 2013:73). Approximately 6.5 million South Africans have a blood pressure above 140/95mmHg and 3.2 million above 160/95mmHg (Van Rooyen *et al.*, 2000:779; SANHANES-1, 2013:73), compared to a blood pressure of <120/80 mmHg which is classified as normal (Van Rooyen *et al.*, 2000:779). Obesity – another risk factor – has a prevalence of overweight and obesity in South Africa of 56% in women and 29% in men (BMI of ≥ 25 kg/m²) (Van Zyl *et al.*, 2010:73). Urbanisation in South Africa has led to a significant increase in the chronic diseases of lifestyle such as hypertension, diabetes, coronary heart disease and cerebrovascular disease (Van Rooyen *et al.*, 2000:779; Assah *et al.*, 2011:491).

According to the American College of Sports Medicine (ACSM) chronic diseases of lifestyle can be addressed by introducing 45-60 minutes of moderate physical activity most days of the week. Physical activity appears to be lower in rural (compared to suburban and urban) populations (Frost *et al.*, 2010:267), which is problematic, given the beneficial effects of physical activity on the development and effective management of many chronic diseases of lifestyle. Studies also showed

that increased physical activity was associated with a lower waist:hip ratio and a higher-high density lipoprotein-cholesterol level in women and that physical activity was inversely associated with body mass index (BMI) and percentage body fat (Kruger *et al.*, 2003:17). These results support the idea that regular exercise decreases the risk of NCDs.

In a study conducted by Kruger and associates (2003:16) where the aim of the study was to determine the physical activity levels of black South Africans in the North-West Province and to assess the relationship between physical activity and the prevalence of risk factors for NCDs, they found that men were significantly more active than women, and that persons from the rural areas were more active than the urbanised participants. Physical activity was measured with the Baecke questionnaire (Baecke *et al.*, 1982:936). Kruger and associates (2003:16) also reported that in men only fasting serum insulin was significantly associated with physical inactivity, but in women high-density lipoprotein (HDL)-cholesterol, triglyceride concentration and fasting serum glucose were significantly associated with physical inactivity. Bloemhoff (2010:25) conducted a study to determine physical activity levels of undergraduate students at a South African university campus using the International Physical Activity Questionnaire (IPAQ)(Craig *et al.*, 2003:1381) and found that a third of all the respondents, irrespective of race, did not comply with the minimum suggested activity level.

Today, physical inactivity is responsible for a large worldwide burden of disease and health care cost (Gauthier *et al.*, 2009:S55). Assessing physical activity is of importance to examine the relationship between inactivity and/or activity and the development of NCDs (Gauthier *et al.*, 2009:S55). Developing accurate and reliable tools for quantifying physical activity behavior in children and adolescents continues to be a research priority (Trost *et al.*, 2000:427; Gauthier *et al.*, 2009:S55; Lee *et al.*, 2011:S84). A wide range of methods have been used to quantify physical activity behaviour. These methods include subjective measures such as child and parent self-reports, and objective measures such as direct observation, heart rate monitoring, motion sensors, and doubly-labelled water (Gauthier *et al.*, 2009:S55; Hallai *et al.*, 2010:S259).

Questionnaires represent the most widely used method to assess habitual physical activity in large population studies, as they are generally well accepted by participants and easy to administer at a low cost (Tehard *et al.*, 2005:1535; Standage *et al.*, 2012:233). Numerous questionnaires like the Global Physical Activity Questionnaire (2009), the International Physical Activity Questionnaire (IPAQ) (Gauthier *et al.*, 2009:S54) and the questionnaire designed by Baecke *et al.*, (1982:936) to

name but a few; measuring various dimensions of physical activity have been developed, some of which have been tested for validity and repeatability (Craig *et al.*, 2003:1381; Tehard *et al.*, 2005:1535; Haskell *et al.*, 2009:280).

Studies that reported physical activity by making use of physical activity questionnaires, had conflicting findings on the impact of gender on physical activity (Keating *et al.*, 2005:118) and Behrens and Dinger (2003:169) reported no gender differences in physical activity. This finding is, however, contradicted by Miller *et al.* (2005:215) who states that females are more likely to participate in moderate activity.

Few studies could be found on the physical activity level of South Africans. More than 30 years ago Seftel (1978:100) stated that South African blacks were far more active than whites, on the observation that they did not have cars or other labour-saving devices, but no physical activity data were available at the time. Against the back round of the current literature, the physical activity patterns of South Africans in transition have not been studied extensively, neither has the most appropriate physical activity measurement for collecting physical activity data been evaluated and clarified for application in large sample sizes.

Due to low literacy of black South Africans in the North-West Province an adapted Baecke physical activity questionnaire (Kruger *et al.*, 2000:54-64) was developed tested and standardised (Kruger *et al.*, 2003:16-23). International studies made use of the IPAQ like the international PURE-study. Due to our experience with the IPAQ in the North-West Province we use both and now value to see the correlation.

Therefore, the research questions to be answered with this study are:

- What is the correlation between the adapted Baecke physical activity questionnaire and the IPAQ-Short version?
- What changes in physical activity occurred and how do these changes relate to changes in BMI?
- What is the relationship between changes in physical activity and the changes in the risk factors for NCDs in a South African population?

CHAPTER 1

The benefits of the proposed study are that the role of physical activity as modifier in chronic diseases in an African population in transition will be better understood. The outcomes of the study will assist with influencing decision-making policy determination in the health of future South-Africans.

1.3 OBJECTIVES

The objectives set for this study are to determine:

- The correlation between the adapted Baecke physical activity questionnaire and IPAQ-S in a black South African population.
- Changes in physical activity and how these changes relate to changes in BMI among a black South African population in transition.
- The relationship between the changes in physical activity and the changes in the risk factors for NCDs in a black South African population in transition.

1.4 HYPOTHESES

The study is based on the following hypotheses:

- There is a non-significant correlation between the adapted Baecke physical activity questionnaire and the IPAQ-S in a black South African population.
- The physical activity of people will decrease significantly from 2005 to 2010 and the changes are significantly inversely related to increase in BMI in a black South African population in transition.
- There is a significantly inverse relationship between changes in physical activity and the changes in the risk factors for NCDs from 2005 to 2010 in a black South African population in transition.

1.5 CONTEXTUALISATION WITHIN THE PURE-STUDY

This study was a sub-study within the South African leg of the Prospective Urban and Rural Epidemiology study (PURE).

Although the student (Tershia van Niekerk) was not part of the team collecting data in 2005 and 2010 permission was granted for the data to be used in this study:

Prof S.J Moss Physical Activity questionnaires _____

Prof A Schutte Blood Pressures _____

Prof A Kruger Questionnaires & Blood samples _____

The role of the student in this study:

- Literature review
- Data capturing and cleaning
- Statistical analyse and interpretation
- Writing of manuscripts

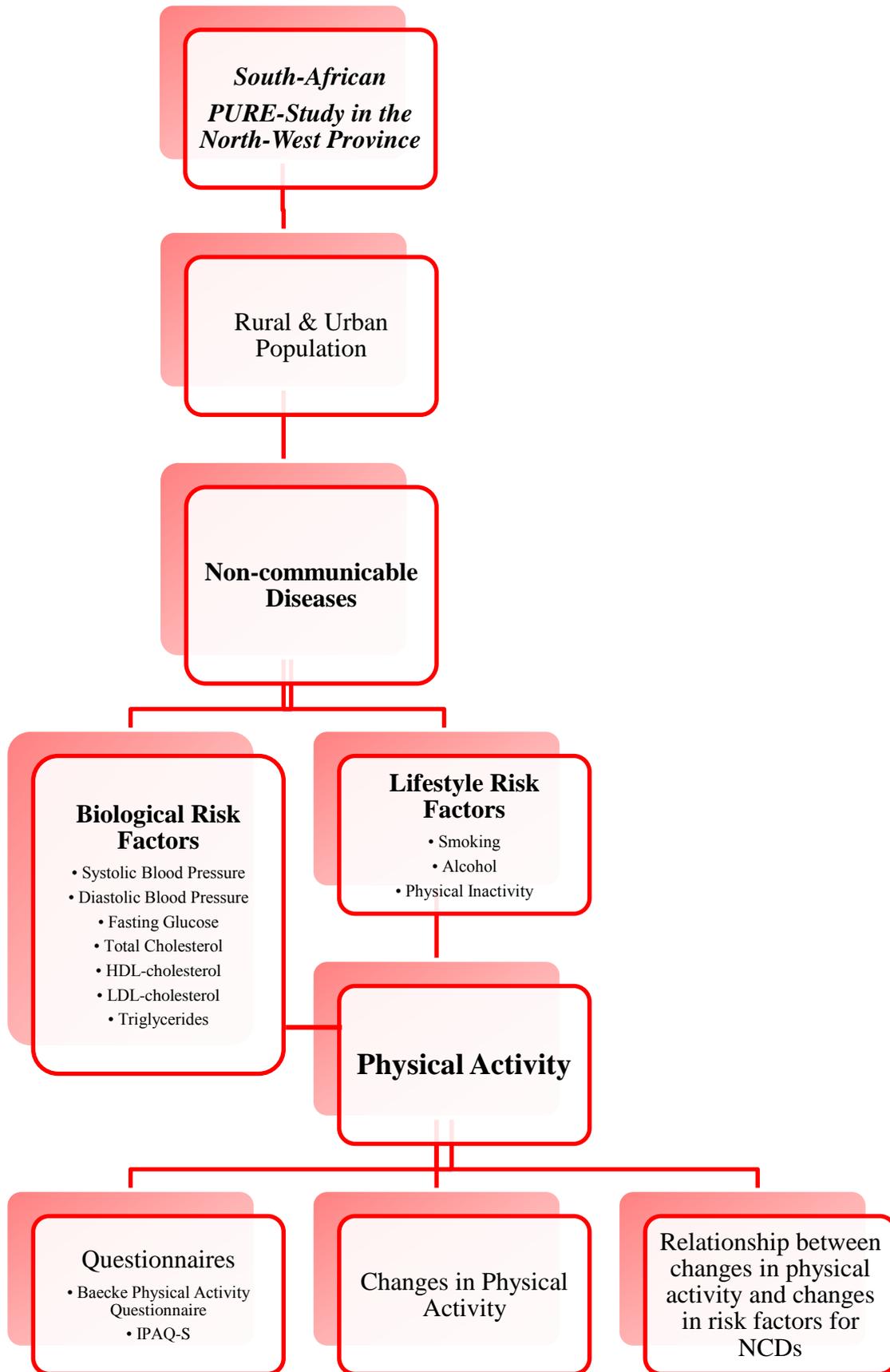


Figure 1.1: Focus of this thesis within the larger PURE-study

1.6 STRUCTURE OF THE THESIS

This thesis is presented in six main parts, namely an introduction (Chapter 1), a literature review (Chapter 2), and three research articles (Chapters 3-5). A summary with the discussion, conclusions and recommendations (Chapter 6), follow after the research articles as presented in Figure 1.3

Chapter 1 introduces the problem, and states the aim and hypotheses of this study. The literature review in Chapter 2 is based on the evidence of non-communicable disease and physical activity. Chapters 3-5 are presented in article format. Chapter 3: Correlation between Baecke physical activity questionnaire and IPAQ-S in a black South African population. Chapter 4: Changes in physical activity of a black South African population in transition: The PURE-study. Chapter 5: The relationship between changes in physical activity and changes in risk factors for non-communicable disease in a black South African population: The PURE-study. Chapter 6 is the final chapter and will be a collective summary with a conclusion, recommendations and limitations of the study. Chapter 6 is followed by a list of appendices.

This thesis is submitted in article format, as approved by the senate of the North-West University (NWU) (Potchefstroom Campus), according to the 2008 Guidelines for Post-Graduate Studies. Chapter 1, 2 and 6 has been written according to the prescribed standards of the NWU, Guidelines for References. The articles have been prepared for publication in accredited journals (South African journal for research in sport, physical education and recreation, South African journal of sports medicine, and Journal of behavioural nutrition and physical activity). Articles have been written according to the guidelines to authors of the various journals (see the relevant appendices). For the purpose of uniformity and examination, the font and spacing is kept the same throughout the thesis. The tables and figures are also placed in between the text and not at the end of each article. The results of the research articles in Chapters 3-5 are presented and interpreted in each chapter respectively.

The structure of the thesis is presented in Figure 1.2

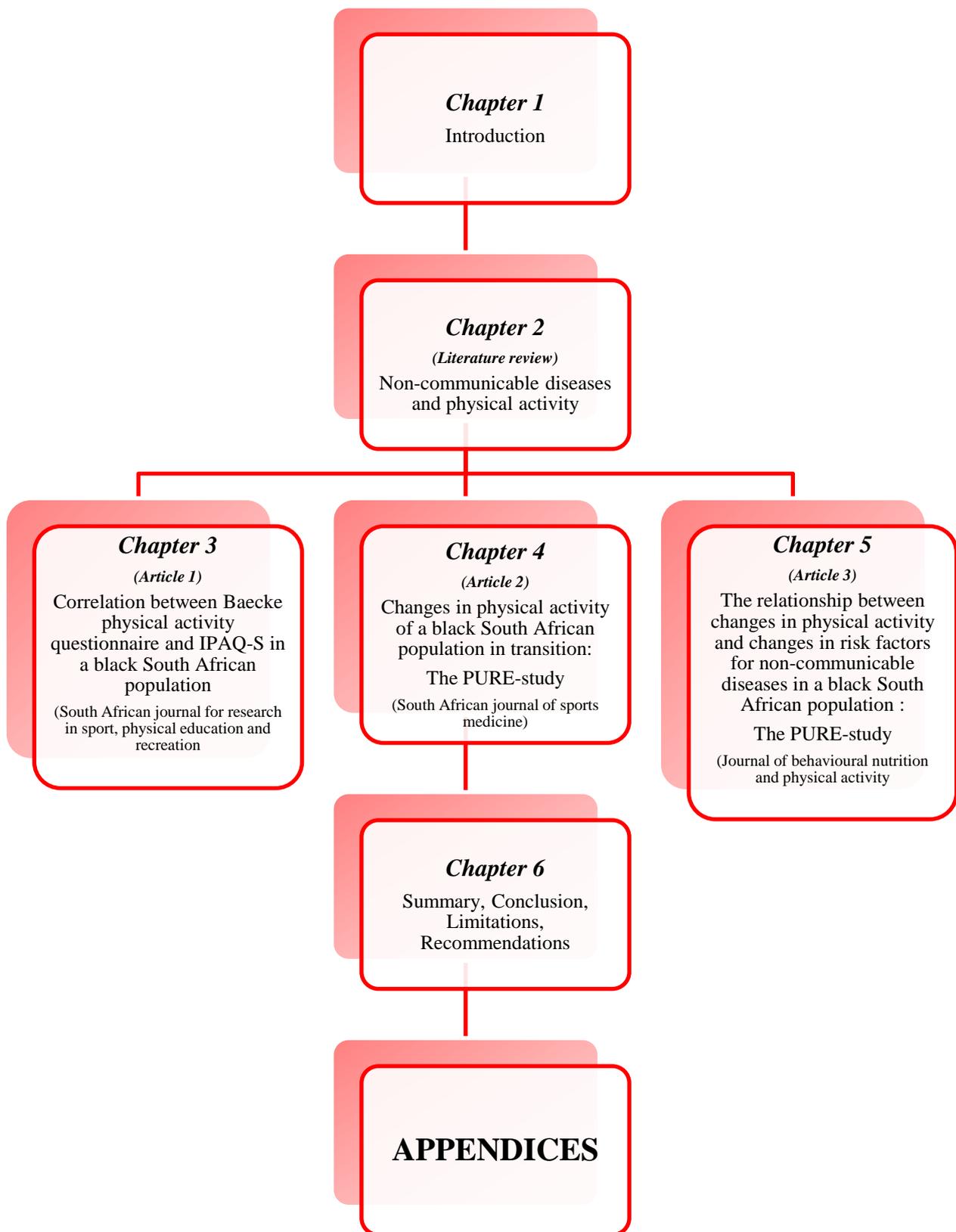


Figure 1.2: Structure of the thesis

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Chapter 2

*Non-communicable diseases and
physical activity*

2

Non-communicable diseases and physical activity

- 2.1 INTRODUCTION
 - 2.2 NON-COMMUNICABLE DISEASES IN SOUTH AFRICA
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 - 2.2.2 Cardio-respiratory diseases
 - 2.3 RISK FACTORS FOR NON-COMMUNICABLE DISEASES
 - 2.3.1 Hypertension
 - 2.3.2 Hyperglycaemia
 - 2.3.3 High Serum Cholesterol
 - 2.3.4 Tobacco smoking
 - 2.3.5 Alcohol abuse
 - 2.3.6 Overweight and obesity
 - 2.3.7 Physical Inactivity
 - 2.4 PHYSICAL ACTIVITY AS A MODIFIER OF RISK FACTORS FOR NCDs
 - 2.5 PHYSICAL ACTIVITY MEASURE INSTRUMENTS
 - 2.5.1 Subjective determination of PA
 - 2.5.2 Objective determination of PA
 - 2.6 THE EFFECT OF TRANSITION ON RISK FACTORS FOR NCDs
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 - 2.7 SUMMARY
- REFERENCES

2.1 INTRODUCTION

Non-communicable diseases (NCDs) are chronic medical conditions or diseases which are non-infectious (Allender *et al.*, 2010:297) and they are a major contributor to the burden of disease in developed countries, and increasing rapidly in developing countries (Allender *et al.*, 2010:297).

Currently, more than 63% of all deaths worldwide stem from NCDs – mainly cardiovascular disease, metabolic diseases and chronic respiratory disease. These deaths are distributed widely among the world’s population – from high-income to low-income countries and from young to old (WHO, 2011:5). It is projected that by 2020, NCDs will account for 73% of deaths and 60% of the disease burden globally (Yadav & Krishnan, 2008:400; Allender *et al.*, 2010:297). Moreover, what were once considered “diseases of affluence” have now encroached on developing countries (Yadav & Krishnan, 2008:400; Allender *et al.*, 2010:297). It is expected that by 2020 in developing countries, NCDs will account for 69% of all deaths, with cardiovascular diseases in the lead (Boutayeb & Boutayeb, 2005:2; WHO, 2008:2). In 2008, roughly four out of five NCD deaths occurred in low- and middle-income countries (WHO, 2011:5). Moreover, NCDs are having an effect throughout the age distribution – already one-quarter of all NCD-related deaths are among people below the age of 60 years (WHO, 2011:6).

According to the World Health Organisation, NCDs are defined as diseases of long duration, generally slow progression and they are the major cause of adult mortality and morbidity worldwide. Four main diseases are generally considered dominant in NCDs mortality and morbidity: cardiovascular diseases (including heart disease and stroke), diabetes, cancer and chronic respiratory diseases (including chronic obstructive pulmonary disease and asthma) (Mayosi *et al.*, 2009:934; Allender *et al.*, 2010:297).

NCDs are the top cause of death worldwide (Table 2.1), killing more than 36 million people in 2008 (WHO, 2012:34). Cardiovascular diseases were responsible for 48% of these deaths, cancers 21%, chronic respiratory diseases 12%, and diabetes 3% (WHO, 2012:35). The World Health Organisation (WHO) reports NCDs to be by far the leading cause of mortality in the world, representing over 60% of all deaths. Out of the 35 million people who died from NCDs in 2005, half were under age 70 and half were women (WHO, 2012:34; Fernstrom *et al.*, 2012:301). Of the 57 million global deaths in 2008, 36 million were due to NCDs (Fernstrom *et al.*, 2012:301). That is approximately 63% of total deaths worldwide, and an increase of 1 million deaths in 3 years. Risk

factors such as a person's background, lifestyle and environment are known to increase the likelihood of certain NCDs. Every year, at least 5 million people die due to the use of tobacco, and about 2.8 million die from being overweight. High cholesterol accounts for roughly 2.6 million deaths and 7.5 million die because of high blood pressure. It is projected that the annual number of deaths due to cardiovascular disease will increase from 17 million in 2008 to 25 million in 2030, with annual cancer deaths increasing from 7.6 million to 13 million. As a result of such trends, the total number of annual NCDs deaths is projected to reach 55 million by 2030 (WHO, 2012:35; Fernstrom *et al.*, 2012:301).

Table 2.1: Cause-specific mortality and morbidity*

WHO Region	Communicable disease	Non-Communicable disease	Injuries
African Region	798	779	107
Region of the Americas	72	455	63
South East Asia Region	334	676	101
European Region	51	532	63
Eastern Mediterranean	254	706	91
Western Pacific Region	74	534	64

*World Health Statistics 2012

NCDs are largely due to preventable and modifiable risk factors such as, high blood pressure, diabetes, high cholesterol, tobacco smoking, inappropriate use of alcohol, overweight and obesity, and physical inactivity which are not managed (Goedecke *et al.*, 2006:66; Steyn *et al.*, 2006:267; WHO, 2008:2). These factors result in various long-term disease processes, culminating in high mortality rates attributable to stroke, heart attack, tobacco- and nutrition-induced cancers, obstructive lung diseases and many other diseases (Steyn & Fourie, 2005:iv).

NCDs are also referred to as “lifestyle” diseases because the majority of these diseases are preventable illnesses; the most common causes for NCDs include tobacco use (smoking), alcohol abuse, poor diets (high consumption of sugar, salt, saturated fats, and trans fatty acids) and physical inactivity. NCDs are a group of disease that share similar risk factors as a result of exposure over many decades to unhealthy diets, smoking, lack of regular exercise, and possibly stress (Steyn & Fourie, 2005:iv; Mayosi *et al.*, 2009:935). The major risk factors are high blood pressure, tobacco addiction, high blood cholesterol, diabetes and obesity (Steyn & Fourie, 2005:iv; Mayosi *et al.*, 2009:935). These result in various long-term disease processes, culminating in high mortality rates

attributable to strokes, heart attacks, tobacco- and nutrition-induced cancers, chronic bronchitis, emphysema, renal failure and many others (Steyn & Fourie, 2005:iv; Mayosi *et al.*, 2009:935).

Currently, NCDs kills 36 million people a year, a number that by some estimates is expected to rise by 17-24% within the next decade (Steyn & Fourie, 2005:iv; Mayosi *et al.*, 2009:936).

2.2 NON-COMMUNICABLE DISEASES IN SOUTH AFRICA

South Africa has a quadruple burden of disease that is dominated by HIV/AIDS. Maternal and child health, as well as trauma related to interpersonal violence and road traffic accidents, make up two of the other quadrants, and the fourth element in this burden of disease is increasingly that of chronic diseases such as asthma, chronic obstructive pulmonary disease (COPD), hypertension, ischaemic heart disease and diabetes (Norman *et al.*, 2007:638; Mash, 2010:438).

The major NCDs in South Africa (Figure 2.1) are cardiovascular diseases, diabetes, cancers, chronic respiratory diseases and mental illness (Mayosi *et al.*, 2009:934; Allender *et al.*, 2010:297).

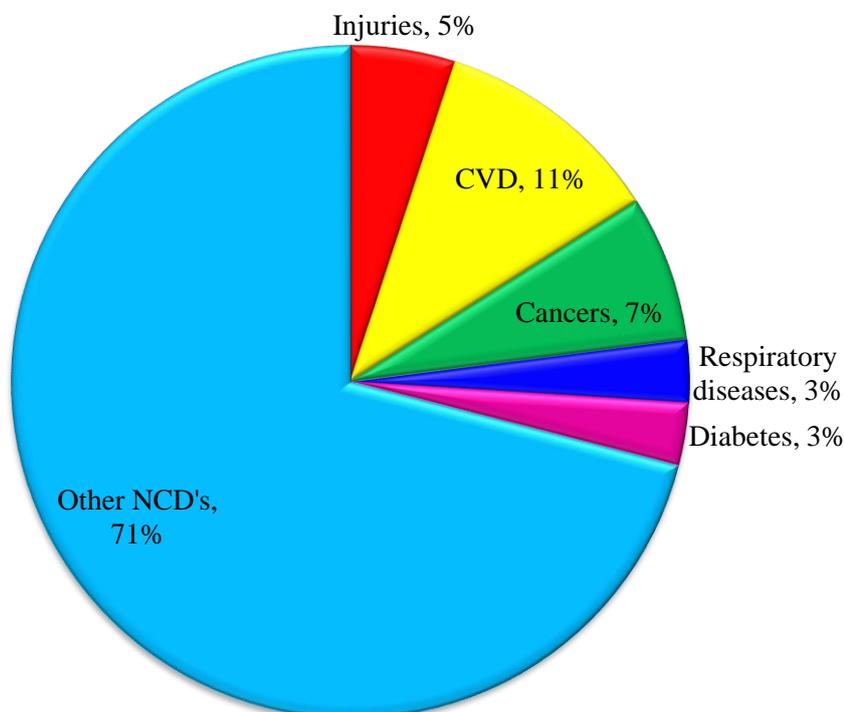


Figure 2.1: Non-communicable disease in South Africa (Adapted from the World Health Organisation 2011)

CHAPTER 2

According to WHO (2011:34), the top ranking main group of cause of death in 2010 in South Africa (Figure 2.2) was certain infections and parasitic diseases, comprising a quarter (25%) of all deaths. The second most common main group of cause of death was diseases of the circulatory system (15%), followed by symptoms and signs not elsewhere classified (13%), and diseases of the respiratory system (12%). Less than 10% of the deaths were due to external causes of morbidity and mortality (9%).

The main groups of cause of death that showed a consistent increase in the proportions of deaths over a period of three years (2008-2010) were diseases of the circulatory and genitourinary systems, neoplasms, endocrine, and nutritional and metabolic diseases.

Causes of death that was common for all nine provinces were tuberculosis, diabetes mellitus, cerebrovascular diseases, hypertensive diseases and other forms of heart disease, which is a big concern (WHO, 2011:34).

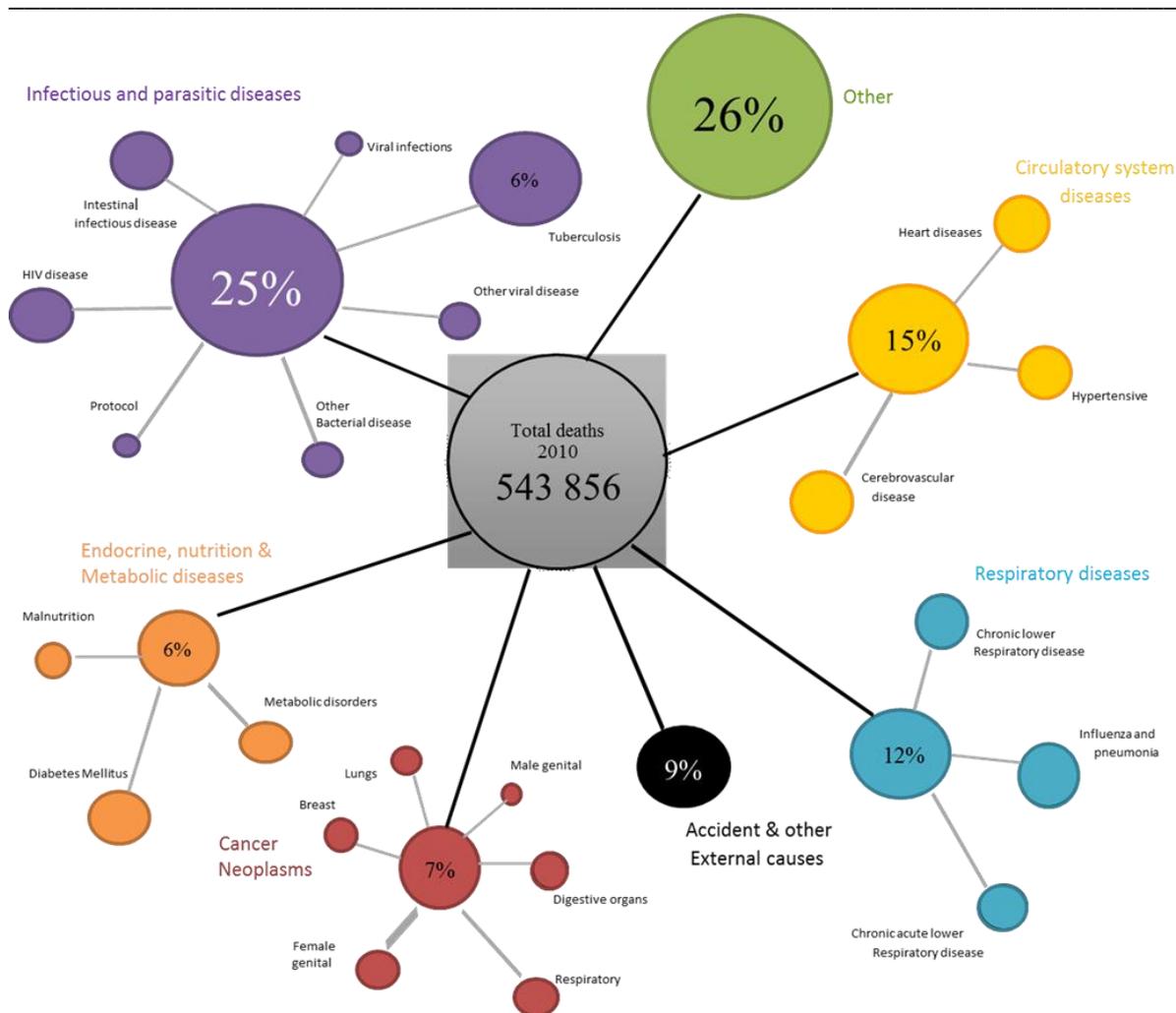


Figure 2.2: What South Africans died of in 2010

2.2.1 Metabolic syndrome

The metabolic syndrome (MetS) stands for a cluster of risk factors that predispose individuals to cardiovascular disease (CVD) and Type 2 diabetes (He *et al.*, 2006:1588; Wang *et al.*, 2010:266). These factors include abdominal obesity, high serum triglycerides, low serum HDL-cholesterol levels, high blood pressure and high fasting plasma glucose (He *et al.*, 2006:1588; Malan *et al.*, 2008:323; Wang *et al.*, 2010:266).

The International Diabetes Federation, consensus worldwide definition of the metabolic syndrome is: Central obesity (defined as waist circumference with ethnicity-specific values) AND any two of the following (Alberti *et al.*, 2006:476; Ntyintyane *et al.*, 2007:12):

Table 2.2: Metabolic syndrome according to the International Diabetes Federation

Any two of the following:	
Raised serum triglycerides	>150 mg/dL (1.7 mmol/L)
Reduced serum HDL cholesterol	< 40 mg/dL (1.03 mmol/L) in males < 50 mg/dL (1.29 mmol/L) in females
Raised blood pressure (BP)	Systolic BP > 130 mmHg or Diastolic BP > 85 mmHg
Raised fasting plasma glucose (FPG)	>100 mg/dL (5.8 mmol/L)

(Alberti *et al.*, 2006:476; Ntyintyane *et al.*, 2007:12)

Metabolic syndrome (MetS) has been found to be associated with genetic factors and lifestyle behaviors that include a lack of physical activity (Eckel *et al.*, 2005:1415; Miettola *et al.*, 2012:10), smoking, alcohol intake and unhealthy dietary habits, particularly a high intake of carbohydrates and fat (Lutsey *et al.*, 2008:754; Wang *et al.*, 2010:266). Sedentary behavior during leisure time has also been found to be associated with metabolic diseases (Sisson *et al.*, 2009:529; Miettola *et al.*, 2012:10).

Information on the prevalence of MetS in epidemiology studies reports on West Africans in Cameroon (Fezeu *et al.*, 2007:74), Benin (Ntandou *et al.*, 2009:185), and Nigeria (Oladapo *et al.*, 2010:27) (Motala *et al.*, 2011:1032). The crude prevalence in these studies ranged from an absence or low prevalence (0-4%) in rural communities in all three countries as well as in an urban community in Cameroon (Motala *et al.*, 2011:1032). In Benin, prevalence was higher in semi-urban (6.4%) and urban samples (11%). According to a study by Motala and colleagues (2011:1032) the prevalence of metabolic syndrome was higher in women (25%) than men (10.5%) in a rural South African black community.

2.2.2 Cardiovascular disease

Cardiovascular disease refers to any disease that affects the cardiovascular system, principally cardiac disease, vascular diseases of the brain and kidneys, and peripheral arterial disease (Ginsberg, 2013:S1). Over 82% of the mortality burden is caused by ischaemic or coronary heart disease, stroke, hypertensive heart disease or congestive heart failure (WHO, 2011:12). The causes of cardiovascular disease are diverse but atherosclerosis and/or hypertension are the most common.

Over the past decade, CVD has become the single largest cause of death worldwide, representing nearly 30% of all deaths and about 50% of NCD deaths (WHO, 2011:12). Cardiovascular diseases remain the biggest cause of deaths worldwide, although over the last two decades, cardiovascular mortality rates have declined in many high-income countries. Conversely cardiovascular deaths and disease have increased at an astonishingly fast rate in low- and middle-income countries (Gaziano *et al.*, 2010:73; Maredza *et al.*, 2011:48). Although cardiovascular disease usually affects older adults, the antecedent of cardiovascular disease, notably atherosclerosis begins in early life, making primary prevention efforts necessary from childhood (Maredza *et al.*, 2011:48). There is thus an increased emphasis on preventing atherosclerosis by modifying risk factors, such as healthy eating, exercise, and avoidance of smoking (Gaziano *et al.*, 2010:73).

Almost all cardiovascular disease in a population can be explained in terms of the following risk factors: age, gender, high blood pressure, high serum cholesterol levels, tobacco smoking, excessive alcohol consumption, family history, obesity, lack of physical activity, psychosocial factors, diabetes mellitus, and air pollution (Gaziano *et al.*, 2010:73). While the individual's contribution of each risk factor varies between different communities or ethnic groups, the consistency of the overall contribution of these risk factors is remarkably strong (Gaziano *et al.*, 2010:73; Maredza *et al.*, 2011:48).

Cardiovascular disease (CVD) including hypertension and stroke, constitutes an estimated 60% of all chronic NCD deaths worldwide (Yach *et al.*, 2004:2616; Maredza *et al.*, 2011:48). Heart disease affects people across the globe and does not discriminate against race, age or gender (Maredza *et al.*, 2011:48).

In South Africa (SA), approximately 195 people die per day due to CVD, representing about 20% of the daily deaths due to HIV/AIDS (Maredza *et al.*, 2011:48).

When considering the United Nations projections that the percentage of the population above 60 years will more than double between the years 1999-2050 in SA, the burden due to CVD is predicted to become the prime contributor to total morbidity and mortality in the over 50-year age group (Maredza *et al.*, 2011:48). However, CVD is taking its toll even among younger age groups, with deaths projected to increase by over 40% in the 35-to 64-year age group by 2030 in SA.

2.2.2.1 Respiratory disease

The most common chronic respiratory diseases in South Africa are asthma and chronic bronchitis/chronic obstructive pulmonary disease (COPD) (Steyn & Fourie, 2005:123).

Asthma is the common chronic inflammatory disease of the airways characterised by variable and recurring symptoms, reversible airflow obstruction, and bronchospasm (Yawn, 2008:138; Lemanske & Busse, 2010:S96). Symptoms include wheezing, coughing, chest tightness and shortness of breath (Lemanske & Busse, 2010:S96). Asthma is clinically classified according to the frequency of symptoms, forced expiratory volume in 1 second (FEV1), and peak expiratory flow rate (Yawn, 2008:139; Lemanske & Busse, 2010:S97). Asthma may also be classified as atopic (extrinsic) or non-atopic (intrinsic) (Kumar *et al.*, 2010:688).

Chronic obstructive pulmonary disease (COPD), also known as chronic obstructive lung disease (COLD), chronic obstructive airway disease (COAD), chronic airflow limitation (CAL) and chronic obstructive respiratory disease (CORD), is the occurrence of chronic bronchitis or emphysema, a pair of commonly co-existing diseases of the lungs in which the airways become narrowed (Nathell *et al.*, 2007:89). This leads to a limitation of the flow of air to and from the lungs, causing shortness of breath (dyspnea). In clinical practice, COPD is defined by its characteristically low airflow on lung function tests (Nathell *et al.*, 2007:89). In contrast to asthma, this limitation is poorly reversible and usually gets progressively worse over time.

COPD occurs in 34 out of 1 000 people greater than 65 years old (Torres & Moayed, 2007:308). In England, an estimated 842 100 of 50 million people have a diagnosis of COPD; translating into approximately one person in 59 receiving a diagnosis of COPD at some point in their lives. In the most socioeconomically deprived parts of the country, one in 32 people were diagnosed with COPD, compared with one in 98 in the most affluent areas (Simpson *et al.*, 2010:483). In the United States, the prevalence of COPD is approximately 1 in 20 or 5%, totalling approximately 13.5 million people in USA (Simpson *et al.*, 2010:483), or possibly approximately 25 million people if undiagnosed cases are included.

Worldwide in 2001, COPD was the fifth most common cause of death (Pauwels *et al.*, 2004:614), responsible for 4.7% of deaths and 2% of Disability Adjusted Life Years (DALY) (WHO, 2005:1). A 30-year projection from 1990 predicted a steady rise in the number of COPD deaths to become the third most common cause worldwide by 2020 (Murray & Lopez, 1997:1436). Most of the projected DALY burden will fall on developing countries (Murray & Lopez, 1997:1436). Affecting

more than 210 million people worldwide, COPD accounts for 3-8% of total deaths in high-income countries, and 4-9% of total deaths in low- and middle-income countries (Mannino & Buist, 2007:765).

In South Africa, respiratory disease as a group (but excluding tuberculosis), was ranked as the seventh most important cause of DALY (4.7%) (Bradshaw *et al.*, 2003:682). While South Africa is ranked 25th worldwide in the prevalence of asthma (estimated at 8.1% over all ages), it runs fourth in asthma mortality rates in the 5-34-year age group, at approximately 1.5 per 100 000, falling between Turkmenistan and Uzbekistan (Masoli *et al.*, 2004:469). Similarly, the asthma case fatality rate in South Africa is reported as being the fifth highest in the world at 18.5 per 100 000 asthmatics (Masoli *et al.*, 2004:469).

In South Africa, the pattern of asthma and COPD reflects the structure of society with its high degree of industrialization, high rates of smoking among some sections of the population, extensive urban and rural poverty, and the persistence of epidemic infectious diseases (Steyn & Fourie, 2005:123).

2.3 RISK FACTORS OF NON-COMMUNICABLE DISEASES IN SOUTH AFRICA

NCDs have long been the main health problem in developed countries, while in recent decades the prevalence of these diseases and their antecedent risk factors have rapidly increased in developing countries (Yamauchi *et al.*, 2001:65, Yadav & Krishnan, 2008:402; Draper *et al.*, 2010:398). NCDs contributed to 60% of deaths and 43% of the global burden of disease in 2002, and by 2020 are projected to account for 73% of deaths and 60% of disease burden respectively (Yadav & Krishnan, 2008:402). According to the World Health Organisation, about 60% of deaths in the world are now caused by NCDs (Yadav & Krishnan, 2008:402). By 2020, studies indicate that mortality by NCDs is expected to increase by 120% for women and 137% for men (Yach *et al.*, 2004:2617; BeLue *et al.*, 2009:10). The major determinants of the increasing burden of NCDs are globalisation, urbanisation and economic liberalisation (Yadav & Krishnan, 2008:402). Rapid urbanisation is accompanied by unhealthy dietary practices, sedentary lifestyle and obesity, all of which are major risk factors of NCDs (Yadav & Krishnan, 2008:402). All these risk factors are lifestyle-related and are influenced by change from rural to urban lifestyles (Yadav & Krishnan, 2008:402). Even in

rural areas, with modernisation and the advent of mass media there is a gradual shift to an urbanised lifestyle (Yadav & Krishnan, 2008:402).

Globally, NCDs are the leading cause of mortality and morbidity (Mendis, 2005:15; Masterson Creber *et al.*, 2010:1). Currently, 80% of deaths and 87% of disability from NCDs occurs in low- and middle-income countries (Mendis, 2005:15; Misra & Khurana, 2008:10; Masterson Creber *et al.*, 2010:1).

NCDs share similar modifiable risk factors, which include hypertension, diabetes, high cholesterol, tobacco smoking, alcohol abuse, overweight and obesity, and physical inactivity (Van Zyl *et al.*, 2010:72).

2.3.1 Hypertension

Hypertension or high blood pressure is a chronic medical condition in which the blood pressure in the arteries is elevated (BeLue *et al.*, 2009:13). This requires the heart to work harder than normal in order to circulate blood through the blood vessels. Blood pressure is summarised by two measurements: systolic and diastolic, which depend on whether the heart muscle is contracting (systole) or relaxed between beats (diastole). Normal blood pressure at rest is within the range of 100-140 mmHg systolic (top reading) and 60-90 mmHg diastolic (bottom reading). High blood pressure is said to be present if it is persistently at or above 140/90 mmHg.

Table 2.3: Blood pressure classification

Classification	Systolic Pressure (mmHg)	Diastolic Pressure (mmHg)
Normal	90 – 119	60 – 79
Prehypertension	120 – 139	80 – 89
Stage 1 Hypertension	140 – 159	90 – 99
Stage 2 Hypertension	≥ 160	≥ 100

(BeLue *et al.*, 2009:13)

Hypertension is classified as either primary hypertension or secondary hypertension; about 90-95% of cases are categorised as "primary hypertension" which means high blood pressure with no obvious underlying medical cause (Papadopoulos *et al.*, 2010:329). The remaining 5-10% of cases (secondary hypertension) is caused by other conditions that affect the kidneys, arteries, heart or endocrine system (Papadopoulos *et al.*, 2010:329).

Hypertension is the most important preventable risk factor for premature death worldwide (Dionne *et al.*, 2012:18), as it is the greatest risk factor for cardiovascular disease, (Vasan *et al.*, 2001:1291; Danaei *et al.*, 2011:568), responsible for up to 7 million deaths worldwide every year (Ezzati *et al.*, 2002:1347; Danaei *et al.*, 2011:569). Over 1.5 billion people suffer from hypertension worldwide and it is among the top cause of deaths related to cardiovascular disease and more than half a billion more will harbour this silent killer by 2025 (Ezzati *et al.*, 2002:1347; Danaei *et al.*, 2011:569). Hypertension increases the risk of ischemic heart disease, strokes, peripheral vascular disease, and other cardiovascular diseases, including heart failure, aortic aneurysms; diffuse atherosclerosis and pulmonary embolism (Dionne *et al.*, 2012:18). Hypertension is also a risk factor for cognitive impairment and dementia and chronic kidney disease (Duda *et al.*, 2007:116).

Even moderate elevation of arterial blood pressure is associated with a shortened life expectancy. Dietary and lifestyle changes can improve blood pressure control and decrease the risk of associated health complications, although drug treatment is often necessary in people for whom lifestyle changes prove ineffective or insufficient (Dionne *et al.*, 2012:18).

People who have hypertension are usually unaware that they have the condition, unless their BP has been measured at a health-care facility. It is therefore frequently referred to as a 'silent epidemic' in South Africa. Consequently, hypertension is universally underdiagnosed and or inadequately treated resulting in extensive target-organ damage and premature death.

According to the American Heart Association, in the United States, about 76.4 million people aged 20 and older have hypertension (Ezzati *et al.*, 2002:1347; Danaei *et al.*, 2011:569).

In a study done by Yoon *et al* (2012:20) on the National Health and Nutrition Examination Survey (NHANES) data (2005-2008) researchers found that up until the age of 45 a higher percentage of men than women have hypertension. From ages 45-54 and 55-64, the percentage of men and women is similar; after that a much higher percentage of women than men have hypertension. The study also projects that by 2030, an additional 27 million people could have hypertension.

In South Africa, more than 6.5 million people have blood pressure (BP) above 140/95 mmHg and 3.2 million of these have a blood pressure measurement higher than 160/95 mmHg (Norman *et al.*, 2007:692). An estimated 53 men and 78 women die in South Africa each day from the impact of hypertension (Norman *et al.*, 2007:692).

Hypertension is a major public health concern in the urbanised black population in South Africa, including the North West Province (Van Rooyen *et al.*, 2000:779). In an epidemiological study of hypertension and its determinants in a population in transition: the THUSA study, conducted by Van Rooyen and partners (2000:779-787) in the North West Province results showed that 22.8% of the subjects had systolic and 20.7% diastolic blood pressures above 140/90 mmHg. Van Rooyen and partners (2000:781) also reported that blood pressure correlated positively with age, level of urbanisation, WHR and smoking. Malan and associates (2008:325) also reported that the urbanised participants had a higher blood pressure (119/80) compare to their rural counterparts (111/70).

According to the South African Health and Nutrition Examination Survey (SANHANES-1) (2013:70) 30.9% of South Africans reported a family history of high blood pressure. SANHANES-1 (2013:72) also reported that females had a significantly higher rate of high blood pressure than males (20.6% and 12%). Mean systolic blood pressure for males (130 mmHg) was significantly higher than for females (127 mmHg) but no significant differences were found for diastolic blood pressure. Blood pressure increases progressively with increasing age (SANHANES-1, 2013:73).

SANHANES-1 (2013:80) reported that across localities, people in urban informal and rural informal environments had the lowest mean systolic blood pressure, while across provinces, the highest systolic blood pressure measurements were recorded in the Western Cape (131.8 mmHg), Free State (133.9 mm Hg) and North-West (131 mmHg). White (130.8 mmHg) and Coloured (132.1 mmHg) race groups had the highest mean systolic blood pressure. A similar pattern was seen overall for the mean diastolic blood pressure (SANHANES -1, 2013:80)

2.3.2 Hyperglycaemia

Diabetes is a chronic illness that occurs when the pancreas does not produce enough insulin, or when the body cannot effectively use the insulin it produces. Hyperglycaemia, or raised blood sugar, is a common effect of uncontrolled diabetes and over time leads to serious damage to many of the body's systems especially the nerves and blood vessels (BeLue *et al.*, 2009:13).

There are three main types of diabetes mellitus (DM). Type 1 diabetes results from the body's failure to produce insulin, and presently requires the person to inject insulin or wear an insulin pump. This form was previously referred to as "insulin-dependent diabetes mellitus". Without daily administration of insulin, Type 1 diabetes is rapidly fatal. Symptoms include excessive excretion of urine (polyuria), thirst (polydipsia), constant hunger, weight loss, vision change and

fatigue. These symptoms may occur suddenly. Type 2 diabetes results from insulin resistance, a condition in which cells fail to use insulin properly, sometimes combined with an absolute insulin deficiency. This form was previously referred to as “non-insulin-dependent diabetes mellitus”. Type 2 diabetes comprises 90% of people with diabetes around the world and is largely the result of excess body weight and physical inactivity. The third main form, gestational diabetes occurs when pregnant women without a previous diagnosis of diabetes develop a high blood glucose level. Diabetes can be defined either by physician diagnosis, in-situ capillary whole blood glycaemia test or by a urine report (BeLue *et al.*, 2009:13).

Diabetes without proper treatment can cause many complications. Acute complications include hypoglycaemia, diabetic ketoacidosis, or non-ketotic hyperosmolar coma. Serious long-term complications include cardiovascular disease, chronic renal failure and diabetic retinopathy (retinal damage). All forms of diabetes increase the risk of long-term complications. These typically develop after many years (Boussageon *et al.*, 2011:4169), but may be the first symptom in those who have otherwise not received a diagnosis before that time. The major long-term complications relate to damage to blood vessels.

Diabetes doubles the risk of cardiovascular disease (Sattar *et al.*, 2010:736; Boussageon *et al.*, 2011:4169). The main “macro vascular” disease (related to atherosclerosis of larger arteries) is ischemic heart disease (angina and myocardial infarction), stroke and peripheral vascular disease. Diabetes also causes “micro vascular” complications - damage to the small blood vessels (Boussageon *et al.*, 2011:4169). Diabetic retinopathy, which affects blood vessel formation in the retina of the eye, can lead to visual symptoms, reduced vision, and potentially blindness. Diabetic nephropathy, the impact of diabetes on the kidneys, can lead to scarring changes in the kidney tissue, loss of small or progressively larger amounts of protein in the urine, and eventually chronic kidney disease requiring dialysis. Diabetic neuropathy is the outcome of diabetes on the nervous system, most commonly causing numbness, tingling and pain in the feet and also increasing the risk of skin damage due to altered sensation. Together with vascular disease in the legs, neuropathy contributes to the risk of diabetes-related foot problems (such as diabetic foot ulcers) that can be difficult to treat and occasionally require amputation (Sattar *et al.*, 2010:736; Boussageon *et al.*, 2011:4169).

Diabetes is a global health problem and it is estimated that 366 million people will be affected by the year 2030 (Allender *et al.*, 2010:297). Unfortunately, four-fifths of all patients with diabetes live in developing countries (Allender *et al.*, 2010:297). One of the greatest contributors to the development of diabetes is obesity. More than 80% of cases of Type 2 diabetes can be attributed to obesity (Allender *et al.*, 2010:298).

Data from NHANES (2005-2008), shows that an estimated 18.3 million Americans ≥ 20 years of age has physician-diagnosed DM (Allender *et al.*, 2010:298). An additional 7.1 million adults have undiagnosed DM, and 81.5 million adults have pre-diabetes (e.g., fasting blood glucose of 100 to <126 mg/dL) (Allender *et al.*, 2010:298). The prevalence of pre-diabetes in the US adult population is nearly 37% (Allender *et al.*, 2010:299).

It has been estimated that there are approximately 1.5 million South Africans with diabetes. (Bradshaw *et al.*, 2007:644). In sub-Saharan Africa the number of people with diabetes is predicted to increase by 80% from 10.4 million to 18.7 million by 2025 (Bradshaw *et al.*, 2007:644). The prevalence of diabetes mellitus will almost double in the next 25 years and at least 75% of those affected will be in developing countries (Allender *et al.*, 2010:297). Data from the SANHANES-1 (2013:94) showed that 20.7% of South Africans reported a family history of high blood sugar.

In a study done by Vorster and partners (2007:315) on cardiovascular disease risk factors and socio-economic position of Africans in transition: the THUSA study in the North West Province it was reported that mean fasting serum glucose levels were the lowest in the upper urban group (4.2 mmol/L) compare to the deep rural group (5.0 mmol/L). This is in contrast with a study that was done by Pisa and associates (2012:371) who reported that urban participants had a higher fasting serum glucose level (5.19 mmol/L) compared to the rural participants (4.94 mmol/L). These finding are supported by Malan and parteners (2008:325) who also reported that the urban participants had a higher fasting serum glucose level (4.74 mmol/L) compared to the rural participants (4.71 mmol/L).

Diabetes rates vary among the South African population groups. In 2000, in people older than 30 years, the highest rate was recorded in Indians, where 18% of men and 16% of women had diabetes (Draper *et al.*, 2010:399). SANHANES-1 (2013:94) also found that the Asian/Indian population had the highest prevalence of diabetes (30.7%). The rate of diabetes found in the coloured group

was 13.4%. SANHANES-1 (2013:94) reported that diabetes was the highest among rural informal (11.9%) and urban formal (11.3%) residents.

According to SANHANES-1 (2013:98), the four provinces with overall significantly higher values of 6% or greater blood sugar measurements were the Western Cape, Eastern Cape, Northern Cape and North-West.

2.3.3 High Serum Cholesterol (Dyslipidaemia)

Hypercholesterolemia is the presence of high levels of cholesterol in the blood (Kontush & Chapman, 2006:144). It is a form of "hyperlipidaemia" (elevated levels of lipids in the blood) and "hyperlipoproteinemia" (elevated levels of lipoproteins in the blood).

Dyslipidaemia is an abnormal amount of lipids (e.g. cholesterol and/or fat) in the blood. Physicians and basic researchers classify dyslipidaemia in two distinct ways: phenotype, or the presentation in the body (including the specific type of lipid that is increased), and etiology, or the reason for the condition (genetic or secondary to another condition).

Since cholesterol is insoluble in water, it is transported in the blood within protein particles (lipoproteins). Lipoproteins are classified by their density (very low-density lipoprotein (VLDL), intermediate-density lipoprotein (IDL), low-density lipoprotein (LDL) and high-density lipoprotein (HDL)) (Kontush & Chapman, 2006:144). All the lipoproteins carry cholesterol, but elevated levels of the lipoproteins other than HDL (termed non-HDL cholesterol), particularly LDL-cholesterol is associated with an increased risk of atherosclerosis and coronary heart disease (Kontush & Chapman, 2006:144; Finn *et al.*, 2010:1282). In contrast, higher levels of HDL-cholesterol are protective (Kontush & Chapman, 2006:144; Finn *et al.*, 2010:1282). Elevated levels of non-HDL-cholesterol and LDL in the blood may be a consequence of diet, obesity, inherited (genetic) diseases (such as LDL receptor mutations in familial hypercholesterolemia), or the presence of other diseases such as diabetes and an underactive thyroid (Finn *et al.*, 2010:1282).

Although hypercholesterolemia itself is asymptomatic, longstanding elevation of serum cholesterol can lead to atherosclerosis (Bhatnager *et al.*, 2008:993). Over a period of decades, chronically elevated serum cholesterol contributes to formation of athermanous plaques in the arteries. This can lead to progressive stenosis (narrowing) or even complete occlusion (blockage) of the involved arteries. Alternatively smaller plaques may rupture and cause a clot to form and obstruct blood flow

(Finn *et al.*, 2010:1282). A sudden occlusion of a coronary artery results in a myocardial infarction or heart attack. An occlusion of an artery supplying the brain can cause a stroke (Finn *et al.*, 2010:1282).

If the development of the stenosis or occlusion is gradual, blood supply to the tissues and organs slowly diminishes until organ function becomes impaired. At this point that tissue ischemia (restriction in blood supply) may manifest as specific symptoms. For example, temporary ischemia of the brain (commonly referred to as a transient ischemic attack) may manifest as temporary loss of vision, dizziness and impairment of balance, aphasia (difficulty speaking), paresis (weakness), and paraesthesia (numbness or tingling), usually on one side of the body. Insufficient blood supply to the heart may manifest as chest pain, and ischemia of the eye may manifest as transient visual loss in one eye. Insufficient blood supply to the legs may manifest as calf pain when walking, while in the intestines it may present as abdominal pain after eating a meal (Finn *et al.*, 2010:1283). Some types of hypercholesterolemia lead to specific physical findings. For example, familial hypercholesterolemia (Type II hyperlipoproteinemia) may be associated with xanthelasma palpebrarum (yellowish patches underneath the skin around the eyelids) arcus senilis (white or grey discoloration of the peripheral cornea) (Finn *et al.*, 2010:1284), and xanthoma (deposition of yellowish cholesterol-rich material) of the tendons, especially of the fingers (Finn *et al.*, 2010:1284). Type III hyperlipidaemia may be associated with xanthoma of the palms, knees and elbows (Finn *et al.*, 2010:1284).

Dyslipidaemia has emerged as an important cardiovascular disease risk factor (BeLue *et al.*, 2009:14). Norman and colleagues (2007:708) found that high cholesterol levels (≥ 3.8 mmol/l) accounted for 59% of ischemic heart disease and 29% of ischemic stroke burden in adults age 30 and over.

Nationally, an estimated 33.5 million adult's ≥ 20 year of age have total serum cholesterol levels ≥ 240 mg/dL (Norman *et al.*, 2007:708). Data from SANHANES-1 (2013:86) indicates that in South Africa the formal urban and formal rural areas had the highest total serum cholesterol levels. Provincially, the Western Cape reported the highest total serum cholesterol levels and by race, the black African group had the lowest total serum cholesterol levels (SANHANES-1, 2013:86). A study done by Vorster (2002:239-243) to review the available data on risk factors for cardiovascular disease, the influence of urbanisation of Africans on these risk factors and to examine why stroke emerges as a higher risk than ischaemic heart disease in the health transition of black South

Africans it was reported that black men (4.20 mmol/L) and women (4.70 mmol/L) had the lowest total serum cholesterol levels compared to coloured men (6.09 mmol/L) and women (6.30 mmol/L), Indian men (6.28 mmol/L) and women (5.86 mmol/L) and white men (6.39 mmol/L) and women (6.62 mmol/L).

In a study done by Pisa and partners (2012:371) who looked at the social drift of cardiovascular disease risk factors in Africans from the North West Province of South Africa: the PURE study, Pisa and partners reported that the urban women had higher total serum cholesterol levels (5.20 mmol/L) compared to the rural women (5.11 mmol/L). The urban men also reported higher total serum cholesterol levels (4.88 mmol/L) compared to the rural men (4.72 mmol/L) (Pisa *et al.*, 2012:374). These findings are supported by Vorster and partners (2007:317) who also found higher total serum cholesterol levels in both urban men (4.6 mmol/L) and women (4.5 mmol/L) compared to the rural men (4.0 mmol/L) and women (4.1 mmol/L), these results shows that the burden of CAD will be carried by those Africans with higher socio-economic positions.

2.3.4 Tobacco smoking

Tobacco smoking is the practice of burning tobacco and inhaling the resulting smoke (consisting of particle and gaseous phases). The practice may have begun as early as 5000-3000 BC (Mariolis *et al.*, 2006:1145; Talhout *et al.*, 2007:628). Smoking is the most common method of consuming tobacco, and tobacco is the most common substance smoked. The agricultural product is often mixed with additives and then pyrolysis. The resulting smoke is then inhaled and the active substance absorbed through the alveoli in the lungs. The active substances trigger chemical reactions in nerve ending which elevate heart rate, alertness and reaction time. Dopamine and endorphins are released, which are often associated with pleasure (Mariolis *et al.*, 2006:1145). As of 2000, smoking is practised by approximately 1.22 billion people. In most communities men are more likely to smoke than are women (Mariolis *et al.*, 2006:1145), through the gender gap tends to be less pronounced in lower age groups (Mariolis *et al.*, 2006:1145; Talhout *et al.*, 2007:628).

Tobacco use leads most commonly to diseases affecting the heart and lungs, with smoking being a major risk factor for heart attacks, strokes, chronic obstructive pulmonary disease (COPD), emphysema, and cancer (particularly lung cancer, cancer of the larynx and mouth, and pancreatic cancer). Cigarette smoking increases the risk of Crohn's disease as well as the severity of the course of the disease (Rom *et al.*, 2013:25).It is also the number one cause of bladder cancer. The smoke

from tobacco elicits carcinogenic effects on the tissues of the body that are exposed to the smoke (Rom *et al.*, 2013:25).

The World Health Organisation estimates that tobacco caused 5.4 million deaths in 2004 (WHO, 2008:44) and 100 million deaths over the course of the 20th century (WHO, 2008:44). Similarly, the United States Centre for Disease Control and Prevention describes tobacco use as "the single most important preventable risk to human health in developed countries and an important cause of premature death worldwide (WHO, 2008:45).

Lung cancer occurs in non-smokers at a rate of 3.4 cases per 100 000 population. For people who smoke half a pack of cigarettes a day this figure rises to 51.4 per 100 000; 1-2 packs - up to 143.9 per 100 000 and if the intensity of smoking is over 2 packs a day - up to 217.3 per 100 000 population (Rom *et al.*, 2013:25). Tobacco smoke can combine with other carcinogens present within the environment in order to produce elevated degrees of lung cancer (Rom *et al.*, 2013:25). Second-hand smoke presents a very real health risk, to which 600 000 deaths were attributed in 2004 (Rom *et al.*, 2013:25).

Information from the Centre for Disease Control's (CDC) Health Effects of Cigarette Smoking Fact Sheet, published in 2004, indicated that cigarette smoking approximately doubles a person's risk for stroke (Peer *et al.*, 2013:19217). Smoking tobacco caused about 4.8 million adult deaths worldwide in 2000 (Peer *et al.*, 2013:19217).

Rates of smoking have generally levelled-off or declined in the developed world (Mostafa, 2011:55). Smoking rates in the United States have dropped by half from 1965-2006, falling from 42% to 20.8% in adults (Mostafa, 2011:55). However, in the developing world, tobacco consumption is rising by 3.4% per year (Mostafa, 2011:55). In the UK, lung cancer is the second most common cause of death (41.4 per 100 000) (Iyen-Omofoman *et al.*, 2011:857). According to Cohen & Martinez (2012:1), the percentage of US adults' ≥ 18 years of age who were current cigarette smokers was 18%, which is a decline from 24.1 % in 1998. In 2012, among Americans ≥ 18 years of age, 20.4% of men and 15.8% of women were current cigarette smokers (Cohen & Martinez, 2012:1)

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According to the American Heart Association, cigarette smoking is the most important preventable cause of death in the United States (Peer *et al.*, 2013:19217). It accounts for more than 440 000 of the more than 2.4 million annual deaths, and between 22 700-69 600 premature deaths are caused by other people's smoke each year. In adults ≥ 35 years of age, a total of 32.7% of these deaths were related to CVD (Fryar *et al.*, 2009:2). Each year from 2000 to 2004, smoking caused the loss of 3.1 million years of potential life for males, and 2 million years for females - excluding deaths attributable to smoking-attributable residential fires, and adult deaths attributable to second hand smoke (Fryar *et al.*, 2009:2). From 2000 to 2004, smoking during pregnancy resulted in an estimated 776 infant deaths annually (Fryar *et al.*, 2009:3). Unless stronger action is taken now, the 3.4 million tobacco-related deaths today will become 6.8 million in 2030 (Peer *et al.*, 2013:19217).

According to a study conducted by Groenewald *et al* (2007:674) they showed that tobacco smoking in South Africa accounted for 12-15% of deaths in adults over the age of 35 years in 2000. In 2000, 93 men and 28 women aged 30 years or older died per day due to tobacco use (Groenewald *et al.*, 2007:674).

The highest tobacco-related death rate for men 30 years or older in 2000, was found in coloureds (417/100 000), followed by Africans (279/100 000) and Indians (276/100 000), with the lowest rate in the white population group (215/100 000) (Groenewald *et al.*, 2007:672). For women 30 years or older in 2000, the tobacco-related death rate was much lower than for men. Again the highest rate was found in the coloured group (200/100 000), followed by whites (104/100 000), Africans (36/100 000) and Indians (34/100 000) (Groenewald *et al.*, 2007:674). Lung cancer rates followed the pattern of smoking rates in populations by about 10 years. Currently the highest lung cancer rate in South Africa is found in coloured men and women, reflecting their high smoking rates (Groenewald *et al.*, 2007:674).

SANHANES-1 (2013:96) showed that overall 20.8% of South Africans have reported a history of ever having smoked tobacco, and 6.7% were reported to have used other tobacco products. Of those individuals who reported ever smoking tobacco, 72.5% currently smoked daily. Daily smoking rates were significantly higher among males (76.1%) than females (62%). Individuals from rural formal localities reported a higher prevalence of smoking daily (83.3%) compared to urban formal (71.8%) and rural informal (69%) (SANHANES-1, 2013:96).

According to the SANHANES-1 (2013:97) study, the mean age of initiation of tobacco smoking was 17.4 years. Western Cape residents had the lowest mean age of initiation of smoking (14.5 years), and Indian individuals had the lowest mean age of initiation of smoking (10.9 years). The mean duration of smoking among individuals who currently smoke was 17.9 years, with the highest average of duration of smoking for the Free State province (20.2 years). The mean number of cigarettes smoked per day was 8.5 among current smokers, with the Northern Cape reporting the highest number of cigarettes smoked per day (13.5). Black African individuals reported a mean age of initiation of smoking (18.1 years and the lowest number of cigarettes smoked per day (7.6) compared to the other entire race groups (SANHANES-1, 2013:97).

The impact of the tobacco control policies in South Africa was dramatic as severe price increases were implemented. The prevalence of smoking decreased from 32% in 1993 to 24% in 2003 (Van Walbeek, 2005:468). According to SANHANES-1 (2013:97) the Northern Cape had the highest rate (61.6%) of reporting that cigarette warning labels encouraged them to think about quitting, while Limpopo had the lowest rate 36.5%.

2.3.5 Alcohol consumption

The long-term effects of alcohol consumption range from possible health benefits for low levels of alcohol (ethanol) consumption to severe detrimental effects in cases of chronic alcohol abuse. There is a strong correlation between 'high levels' of alcohol consumption and an increased risk of developing alcoholism, cardiovascular disease, chronic pancreatitis and alcoholic liver disease (Parry *et al.*, 2011:1718). Damage to the central nervous system and peripheral nervous system can occur from chronic alcohol abuse (Parry *et al.*, 2011:1719). Long-term use of alcohol in excessive quantities is capable of damaging nearly every organ and system in the body (Rehm *et al.*, 2010:817; Parry *et al.*, 2011:1719). The developing adolescent brain is particularly vulnerable to the toxic effects of alcohol, as is the developing brain of the unborn, possibly resulting in Foetal Alcohol Syndrome (FAS) (Parry *et al.*, 2011:1719).

Historically doctors have promoted alcohol for its perceived health benefits and most recently for protection against coronary heart disease. This is known as the French paradox. There is evidence of cardiovascular benefits from the intake of 1-2 drinks per day; however, the health benefits from moderate intake of alcohol are controversial. Alcohol should be regarded as a recreational drug with potentially serious adverse effects on health and it is not recommended for cardio-protection in the

place of safer and proven traditional methods such as exercise and proper nutrition (Lim *et al.*, 2012:2224).

Some experts argue that the benefits of moderate alcohol consumption may be outweighed by other increased risks, including those of injuries, violence, foetal damage, certain forms of cancer, liver disease and hypertension (Parry *et al.*, 2011:1719; Lim *et al.*, 2012:2224). As the apparent health benefits of moderate alcohol consumption are limited for populations with a low risk of heart disease, other experts urge caution because of the possibility that recommending moderate alcohol consumption may lead to an increased risk of alcohol abuse (Lim *et al.*, 2012:2224).

Alcohol misuse is responsible for 3.2% of the total burden of disease and injury in Australia (Rehm *et al.*, 2009:2223; Lim *et al.*, 2012:2225). About one-third of the Australian population (7.5 million people) live in rural and remote areas. In those areas alcohol consumption and its associated harms are consistently higher than in urban areas (Lim *et al.*, 2012:2225). Compared with residents of major cities, those who live in rural and remote areas are 32% more likely to drink at levels that risk causing lifetime harm, and 24% are more likely to drink at levels that are at risk of resulting in single-occasion harm. The 2010 National Drug Strategy Household Survey shows that the proportion of those drinking at risky levels increases with increasing remoteness. The Australian Institute of Health and Welfare (AIHW) has reported that among those living in rural areas, men and youths are particularly likely to drink at high-risk levels (Lim *et al.*, 2012:2225).

The harmful use of alcohol results in 2.5 million deaths globally each year (WHO, 2011:174). According to the World Health Organization (2011:174) 320,000 young people between the ages of 15-29 die from alcohol-related causes.

In a study conducted by Peltzer and partners (2011:30) indicated that of 9.6% South Africans (17.1% of men and 3.8% of women) engaged in binge drinking. They also reported that hazardous or harmful alcohol use was at a rate of over 9% (men 17%, and women 2.9%). The pattern of drinking in South Africa is also one with high potential for causing health or social harm (Peltzer *et al.*, 2011:30). With regard to area difference, urban residency was associated with hazardous or harmful drinking in women but not in men (Peltzer *et al.*, 2011:30), and with regard to population group, people of Colored race had significantly higher rates of hazardous or harmful drinking compared with other population groups (Peltzer *et al.*, 2011:30).

The majority of South Africans (53.2%) reported not having anyone who consumed alcohol in their household (SANHANES-1, 2013:148). According to SANHANES-1 (2013:148), 31% of males and 9.3% of females reported alcohol consumption. Among those who reported alcohol consumption the majority were not perceived as having a problem of misuse of alcohol by the head of the household (SANHANES-1, 2013:149).

According to a study done by Gopane and associates (2010:16-21) to examine the biological effects of alcohol consumption in an African population in transition in the North-West Province of South Africa, Gopane and associates (2010:18) reported that 61.5% of the men and 25.2% of the women reported that they consumed alcoholic beverages. The mean alcohol intake of men (30.2 ± 47.8 g/day) exceeded the recommend value of 21 g/day (Gopane *et al.*, 2010:18). The women had a mean intake of 11.4 ± 18.8 g/day, falling within the 12 to 15 g/day recommendation (Gopane *et al.*, 2010:18). Gopane and associates also reported that the level of urbanisation had little effect on amounts consumed. Drinkers had significantly higher HDL cholesterol, serum triglycerides, blood pressure and iron status variables than non-drinkers. In another study done by Pisa and partners (2010:29-37) who assessed the association between alcohol consumption and CVD risk factors in an African population in transition also reported that the increased alcohol consumption was associated with higher HDL cholesterol levels but also with increased blood pressure values.

2.3.6 Overweight and obesity

Obesity can be defined as an over-accumulation of adipose tissue because of a positive energy balance (Underhay *et al.*, 2003:77; Rossouw *et al.*, 2012:1). The accumulation of body fat is an indication that more energy has been stored than has been used (Bray, 1990:457; Epstein *et al.*, 1996:428; Rossouw *et al.*, 2012:1). Obesity is a medical condition in which excess body fat has accumulated to the extent that it may have an adverse effect on health (Roussouw *et al.*, 2012:1). It is defined by body mass index (BMI) and further evaluated in terms of fat distribution via the waist-hip-ratio and total cardiovascular risk factors (Groenewald *et al.*, 2007:674; De Onis & Lobstein, 2010:459). BMI is closely related to both percentage body fat and total body fat. BMI is calculated by dividing the subject's mass by the square of his or her height. The most commonly used definitions were established by the World Health Organisation (WHO) in 1997 and published in 2000, and provide the values listed in Table 2.4 (Lee *et al.*, 2008:646).

Table 2.4: BMI Classification according to the WHO

BMI	Classification
< 18.5	Underweight
18.5–24.9	normal weight
25.0–29.9	overweight
30.0–34.9	class I obesity
35.0–39.9	class II obesity
≥ 40.0	class III obesity

(Lee *et al.*, 2008:646)

Another anthropometric measure for overweight/obesity is the waist-to-height ratio (WHtR). Waist-to-height ratio of a person is defined as the person's waist circumference (in cm), divided by the person's height (in cm). A WHtR ≤ 0.50 is used to determine abdominal obesity (Ashwell & Hsieh, 2005:303). This anthropometric index has been used by several researchers to evaluate abdominal obesity among children (McCarthy & Ashwell, 2006:988; Sung *et al.*, 2008:324; Goon *et al.*, 2009:668) and is known to correlate well with cardiovascular disease risk factors in children and adolescents (Freedman, *et al.*, 2007:33; Meininger *et al.*, 2010:119; Campagnolo *et al.*, 2011:265).

The WHtR is a valid method for assessing an excessive amount of upper body fat that poses a risk to health (Goon, 2009:668; Toriola *et al.*, 2013:740) with a simple message: keep your waist circumference to less than half your height (McCarthy & Ashwell, 2006:988; Toriola *et al.*, 2013:740). This anthropometric index is easy and inexpensive and can be used in both laboratory and field settings. The WHtR indicator assumes that individuals with a certain anthropometric measure of fat patterning would have the same degree of fat regardless of their age, race, or gender. Also, WHtR has the advantage of better measurement of fat distribution in different ages and statures (Kimani-Murage *et al.*, 2010:158; Toriola *et al.*, 2013:740). This anthropometric index has not been extensively studied in South Africa (Toriola *et al.*, 2013:740).

Obesity increases the risk of many physical and mental conditions. These co-morbidities are most commonly shown in metabolic syndrome, a combination of medical disorders which includes: diabetes mellitus Type 2, high blood pressure, high blood cholesterol and high triglyceride levels (De Onis *et al.*, 2010:1258; Lee *et al.*, 2011:504). Complications are either directly caused by obesity or indirectly related through mechanisms sharing a common cause, such as a poor diet or a sedentary lifestyle (Rossouw *et al.*, 2012:2).

Health consequences fall into two broad categories: those attributable to the effects of increased fat mass (such as osteoarthritis, obstructive sleep apnea, and social stigmatisation) and those due to the increased number of fat cells (diabetes, cancer, cardiovascular disease, non-alcoholic fatty liver disease) (Reilly & Kelly, 2010:892).

Obesity is associated with an increased risk of developing hypertension as well as with an increased risk of developing other NCDs, for example, coronary heart disease, diabetes, and stroke (Van Zyl *et al.*, 2010:72).

Obesity is an emerging epidemic worldwide (Sattar *et al.*, 2008:1927; Ding *et al.*, 2011:37) and with increases in the prevalence of obesity (Ding *et al.*, 2011:37) 2.8 million people die each year as a result of being overweight or obese (WHO, 2005:57). The WHO estimates that by 2015 the number of overweight people worldwide will increase to 2.3 billion, while more than 700 million will be obese (WHO, 2005:57; Ding *et al.*, 2011:37).

The prevalence rate of obesity is a problem in both the developed and developing world (Ali & Crowther, 2005:878). Obesity affects people regardless of gender across the whole life spectrum and is influenced by the lifestyle, environment and socio-economic status of an individual or population (Antipatis & Gill, 2001:21). Overweight and obesity lead to serious health consequences. Risk for NCDs increases progressively as body mass index (BMI) increases and can be prevented by increased physical activity and a healthy diet (Antipatis & Gill, 2001:21).

According to nutritional surveys from the World Health Organisation's Global Database on Child Growth and Malnutrition, in 2010 43 million preschool children worldwide were either overweight or obese, and an additional 92 million were at risk of becoming overweight (Rossouw *et al.*, 2012:3). Worldwide, the prevalence of childhood obesity increased from 4.2% in 1990 to 6.7% in 2010 (Rossouw *et al.*, 2012:3). The American Heart Association reported that overall, 68% of US adults were either overweight or obese (72% of men and 64% of women) (Rossouw *et al.*, 2012:3).

Data from almost all the countries of the industrialized world and the developing world reveal growing proportions of overweight and obesity across the lifespan (WHO, 1998:105). This trend is also true for South African adults (30-79 years) where higher BMI values was measured compared to other African countries when categorized by age and gender (Goedecke *et al.*, 2006:66). Overweight and obesity in South Africa is very high (Van Zyl *et al.*, 2010:72; Rossouw *et al.*,

2012:3). Studies indicate that 56% of women and 29% of men have a BMI ≥ 25 kg/m² (Van Zyl *et al.*, 2010:72; Mash, 2010:438).

In South Africa, four major ethnic groups are recognised: black African, people of mixed origin (coloured), Indian and Caucasian (white). Several studies have reported BMI values for these groups over the past 25 years according to Van der Merwe and Pepper (2006:315). However, geographical location and other variables (age, physical activity and urbanisation) were inconsistent between the studies to perform meaningful comparisons (Van der Merwe & Pepper, 2006:315). Puoane and partners (2002:1038) estimated that the prevalence of obesity (≥ 30 kg/m²) in black African women was 31-34%, 18-24% in Caucasian women and 20-22% in Indian and 26-28% in coloured women. The prevalence of obesity in black, Indian and coloured men was 8%, 3-9% and 6-9% respectively, with the highest prevalence in Caucasian males 15-20%.

In a study conducted by SANHANES-1 (2013:137) overall 25% of adult women were overweight and 40.1% were obese, while 19.6% of adult men were overweight and 11.6% were obese; the mean body mass index (BMI) is 29.0 kg/m² for women and 23.2 kg/m² for men. It has been estimated that in the age group of people 30 years or older, 32 men and 68 women die per day because of the impact of a high BMI (Joubert *et al.*, 2007:683).

A higher prevalence of obesity and abdominal obesity has been seen in women compared with men in many developing countries, consistent with the sedentary lifestyle (Gu *et al.*, 2005:1398; Misra & Khurana, 2008:12; SANHANES-1, 2013:138). Mean waist circumference for males and females was 81.2cm and 89.0cm respectively (SANHANES-1, 2013:138), 9.9% of the males had a waist circumference equal to or larger than 102cm, while 50.5% of females had a waist circumference equal to or larger than 88cm (SANHANES-1, 2013:138). Similar to adults, the prevalence of overweight and obesity in children in developing countries shows an increasing trend (Misra & Khurana, 2008:12).

Yadav and Krishnan (2008:400) reported that the body mass index was highest among urban men (22.8 kg/m²) compared to rural men (20.6 kg/m²). A similar trend was seen for women. They also reported that prevalence of obesity was highest for urban population (male = 5.5%, female = 12.6%) compared to rural populations (male = 1.6%, female = 3.8%). Bhardwaj and colleagues (2008:172) found that overweight children were more common in urban rather than rural areas. In another study done by Kruger and colleagues (2006:351) to investigate the determinants of

overweight and obesity among 10- to 15-year old schoolchildren in a population in the transitional phase in the North West Province of South Africa also reported that most of the overweight/obese children lived in the urban areas. Kruger and colleagues (2006:351) also reported that the prevalence rate of overweight/obesity was higher in females and white children compared to that of boys.

Possible causes for this increased prevalence of obesity are modernisation, rapid urbanisation in developing countries, and unsafe environments which all lead to a more inactive lifestyle (Wang *et al.*, 2007:272; Ding *et al.*, 2011:37). In 2000, 25.6% of the urban and 17.3% of the rural populations were overweight or obese, compared to 12.2% and 7.7% in 1989 (Wang *et al.*, 2007:272; Ding *et al.*, 2011:37).

In a study done by Malhotra and partners (2008:315), the obesity rate for men was the highest in whites (18%), followed by Indians and coloureds (8%), and then Africans (6%) (Malhotra *et al.*, 2008:315). For women the differences among the groups were much smaller with the highest rates in Africans (32%), followed by coloureds (26%), whites (23%), and then Indians (21%) (Joubert *et al.*, 2007:683). Urban people had higher weights than people who were living outside cities (Joubert *et al.*, 2007:683). Some of the poorer South African provinces had high prevalence rates for overweight and/or obesity, with the lowest rate observed in Limpopo (44% of women and 22% of men) (Joubert *et al.*, 2007:684).

According to SANHANES-1 (2013:137), in 2012, more males (69.2%) than females (63.3%) were happy with their current weight; more South Africans (11.5%) attempted to lose weight than gain weight (8.6%) over the last 12 months; and more females (14.6%) attempted to lose weight than males (8.0%). Very few African women (16%) considered themselves overweight, while 59% were overweight or obese. In contrast, 54% of white women thought they were overweight, while 49% were in fact overweight or obese (Joubert *et al.*, 2007:684).

Obese Sub-Saharan African women perceive themselves as overweight and moderately overweight women are perceived by the community as attractive, thus associating thinness with illness (Kruger *et al.*, 2005:492). These findings indicate that African black women are physically inactive and, therefore, predisposed to higher prevalence of obesity. The current Western population has a decreased activity as compared to their ancestors. The same trend is prevalent in urban and rural

African men and women but urban Africans are more active than Caucasians (Walker *et al.* 2001:369).

South African girls are heavier than boys (27.2 kg compared with 24.8 kg) and had a mean BMI of 17.7 kg/m² compared to a mean BMI of 17.0 kg/m² for boys (SANHANES-1, 2013:137). The prevalence of overweight and obesity is also higher in girls than boys (16.5% and 7.1% compared with 11.5% and 4.7%, for girls and boys respectively) (SANHANES-1, 2013:137). SANHANES-1 (2013:137) reported that overweight and obesity are the highest in urban formal (11.8% and 5.4% for boys; 19.4% and 8.9% for girls, respectively) and informal areas (20.0% and 5.2% for boys; 20.8% and 9.3% for girls, respectively), these findings are supported by Kruger and colleagues (2006:351). Boys are the most obese in Mpumalanga, KwaZulu-Natal, and Gauteng (6.1%, 6.1%, and 5.3%) while in North West, Limpopo, and Eastern Cape they were the least obese (2.7%, 3.3%, and 3.7%). Moreover, girls were the most obese in Gauteng, KwaZulu-Natal, and Western Cape (10.0%, 8.5%, and 7.25%) and girls were the least obese in Northern Cape, North West and Limpopo (3.5%, 4.3% and 4.3%). SANHANES-1 (2013:137) also reported that black African girls had a higher mean BMI when compared with black African boys.

According to SANHANES-1 (2013:137) there is a trend demonstrating that BMI (weight, overweight and obesity) increases with age in both sexes.

2.3.7 Physical Inactivity

Physical inactivity is not about formal exercise, but is defined as "doing no or very little physical activity at work, at home, for transport or in one's discretionary time" (Mash, 2010:439).

Evidence is very strong that a sedentary lifestyle causes heart disease along with its risk factors (overweight and obesity, high blood pressure, diabetes and abnormal blood fats, such as high blood cholesterol) (Woodcock *et al.*, 2011:122; Najdi *et al.*, 2011:355; Lee *et al.*, 2012:219). A sedentary lifestyle is also associated with breast cancer, colon cancer, osteoporosis, stress, anxiety, depression and aging less healthily (Woodcock *et al.*, 2011:122; Najdi *et al.*, 2011:355; Lee *et al.*, 2012:219).

According to Guthold and partners (2008:487), data from 212,021 adults in 51 developing countries showed that around 15% of men and 20% of women were at risk for NCD due to physical inactivity (Guthold *et al.*, 2008:487). In most of the survey, women were generally reported to be more physically inactive than men. Physical inactivity was more prevalent in women than men in urban

east India (85.4% vs. 75.4%) (Ghosh, 2006:266) and in Saudi Arabia (98.1% vs. 93.9%) (Al-Nozha *et al.*, 2007:559).

Cohen and Martinez (2012:1) reported data from the National Health Interview Survey (where “no leisure-time physical activity/inactivity” refers to no sessions of light/moderate or vigorous physical activity at least 10 minutes duration), 33% of adults (≥ 18 years of age) did not engage in leisure-time physical activity. Inactivity in 2010 was higher among women than men (35% versus 20.7%) and it increased with age.

South Africa has a particularly high prevalence of physical inactivity (Joubert *et al.*, 2007:683; Mash, 2010:439). According to the World Health Organisation, for adults between 18-64 years of age, physical activity includes recreational or leisure-time physical activity, transportation (e.g. walking or cycling), occupational (i.e. work), household chores, play, games, sports or planned exercise, in the context of daily, family, and community activities (Mash, 2010:439).

In order to improve cardiorespiratory and muscular fitness, bone health, as well as reduce the risk of NCDs and depression, the following are recommended (Mash, 2010:439):

1. Adults aged 18-64 years should do at least 150 minutes of moderate-intensity aerobic physical activity throughout the week, or do at least 75 minutes of vigorous-intensity aerobic physical activity throughout the week, or an equivalent combination of moderate and vigorous-intensity activity.
2. Aerobic activity should be performed in bouts of at least 10 minutes duration.
3. For additional health benefits, adults of this age group should increase their moderate intensity aerobic physical activity to 300 minutes per week, or engage in 150 minutes of vigorous-intensity aerobic physical activity per week, or an equivalent combination of moderate- and vigorous-intensity activity.
4. Muscle-strengthening activities involving major muscle groups should be performed 2 or more days a week.

In a study conducted by Peltzer and Phaswana-Mafuya (2012:447), investigating the physical activity levels of adult South Africans, found that less than one-third of South Africans met the American College of Sport Medicine and Centre for Disease Control and Prevention recommendations for health-enhancing physical activity. Forty six percent of all South African adults were reported to be inactive (Lambert & Kolbe-Alexander 2006:25; Mash, 2010:439;

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McVeigh & Norris, 2012:43; Peltzer & Phaswana-Mafuya, 2012:447), of which 63.2% were men and 75.3% were women (Alberts *et al.*, 2005:347; Joubert *et al.*, 2007:726; Mash, 2010:439). Joubert and partners (2007:726) showed that physical inactivity is slightly higher for women than men, and increases with age (67.3% of women and 67% of men aged 55-64 years were found to be physically inactive). Joubert and partners (2007:726) made use of the International Physical Activity Questionnaire (IPAQ)(Craig *et al.*, 2003:1381), and the Global Physical Activity Questionnaire (GPAQ)(Armstrong & Bull, 2006:66) to generate their data.

Estimates have been made by the Heart and Stroke Foundation that the deaths of 3% of men and 4% of women in South Africa who are 30 years and older can be attributed to a lack of physical activity (McVeigh & Norris, 2012:43). Consequently in 2000, 20 men and 26 women of 30 years or older, died per day because of a lack of regular physical activity (McVeigh & Norris, 2012:43; Peltzer & Phaswana-Mafuya, 2012:447).

South African children are also showing trends of obesity and overweight, similar to values reported from high-income countries 15 years ago (Malhotra *et al.*, 2008:315). The decline in overall physical activity levels has occurred concomitantly with the rising trend of obesity (Malhotra *et al.*, 2008:315) and less than one-third of South African children now participate in sufficient physical activity on a weekly basis (defined as participation in activities such as soccer, netball, rugby or running for 20 minutes or more on at least 3 of the 7 days) (Malhotra *et al.*, 2008:315). There is an ethnic disparity regarding levels of physical activity in South African children with a greater percentage of black youths (37.5%) found to be insufficiently active compared with white youths (29.4%) (Malhotra *et al.*, 2008:315). This is a big concern for South Africa.

In the study carried out by Engelbrecht and colleagues (2004:42) in the North-West Province, Indian girls (94.1%) were the most inactive group followed by those from mixed ancestry (87.5%), then Africans (73.0%) and Caucasians (61.0%). African girls were involved in moderate physical activity (23.2%) and Caucasian girls in high physical activity (16.6%). Caucasian girls participated mostly in organized school sport (athletics), while traditional games and house chores were the main source of activity among Africans. Walking slowly was the activity enjoyed by all racial groups (Engelbrecht *et al.*, 2004:42).

On rural farms in the North-West Province, physical activity was high among 9-16 year old children. The patterns were accounted for by walking, daily chores, tasks to be carried out on the farm, games played and few hours of watching television (TV) (Prinsloo & Pienaar, 2005:112-113). Furthermore, in the North-West Province children's physical activity was higher on weekends than on weekdays, with boys being more active than girls. Both genders were least active on weekdays due to low involvement in school activities and sport and increased hours of watching TV (Kruger *et al.*, 2006:356). Another study on 951 high school learners in public schools showed that 32% of the participants did not meet the requirements of participating in physical activity for three and a half hours per week in order to be classified as active. The mean time of participants who participated in moderate and vigorous physical activity was 2.8 h/week and 4.16 h/week respectively (Franz, 2006:77).

In SANHANES-1 (2013:133) the level of physical fitness was measured in participants between 18-40 years of age using, a simple submaximal exercise test called the three-minute step test. The level of fitness was determined according to the age and sex based guidelines on the three-minute step test pulse rate of the Canadian Public Health Association Project (Shephard *et al.*, 1991:358).

Almost two-thirds of male participants (62.4%) were found to be physically fit compared to 27.9% of males who tested to be unfit (SANHANES-1, 2013:133). On the other hand, only 42% of female participants were found to be physically fit and this did not differ significantly from those who tested to be unfit (45.2%) (SANHANES-1, 2013:133). More than 57% of male participants in each age group 18-24 (65.9%), 25-29 (61.9%), and 30-40 (57.1%) were found to be physically fit (SANHANES-1, 2013:133). However, a notable but statistically insignificant reversal of this trend was found among all female participants where 38% of those aged 18-24 years who tested to be fit increased to 45.8% in those aged 25-29 years and 45% in those aged 30-40 years. In summary, therefore, one out of four males (27.9%) and one out of two females (45.2%) were unfit (SANHANES-1, 2013:133).

The majority of female participants living in urban informal settlements (51.4%) had a significantly better cardiovascular fitness compared to those who were found to be fit (33.9%) from formal urban settlements (SANHANES-1, 2013:133). Among female participants from urban formal localities, a significant majority (52.9%) tested to be unfit. On the other hand, a significant majority of female participants from rural informal localities (50.7%) tested to be fit, a finding that perhaps attests to the higher level of activity normally required in rural areas and the fact that most of these activities

are usually carried out by females (SANHANES-1, 2013:133). A significant majority of male participants from the urban formal (57.2%) and urban informal (74.6%) localities, tested to be fit. Similarly, a significant majority of male participants from rural informal (66.1%) and rural formal (70.5%) localities were found to be fit (SANHANES-1, 2013:133).

According to the SANHANES-1 (2013:133) male participants from six provinces (Free State, Kwazulu–Natal, North-West, Gauteng, Mpumalanga and Limpopo) tested to be fit and formed a significant majority in comparison with those male participants who tested to be unfit from these same six provinces. The findings from SANHANES-1 (2013:133) are supported by Kruger and associates (2003:16) who reported that men from the North-West Province were significantly more active than women, with a mean physical activity index scores of 3.66 ± 1.78 and 2.75 ± 1.04 respectively. The provinces with the largest proportion of fit male participants were Mpumalanga (82.5%), Free State (73.5%) and Limpopo (70.7%). In contrast, provinces with the largest proportion of unfit male participants were Western Cape (35.5%), Eastern Cape (33.8%) and Gauteng (31.7%). A significant majority of female participants who tested to be unfit came from two provinces, Western Cape (67.2%) and Eastern Cape (52.6%), when compared to those who tested to be fit. On the other hand, two other provinces, Mpumalanga (68.7%) and Free State (65.1%), had a significant majority of female participants who were found to be fit compared to those who were unfit. Black African male participants formed a significant majority of South Africans who tested to be fit (64.6%) compared to those who tested to be unfit (25.4%). Coloured female participants who were found to be unfit (62%) formed a significant majority compared to those coloured females who tested to be fit (29.7%) (SANHANES-1, 2013:133).

2.4 PHYSICAL ACTIVITY AS A MODIFIER OF RISK FACTORS FOR NON-COMMUNICABLE DISEASES

There is an extensive body of empirical evidence which demonstrates the physical and psychological health benefits of physical activity (Bloemhoff, 2010:25; Craike *et al.*, 2010:20). Studies showed that increased physical activity is associated with a lower waist:hip ratio and a higher HDL-cholesterol level in women (Draper *et al.*, 2010:398; Frost *et al.*, 2010:268), and that physical activity was inversely associated with body mass index (BMI) and percentage body fat (Draper *et al.*, 2010:398; Frost *et al.*, 2010:268). Physical activity is associated with lower mortality rates for both older and younger adults, a decreased risk of cardiovascular disease mortality in

general, and coronary heart disease in particular (Bloemhoff, 2010:25; Peltzer & Phaswana-Mafuya, 2012:447).

Though the health benefits of regular physical activity are widely recognised, sedentary lifestyles are predominant in urban areas worldwide and are one of the top five major risk factors for NCDs (Giannuzzi *et al.*, 2003:319; Masterson Creber *et al.*, 2010:1; Woodcock *et al.*, 2011:121). Changes of occupations, the advent of newer technologies, and the rapid pace of urban life have increasingly resulted in more sedentary work and less energy expenditure (Misra & Khurana, 2008:21). Leisure time activities have also shifted from outdoor play to indoor entertainment, television viewing and computer games (Popkin, 2001:8715).

As communities become urbanised, physical activity declines because of sedentary employment (Stern *et al.*, 2010:2), limited outdoor space (Bradley & Puoane, 2007:50; Friel *et al.*, 2007:1241), and high rates of street violence (Sanders & Chopra, 2006:74). The urban transition is also accompanied by transition in the environment that impact on behaviors such as diet, physical activity and risk factors for NCDs (Van Rooyen *et al.*, 2000:779; Kruger *et al.*, 2006:351; Koon *et al.*, 2009:2).

In a study carried out by Masterson Creber and associates (2010:1) it was found that people living in a rural area had much higher levels of physical activity and hence a lower risk of being overweight and obese when compared to those living in an urban area of Lima. Yadav and Krishnan (2008:400) also found that rural men reported five times higher physical activity levels compared with urban men, and rural women reported seven times higher physical activity compared with urban women.

A recent study by Frost and partners (2010:267) examined the role of environment on physical activity and found a positive relationship between pleasant scenery, safe neighbourhoods, multiple destinations within walking distance, sidewalks and light traffic and being physically active (Berke *et al.*, 2007:489; Frost *et al.*, 2010:267). The research focused on adults living in suburban and urban areas (Frost *et al.*, 2010:267). Comparisons between rural and urban areas have found greater accessibility to physical activity resources for urban residents (Jilcott *et al.*, 2007:04; Frost *et al.*, 2010:267), and examinations across varying rural densities demonstrates that the most rural areas have the fewest resources (Badland *et al.*, 2008:265).

Access to limited physical activity resources is particularly important given that rural residents appear to be at the highest risk for poor health compared with their suburban and urban counterparts, and they experience greater prevalence of health conditions such as cardiovascular disease, arthritis, obesity, Type 2 diabetes and certain cancers (Martin *et al.*, 2005:239; Frost *et al.*, 2010:267). In addition, rates of leisure time physical activity appear to be lower in rural compared to urban areas (Reis *et al.*, 2004:2093; Frost *et al.*, 2010:267), which is problematic given the beneficial effects of physical activity on the development and effective management of many chronic conditions (Frost *et al.*, 2010:267).

China has experienced a noticeable decrease in energy expenditure in both urban and rural areas (Ng *et al.*, 2009:1305). Decreases in physical activity have been reported for several domains, including occupation, transportation and household activity (Bauman *et al.*, 2008:119). According to the China Health and Nutrition Survey (CHNS), between 1991-2000, energy expenditure from occupational physical activity decreased by 22% among men, and 24% among women, and this decrease contributed to the increase in body weight (Monda *et al.*, 2008:1318). In China, rural residents are currently more physically active and less obese than their urban counterparts (Muntner *et al.*, 2005:1631).

Physical inactivity is the fourth leading risk factor for global death, after high blood pressure, smoking, and high blood glucose, and levels of physical inactivity are rising in many countries (WHO, 2011:174). This increase has major implications for health and the prevalence of NCDs, such as:

1. Approximately 3.2 million deaths per year, including 2.6 million in low- and middle-income countries, are due to physical inactivity.
2. Over 670 000 premature deaths (people aged less than 60 years).
3. Physical inactivity is estimated as being a cause of breast and colon cancer, and 27% of diabetes, and 30% of ischaemic heart disease.

In South Africa an overall of 17 037 deaths or 3.3% of all deaths in 2000 were attributed to physical inactivity. (Joubert *et al.*, 2007:683). The majority of the attributable deaths were due to ischaemic heart disease. Attributable DALYs amounted to the loss of an estimated 176 252 health years of life, or 1.1% of all DALYs (Joubert *et al.*, 2007:683). Ischaemic heart disease accounted for most of the attributable burden in both males (58.9%) and females (40.6%), followed by ischaemic stroke (Joubert *et al.*, 2007:683).

In terms of attributable deaths, physical inactivity ranked 9th compared with the other risk factors studied in South Africa, and 8th globally. In terms of attributable DALYs, it ranked 12th in South Africa, 7th in developed countries and 14th globally (Joubert *et al.*, 2007:683).

2.5 PHYSICAL ACTIVITY MEASURE INSTRUMENTS

Assessing physical activity is of importance in epidemiological studies in order to examine the relationships between inactivity and/or activity and the development of NCDs. The results are used in health prevention and the formation of physical activity recommendations. Today, physical inactivity is responsible for a large worldwide burden of disease and health care costs. For this reason, the World Health Organisation has raised focus on national monitoring and surveillance of physical activity (Gauthier *et al.*, 2009:S55).

Developing accurate and reliable tools for quantifying physical activity behaviour in children and adolescents continues to be a research priority (Troost *et al.*, 2000:427; Gauthier *et al.*, 2009:S55; Lee *et al.*, 2011:S84). Precise measures of habitual physical activity are a necessity in studies designed to:

- 1) Document the frequency and distribution of physical activity in defined population groups;
- 2) Determine the amount or dose of physical activity required to influence specific health parameters;
- 3) Identify the psycho-social and environmental factors that influence physical activity behaviour in patients; and
- 4) Evaluate the effectiveness of programs to increase habitual physical activity (Troost *et al.*, 2000:427; Hallai *et al.*, 2010:S259).

A wide range of methods have been used to quantify physical activity behaviour. These methods include subjective measures such as child and parent self-reports, and objective measures such as direct observation, heart rate monitoring, motion sensors, and doubly-labelled water (Gauthier *et al.*, 2009:S55; Hallai *et al.*, 2010:S259). Both subjective and objective assessment tools have advantages and disadvantages depending on the population being studied and the research question being investigated (Ono *et al.*, 2007:62; Lee *et al.*, 2011:S84).

2.5.1 Subjective determination of physical activity

Subjective measures often provide detailed information regarding type of activity, and because of their low cost and ease of administration, investigators conducting field-based research have used self-report (subjective) methods to assess physical activity (Hallai *et al.*, 2010:S260; McVeigh & Norris, 2012:43). This makes it ideal for large population studies. However, because they rely on self-report of activity they are subject to both response bias *and* recall bias. In particular, they have limited accuracy at capturing activities that are unstructured and of light intensity (Lee *et al.*, 2011:S84; McVeigh & Norris, 2012:43), both of which tend to be performed in greater frequency in women and in older populations (Van Weering *et al.*, 2011:256). Thus, using a subjective measure of physical activity may not provide an accurate description of activity in these groups. It is important to measure total physical activity (which includes light intensity and unstructured activities) because it may have a greater impact on several health outcomes, such as diabetes, compared to moderate-to-vigorous physical activity alone (Hagstromer *et al.*, 2010:541; Lee *et al.*, 2011:S84); this is why objective measures such as heart rate monitors and motion sensors are being used with increasing regularity.

Questionnaires represent the most widely used method to assess habitual physical activity in large population studies, as they are generally well accepted by participants and easy to administer at a low cost (Tehard *et al.*, 2005:1535; Standage *et al.*, 2012:233). Numerous questionnaires like the Godin Shepard Leisure Time Questionnaire (1985), Paffenbarger Physical Activity Questionnaire (1985) and the Global Physical Activity Questionnaire (2009), to name but a few; measuring various dimensions of physical activity have been developed, some of which have been tested for validity and repeatability (Craig *et al.*, 2003:1381; Tehard *et al.*, 2005:1535; Haskell *et al.*, 2009:280).

Baecke questionnaire

The questionnaire designed by Baecke *et al.*, (1982:936) is an instrument that is simple to use and has been extensively used in physical activity research over the past 20 years. Physical activity assessment using the Baecke questionnaire was validated against energy expenditure measurements using the double-labelled water technique ($r = 0.62$ in 19 healthy men aged 40 years) (Tehard *et al.*, 2005:1536; Ono *et al.*, 2007:62). Reliability was demonstrated with correlations ranging from 0.65 to 0.93 for 11-month and 1-month test-retest, respectively (Tehard *et al.*, 2005:1536; Ono *et al.*, 2007:62; Van Weering *et al.*, 2011:256). The Baecke questionnaire has been adapted for South African studies such as the THUSA-study. The THUSA-PAQ compiled by Kruger *et al* (2000:54-

64), derived from the Baecke PA questionnaire (Baecke *et al.*, 1982:936) which was used to determine physical activity levels of the Tswana speaking people of the NWP. The questionnaire reported physical activity in the form of commuting, stair climbing, sport participation, occupational activity and leisure time activity and the total physical activity index (PAI) was calculated by combining the above mentioned indices. PAI score of 1-3.33 was classified as low, 3.34-6.67 as moderate and >6.67 as high (Kruger *et al.*, 2003:18). Duration, frequency and intensity of these activities were also reported in the questionnaire.

International Physical Activity Questionnaire (IPAQ)

The International Physical Activity Questionnaire (IPAQ), which was designed as a versatile measure of physical activity in adult populations (aged 15-69 years), consists of a long version (31 items) and a short version (7 items), both of which can be self-administered or by way of a structured telephone interview. The IPAQ assesses the frequency, duration, and intensity of physical activity. The short version provides total activity scores expressed in metabolic equivalent (MET) minutes. While the long version also provides the researcher with total activity scores, it does so by dividing the total by an underlying activity domain (i.e., leisure-time, domestic and gardening, occupational, and transportation related activities). Both categorical (low, moderate, high) and continuous (MET-minutes/week) indicators of physical activity are obtained with the IPAQ (Gauthier *et al.*, 2009:S54).

A 12-country reliability and validity study considering the acceptable measurement properties of IPAQ showed that 75% of test-retest correlations (in the 12 countries) were above 0.65 and that the overall estimation of physical activity by this questionnaire was correlated, though moderately ($r = 0.30$), to a 7-d measurement of accelerometer (Craig *et al.*, 2003:1381). IPAQ has been used increasingly in various populations and settings (Rutten *et al.*, 2003:371; Rutten & Abu-Omar, 2004:281). In contrast with the Baecke questionnaire, which provides results expressed in arbitrary units, physical activity assessment by the IPAQ is based on current recommendations for moderate (Tehard *et al.*, 2005:1536) and vigorous (Tehard *et al.*, 2005;1536) activity.

2.5.2 Objective determination of physical activity

Objective measures with real time data storage capabilities such as pedometers, which measure steps, and accelerometers, which measure movement intensity offer a distinct advantage over self-report methods in that they provide reliable information on patterns of physical activity within a given day or over several days (Troiano *et al.*, 2008:182; McVeigh & Norris, 2012:44). These

devices are small, can store data for multiple days and are increasingly reliable and affordable (Troiano *et al.*, 2008:182; Lee *et al.*, 2011:S84). Objective measures do not provide detailed information on the type of activities being performed, but they do however record physical activity across all intensities and are not subject to the biases of self-report. Objective measures (accelerometers) can be used to estimate the time spent in light, moderate, and high intensity physical activity and the contribution of each to total physical activity (Hagstromer *et al.*, 2010:541; Van Weering *et al.*, 2011:256). Over the last decade or so, many investigations have evaluated the validity of objective monitoring devices in children and adolescents. Collectively, the results of these studies support the conclusion that objective measures such as heart rate monitors and accelerometers are useful tools for adolescents (Hagstromer *et al.*, 2010:541; Van Weering *et al.*, 2011:256).

The most common objective methods for research purposes are doubly labelled water and motion sensors (accelerometers, pedometers and ActiHeart®). Each of the methods mentioned has been widely used in the literature. Each method has advantages, limitations and applicability in a scientific setting as will be discussed in the following section.

Doubly labelled water

This is the most precise and objective method to measure energy expenditure and is regarded as the golden standard for the validation of other instruments measuring physical activity (Bonney *et al.*, 2001:28; Koebnick *et al.*, 2005:303; Warns, 2006:79; Pomeroy *et al.*, 2011:18943; Campbell *et al.*, 2012:589). Doubly labelled water involves the administration of an oral dose of water containing specific isotopes of hydrogen and oxygen per kilogram body mass. The amount of isotopes measured in excreted urine after a 24-hour period is equivalent to the amount of metabolic carbon dioxide removed by the body. The metabolic carbon dioxide is then used to estimate the energy expenditure (Bonney *et al.*, 2001:28; Arvidsson *et al.*, 2005:377; Koebnick *et al.*, 2005:303; Warns, 2006:80; Pomeroy *et al.*, 2011:18943; Campbell *et al.*, 2012:589).

This method is expensive, has limited applicability, does not provide information about the type, pattern, frequency, intensity and duration of physical activity carried out during the day, and is not feasible for large populations due to financial cost. In addition, doubly labelled water is scarce, special equipment is needed, highly trained personnel are required to carry out the test, as well as the necessity for collection of complete urine samples which limits its usefulness for people with disabilities who may have incontinence or use urinary collection equipment (Bonney *et al.*,

2001:29; Arvidsson *et al.*, 2005:377; Koebnick *et al.*, 2005:303; Warns, 2006:80; Pomeroy *et al.*, 2011:18943; Campbell *et al.*, 2012:589).

Campbell and partners (2012:589) investigated the validity of the ActiHeart® device for estimating free-living Physical Activity Energy Expenditure (PAEE) in adolescents. Total Energy Expenditure (TEE) was measured in eighteen Canadian adolescents, aged 15-18 years, by DLW. Physical activity energy expenditure was calculated as $0.9 \times \text{TEE}$ minus resting energy expenditure, assuming 10% for the thermic effect of feeding. Participants wore the chest mounted ActiHeart® device which records simultaneously minute-by-minute acceleration (ACC) and heart rate (HR). They concluded that there is a relatively poor measurement of agreement between the ActiHeart® and DLW for assessing free-living PAEE in adolescents.

In a systematic overview of all recent (2007-2011) accelerometer validation studies using the DLW as the reference, Plasqui and associates (2013:452) reported that there was a large variability in accelerometer output and their validity to assess daily physical activity.

Because by definition all physical activities lead to energy expenditure, the doubly labelled water (DLW) method as the gold standard to assess total energy expenditure over longer periods of time is the method of choice to validate all objective and subjective methods in their ability to assess daily physical activities (Plasqui *et al.*, 2013:452).

Heart rate and accelerometry combined

Combined monitoring, namely accelerometry (ACC) with heart rate (HR) monitoring, has improved estimations of physical activity related energy expenditure (PAEE) (Corder *et al.*, 2007:2180; Campbell *et al.*, 2012:590; de Groot *et al.*, 2013:104). The ActiHeart® (CamNtech, Cambridge, UK) is a single device that simultaneously collects real time ACC and HR data, which reduces the complexity and participant burden associated with combined sensing and improves the overall practicality of determining activity energy expenditure (Takken *et al.*, 2010:1494; Standage *et al.*, 2012:233; Campbell *et al.*, 2012:590).

Previous validation studies conducted for the ActiHeart® (CamNtech, Cambridge, UK) have shown the device to provide reasonable estimates of PAEE during treadmill walking and running in adults (Brage *et al.*, 2005:561; Brage *et al.*, 2006:517) and children (Corder *et al.*, 2005:1761) and for a range of low-to-moderate intensity laboratory-based activities in 25-year old adults (Thompson *et*

al., 2006:1037). One study, conducted in a sample of sub-Saharan African adults has also demonstrated the ActiHeart® to provide valid group level estimates of free-living PAEE compared with the DLW method (Assah *et al.*, 2011:491).

ActiHeart® has been used all over the world and in different kind of studies like: Brage *et al* (2005:561), Europe; Barreira *et al* (2009:60), United States; Nichols *et al* (2010:487), Southern California; Standage & Ryan (2012:233), Britain; and De Groot *et al* (2013:103), Netherlands. But no studies have been done in South Africa measuring AEE making use of the ActiHeart®.

Accelerometers

Accelerometers are widely accepted as valid objective measures of physical activity, and the ActiGraph is the most commonly used brand (Cain, *et al.*, 2013:51). There have been several models of ActiGraph distributed since 1993: old generation models such as the 7164 and new generation models such as the GT1M, GT3X and the GT3X+ (Cain *et al.*, 2013:51). Many population based physical activity studies have been done making use of the ActiGraph (Cain *et al.*, 2013:51).

A study by Cook and partners (2012:300) looked at describing the effect of two different accelerometer cut-points on physical activity patterns in rural and urban black South African women, and it was found that rural women accumulated greater amounts of PA than urban women. Hip-mounted uni-axial accelerometers were worn for 6-7 days by rural (n = 272), and urban (n = 16) participants. Twenty-hour PA counts and volumes were extracted: sedentary (SED, <100 cts·min¹), light (100-759 cts·min¹), moderate (MOD1, 760-1951 cts·min¹), moderate-2 to vigorous (MOD2VG, ≥1952 cts·min¹) in this study. The use of appropriate accelerometer cut-points provides unique insights into PA patterns, especially when comparing communities that might differ in terms of PA modes, and also as PA choices change as the Physical Activity Transition progresses (Cook *et al.*, 2012:309).

In a study which looked at children's school day physical activity patterns in relation to meeting daily recommended guidelines (Walter, 2011:780), physical activity was measured with GT1M ActiGraph accelerometers, small motion sensors attached to adjustable elastic belts and worn over the right hip. These sensors record a change in acceleration and convert this data into physical activity "counts" which are then quantified in relation to duration, frequency and intensity of activity. Reports on time spent being sedentary and in light, moderate and vigorous physical

activity were generated. Walter (2011:780) reported that children accumulated 35 minutes of in-school moderate-to-vigorous physical activity (MVPA), contributing to 58% of the 60 minutes of MVPA a day recommendation. This indicates that schools need to increase PA through the provision of quality physical education and find cost effective ways of promoting school-day PA.

Pedometers

The pedometer is a useful self-monitoring and feedback tool and therefore a useful motivational aid for increasing PA (Lubans *et al.*, 2009:310; Pillay *et al.*, 2012:882). Researchers have acknowledged that in terms of practicality, pedometers offer a good solution for a low cost, objective monitoring and behavioural modification tool, and a practical aid for PA interventions (Richardson *et al.*, 2008:71; Pillay *et al.*, 2012:882). Pedometers have therefore gained popularity for use in PA interventions in various settings (Bravata *et al.*, 2007:2298; Pillay *et al.*, 2012:882) to facilitate behavioural change.

Cook and partners (2012:300) investigated the distribution of pedometry-assessed ambulation in a large rural black South African population. The participants wore piezoelectric pedometers (NL-2000; New Lifestyles Inc., Kansa City, MO) for nine consecutive days so that when the pedometers were collected, the total number of steps during the seven complete days was stored and recalled. Public health indices (thresholds) for steps per day were defined as follows: sedentary, <5 000 steps per day; low active, 5 000-7 499 steps per day; somewhat active, 7 500-9 999 steps per day; active $\geq 10\ 000$ steps per day; and very active, $\geq 12\ 500$ steps per day (Tudor-Locke & Bassett, 2004:5). Cook and partners (2012:300) concluded that the ambulation levels were high for this rural African sample, and prevalence for inactive (sedentary), and active-very-active differed from published self-reported estimates.

2.6 THE EFFECT OF POPULATION TRANSITION ON RISK FACTORS FOR NON-COMMUNICABLE DISEASES

In most middle- and high-income countries NCDs were responsible for more deaths than all other causes of death combined, with almost all high-income countries reporting the proportion of NCD deaths to total deaths to be more than 70% (Masterson Creber *et al.*, 2010:1). Low- and lower-middle-income countries have the highest proportion of deaths under 60 years as a result of NCDs. Premature deaths occurred in 13% of under 60-year old persons from high-income countries, and in 25% of upper-middle-income countries. In lower-middle-income countries, the proportion of

premature NCD deaths under 60 years rose to 28%, more than double the proportion in high-income countries. In low-income countries, the proportion of premature NCD deaths under 60 years was 41%, three times the proportion in high-income countries.

NCDs have long been the main health problem in developed countries, while in recent decades the prevalence of these diseases and their antecedent risk factors have rapidly increased in developing countries, known as the 'health transition' (Assah *et al.*, 2011:491). These changes are caused to a large extent by dietary changes from traditional to Westernised diets and a reduction in daily physical activity in relation to socioeconomic and living environmental conditions (Lopez *et al.*, 2006:1747; Assah *et al.*, 2011:491).

The major determinants of the increasing burden of NCDs are globalisation, urbanisation and economic liberalisation (Yadav & Krishnan, 2008:400). Rapid urbanisation is accompanied by unhealthy dietary practices, sedentary lifestyle and obesity, all of which are major risk factors of NCDs (Yadav & Krishnan, 2008:400). All these risk factors are related to lifestyle and are influenced when changing from a rural to an urban lifestyle.

The prevalence of NCDs, previously associated with developed countries and more affluent populations, is increasing in poorer countries (Yadav & Krishnan 2008:400; Stern *et al.*, 2010:1). The growing trend has been exacerbated by the rapid increase in urbanisation (Stern *et al.*, 2010:1), which includes migration of impoverished people from rural areas (Stern *et al.*, 2010:1). This migration contributes to the increasing inequalities between the rich and poor (Sanders *et al.*, 2008:509); people who live in poverty tend not to benefit from the higher living standards of urban life (de Swart *et al.*, 2005:102; Puoane & Tsolekile, 2008:10).

South Africa is experiencing a rapid transition. Vorster and partners (2011:429-441) asked the question whether this transition can be steered in a positive way to avoid the health problems experienced by developed countries and to learn from these experiences.

2.6.1 Health and lifestyle in rural settings

The term rural appears to be used for 'areas outside the capital cities or large regional centers' as the basis (Treiman, 2011:33). Most rural towns are many kilometers apart and can hardly be considered large regional centers since they have a moderate to low population density in their hinterlands (Treiman, 2011:33).

CHAPTER 2

At present, 47% of the global population consists of people living in rural areas of developing countries (Treiman, 2011:34).

Rural communities in developing countries are home to some of the most disadvantaged and marginalised people in today's world: the landless; the chronically poor; women who are heads of households; people affected by chronic diseases such as HIV/AIDS, tuberculosis or malaria; disadvantaged youth; the elderly, and persons with disabilities (Treiman 2011:34).

In rural areas those in poverty and at risk of health outcomes may be dispersed across a community and living side by side with affluent neighbours. Some rural communities have high numbers of manual and low-waged workers, and in general these workers are more likely to have higher rates of adverse lifestyle factors, such as smoking and lower consumption of fruit and vegetables (Treiman, 2011:34).

Over the past few years, the health of rural communities has become a concern due to the general decline of the population and services. One of the features of rural communities is the shortage of human service professionals. Attracting qualified staff remains a concern. Rural and remote towns have a generally discrete and small population which increases people's visibility. Unlike those living in large metropolitan areas, clients are not able to access a service in another suburb which is outside their residential location.

Studies have shown that rural residents are currently more physically active and less obese than their urban counterparts (Masterson Creber *et al.*, 2010:1 Assah *et al.*, 2011:491; Ding *et al.*, 2011:38). These findings are supported by a study done by Tlhongolo and associates (2008:13) to determine physical activity in urban and rural Tswana speaking people in the North West Province with pedometers and a Transition and Health During Urbanisation physical activity questionnaire (THUSA-PAQ, an adapted Baecke questionnaire), the results indicate that rural male and female participants reported a higher self-reported physical activity index (9.49 ± 3.67 and 8.10 ± 1.26) compared to urban male and female participants (8.13 ± 2.47 and 7.51 ± 1.65).

But South Africa is currently experiencing rapid urbanization, especially of Africans leaving underdeveloped rural areas to seek a better lifestyle in and around the cities (Underhay *et al.*, 2003:78; Ding *et al.*, 2011:39). A national study found a greater decrease in physical activity in rural areas than in urban areas over a recent ten-year period (Xie *et al.*, 2008:33; Ding *et al.*,

2011:39). In a study conducted by Kruger and associates (2003:16), to determine the physical activity levels of black South Africans in the North West Province, they also reported low activity levels among the rural populations.

This is a big concern as we know that decrease in physical activity might lead to an increase in body weight which in terms will lead to an increase in the risk factors for NCDs.

2.6.2 Health and lifestyle in urban settings

Urbanization is associated with epidemiological transition such as decreased physical activity, infant mortality, fertility, infectious diseases, increase in life expectancy and chronic diseases of life (Vorster *et al.*, 2000:505).

Since 2008, and for the first time in human history, over 50% of the world's population lives in urban areas (Unwin *et al.*, 2010:272). In sub-Saharan Africa it is estimated that in 2005 35% of the population lived in urban areas, and that by 2050 this figure will have risen to 61% (Unwin *et al.*, 2010:272). In Tanzania, the urban population is increasing at a rate of 4.2% per year, compared to 1.9% for the rural population (Unwin *et al.*, 2010:272).

China has become the world's largest urban nation with over 600 million urban citizens today, a figure that is projected to reach 900 million by 2050 (Unwin *et al.*, 2010:272). Urbanisation is often associated with extreme changes in dietary habits and habitual physical activity (Ojiambo *et al.*, 2012:115) that underlie the distinct socioeconomic and environmental differences between rural and urban areas such as; active commuting to schools, collecting firewood, cattle herding, and fetching water from distant streams, all of which are typical energy-intensive occupational physical activities in many rural environments (Christensen *et al.*, 2008:234; Unwin *et al.*, 2010:273). On the other hand, typical urban lifestyles are characterized by consumption of energy-dense foods and sedentary activities such as motorised transport to school, TV viewing, and mechanisation/automation of chores (Christensen *et al.*, 2008:234; Unwin *et al.*, 2010:273) which may partially explain the observed differences in prevalence of lifestyle disorders such as obesity, hypertension, and diabetes between rural and urban populations in Africa (Ojiambo *et al.*, 2012:115).

Urbanisation has an effect on almost all the aspects of the migrants' lifestyle that contributes to increasing levels of NCDs. This includes the influence on migrants' diets, exercise patterns, and the amount of tobacco products they use (Allender *et al.*, 2010:297; Ojiambo *et al.*, 2012:115). In most

cases reported, the diet of people in urban settings is more energy rich, with a higher salt, fat, and processed sugar-based intake, while due to less fruit and vegetables, fiber and potassium intake is lower than found in rural settings (Allender *et al.*, 2010:297; Unwin *et al.*, 2010:273). Most studies have also shown higher rates of tobacco use in the cities than in rural settings. In urban settings, people tend to do less aerobic exercise. They use public transport and thus walk less, tend to do less labour-intensive work, and tend to watch television even in the poorer urban settings, compared to those living in rural settings (Allender *et al.*, 2010:297; Unwin *et al.*, 2010:273).

South Africa is regarded as one of the developing countries in the world because of its rapid urbanisation and adoption of Western lifestyle, especially among Africans who migrate from rural to urban areas seeking employment for better life (Vorster *et al.*, 2000:505; Walker *et al.*, 2001:368; Kruger *et al.*, 2005:491 & Kruger *et al.*, 2006:351).

A number of cross-sectional studies in South Africa have shown that people who have spent a larger proportion of their lives in an urban setting had significantly higher rates of diabetes, hypertension and smoking tobacco (women only) than those who had spent only a small proportion of their lives in the city (Steyn & Fourie, 2005:2).

With the increase in urbanisation in South Africa, many black people have been subjected to a process of rapid urbanisation which may lead to social and cultural disruption (Van Rooyen *et al.*, 2000:779; Malhotra *et al.*, 2008:315).

In South Africa according to the World Health Organisation standards, 29% of men and 56% of women are overweight (Reddy, 2005:175; Goedcke & Jennings, 2006:546). Obesity in South Africa is more prevalent in urban than rural people and is highest in the Western Cape, Kwa-Zulu Natal and Gauteng provinces. Similar results were observed in the THUSA (Transition and Health during Urbanisation in South Africa) study carried out in the North-West Province where rural women had a lower BMI than urban women (Kruger *et al.*, 2005:492).

In the North-West Province, among 10-15 year old children, the distribution of overweight and obesity was similar in all groups, being the smallest in the 11 year old group (6.7%) and the largest in the 10 and 15 year groups (9.1%) respectively (Kruger *et al.*, 2006:356). In the same study Kruger and associates (2006:356) also reported the prevalence of obesity was high in Caucasian children

compared to other races more in females than in males, more apparent in urban areas (Kruger *et al.*, 2006:356).

Vorster and colleagues (2000:505) studied the impact of urbanisation and the resultant demographic transition on the physical, physiological and mental health of Africans in the North West Province of South Africa and found that urbanisation of Africans is associated with improved mental, physiological and physical health in the more affluent groups, but those in transition living in poverty on farms or in densely populated areas are experiencing a high risk of the double burden of disease associated with under-nutrition on the one hand, and over-nutrition on the other.

Whatever the mechanism, urbanisation in South Africa has led to a significant increase in disease of lifestyle, like hypertension, diabetes, high cholesterol and cardiovascular diseases (Malhotra *et al.*, 2008:315).

In South Africa, it is estimated that 56% of the population now live in urban centres, with the urbanisation of the Black population increasing rapidly (Malhotra *et al.*, 2008:315). This rapid urbanisation, in the context of globalisation, accompanied by large shifts in the health patterns of South Africans, thus increasing the prevalence of non-communicable diseases.

2.7 SUMMARY

The burden of cardiovascular and other non-communicable diseases is rising rapidly in developing countries as indicated in the preceding evidence-based literature. This epidemiological transition is characterized by the increasing prevalence of etiological risk factors such as hypertension, diabetes, high cholesterol, tobacco smoking, alcohol abuse, overweight and obesity, and physical inactivity. The clustering of these factors confers a greater risk of premature morbidity and mortality. Epidemiological studies suggest that a significant part of the cardiovascular disease (CVD) epidemic is attributable to changes in lifestyle risk factors, exemplified by reduction in physical activity and increased consumption of high-energy processed foods. The body of evidence available on the role of physical activity in addressing NCDs is ample, with the measure instrument of determining levels of PA as the limiting factor currently in large epidemiological studies.

Physical activity is associated with many health and psychological benefits (Bloemhoff, 210:27; Craike *et al.*, 2010:22). According to WHO (2008:44), 30 minutes of moderate intensity in most, if

not all days of the week is necessary to achieve health benefits. Although the health benefits of regular physical activity are widely recognised, sedentary lifestyles are predominant in urban areas worldwide and are one of the top five major risk factors for NCD (Giannuzzi *et al.*, 2003:320; Masterson Creber *et al.*, 2010:2; Woodcock *et al.*, 2011:121).

There are different ways to determine habitual physical activity in research to assess whether people reach the minimum physical activity required, namely motion sensors, physical activity questionnaires, doubly labelled water, diaries and logs, direct and indirect calorimetry and many others (Gauthier *et al.*, 2009:S55; Hallai *et al.*, 2010:S259). The only questionnaire that has been validated to determine physical activity among Tswana speaking South Africans in the NWP is the THUSA-PAQ which was developed from the Baecke questionnaire (Baecke *et al.*, 1982:936-942). This questionnaire shows valuable results and is useful during research. No other questionnaire has been validated, specifically for the North West Province. This is important as each province and their population is different than the next. People interpret things in different ways and that is why it is important that questionnaires are specifically developed for different provinces and countries. So that correct measurements of physical activity can be measured.

There is a lack of research regarding the use of objective methods (such as motion sensors) to measure physical activity in South Africa as a whole. Physical activity participation is hampered by internal (e.g. lack of motivation), and external (e.g. lack of facilities) barriers (Chinn *et al.*, 2006:309-315). Socioeconomic status and culture are also strongly associated with participation in physical activity (Garcia, 2006:20S-22S).

Even with the compelling benefits of PA, 40.5% females and 24.2% males are inactive in South Africa (Bloemhoff, 2010:26). McVeigh and colleagues (2004:984) reported that there were significant racial differences in patterns of activity in South African schools. White children were found to be more active than black children and were more likely to participate in physical education classes at school. According to Bloemhoff (2010:26) black students demonstrated significantly higher levels of physical activity than white students. Literature on physical activity during transition, as well as research on the relationship between changes in physical activity and risk factors for NCDs was not found for a black South African population. It is recommended that future research should adapt longitudinal measurements of change in PA in transition. Furthermore, in South Africa additional research should be carried out in determining habitual physical activity using specific measurements for the South African context.

CHAPTER 2

The decline in physical activity is problematic given the beneficial effect of PA on the development and effective management of many chronic conditions. Within the South African context, the relationship between physical activity and risk factors for NCDs has not been investigated in populations that are in transition between rural and urban areas. Furthermore no studies could be found on the relationship between change in physical activity and the changes in risk factors in a black South African population. Further research should be directed to understand the relationship between physical activity and risk factors, as well as how the changes in physical activity impact on the changes in risk factors for NCDs. Findings will direct the future research importance of introducing appropriate physical activity interventions.

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Chapter 3

Correlation between Baecke physical activity questionnaire and IPAQ-S in a black South African population

Mrs. Tershia van Niekerk,¹MA (HMS); S J Moss,¹PhD. (HMS); M A Monyeki,¹PhD. (HMS); H S Kruger,²PhD. (Nutrition); A Kruger,³PhD. (Nutrition)

¹Physical Activity, Sport and Recreation (PhASRec), Faculty of Health Sciences, North-West University, Potchefstroom

²Centre of Excellence in Nutrition, Faculty of Health Sciences, North-West University, Potchefstroom

³Africa Unit for Trans disciplinary Health Research (AUTHeR), Faculty of Health Sciences, North-West University, Potchefstroom

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ABSTRACT

Aim: The aim of this study was to determine the correlation between the adapted Baecke physical activity questionnaire and the short version of the international physical activity questionnaire (IPAQ-S) in a black South African population.

Participants and methods: This study, part of the 2010 data of the South African leg of the Prospective Urban and Rural Epidemiological (PURE) study of a black South African population in the North-West Province obtained informed consent from 746 males and 1,264 females, aged 29 - 94 years. Participants completed the adapted Baecke physical activity questionnaire and the short last 7-day version of the IPAQ-S. The Baecke questionnaire report work, sports, and non-sports leisure activity, scoring on a five-point Likert scale. The items in the IPAQ-S form were structured to provide separate scores on walking, moderate-intensity and vigorous-intensity activity. A physical activity index was calculated with the Baecke, while the total MET.min/week was determined with the IPAQ-S. A partial correlation between the total PAI from Baecke and total MET.min/week calculated with the IPAQ-S was performed and adjusted for age and BMI.

Results: Significant differences were found for age and BMI between the participants from the rural area compared to urban participants of 2010. The urban participants were older (56.1 ± 10.6 years) than the rural participants (54.2 ± 9.7 years), but the urbans had a higher BMI (26.00 ± 7.82 kg/m²) compared to rural participants (25.33 ± 7.10 kg/m²). Females had a higher BMI (27.80 ± 7.57 kg/m²) compared to male participants (21.26 ± 4.74 kg/m²). PAI determined with Baecke and IPAQ-S in MET.min/week reported a significantly low positive coefficient ($r = 0.24$; $p = 0.00$) when adjusted for age and BMI.

Conclusion: The weak correlation observed between the Baecke and IPAQ-S indicated that the questionnaires should be used with caution within the South African context. Objective measurements should be applied if possible in the determination of physical activity of South Africans, with the adapted Baecke the preferred subjective questionnaire because of the presence of domains of activity that the IPAQ-S does not determine.

Key words: Baceke physical activity questionnaire, IPAQ, rural, urban, physical activity

Correlation between Baecke physical activity questionnaire and IPAQ-S in a black South African population

INTRODUCTION

Evidence supporting the positive relationship between physical activity and better health outcomes began to emerge in the mid-20th century, a time when heart disease was appearing in epidemic proportions (Gauthier *et al.*, 2009). Since then physical inactivity has been recognised as an independent risk factor for the development of cardiovascular disease (Eyre *et al.*, 2004; Atun *et al.*, 2013), Type 2 diabetes (Laaksonen *et al.*, 2005; Mang'eni *et al.*, 2013), metabolic syndrome (Laaksonen *et al.*, 2005; Atun *et al.*, 2013) and certain types of cancer (Eyre *et al.*, 2004; Mang'eni *et al.*, 2013). In addition, physical inactivity, along with unhealthy diets, is considered among the most important preventable causes of mortality related to non-communicable diseases (Mokdad *et al.*, 2004; Atun *et al.*, 2013). In 1990, there were 26.6 million deaths worldwide from NCDs (57.2% of 46.5 million total deaths). The incidence increased to 34.5 million in 2010 (65.5% of 52.8 million deaths) becoming the leading cause of death (Lozano *et al.*, 2012; Atun *et al.*, 2013).

The role of inactivity in NCDs helped develop our initial understanding of the impact of various physical activities on health and more specifically, active work and leisure-time physical activities. Today, in addition to leisure-time activities and occupational work, researchers include exercise, sport, transportation, and chores under the general umbrella of physical activity (Ono *et al.*, 2007; de Groot *et al.*, 2013).

Physical activity, however, is a complex and multidimensional exposure variable, making population-based measurement difficult (Ono *et al.*, 2007; de Groot *et al.*, 2013). To assist researchers, some direct and indirect measurement techniques for physical activity have been developed (Gauthier *et al.*, 2009; Loney *et al.*, 2011; de Groot *et al.*, 2013).

Data collection at the population level often involves self-report (subjective) measures of physical activity using questionnaires, diaries/logs, surveys and interviews (Ortiz-Hernández & Ramos-Ibàñez, 2010; Lee *et al.*, 2011). These measurements are frequently used due to their practicality, low cost, low participant burden, and general level of acceptance (Prince *et al.*, 2008; Ortiz-Hernández & Ramos-Ibàñez, 2010). Although self-reports are useful for gaining insight into the physical activity levels of populations, they have the capacity to over or under estimate true

physical activity energy expenditure and rates of inactivity. The self-report methods are often wrought with issues of recall and response bias (e.g. social desirability, inaccurate memory), and the inability to capture the absolute level of physical activity. Culture, language and gender are other factors that affect the outcome of the questionnaire results as well as cultural dimensions of physical activity definitions, perceptions and level of education (Ortiz-Hernández & Ramos-Ibáñez, 2010).

As self-report methods possess several limitations in terms of their reliability and validity (Prince *et al.*, 2008), direct measures of physical activity are commonly used to increase precision and accuracy and to validate the self-report measures. Direct measures are believed to offer more precise estimates of energy expenditure and remove many of the issues of recall and response bias (De Graauw *et al.*, 2010). Direct measures consist of calorimetric (i.e. doubly labelled water and direct calorimetry), physiologic markers (i.e. cardiorespiratory fitness biomarkers), motion sensors and monitors (i.e. accelerometers, pedometers, heart rate monitors), and direct observation (Crouter *et al.*, 2008; de Groot *et al.*, 2013).

Increased use of objective measures (i.e., accelerometers and heart rate monitors) has overcome some of the limitations associated with self-report methods (Corder *et al.*, 2007; Campbell *et al.*, 2012), and minimises some of the challenges (such as recall bias and use of reference values for assigning energy costs) associated with assessing physical activity levels and energy costs in the free-living environment. Combined monitoring, namely accelerometry (ACC) with heart rate (HR) monitoring, has improved estimations of physical activity-related energy expenditure (PAEE) compared with other methods independently (Corder *et al.*, 2007; Campbell *et al.*, 2012; de Groot *et al.*, 2013). The construction and commercial availability of a single device that simultaneously collects real time ACC and HR data, the ActiHeart® (CanNtech Ltd, Cambridge, United Kingdom) further reduces the complexity and participant burden associated with combined sensing, and improves the overall practicality of determining activity energy expenditure (Takken *et al.*, 2010; Loney *et al.*, 2011; Campbell *et al.*, 2012).

Despite the advantages of using direct measurement for PA, the measures are often time and cost intensive and intrusive, rendering them difficult to apply to large epidemiologic studies and settings in remote areas of a country such as South Africa where differences in lifestyle have been observed in rural and urban populations (Campbell *et al.*, 2012). Specialised training and the physical proximity of the participant for data collection is often required (Prince *et al.*, 2008).

The subjective and objective measurements each have advantages and disadvantages. Administered questionnaires have become an invaluable tool for physical activity research because of minimal expense and scoring flexibility. Information from questionnaires allows for greatest flexibility in providing behavioural descriptions of physical activity patterns and/or more quantitative summary estimates of energy expenditure due to physical activity (Ono *et al.*, 2007).

Questionnaires are the most widely used method to assess habitual physical activity in large population studies, because they are generally well accepted by participants and easy to administer at a low cost (Tehard *et al.*, 2005; Loney *et al.*, 2011). Numerous questionnaires measuring various dimensions of physical activity have been developed, for example, the Bouchard Three-Day physical activity record (1983), Godin Shepard Leisure Time questionnaire (1985), and the Global Physical Activity Questionnaire (2009), to name but a few, some of which have been tested for validity and repeatability (Craig *et al.*, 2003; Tehard *et al.*, 2005; Haskell *et al.*, 2009). However, most questionnaires have been developed for Western countries, and few of the PA instruments have been studied or compared with each other, particularly in a South African context.

The questionnaire designed by Baecke *et al.* (1982) is an instrument that is simple to use and has been extensively used in physical activity research for the past 20 years. Physical activity assessment using the Baecke questionnaire was validated against energy expenditure measurements using the doubly-labelled water technique ($r = 0.62$ in 19 healthy men aged 40 years) (Tehard *et al.*, 2005; Ono *et al.*, 2007). Reliability was demonstrated with correlations ranging from 0.65 to 0.93 for 11-month and 1-month test-retest, respectively (Tehard *et al.*, 2005; Ono *et al.*, 2007; Van Weering *et al.*, 2010).

The International Physical Activity questionnaire (IPAQ), which was designed as a versatile measure of physical activity in adult populations (aged 15 to 69 years), consists of a long version (31 items) and a short version (7 items), both of which can either be self-administered or by way of a structured telephone interview. The IPAQ-S assesses the frequency, duration, and intensity of physical activity. The short version provides total activity scores expressed in metabolic equivalent minutes (METs) while the longer version further provides the researcher with total activity scores, by dividing the total by an underlying activity domain (i.e., leisure-time, domestic and gardening, occupational, and transportation related activities). Both categorical (low, moderate, high), and continuous (MET-minutes/week) indicators of physical activity are obtained with the IPAQ-S (Gauthier *et al.*, 2009).

A 12-country reliability and validity study considering the acceptable measurement properties of IPAQ-S showed that 75% of test-retest correlations (in the 12 countries) were above 0.65 and that the overall estimation of physical activity via this questionnaire was correlated, though moderately ($r = 0.30$), to a 7-day measurement of accelerometer (Craig *et al.*, 2003). IPAQ-S has been used increasingly in various populations and settings (Rutten *et al.*, 2003; Rutten & Abu-Omar, 2004). In contrast with the Baecke questionnaire which provides results expressed in arbitrary units, physical activity assessment by the IPAQ is based on current recommendations for moderate and vigorous activity (Tehard *et al.*, 2005).

Both questionnaires have been tested repeatedly for reliability and validity (Tehard *et al.*, 2005), but no publications on South African data could be found where both questionnaires were compared within one study population. According to Warren and colleagues (2010) the IPAQ-S was developed for surveillance studies and is not recommended for other purposes. Warren and colleagues (2010) also state that the Modified Baecke Questionnaire was specifically designed for the elderly segment of the population and is not recommended for other purposes. Both the Baecke and IPAQ-S are repeatedly used for the collection of physical activity data in the South African context (Tehard *et al.*, 2005). Physical activity data captured in research projects conducted in the North-West Province normally make use of the Baecke questionnaire while in the Western Cape areas IPAQ-S has been the preferred method. In a country as vast and diverse as South Africa with 11 official languages, it is important to be able to collect valid data on physical activity, as well as to compare physical activity levels across cultural and environmental regions, not only within South Africa, but internationally.

Against the background set, it has become imperative to correlate physical activity determined by means of these two questionnaires in one population. Therefore, the aim of this study is to determine the correlation between the adapted Baecke physical activity questionnaire and the IPAQ-S in a black South African population. Findings from this study will inform researchers on the comparability of physical activity data determined by either of the questionnaires in a black African population of South Africa.

RESEARCH DESIGN AND METHODS

Study design

This study formed part of the 2010 data from the North-West Province in the South African leg of the Prospective Urban and Rural Epidemiological (PURE) study that is planned for 10 years to investigate the health transition on chronic diseases of lifestyle in urban and rural participants. The international PURE study aims to recruit 150 000 adults initially aged 35 - 70 years from communities in low-, middle-, and high income regions of the world representing various levels of development and encompassing great sociocultural diversity (Koon *et al.*, 2009). In the PURE study changing lifestyles, risk factors and chronic disease will be tracked using periodic standardised data collection in urban and rural areas of selected countries in transition (Koon *et al.*, 2009). The population in this SA PURE study consisted of black Setswana speaking South African males (746) and females (1 264), living in either an urban or rural area in the North-West Province. Participants were included in the study if they were 30 years and older and did not report any chronic diseases. The study was approved by the Ethics Committee of the North-West University (Potchefstroom Campus) in accordance with the Declaration of Helsinki revised in 2000 (Ethics nr. 04M10). Permission was also obtained from the Provincial Department of Health of the North-West Province, local Government authorities of each town, and the tribal chief of the rural communities. Participants were fully informed about the objectives and procedures of the study prior to their recruitment. Well-trained fieldworkers explained the aims and procedures of the study to the participants in their own language. All participants newly identified to have hypertension, diabetes or other abnormalities were referred to a local clinic, hospital or physician.

Demographic Information

Demographic information was collected through a questionnaire designed for the global study, and adjusted and tested in each country (Koon *et al.*, 2009). This questionnaire were filled out by the participants with the assistance of extensively trained fieldworkers and applied in the language of the participant's choice. For the correlation between the two questionnaires, the adapted Baecke physical activity questionnaire and the International Physical Activity Questionnaire (IPAQ-S), all 2 010 subjects (1 006 urban and 1 004 rural areas) who completed the questionnaires were used in the analyses.

Anthropometric measurements

All anthropometric measurements were conducted according to the guidelines of the International Society for the Advancement of Kinanthropometry (ISAK) (Marfell-Jones *et al.*, 2001). Measurements were obtained with the participant wearing minimal clothing without shoes. Maximum height and weight were measured with calibrated instruments (Precision Health Scale, A&D Company, Japan; Seca Stadiometer, Hamburg, Germany). Subsequently, body mass index (BMI) was calculated as weight divided by height squared (weight/height²). The BMI values were used to classify the participants into underweight (BMI, <18.5 kg/m²), normal weight (BMI, 18.5 - 24.9 kg/m²), overweight (BMI, 25.0 - 29.9 kg/m²), and obese (BMI, 30.0 - 34.9 kg/m²) according to WHO classifications (WHO, 2000).

Questionnaires

Questionnaires were issued during individual interviews and were conducted by extensively trained fieldworkers in the preferred language of the participants.

Baecke Physical Activity Questionnaire

Participants completed the adapted Baecke physical activity questionnaire (Baecke *et al.*, 1982) which is a short questionnaire for the measurement of habitual physical activity in epidemiological surveys, the questionnaire consists of 16 questions organised into three sections: physical activity at work (Questions 1-8), sport during leisure time (Questions 9 - 12), and physical activity during leisure excluding sport (Questions 12 - 16). Questions in each section are scored on a five-point Likert scale, ranging from “never” to “always” or “very often.” The two most frequently reported sports activities are explored in additional questions about the number of months per year and hours per week of participation. The three derived indices – work, sports, and leisure – are scored in arbitrary units ranging from 1 to 5. The sum of the three indices gives an indicator of total physical activity index (PAI) (Baecke *et al.*, 1982). The questionnaire defines three levels of occupational physical activity, namely low (clerical work, driving, shop keeping, teaching, studying, housework, medical practice, and other occupations with a university education), middle (factory work, plumbing, carpentry, farming), and high (dock work, construction work, sport). Similarly, sports are categorised into three levels: low (billiards, sailing, golf), middle (badminton, cycling, dancing, tennis), and high (boxing, rugby, football, rowing). A sport score is calculated from the intensity factor, the number of times per week participating in that type of sport, and the proportion of the year in which the sport is played. Indices of physical activity for three dimensions, namely occupational physical activity, sport during leisure-time and physical activity during leisure time,

excluding sport, can be calculated using the Baecke questionnaire. The questionnaire can be used for the various socioeconomic classes in the general population, and has been applied in the assessment of physical activity of subjects between the ages of 20 - 70 years, reporting significant correlation coefficients ranging from 0.76 to 0.93 in reliability testing (Baecke *et al.*, 1982).

International Physical Activity Questionnaire (IPAQ) - Short version

Participants also completed the International Physical Activity Questionnaire (short version) (IPAQ-S). The IPAQ-S is a self-report measure that provides internationally comparable data (Craig *et al.*, 2003; Fogelholm *et al.*, 2006). The IPAQ-S was designed as a versatile measure of physical activity in adult populations (aged 15 - 69 years). The IPAQ-S assesses the frequency, duration and intensity of physical activity. The short version provides total activity scores expressed in metabolic equivalent minutes (METs).

The IPAQ-S version used in this study was the last 7-day recall questionnaire (Craig *et al.*, 2003). This version consists of seven questions that assessed the frequency and duration of participation in vigorous, moderate-intensity, and walking activity, as well as the time spent sitting during a weekday, globally in all contexts of everyday life. Scores for vigorous, moderate, and walking activity are calculated in minutes per week, as is time spent sitting. The sum of the three activity scores gives an indication of total physical activity. After multiplying the number of hours per week of each type of activity by an average metabolic cost (MET), an energy expenditure indicator can also be obtained expressed in MET.-minutes per week. One MET represents the metabolic rate of an individual at rest (sitting quietly) and is set at 3.5 mL of oxygen consumed per kilogram of body mass per minute, or approximately 1 kCal/kg/h. As proposed by the IPAQ executive committee (Craig *et al.*, 2003), the METs per week for vigorous, moderate, and walking activity were multiplied by a factor of 8, 4, or 3.3 respectively, according to the intensity of the activity. Total energy expenditure is the sum of all activities in MET.min/week.

Statistical analysis

Statistical analysis was performed using SPSS for Windows (Version 21) (IBM Corporation, 1989, 2011). Descriptive statics (mean, SD, frequencies) were calculated for the characteristics of the participants and all the physical activity variables determined with the Baecke and IPAQ-S questionnaire. A Pearson correlation analysis was performed between the Baecke and IPAQ-S questionnaire and adjusted for age and body-mass index.

RESULTS

The characteristics of the participants (Table 1) indicated that the average age was 55 ± 10 years with no significant differences between the rural and urban participants. Approximately 50% of the participants were from the rural area.

Table 1: Participant characteristics

<i>Variable</i>	<i>All</i> <i>Mean ± SD</i>	<i>p-value</i> <i>(setting)</i>	<i>Males</i> <i>Mean ± SD</i>	<i>Females</i> <i>Mean ± SD</i>	<i>p-value</i> <i>(gender)</i>
Age (years)	55.4±10.2		55.5±10.2	54.8±10.2	0.24
Rural	54.2±9.7	0.00	55.2±10.1	53.6±9.6	0.06
Urban	56.1±10.6		55.8±10.3	56.3±10.8	0.60
BMI (kg/m²)	25.61±7.44		21.26±4.74	27.80±7.57	0.00
Rural	25.33±7.10	0.10	21.37±4.83	26.92±7.19	0.00
Urban	26.00±7.81		21.14±4.67	28.9±7.90	0.00

Although the total group presented a normal BMI (25.61 ± 7.44 kg/m²), the BMI of the males (21.26 ± 4.83 kg/m²) were significantly lower than the females (27.80 ± 7.57 kg/m²). Results reported on the physical activity according to the IPAQ-S (Table 2) indicate significant differences between rural and urban participants regarding vigorous-, moderate-, walking-, sitting- and total MET.min/week. Men were physically more active than the women during all intensities, except for moderate activity levels. The rural participants were physically less active than the urban participants during all intensities, except for sitting. The male participants reported more vigorous intensity (1506.4 ± 4936.8 MET.min/week) of physical activity than the female participants (944.5 ± 3271.7 MET.min/week) and the female participants were more moderate physical active (1960.1 ± 2829.9 MET.min/week) than the male participants (1569.1 ± 2652.8 MET.min/week). In both the rural and urban groups the males reported to be sitting more than the female participants.

The physical activity reported with the Baecke Questionnaire (Table 3) for the same population, indicates that the urban population reported higher physical activity than the rural population, with the exception of leisure activity. Significant differences were found between the rural and urban population regarding indexes for physical activity (PAI), and sports and commute. No data was available for the rural population regarding their commute and sports index.

On average the results of the total physical activity index calculated with the Baecke questionnaire reported males to be physically more active than the females. Overall the male population was more active than the female population.

Table 2: Intensity of physical activity for participants based on the International Physical Activity Questionnaire Short version (IPAQ-S)

<i>Variable</i>	<i>All</i> <i>Mean ± SD</i>	<i>Setting</i> <i>p</i>	<i>Males</i> <i>Mean ± SD</i>	<i>Females</i> <i>Mean ± SD</i>	<i>Gender</i> <i>p</i>
Vigorous min/w	1095.2±3841.3		1506.4±4936.8	944.5±3271.7	0.04
Rural	884.0±3430.0	0.04	1026.0±3995.7	868.4±3270.3	0.62
Urban	1347.0±4269.7		1975.0±5678.4	1039.8±3275.5	0.03
Moderate min/w	1795.0±2735.9		1569.1±2652.8	1960.1±2829.9	0.02
Rural	1261.8±2181.4	0.00	1098.2±2291.0	1374.1±2192.0	0.16
Urban	2400.5±3147.1		2037.6±2900.2	2636.4±3297.3	0.03
Walking min/w	1058.6±2459.4		1262.6±2588.9	982.9±2430.3	0.09
Rural	347.0±614.5	0.00	427.5±784.0	315.5±535.1	0.09
Urban	1864.7±3355.7		2065.3±3356.7	1768.4±3376.2	0.35
Sitting min/w	250.9±207.3		266.0±213.0	242.7±202.9	0.1
Rural	268.2±221.9	0.01	297.3±226.9	253.3±216.2	0.04
Urban	232.8±189.4		237.0±195.6	231.3±187.2	0.75
Total MET min/w	4202.9±5161.5		4316.5±5819.2	4279.2±4887.5	0.92
Rural	2973.4±4528.8	0.00	2866.8±4902.1	3135.2±4469.8	0.55
Urban	5532.3±5469.6		5724.5±6289.7	5527.8±5023.4	0.72

Vigorous min/w = vigorous MET minutes per week; Moderate min/w = moderate MET minutes per week; Walking min/w = walking MET minutes per week; Sitting min/w = sitting MET minutes per week; Total MET min/w = Total MET minutes per week

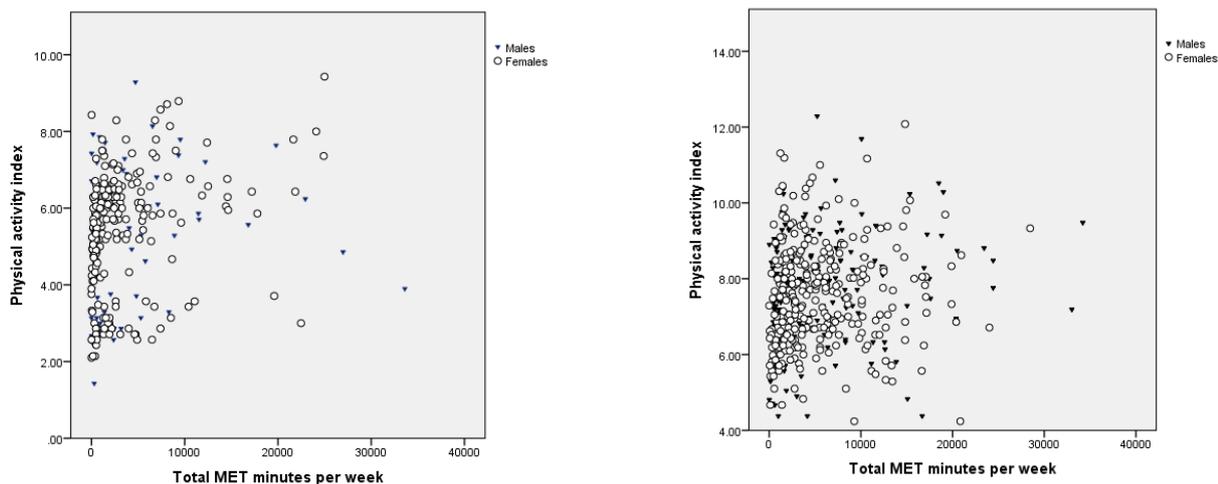
Where participants would be classified by the different categories of activity (PAI score of 1 - 3.33 = low, 3.34 – 6.67 = moderate and >6.67 = high (Kruger *et al*, 2003), the rural participants (both male and female) would be classified as being moderate active and the urban participants (both male and female) would be classified as being highly physical active.

The correlation between the IPAQ-S and the Baecke questionnaire for rural and urban (Figures 1A and 1B) indicated that a significant, although not strong correlation was observed between the Baecke Questionnaire and the IPAQ-S (Table 4). The correlation was even weaker in the urban participants compared to rural participants.

Table 3: Physical activity for participants based on the Baecke Questionnaire

<i>Variable</i>	<i>All Mean ±SD</i>	<i>p-value (location)</i>	<i>Males Mean ±SD</i>	<i>Females Mean ±SD</i>	<i>p-value (gender)</i>
Work Index	2.9±0.5		2.9±0.5	2.9±0.5	0.61
Rural	2.9±0.4	0.40	2.9±0.5	2.9±0.4	0.39
Urban	2.9±0.6		3.0±0.6	2.9±0.5	0.19
Comm Index	1.8±0.5		1.9±0.5	1.7±0.4	0.00
Rural	0	0.00	0	0	0
Urban	1.8±0.5		1.9±0.5	1.7±0.4	0.00
Sport Index	0.0±0.3		0.0±0.2	0.0±0.3	0.41
Rural	0	0.03	0	0	0
Urban	0.0±0.3		0.0±0.2	0.0±0.3	0.38
Leisure Index	2.7±1.0		2.8±1.0	2.7±1.0	0.60
Rural	2.7±1.0	0.69	2.8±1.1	2.8±1.0	0.76
Urban	2.7±1.0		2.8±1.0	2.7±0.9	0.63
PA Index	6.5±1.9		6.7±1.9	6.4±1.8	0.02
Rural	5.1±1.5	0.00	5.1±1.6	5.1±1.5	0.86
Urban	7.5±1.4		7.6±1.5	7.4±1.3	0.12

Comm Index = Commute Index, PA Index = physical activity index, ± = standard deviation



A: Rural participants

B: Urban participants

Figure 1: Scatter plots of the physical activity index (Baecke) and the IPAQ-S for rural (A) and urban (B) participants, indicating both males and females.

Table 4: Partial correlation between physical activity scores from the Baecke questionnaire and the IPAQ-S (MET.min/week)

<i>Variables</i>	<i>Rural</i>		<i>Urban</i>		<i>Total</i>	
	<i>r</i>	<i>p</i>	<i>r</i>	<i>p</i>	<i>r</i>	<i>p</i>
Total activity (MET.min/week)	0.22	0.00	0.12	0.02	0.24	0.00

Adjusted for age and BMI

DISCUSSION

The main finding of this study that correlated physical activity data assessed by the Baecke questionnaire and the IPAQ-S in a black South African population in transition from the North West Province revealed a significant but weak correlation between the two questionnaires.

These findings are in line with that of Tehard and colleagues (2005) who reported a fair but significantly correlation ($r = 0.51$; $p = 0.00$) between the two questionnaires in obese Caucasian subjects between the ages of 20 - 50 years who were recruited from seven European countries.

Both questionnaires reported that the urban participants were more physically active than the rural participants, and that the male participants reported higher physical activity levels than the females.

The findings from this study are supported by Tehard and colleagues (2005) which reported physical activity levels for the male population (7.5 ± 1.3 ; 2831 ± 2717.2) compared to the female (7.4 ± 1.2 MET.min/week; 2465.8 ± 2234.5 MET.min/week) as measured by the Baecke and by the IPAQ respectively.

According to a study conducted by Peer and colleagues (2013) in a black South African population, the urban population was less active (47.05%) than their rural counterparts (36.0%). This is in contrast with the findings from this study. Possible reasons for the difference could be that Peer and colleagues (2013) made use of the global physical activity questionnaire (GPAQ), where this study used the IPAQ and the Baecke questionnaire. The participants in the study by Peer and colleagues (2013) were also much younger (15 – 24 years) than the participants in the present study (29 – 94 years). Cognitive degeneration makes self-reporting of PA difficult in the young and elderly (Sirard & Pate, 2001), so this could also have led to the differences found, and since people in rural areas are still faced with illiteracy, the mastering of the questions in the different questionnaires for the second time would probably differ to the ones in the urban settings. In addition, when the questionnaire in the two measurement points has been conducted by different research assistants this might also have contributed to the differences.

The environmental factors most likely to prevent South Africans from participating in optimal physical activity include a lack of safety and high crime rates, as well as a lack of green areas and recreation facilities (Ojiambo *et al.*, 2012; Peer *et al.*, 2013). Furthermore, better infrastructure in urban centres, with easier access to public transport, and the lower likelihood to walk great distances to access schools, as well as urbanisation providing easier access to sedentary activities, such as television, probably contributed to the higher prevalence of physical inactivity in urban compared to rural participants (Ojiambo *et al.*, 2012; Peer *et al.*, 2013). Peer *et al.* (2013) also reported that their female participants were more physically inactive (49.15%) compared to their male participants (33.9%). The findings from Peer *et al.* (2013) are supported by the findings in this study. The higher prevalence of physical inactivity in females may contribute to the higher prevalence of overweight/obesity and raised waist-to-hip ratio (Peer *et al.*, 2013) in comparison to males.

Women reported significantly less vigorous (mean = 1 955 vs. 2 896 MET.min/week), moderate (mean = 733 vs. 1 309 MET.min/week), walking (mean = 1 080 vs. 1 376 MET.min/week), and total (mean = 3 768 vs. 5 581 MET.min/week) PA on the IPAQ in a study conducted by Lee and

colleagues (2011) in an African American population. These findings are in line with the findings from this study.

The results from the Baecke questionnaire reported that both the rural and urban participants could be classified as being moderately to highly physically active. These findings are supported by Van Weering and partners (2010) who measured physical activity in a cross-sectional study in The Netherlands in participants aged 18 - 65 years. The participants were classified as being highly active (8.6 ± 1.2). These findings are also supported by Terhard and colleagues (2005) who reported that both male (7.5 ± 1.3) and female (7.4 ± 1.2) populations were classified as being highly active.

Both questionnaires aim to provide a detailed assessment of habitual physical activity. However, they differ in the specific dimensions of physical activity assessed in the period of recall and the expression of results. To the best of the author's knowledge no South African study determining the relationship between Baecke and IPAQ-S questionnaires, could be found. A study conducted in Europe revealed a moderate relationship while our study found a weak relationship. PA information selected by means of questionnaires in South Africa should be interpreted with caution.

Several limitations of the present study need to be considered; socio-demographic characteristics, such as education levels and occupation were not accounted for in the study, and as the questionnaires are self-reported, they are subject to both response bias and recall bias. In particular, they have limited accuracy at capturing activities that are unstructured and of time orientation. Another limitation is that the researcher did not have objective measurements of physical activity with which to compare the baseline self-report assessments.

CONCLUSION

Physical activity determined by means of the adapted Baecke questionnaire and the IPAQ-S reported a significant but low correlation for a black South African population. Validity studies between physical activities determined with questionnaires and objective measures of physical activity are needed in South Africa. The adapted Baecke questionnaire is currently the preferred questionnaire based on the smaller dependence on time and the distinction that is made for activity in different domains.

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Chapter 4

Changes in physical activity of a black South African population in transition: The PURE-study

**T van Niekerk,¹MA (HMS); S J Moss,¹PhD. (HMS); M A Monyeki,¹PhD. (HMS);
H S Kruger,²PhD. (Nutrition); A Kruger,³PhD. (Nutrition)**

¹Physical Activity, Sport and Recreation (PhASRec), Faculty of Health Sciences, North-West University, Potchefstroom

²Centre of Excellence in Nutrition, Faculty of Health Sciences, North-West University, Potchefstroom

³Africa Unit for Trans disciplinary Health Research (AUTHeR), Faculty of Health Sciences, North-West University, Potchefstroom

Corresponding author: S.J. Moss (Hanlie.moss@nwu.ac.za)

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ABSTRACT

Background: Physical inactivity levels are rising in many countries with major implications on non-communicable diseases.

Objective: To determine changes in physical activity (PA) from 2005 to 2010 and how these changes relate to changes in BMI among a black South African population in transition.

Methods: This study, part of the South African Prospective Urban and Rural Epidemiological (PURE) longitudinal study on black South Africans in the North West Province determined physical activity index (PAI) from 746 males and 1 264 females, aged 29 - 94 years with the adapted Baecke questionnaire that reports work, sports, and leisure activity, each domain scoring on a Likert scale. Body mass index (BMI) was calculated from body mass and height measurements. Independent and paired sample t-tests were performed to determine the differences between gender, settings and time points, while linear regression analysis was performed to determine the relationship between changes in BMI and changes in PAI.

Results: PAI in the urban participants increased from 6.40 ± 1.84 to 7.50 ± 1.40 , while the PAI decreased from 8.21 ± 1.48 to 5.10 ± 1.5 in the rural participants. Rural women gained significantly more weight than urban women. Change in BMI was significantly associated with change in PAI for the urban population ($\beta = -0.10$; $p = 0.004$) after adjusting for gender, change in age and setting (rural/urban).

Conclusion: Physical activity decreased in this black South African population, over a 5-year period while the BMI in women increased. The increase in BMI was related to the decrease observed in physical activity index in rural women.

Introduction

Physical inactivity has been identified as the fourth leading risk factor for global mortality (6% of deaths globally). This follows high blood pressure (13%), tobacco use (9%) and high blood glucose (6%). Levels of physical inactivity are rising in many countries with major implications for the general health of people worldwide and for the prevalence of NCDs such as cardiovascular disease, diabetes and cancer, and their associated risk factors such as raised blood pressure, elevated blood sugar, overweight and obesity. Physical inactivity is estimated as being the principal cause for approximately 21 - 25% of breast and colon cancer, 27% of diabetes, and approximately 30% of ischemic heart disease ^[1]. In addition, NCDs nowadays account for nearly half of the overall global burden of disease. It is estimated currently that 6 out of every 10 deaths, attributable to non-communicable conditions ^[1]. The projection is that by 2020 non-communicable disease (NCDs) will account for 69% of all deaths in developing countries ^[1].

The increase of obesity and decrease in physical activity in populations are well documented in cross-sectional studies. However, few longitudinal studies identify factors that influence individual PA and weight gain patterns over time and in relation to social- economic changes ^[2].

The association between a physically active lifestyle and the prevention of many chronic diseases is well-documented ^[2]. Physical activity has beneficial effects on adiposity, musculoskeletal health, fitness and cardiovascular health ^[2]. In adults, physically active individuals appear to have a lower risk of lifestyle diseases and health conditions such as cardiovascular disease (CVD), hypertension, Type II diabetes, and obesity when compared to sedentary individuals ^[2].

Physical activity (PA) is defined as "any bodily movement produced by the skeletal muscles that result in energy expenditure (EE)" ^[3]. Moderate and vigorous physical activity is associated with lower body fat, greater bone mineral density, better respiratory and immune system functioning, less peripheral vascular resistance, lower LDL- and higher HDL-cholesterol concentrations, and greater sensitivity to insulin, which is related to lower risk of CVD, diabetes, cancer and osteoporosis ^[3,4]. Physical activity also exerts positive effects on mental health, reducing depressive symptoms and increasing self-esteem ^[3,4]. Changes in PA patterns will therefore implicate changes in long-term health outcomes.

The current rapid transition from rural to urban areas in developing countries has influenced the PA patterns observed in these countries ^[5]. The changes may be explained by rapid urbanisation and adoption of Westernised lifestyles ^[5]. Urbanisation is often associated with extreme changes in dietary habits and habitual physical activity that underlies the distinct socioeconomic and environmental differences between rural and urban areas such as; walking to school, cattle herding, and fetching firewood and water from distant streams, all of which are typical energy-intensive

chores related to physical activities in many rural environments^[5]. On the other hand, typical urban lifestyles are characterised by consumption of energy dense-foods and sedentary activities such as motorised transport to school, TV viewing, and mechanisation/automation of chores^[5], which may partially explain the observed differences in prevalence of lifestyle disorders such as obesity, hypertension, and diabetes between rural and urban populations^[5].

Although obesity has increased rapidly during the past years recent studies reported a decline in the rate of increase^[6]. A recent study also reported a small increase in physical activity in the USA^[6], but levels of obesity and PA are likely to vary substantially across states and countries. Dwyer-Lindgren *et al*^[6] studied the prevalence of PA and obesity in US counties from 2001 to 2011 and reported an increase in the prevalence of sufficient physical activity. Levels were generally higher in men than in women, but the increase was greater in women than men. This increase in activity levels was matched by an increase in obesity in almost all counties, which seems to indicate that an increase in PA alone has a small impact on obesity prevalence, thus other changes such as reduction in caloric intake, are likely needed to curb the obesity epidemic.

The trends in obesity have been reported to level off in several Western countries^[7] and between 2002 and 2010 trends in BMI and the prevalence of obesity in Sweden were reported to stabilise between 2002 and 2006 as determined with BMI in both men and women. From 2006 to 2010, both obesity and BMI increased, with a relatively high BMI associated with a decrease in PA.

Hamer *et al*^[8] investigated PA patterns over 10 years in relation to BMI and waist circumference (WC) and found that an increase in PA resulted in lower gains in BMI and WC.

Few longitudinal studies have tracked adults over long periods in populations undergoing rapid social and economic changes and thus the limited longitudinal data hinders identification of individual and community level influences on weight gain and development of obesity in populations experiencing the rapid changes. Longitudinal tracking of physical activity within South Africa is currently lacking.

Therefore, the aim of this study was to determine changes in physical activity from 2005 to 2010 and how these changes relate to the changes in BMI among a black South African population in transition.

Methods

Participants

This study formed part of the North West Province in the on-going South African leg of the Prospective Urban and Rural Epidemiological (PURE) study which is planned to run for 10 years, investigating the health transition of chronic diseases of lifestyle in urban and rural participants. For

the purpose of this study data from 2005 and 2010 was analysed. The International PURE study aims to recruit 150 000 adults initially aged 35 - 70 years from communities in low-, middle-, and high income regions of the world representing various levels of development, and encompassing great sociocultural diversity ^[9]. The PURE study is a prospective cohort study that will track changing lifestyles, risk factors and chronic disease using periodic standardised data collection in urban and rural areas of selected countries in transition ^[9]. The population in this study consisted of black Setswana speaking South African males (746) and females (1264), living in either an urban or rural area in the North West Province of South-Africa. Participants were included in the study if they were 30 years and older and appeared healthy. The study was approved by the Ethics Committee of the North-West University (Potchefstroom Campus) in accordance with the Declaration of Helsinki revised in 2000 (Ethics nr. 04M10). Permission was also obtained from the Provincial Department of Health of the North West Province, local government authorities in each town and the tribal chief of the rural communities. Participants were fully informed about the objectives and procedures of the study prior to their recruitment. Well-trained fieldworkers explained the aims and procedures of the study to the participants in their own language. All participants newly identified to have hypertension, diabetes or other abnormalities were referred to a local clinic, hospital or physician.

Demographic Information

Demographic information was collected through a questionnaire designed for the global study, and adjusted and tested in each country ^[9].

Anthropometric measurements

All anthropometric measurements were made according to the guidelines of the International Society for the Advancement of Kinanthropometry (ISAK) ^[10]. Measurements were obtained with the participant wearing minimal clothing without shoes. Maximum height and weight were measured with calibrated instruments (Precision Health Scale, A&D Company, Japan; Seca Stadiometer, Hamburg, Germany). Subsequently, BMI was calculated as weight divided by height squared ($\text{Weight}/\text{height}^2$). The BMI values were used to classify the participants into four groups, namely underweight (BMI, $<18.5 \text{ kg/m}^2$), normal weight (BMI, $18.5 - 24.9 \text{ kg/m}^2$), overweight (BMI, $25.0 - 29.9 \text{ kg/m}^2$) and obese (BMI, $30.0 - 34.9 \text{ kg/m}^2$) according to WHO classifications ^[13].

Physical activity Questionnaire

The Baecke physical activity questionnaire was completed during individual interviews and was conducted by extensively trained fieldworkers in the preferred language of the participants ^[11].

This questionnaire measures habitual PA in epidemiological surveys. It defines three levels of occupational PA, namely low (clerical work, driving, shop keeping, teaching, studying, housework, medical practice, and other occupations with a university education), middle (factory work, plumbing, carpentry, farming), and high (dock work, construction work, sport). Similarly, sports are categorised into three levels: low (billiards, sailing, golf), middle (badminton, cycling, dancing, tennis) and high (boxing, rugby, football, rowing). A sport score is calculated from the intensity factor, the number of times per week participating in that sport and the proportion of the year in which the sport is played. Indices of PA for three dimensions, namely occupational PA, sport during leisure time and PA during leisure time, excluding sport, can be established using the Baecke questionnaire and has a test-retest reliability of the work, sport and leisure time index variants between 0.74 and 0.88 ^[11]. The questionnaire can be used for various socioeconomic classes in the general population and has been used to assess PA of subjects between the ages of 20 - 70, and significant correlation coefficients ranging from 0.76 to 0.93 were found in reliability testing ^[11].

Statistical analysis

The computer software SPSS Version 21 (IBM Corporation, 1989, 2011) was used to perform the statistical analyses. The means and standard deviations for the PAI as well as for each of the PA domains were calculated. Independent and paired sample t-tests respectively were used to determine the differences between genders and the two measurement points. Changes in PAI were calculated for each individual by subtracting the mean value of 2005 from the value of 2010 (positive changes indicate an increase and negative changes a decrease in PAI and BMI during two measurement points). Linear regression analyses were used to determine the relationship between the changes in PA (dependent variable), and changes in BMI as predictor variables. The analyses were adjusted for gender and change in age. A significant relationship (in the case of setting, urban versus rural) resulted in separate analyses performed for rural and urban participants. Level of significance was set at $p \leq 0.05$.

Results

The mean age of participants for 2005 was 50 ± 10 years and 55 ± 10 years in 2010 (Table 1). Significant differences were found between rural and urban participants regarding age, weight and BMI in 2005. Rural women gained an average of three kilograms in five years, while urban women only gained an average of one kilogram over the same period. The females in rural and urban areas were significantly heavier than the males for both the 2005 and 2010 measurements. It was also interesting to note that there was a decrease in height for the urban population in both male and female participants.

The THUSA-PAQ compiled by Kruger *et al* ^[12], derived from the Baecke PA questionnaire ^[11] which was used to determine PA levels, showed that although the overall PAI (Table 2) of the participants indicates a decrease from 2005 to 2010, the PAI increased in urban, but decreased in rural participants. In the rural area the decrease seems to be due to a decrease in all activities (work index, leisure index, commute index and sport index), while the increase in the PAI of the urban participants seems to be due to the increase in the commute and work indices reported for 2005 and 2010.

Table 1: Participant characteristics for 2005 and 2010

<i>Variables</i>	<i>2005</i>					<i>2010</i>				
	<i>All Mean ± SD</i>	<i>p-value (settings)</i>	<i>Males Mean ± SD</i>	<i>Females Mean ± SD</i>	<i>p-value (gender)</i>	<i>All Mean ± SD</i>	<i>p-value (settings)</i>	<i>Males Mean ± SD</i>	<i>Females Mean ± SD</i>	<i>p-value (gender)</i>
Age (years)	49.9±10.4		50.2±10.2	49.6±10.5	0.30	55.4±10.2		55.5±10.2	54.8±10.2	0.24
Rural	49.0±10.0	0.00	49.8±10.1	48.6±10.0	0.08	54.2±9.7	0.00	55.2±10.1	53.61±9.6	0.06
Urban	50.7±10.7		50.5±10.3	50.8±11.0	0.71	56.1±10.6		55.8±10.3	56.3±10.8	0.60
Height (m)	1.61±0.08		1.67±0.07	1.57±0.07	0.00	1.60±0.08		1.67±0.07	1.57±0.07	0.00
Rural	1.61±0.10	0.50	1.67±0.07	1.57±0.07	0.00	1.60±0.08	0.80	1.67±0.07	1.57±0.07	0.00
Urban	1.61±0.10		1.67±0.07	1.57±0.07	0.00	1.60±0.09		1.66±0.08	1.56±0.07	0.00
Weight (kg)	63.50±17.00		58.20±12.26	66.57±18.63	0.00	65.04±18.00		58.91±13.44	68.15±19.10	0.00
Rural	62.01±16.13	0.00	58.14±12.44	63.91±17.43	0.00	64.33±17.20	0.13	59.42±13.51	66.28±18.06	0.00
Urban	65.00±17.70		58.23±12.12	69.41±19.45	0.00	66.00±18.80		58.41±13.38	70.46±20.09	0.00
BMI (kg/m²)	24.72±7.10		20.76±4.18	27.01±7.40	0.00	25.61±7.44		21.26±4.74	27.79±7.57	0.00
Rural	24.15±6.60	0.00	20.73±4.25	25.85±6.93	0.00	25.30±7.10	0.10	21.37±4.83	26.92±7.19	0.00
Urban	25.30±7.45		20.80±4.12	28.25±7.70	0.00	26.00±7.81		21.14±4.70	28.87±7.90	0.00

SD = standard deviation; BMI = body mass index

Table 2: Intensity of PA for participants based on the Baecke Questionnaire

<i>Variables</i>	<i>2005</i>					<i>2010</i>				
	<i>All Mean ±SD</i>	<i>p-value (settings)</i>	<i>Males Mean ±SD</i>	<i>Females Mean ±SD</i>	<i>p-value (gender)</i>	<i>All Mean ±SD</i>	<i>p-value (settings)</i>	<i>Males Mean ±SD</i>	<i>Females Mean ±SD</i>	<i>p-value (gender)</i>
Work Index	3.0±0.6		3.0±0.7	3.0±0.6	0.74	2.9±0.5		2.9±0.5	2.9±0.5	0.61
Rural	3.0±0.8	0.00	3.0±0.8	3.0±0.7	0.67	2.9±0.4	0.40	2.9±0.5	3.0±0.4	0.39
Urban	2.9±0.5		2.9±0.5	2.9±0.4	0.08	2.9±0.6		3.0±0.6	2.9±0.5	0.19
Comm Index	1.2±1.1		1.2±1.1	1.3±1.0	0.15	1.8±0.5		1.9±0.5	1.7±0.4	0.00
Rural	2.0±0.7	0.00	1.9±0.7	2.0±0.5	0.01	0	0.00	0	0	0
Urban	0.5±0.9		0.6±1.0	0.5±0.8	0.03	1.8±0.4		1.9±0.5	1.7±0.4	0.00
Sport Index	0.1±0.9		0.3±1.3	0.0±0.5	0.00	0.0±0.3		0.0±0.2	0.0±0.3	0.41
Rural	0.1±0.6	0.04	0.1±0.8	0.1±0.5	0.26	0	0.03	0	0	0
Urban	0.2±1.0		0.4±1.5	0.0±0.5	0.00	0.0±0.3		0.0±0.2	0.0±0.3	0.38
Leisure Index	3.0±0.7		2.9±0.7	3.1±0.7	0.00	2.7±0.1		2.8±1.0	2.7±1.0	0.60
Rural	3.3±0.7	0.00	3.2±0.7	3.3±0.6	0.39	2.7±1.0	0.70	2.8±1.1	2.7±1.0	0.76
Urban	2.8±0.7		2.6±0.6	2.8±0.7	0.00	2.7±0.9		2.7±1.0	2.7±0.9	0.63
PA Index	7.3±1.9		7.3±2.1	7.3±1.8	0.72	6.5±1.9		6.7±1.9	6.4±1.8	0.02
Rural	8.2±1.5	0.00	8.1±1.6	8.3±1.4	0.08	5.1±1.5	0.00	5.1±1.6	5.1±1.5	0.86
Urban	6.4±1.8		6.6±2.3	6.3±1.5	0.02	7.5±1.4		7.6±1.5	7.4±1.3	0.12

SD = standard deviation; Comm Index = commute index; PA Index = physical activity index

Figure 1 indicates that both groups showed an increase in weight from 2005 to 2010. The increase was the highest in the rural population and more specifically in the women. The men from the urban population were more underweight in 2010 than in 2005.

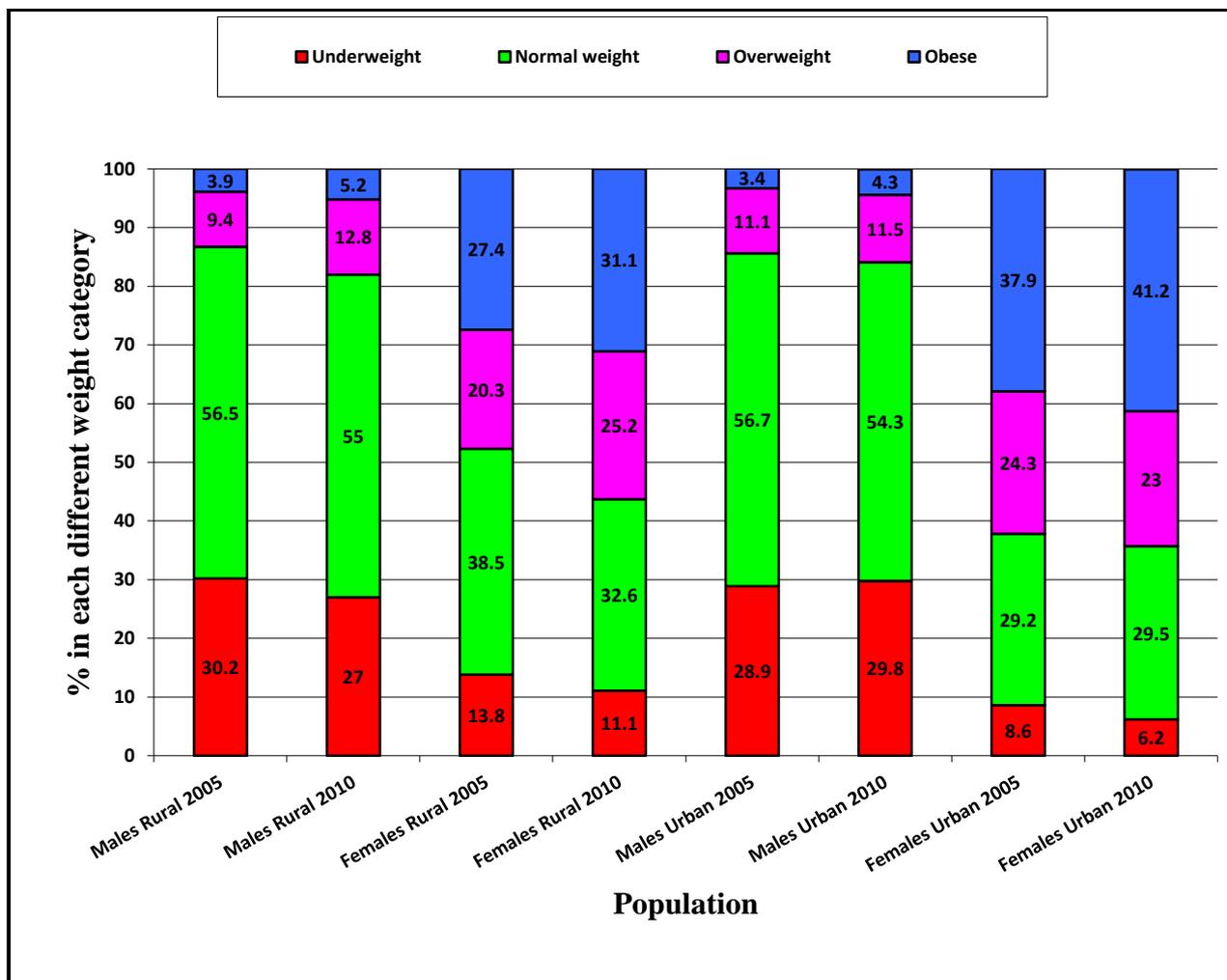


Figure 1: Classification of participants according to weight categories for each gender from rural and urban settings

When participants were classified in the different categories of activity (Figure 2) as reported in a previous South African based-study (THUSA), the PAI score of 1 - 3.33 was classified as low, 3.34 – 6.67 as moderate and > 6.67 as high ^[14]. Percentage urban males and females reporting high levels of PA were six times more than rural participants. There was also no low activity reported for the urban group in 2010 which could be due to the fact that both men and women from the urban population were more highly active in 2010 compared to 2005 (Figure 2), while both men and women from the rural population were less highly active in 2010, and more moderate and low active.

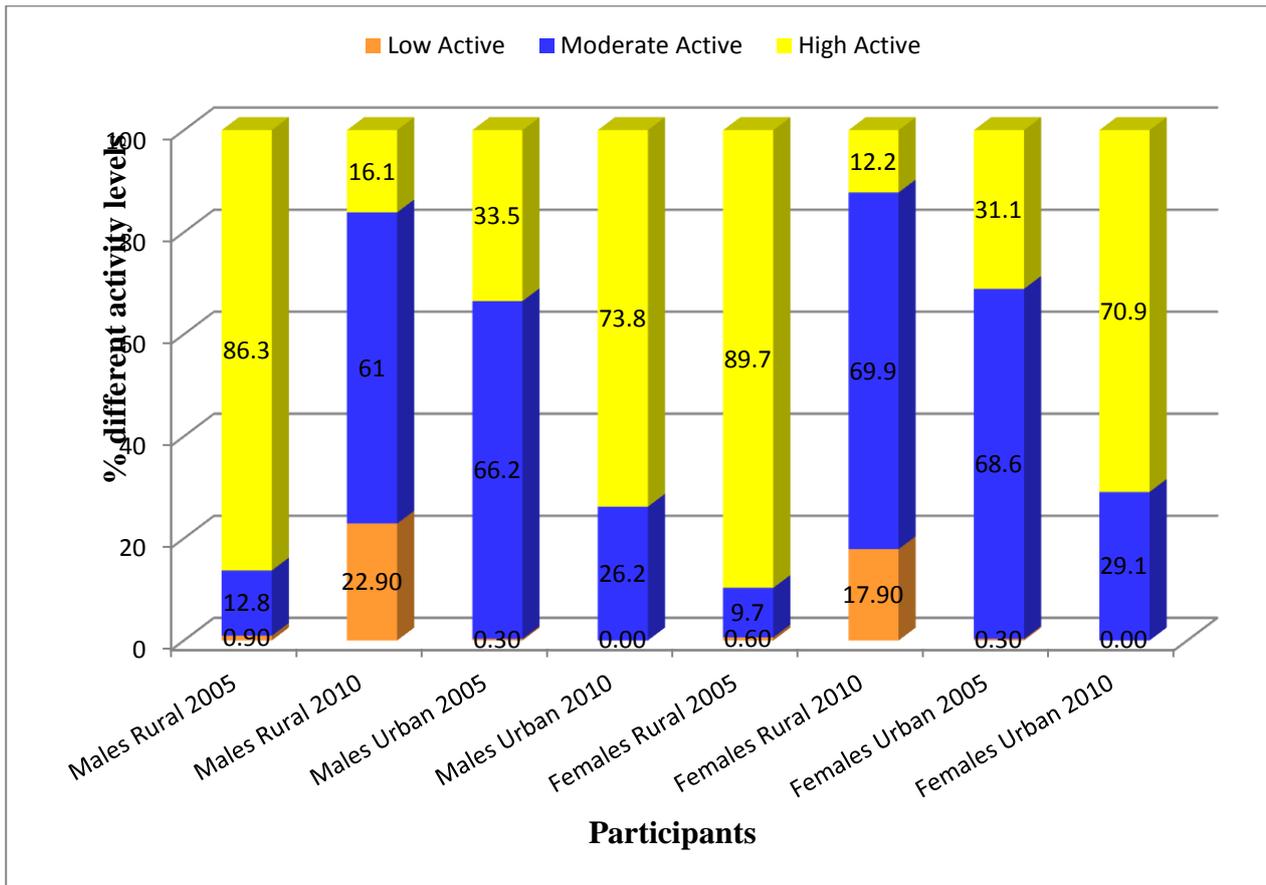


Figure 2: Percentage of the participants in each of the different activity categories

Results of the relationship between change in PA and change in BMI based on the linear regression analyses for the total group and adjusted for gender, change in age and setting of participants (rural/urban) reported no significant relationships for the crude analyses. When adjusted for age, gender and changes in age, a borderline inverse relationship ($\beta = -0.04$; $p = 0.08$) was found (Table 3). A separate analysis was performed for urban and rural settings (Table 4). For participants in an urban setting a relatively significant inverse relationship was found between changes in PAI and BMI ($B = -0.10$; 95% CI [-0.17 - -0.03]; $p = 0.004$).

Table 3: Relationship between changes in PA and changes in body mass index for the total group and separated for rural and urban participants

Change variable	β	95%CI	<i>p</i>
Model 1			
BMI (kg/m ²)	-0.04	-0.10 – 0.02	0.22
Model 2			
BMI (kg/m ²)	-0.04	-0.96 – 0.02	0.23
Model 3			
BMI (kg/m ²)	-0.03	-0.09 – 0.02	0.26
Model 4			
BMI (kg/m ²)	-0.04	-0.08 – 0.004	0.08

Model 1 = Crude analyses; Model 2 = Adjusted for change in age; Model 3 = Adjusted for gender; Model 4 = Adjusted for setting (rural vs. urban).

Table 4: Relationship between changes in PA and changes in body mass index for rural and urban participants separately

	<i>Rural</i>			<i>Urban</i>		
	β	95%CI	<i>p</i>	β	95%CI	<i>p</i>
Change in BMI (kg/m²)	0.01	-0.04 – 0.06	0.73	-0.10	-0.17 – 0.03	0.004

Discussion

The current study set out to describe the differences and changes in PA in rural and urban residents as well as the relationship with changes in body mass index (BMI), since information in a South African population is currently lacking. Marked differences were found in the patterns of PA and obesity among rural and urban dwellers from the North West Province between 2005 and 2010.

The findings on PA are in contrast to the findings of Cook and partners ^[15] who reported with accelerometry data that rural participants from the Limpopo area of South Africa were significantly less sedentary than urban participants, which is consistent with other international studies ^[16,17]. Assah and associates ^[18] also found that in Cameroon rural dwellers were physically more active than urban dwellers. Reasons for the differences could be that both of these cross-

sectional studies made use of objective measurements to determine PA (accelerometer and ActiHeart®), while this study made use of a subjective measurement, the Baecke physical activity questionnaire and has a longitudinal study design. The high level of illiteracy in rural areas may have played a role in the understanding of the questionnaire ^[19]. To correctly interpret the information from the recording period it is important to account for the fact that activity levels may also vary according to the season; shown to be higher during spring and summer compared with autumn and winter ^[20].

It has been well documented that the prevalence of physical inactivity and obesity increased from rural to urban populations with increases being significantly greater for women compared with men ^[16,21,15]. Yadav and Krishnan ^[17], Masterson Creber *et al* ^[16] and Cook *et al* ^[15] also found that people living in urban areas had much lower levels of activity and a higher risk of obesity; contradictory to findings of this study. Possible reasons for the difference could be that the participants in this study were much older (rural, 54.2 years and urban, 56.1 years) compared to the participants in the study conducted by Yadav and Krishnan ^[17] (rural, 35.8 years and urban 38.3 years). Physical activity was measured by Cook and partners ^[15] using accelerometers where this study made use of the Baecke physical activity questionnaire. The participants in Cook and partners ^[15] were also much younger (rural, 35.1 years and urban 30.1 years). The study by Cook and partners ^[15] was done in Limpopo with farming as the main activity, where our study was done in the North-West with very limited rain fall and farming activity.

Masterson Creber and associates ^[16] compared PA and sedentary behaviour patterns of rural-to-urban migrants in Peru versus lifetime rural and urban residents and found that 97.8% of rural residents had moderate/high PA compared to 60.8% of the urban residents. In the PREVENCIÓN study conducted in Arequipa, Peru, the prevalence of low PA was 57.5% among urban resident participants ^[22] compared with 0% in the urban group of this study. Masterson Creber *et al* ^[16] also indicated that 39.2% of the urban participants had low PA.

The difference observed in the findings of this study compared to others might be explained by differences in the educational levels of the participants, number of males vs. females in the study sample, and measurement instrument used (objective vs. subjective). Masterson Creber and associates ^[16] made use of the IPAQ questionnaire where this study used the Baecke questionnaire.

Levels of PA are known to be influenced by overweight and obesity ^[16]. Females in both the rural and urban groups of this study were significantly heavier than the men of the rural and urban groups respectively. Rural women gained on average three times more weight than the urban women over the 5-year period. Despite the smaller increase in weight gain, urban women still reported higher BMI values than the rural women.

The observed high prevalence of obesity, particularly among women, is consistent with previous international studies ^[17,6] and similar to findings from other South African ^[23], and African studies ^[24,5] where the prevalence of obesity was significantly higher among females compared to males.

According to Peer and associates ^[25] higher prevalence of physical inactivity in females may contribute to the higher prevalence of overweight/obesity compared to males. Furthermore, the view that big body size in African women is traditionally desirable and indicative of success and happiness might have contributed to the relatively high prevalence of overweight/obesity ^[25].

Prevalence of physical inactivity and obesity increased for the rural population, with the increase being greater for women than men. This is in contrast with what was found in the literature ^[16,18,15]. Yadav and Krishnam ^[17] reported that 9.9% of rural men in Haryana, India had a BMI ≥ 25 kg/m² compared to 28.1% of the urban male population; this is very similar to what Peer and associates ^[25] reported (BMI ≥ 25 kg.m² was 9.4 % for rural and 30.7% for urban), where the increase in BMI correlated negatively with the decrease in PA. Yadav and Krishnam ^[17] reported that rural men were more active (77.4%) than urban men (57.4%), as was found in the women.

A study by Gu and partners ^[26] in a Chinese population reported high intensity PA levels were more present in urban women compared to rural women, supporting the findings of this study, but reported that high intensity PA was lower for urban men compared to rural men; which is in contrast with our findings. Gu and partners ^[26] also reported contrasting findings, with the prevalence of obesity lower for urban women compared to rural women and higher for urban men compared to rural men.

The contradicting findings in the Chinese population compared to the findings of this study may be because the former investigated the effect of urbanisation on BMI and PA and not the effect of changes in BMI on the changes in PA observed. Another possible reason is that the different populations are at different stages of the nutrition and physical activity transition. Measurement of PA based on questions also imposes restrictions. Gu and partners ^[26] also made use of the IPAQ to measure PA; another possible reason for the different findings.

The increase in the prevalence of obesity observed in recent years in middle-income countries ^[4] is a public health problem, as obesity is a risk factor for chronic disease. According to Ortiz-Hernàndez and Ramos-Ibàñez ^[4], a decrease in energy expenditure due to a low PA level is a factor linked to the increase in obesity. At present, the majority of the population appears to have adopted less active lifestyles as the use of motorised transport, employment of mechanised equipment to perform occupational and domestic tasks, and time spent watching television and using computers have increased ^[4].

The findings of this study is the first in South Africa to determine changes in PA of urban and rural residents over a period of 5 years and how a change in BMI may relate to the changes observed in PA.

Despite the significant findings and large sample size, limitations of this study need to be considered with the interpretation of the findings. The self-reported assessment of PA remains the most feasible and affordable instrument for large surveillances, however, objective measures of PA with pedometers or accelerometers, would strengthen the robust findings obtained with questionnaires.

Conclusion

PA levels in a rural and urban setting of the North West Province declined over a period of 5 years, while the BMI of the participants increased significantly. PA levels were higher in urban settings than rural and a larger percentage of urban dwellers were performing PA at a higher intensity level than rural dwellers. In the urban population an increase in BMI was related to a significant decrease in PAI. Future studies should investigate the reasons for the changes in PA in rural areas in order to implement strategies to prevent a further decrease in physical activities of rural dwellers.

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Chapter 5

The relationship between changes in physical activity and changes in risk factors for non-communicable disease in a black South African population: The PURE-study

TERSZIA VAN NIEKERK¹, S JOHANNA MOSS¹, M ANDRIES MONYEKI¹, H SALOME KRUGER² AND ANNAMARIE KRUGER³

¹Physical Activity, Sport and Recreation (PhASRec), Faculty of Health Sciences, North-West University, Potchefstroom

²Centre of Excellence in Nutrition, Faculty of Health Sciences, North-West University, Potchefstroom

³Africa Unit for Trans disciplinary Health Research (AUTHeR), Faculty of Health Sciences, North-West University, Potchefstroom

Corresponding author: S.J. Moss (Hanlie.moss@nwu.ac.za)

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Abstract

Background: To determine the relationship between changes in physical activity (PA) and changes in risk factors for NCDs in a black South African population in transition.

Methods: Data of the PURE study from 2005 and 2010 was analysed; it comprised 746 males and 1 264 females aged 29 to 94 years from a black South African population from the North West Province. Physical activity index (PAI) was obtained by means of the adapted Baecke questionnaire reporting on: work, sport, and non-sport leisure activity, scoring questions on a five-point Likert scale. Body mass index (BMI) was calculated from body mass and height. Blood pressure was measured with standard procedures. Triglycerides, glucose and cholesterol concentrations were analysed from blood samples. The relationship between changes in PA and changes in risk factors for cardiovascular disease was determined by means of linear regression analyses and adjusted for change in age, gender, settings (rural vs. urban), smoking and alcohol use.

Results: Urban participants were significantly older and heavier than the rural participants with the rural women increasing their average body weight by three kilograms and urban women by only one kilogram. The urban participants had a significantly higher SBP (137.33 ± 25.14 mmHg) and DBP (89.28 ± 14.46 mmHg) than the rural participants (SBP 129.72 ± 23.30 mmHg; DBP 86.16 ± 14.48 mmHg). The urban participants also reported a significantly higher fasting glucose (5.10 ± 1.86 mmol/L) and triglycerides (1.38 ± 0.92 mmol/L) than the rural population (fasting glucose 4.88 ± 1.23 mmol/L; triglycerides 1.21 ± 0.64 mmol/L). But the PAI was significantly higher for the rural population (8.2 ± 1.5) compared to the urban population (6.4 ± 1.8) in 2005. HDL and LDL-cholesterol decreased from 2005 to 2010. Although overall the PAI decreased from 2005 (7.30 ± 1.90) to 2010 (6.46 ± 1.85), it increased in urban participants (6.40 ± 1.84 to 7.50 ± 1.40), yet decreased in rural participants. A significant negative relationship between changes in PAI and changes in blood pressure (systolic and diastolic), total and LDL-cholesterol was found when adjusted for gender and age. Additional adjustments for life style risk factors, smoking and alcohol as well as setting (rural/urban) resulted in a loss of significance. When changes in PA and changes in risk factors were split according to gender, a significant negative relationship was found for diastolic blood pressure (β -0.63; p 0.02) in the male population, and a significant negative relationship for females in systolic blood pressure (β -1.05; p 0.002), and diastolic blood pressure (β -0.59; p 0.003), total cholesterol (β -0.05; p 0.01) and LDL-cholesterol (β -0.07; p 0.00). A significant positive relationship for HDL-cholesterol (β 0.02; p 0.002) was found for the female population.

Conclusion: Risk factors for NCDs increased from 2005 to 2010 in this black South African population in transition. The decrease in physical activity was significantly related to the increase

in SBP and cholesterol. Interventions to increase physical activity should be implemented to prevent the increase in risk factors for NCDs in particular systolic blood pressure and LDL-Cholesterol.

Keywords: Non-communicable disease, physical activity, risk factors, body mass index, rural, urban, Baecke Physical Activity Questionnaire.

Background

Chronic non-communicable diseases (NCDs) are the most serious health challenge facing the world today [1; 2]. According to the World Health Organization, 63% of the 57 million deaths worldwide in 2008 were due to non-communicable diseases [3]. Of these, cardiovascular diseases accounted for approximately 30% of all deaths globally, followed by cancers (13%), chronic lung diseases (7%) and diabetes (2%). Driven by population growth and population ageing, deaths from non-communicable diseases are expected to increase by 17% over the period 2005-2015 [4], accounting for 69% of global deaths by 2030 [5]. Of the NCDs, cardiovascular diseases (CVD) are the leading cause of death in all regions except sub-Saharan Africa and are estimated to rise from 17.3 million deaths (2008) to 23.4 million deaths (2030) [4]. The traditional risk factors for NCDs include age, hypertension, hyperglycaemia, high cholesterol, tobacco smoking, alcohol abuse, overweight and obesity, and inactivity.

The abovementioned risk factors result in various long-term disease processes, culminating in high mortality rates attributable to stroke, heart attack, diabetes, dyslipidaemia, tobacco- and nutrition-induced cancers, and obstructive lung diseases [6].

Hypertension is the greatest risk factor of cardiovascular disease, [7; 8] and is responsible for up to 7 million deaths worldwide every year [9; 8]. Over 1.5 billion people suffer from hypertension worldwide and more than half a billion more will harbour this silent killer by 2025 [10].

Diabetes is a global health problem and it is estimated that 366 million people will be affected by the year 2030 [11]. Unfortunately four-fifths of all patients with diabetes live in developing countries [11]. Obesity is one of the greatest contributors to the development of diabetes with more than 80% of Type 2 diabetes attributable to obesity. With over 1.1 billion adults overweight (312 million of whom are obese), the incidence of diabetes is expected to double from 171 million to 366 million cases over the period 2000 - 2030 [12; 2]. Above the normal weight range (BMI 25.0 - 29.9 kg/m²) mortality rates rise by 30% for every 5 kg/m² increase in BMI [13].

Dyslipidaemia has emerged as an important cardiovascular disease risk factor [14]. Norman and colleagues [15] found that high cholesterol level (≥ 3.8 mmol/L) accounted for 59% of ischemic heart disease and 29% of ischemic stroke burden in adults age 30 and over.

Due to population growth, mergers and acquisitions, and the marketing of global cigarette brands in developing countries, death from tobacco is expected to rise from 5.4 million per year (2005), through 6.4 million (2015), to 8.3 million by 2030 [16]. These figures include a doubling in tobacco deaths in low- and middle-income countries from 3.4 million to 6.8 million lives annually. By 2015, smoking will cause 50% more deaths than HIV/AIDS [5].

The harmful use of alcohol results in 2.5 million deaths globally each year [17]. According to WHO [17] 320 000 young people between the ages of 15 and 29 die from alcohol-related causes.

Physical inactivity is an established modifiable risk factor for non-communicable disease. Various factors have been identified to be associated with physical inactivity including; socio-demographic (female gender, decreasing age, marital status, lower or higher educational level, income, employment status) [18; 19; 20; 21], psychological (self-efficacy, pros, and cons) [20; 22], social (social support, health professional advice) [20], lack of quality of life [23; 24; 25; 22; 26], environmental factors (home fitness equipment, access to facilities, neighbourhood safety, residential area) [20], chronic or other illness conditions, including hypertension [27], diabetes [28], angina or coronary artery disease [28], higher risk of depressive symptoms [29; 30], smoking [18; 21], being overweight or obese, inadequate fruit and vegetable consumption [18], and activity limitation [31].

This significant change in the NCDs may be explained by the transition of the population from rural to urban. Since 2008, and for the first time in human history, over 50% of the world's population lives in urban areas [32; 33]. In low and middle income countries, urban compared to rural living is strongly associated with higher prevalence of certain chronic, non-communicable conditions, including hypertension, hyperglycaemia, high cholesterol, tobacco smoking, alcohol abuse, overweight and obesity, and physical inactivity [34; 32; 33].

Rapid urbanisation has led to the adoption of Westernised lifestyles and is often associated with extreme changes in dietary habits and habitual PA [35] that underlie the distinct socioeconomic and environmental differences between rural and urban areas such as; active commuting, fetching fire wood, cattle herding, and fetching water from distant streams, which are typical energy-intensive physical activities in many rural environments [36; 33]. On the other hand, typical urban lifestyles are characterised by consumption of energy dense-foods and sedentary activities such as motorised transport to school, TV viewing, and mechanisation/automation of chores [36; 33], which may partially explain the observed differences in prevalence of lifestyle disorders such as obesity, hypertension, and diabetes between rural and urban populations [35].

Research has found positive relationships between physical activity and pleasant scenery, safe neighborhoods, and multiple destinations within walking distance, sidewalks, and light traffic. Much of this research, however, has focused on adults living in suburban and urban areas [37; 38; 39]. Comparisons between rural and urban areas have found greater accessibility to PA resources for urban residents [40; 39], and examination across varying rural densities demonstrates that most rural areas have the fewest resources [41]. Access to limited PA resources is particularly important given that rural residents appear to be at the highest risk for poor health compared with their urban

counterparts, and they experience greater prevalence of health conditions such as cardiovascular disease, arthritis, obesity, Type 2 diabetes, and some cancers [39]. In addition, rates of leisure time PA appear to be lower in rural compared with urban areas [39], which is problematic given the beneficial effects of PA on the development and effective management of many chronic conditions.

In South Africa the transition from rural to urban areas has been taking place at a rapid rate because of the perception that more jobs opportunities are available in the urban areas [42]. The effect of this transition influences the level of health as indicated by the risk factors for NCDs. Within the South African context, the relationships between changes in PA and changes in risk factors for NCDs have not been investigated in populations that are in transition between rural and urban areas. Therefore the purpose of this study was to investigate the relationship between the changes in PA and the changes in the risk factors for NCDs in a black South African population in transition.

The findings from this study are relevant in understanding the role of PA in the management and prevention risk factors for NCDs and the importance of future interventions.

Methods

Research design and sample

This study was a cross-sectional study and used data from the North West Province in the South African leg of the Prospective Urban and Rural Epidemiological (PURE) study which is planned to run for 10 years, aims to investigate the health transition on chronic diseases of lifestyle in urban and rural participants. The International PURE study aims to recruit 150 000 adults aged 35 - 70 years from communities in low-, middle-, and high income regions of the world representing various levels of development, and encompassing great sociocultural diversity [43]. It is a prospective cohort study that will track changing lifestyles, risk factors and chronic disease using periodic standardised data collection in urban and rural areas of selected countries in transitions [43]. The population studied in this South African leg of PURE consisted of black Setswana speaking South African men (746) and women (1 264), living either in an urban or rural area in the North West Province.

Of the 2 010 subjects blood pressure was measured on only 1 187 subjects (626 rural and 561 urban); glucose on 1 127 subjects; (614 rural and 513 urban); cholesterol (total-, HDL- and LDL- cholesterol) on 1 135 subjects (615 rural and 520 urban); and triglycerides on 1 125 subjects (609 rural and 516 urban). The mean increase in age at follow-up was 4.57 years for males and 4.58 years for females. The study was approved by the Ethics Committee of the North-West

University (Potchefstroom Campus) (Ethics nr.04M10). Permission was also obtained from the Provincial Department of Health of the North West Province, local government authorities of each town and the tribal chief of the rural communities. Participants were fully informed about the objectives and procedures of the study prior to their recruitment. Extensively trained fieldworkers explained all information in the participants' own language. All participants signed an informed consent form. All participants identified to have hypertension, diabetes or other abnormalities were referred to a local clinic, hospital or physician.

Measurements

Demographic information:

Demographic information was collected through a questionnaire designed for the global study and adjusted and tested in each country [43]. This questionnaire were filled out by the participants with the assistance of extensively trained fieldworkers and applied in the language of the participant's choice.

Biological risk factors

Body composition measurements were taken according to the guidelines of the International Society for the Advancement of Kinanthropometry (ISAK) [44]. Measurements were obtained with the participant wearing minimal clothing without shoes. Maximum height and weight were measured with calibrated instruments (Precision Health Scale, A&D Company, Japan; Invicta Stadiometer, IP 1465, U.K.) from which BMI (kg/m^2) was calculated.

Blood pressure was measured in the sitting position on the right upper arm, using the validated OMRON automated digital blood pressure monitor (OMRON HEM-757).

The lipid profile and glucose concentrations were determined from blood sampled from the anti-cubital vein in the participants' right arm using a sterile butterfly infusion set (Johnson & Johnson, 21G, 19 mm) after at least 10 hours of fasting. Serum was prepared from blood after clotting took place and centrifuged at 3 000 rpm for 15 minutes (Universal 16R™, Hettich, with cooling facilities). Aliquots of 0.5 ml were transferred and stored for later analysis. Plasma was collected in EDTA tubes and centrifuged at 2 000 g for 15 minutes at 4°C (Universal 32R™, Hettich). All serum, plasma, and separated blood cells samples were immediately stored at -18°C to -20°C in the field for 2-4 days and afterwards at -84°C in the laboratory.

Quantitative determination of the total cholesterol, HDL-cholesterol (HDL-C), triglycerides (TG), and fasting glucose (FG) (GOD-POD) concentrations in the serum of the participants was

measured with the Konelab^{2Di}™ auto analyser (Thermo Fisher Scientific Oy, Vantaa, Finland), a clinical chemistry analyser for colorimetric, immunoturbidimetric and ion-selective electrode measurements. LDL cholesterol was calculated using the Friedewald formula [45].

Questionnaire

Questionnaires were issued during individual interviews and were conducted by extensively trained fieldworkers in the preferred language of the participants.

Baecke Physical Activity Questionnaire

The Baecke physical activity questionnaire that was adapted for the South African context which was used in the THUSA- study compiled by Kruger *et al* [46], derived from the Baecke PA questionnaire [47] was issued and completed during individual interviews and was conducted by extensively trained fieldworkers in the preferred language of the participants [47].

Participants completed the adapted Baecke physical activity questionnaire [47] which is a short questionnaire for the measurement of habitual physical activity in epidemiological surveys. It defines three levels of occupational physical activity, namely, low (clerical work, driving, shop keeping, teaching, studying, housework, medical practice, and all occupations with a university education), middle (factory work, plumbing, carpentry, farming), and high (dock work, construction work, sport). Similarly, sports are categorised into three levels: low (billiards, sailing, golf), middle (badminton, cycling, dancing, tennis), and high (boxing, rugby, football, rowing). A sport score is calculated from the intensity factor, the number of times per week participating in that sport, and the proportion of the year in which the sport is played. Indices of PA for three dimensions, namely occupational physical activity, sport during leisure time, and physical activity during leisure time, excluding sport, can be established using the Baecke questionnaire (BQ) and has a test-retest reliability of the work, sport and leisure-time indexes between 0.74 and 0.88 [47]. The questionnaire can be used for the various socioeconomic classes in the general population, and has been used in the assessment of PA for subjects between the ages of 20 and 70 years, where significant correlation coefficients ranging from 0.76 to 0.93 were found in reliability testing [47].

The questionnaire, briefly, consists of 16 questions organised in three sections: PA at work (Questions 1 to 8), sport during leisure time (Questions 9 to 12), and PA during leisure excluding sport (Questions 12 to 16). Questions in each section are scored on a 5-point Likert scale, ranging from “never” to “always” or “very often.” The two most frequently reported sports activities are explored in additional questions about the number of months per year and hours per week of

participation. The three derived indices, work, sports, and leisure, are scored in arbitrary units ranging from one to five [47].

Statistical analysis

The computer software SPSS Version 21 (IBM Corporation, 1989, 2011) was used to perform the statistical analyses. The participants' characteristics were analysed by means of descriptive statistics reporting averages and standard deviations as well as frequency calculations. Independent and paired sample t-tests were used respectively to determine the differences between gender and the two measurement points. Absolute changes in the PAI and changes in the risk factors for NCDs were calculated for each individual by subtracting the mean value of 2005 from the value of 2010 (positive changes indicate an increase and negative changes a decrease in PAI and risk factors between two measurement points). The relationship between the changes in PAI (dependant variable) and the change in the risk factors for NCDs as predictor variables was determined by means of a linear regression analysis. The analyses were adjusted for gender, change in age, and setting (urban/rural). Levels of significance were set at $p \leq 0.05$. Regression analyses indicated that gender contributed significantly to the model and therefore regression analyses were split for males and females. Levels of significance were set at $p \leq 0.05$.

Results

The average ages of participants (Table 1) in the study were 50 ± 10 years in 2005 and 55 ± 10 years in 2010. Significant differences were found between rural (age: 49.0 ± 10.0 years, weight: 62.01 ± 16.14 kg, BMI: 24.15 ± 6.60 kg/m²) and urban (age: 50.7 ± 10.7 years, weight: 65.00 ± 17.70 kg, BMI: 25.30 ± 7.45 kg/m²) participants in total in 2005, while a significant difference in 2010 was only found between the urban (54.2 ± 9.7 years) and rural (56.1 ± 10.6 years) participants for age. The urban participants were older, heavier and had a higher BMI compared to the urban participants. Rural women gained an average of three kilograms in the five years, while urban women only gained an average of one kilogram over the same period. The females in rural and urban areas were significantly heavier than the males for both the 2005 and 2010 measurements. Although the total group presented a normal BMI (25.61 ± 7.44 kg/m²), the BMI of the males (21.26 ± 4.83 kg/m²) were significantly lower than the females (27.80 ± 7.57 kg/m²).

Biological risk factors

In 2005 (Table 2), the urban participants had a significantly higher SBP (137.33 ± 25.14 mmHg) and DBP (89.28 ± 14.46 mmHg) than the rural participants (SBP 129.72 ± 23.30 mmHg; DBP 86.16 ± 14.48 mmHg). The urban participants also reported in 2005, a significantly higher fasting glucose (5.10 ± 1.86 mmol/L) and triglycerides (1.38 ± 0.92 mmol/L) than the rural population (fasting glucose 4.88 ± 1.23 mmol/L; triglycerides 1.21 ± 0.64 mmol/L). But the PAI was significantly higher for the rural population (8.2 ± 1.5) compared to the urban population (6.4 ± 1.8) in 2005. In 2010, the urban participants had significantly higher HDL-cholesterol (1.50 ± 0.65 mmol/L) and PAI (7.50 ± 1.40) than the rural participants (HDL-cholesterol 1.36 ± 0.52 mmol/L; PAI 5.10 ± 1.54). The rural participants had significantly higher LDL-cholesterol (3.00 ± 1.10 mmol/L) than the urban participants (2.73 ± 1.12 mmol/L) in 2010. Total cholesterol, HDL and LDL-cholesterol decreased from 2005 to 2010 for the total group of participants. Although overall the PAI decreased from 2005 (7.30 ± 1.90) to 2010 (6.46 ± 1.85), it increased in urban participants (6.40 ± 1.84 to 7.50 ± 1.40), yet decreased in rural participants (8.21 ± 1.48 to 5.10 ± 1.54). The male participants had a significantly higher SBP (138.94 ± 24.62 mmHg), HDL-cholesterol (1.50 ± 0.64 mmol/L) and PAI (6.68 ± 1.93) than the female participants (SBP 133.34 ± 23.75 mmHg; HDL-cholesterol 1.39 ± 0.56 mmol/L; PAI 6.38 ± 1.82), and the female participants reported significantly higher fasting glucose (5.45 ± 2.10 mmol/L), total cholesterol (5.06 ± 1.20 mmol/L), LDL-cholesterol (3.04 ± 1.10 mmol/L) and triglycerides (1.39 ± 1.10 mmol/L) than the male participants (fasting glucose 4.90 ± 1.11 mmol/L; total cholesterol 4.62 ± 1.15 mmol/L; LDL-cholesterol 2.56 ± 1.06 mmol/L; triglycerides 1.21 ± 0.74 mmol/L).

Lifestyle risk factors

Although the overall physical activity index (PAI) decreased from 2005 (7.30 ± 1.90) to 2010 (6.46 ± 1.85), the PAI in the urban participants increased from 2005 (6.40 ± 1.84) to 2010 (7.50 ± 1.40) but decreased in rural participants from 2005 (8.21 ± 1.48) to 2010 (5.10 ± 1.54).

In both rural and urban participants a decrease in lifestyle risk factors was observed in smoking (rural from 51% to 30% and urban from 53% to 22%), and alcohol use (rural from 30% to 27% and urban from 49% to 47%).

Table 1: Participant characteristics for 2005 and 2010 measurements

<i>Variables</i>	<i>2005</i>					<i>2010</i>				
	<i>All Mean ±SD</i>	<i>p-value (settings)</i>	<i>Male Mean ±SD</i>	<i>Female Mean ±SD</i>	<i>p-value (gender)</i>	<i>All Mean ±SD</i>	<i>p-value (settings)</i>	<i>Male Mean ±SD</i>	<i>Female Mean ±SD</i>	<i>p-value (gender)</i>
Age (years)	49.9±10.4		50.2±10.2	49.6±10.5	0.30	55.4±10.2		55.5±10.2	54.8±10.2	0.24
Rural	49.0±10.0	0.00	49.8±10.1	48.6±10.0	0.08	54.2±9.7	0.00	55.2±10.1	53.61±9.6	0.06
Urban	50.7±10.7		50.5±10.3	50.8±11.0	0.71	56.1±10.6		55.8±10.3	56.3±10.8	0.60
Height (m)	1.61±0.08		1.67±0.07	1.57±0.07	0.00	1.60±0.08		1.67±0.07	1.57±0.07	0.00
Rural	1.61±0.10	0.50	1.67±0.07	1.57±0.07	0.00	1.60±0.08	0.80	1.67±0.07	1.57±0.07	0.00
Urban	1.61±0.10		1.67±0.07	1.57±0.07	0.00	1.60±0.09		1.66±0.08	1.56±0.07	0.00
Weight (kg)	63.50±17.00		58.20±12.26	66.57±18.63	0.00	65.04±18.00		58.91±13.44	68.15±19.10	0.00
Rural	62.01±16.13	0.00	58.14±12.44	63.91±17.43	0.00	64.33±17.20	0.13	59.42±13.51	66.28±18.06	0.00
Urban	65.00±17.70		58.23±12.12	69.41±19.45	0.00	66.00±18.80		58.41±13.38	70.46±20.09	0.00
BMI (kg/m²)	24.72±7.10		20.76±4.18	27.01±7.40	0.00	25.61±7.44		21.256±4.74	27.792±7.57	0.00
Rural	24.15±6.60	0.00	20.73±4.25	25.85±6.93	0.00	25.30±7.10	0.10	21.37±4.83	26.92±7.19	0.00
Urban	25.30±7.45		20.80±4.12	28.25±7.70	0.00	26.00±7.81		21.14±4.70	28.87±7.90	0.00

BMI = Body Mass Index, SD = Standard deviation

Table 2: Participant risk factors for 2005 and 2010 measurements

<i>Variables</i>	<i>2005</i>		<i>2005</i>		<i>p-value</i> <i>(gender)</i>	<i>2010</i>		<i>2010</i>		<i>p-value</i> <i>(gender)</i>
	<i>All (2005)</i> <i>Mean ±SD</i>	<i>p-value</i> <i>(Settings)</i>	<i>Male</i> <i>Mean ±SD</i>	<i>Female</i> <i>Mean ±SD</i>		<i>All (2010)</i> <i>Mean ±SD</i>	<i>p-value</i> <i>(Settings)</i>	<i>Male</i> <i>Mean ±SD</i>	<i>Female</i> <i>Mean ±SD</i>	
Systolic BP (mmHg)	133.53±24.53		135.66±23.45	132.45±25.10	0.00		135.08±24.02	138.94±24.62	133.34±23.75	0.00
Rural	129.72±23.30	0.00	132.32±22.33	128.44±23.68	0.01	0.71	134.85±23.63	139.26±25.77	133.07±22.92	0.00
Urban	137.33±25.14		138.43±24.03	136.69±25.88	0.30		135.35±24.47	138.65±23.54	133.66±24.75	0.02
Diastolic BP (mmHg)	87.72±14.55		86.70±14.71	88.31±14.48	0.02		88.38±13.58	88.33±13.34	88.50±13.85	0.84
Rural	86.16±14.48	0.00	84.72±14.47	86.84±14.51	0.03	0.88	88.43±12.83	88.06±13.02	88.96±12.96	0.58
Urban	89.28±14.46		88.34±14.80	89.87±14.29	0.11		88.31±14.40	88.59±13.67	88.28±14.87	0.80
Fast glucose (mmol/L)	4.96±1.57		4.84±1.53	5.03±1.58	0.01		5.27±1.83	4.90±1.11	5.45±2.10	0.00
Rural	4.88±1.23	0.01	4.82±0.89	4.90±1.29	0.26	0.50	5.24±1.91	4.95±1.23	5.37±2.14	0.00
Urban	5.10±1.86		4.86±1.92	5.19±1.84	0.01		5.31±1.74	4.85±1.00	5.56±2.01	0.00
T Chol (mmol/L)	5.01±1.38		4.80±1.34	5.12±1.38	0.00		4.91±1.21	4.62±1.15	5.06±1.20	0.00
Rural	5.00±1.37	0.17	4.72±1.34	5.06±1.36	0.00	0.06	4.97±1.19	4.72±1.20	5.08±1.16	0.00
Urban	5.05±1.39		4.87±1.34	5.20±1.41	0.00		4.84±1.22	4.51±1.10	5.04±1.25	0.00
HDL-Chol (mmol/L)	1.52±0.63		1.58±0.64	1.48±0.62	0.00		1.42±0.59	1.50±0.64	1.39±0.56	0.00
Rural	1.52±0.62	0.92	1.55±0.65	1.50±0.62	0.24	0.00	1.36±0.52	1.42±0.57	1.34±0.50	0.09
Urban	1.52±0.65		1.60±0.64	1.45±0.63	0.00		1.50±0.65	1.57±0.69	1.45±0.62	0.04
LDL-Chol (mmol/L)	2.90±1.18		2.67±1.16	3.03±1.16	0.00		2.88±1.12	2.56±1.06	3.04±1.10	0.00
Rural	2.91±1.17	0.90	2.65±1.13	3.01±1.17	0.00	0.00	3.00±1.10	2.74±1.11	3.11±1.07	0.00
Urban	3.00±1.20		2.69±1.18	3.06±1.16	0.00		2.73±1.12	2.39±1.00	2.94±1.14	0.00
Trig (mmol/L)	1.30±0.79		1.21±0.83	1.34±0.74	0.00		1.34±1.00	1.21±0.74	1.39±1.10	0.00
Rural	1.21±0.64	0.00	1.16±0.69	1.23±0.61	0.16	0.90	1.34±0.93	1.23±0.64	1.36±1.00	0.04
Urban	1.38±0.92		1.26±1.00	1.45±0.83	0.00		1.34±1.10	1.19±0.83	1.42±1.21	0.01

CHAPTER 5

PA Index	7.30±1.90		7.30±2.14	7.31±1.75	0.72	6.46±1.85		6.68±1.93	6.38±1.82	0.02
Rural	8.21±1.48		8.10±1.56	8.28±1.42	0.08	5.10±1.54		5.08±1.60	5.12±1.52	0.86
Urban	6.40±1.84	0.00	6.60±2.31	6.28±1.45	0.02	7.50±1.40	0.00	7.60±1.45	7.41±1.31	0.12
	Frequency measurements of smoking and alcohol									
Smoking (%)	51.8					29.5				
Rural (Yes)	51.1		56.2	48.6		47.6		51.5	46.0	
Urban (Yes)	52.6		63.9	45.7		47.1		56.0	42.6	
Alcohol (%)	39.5					22.0				
Rural (Yes)	30.0		51.4	19.3		27.3		46.4	18.7	
Urban (Yes)	48.9		67.0	37.2		47.0		67.3	36.2	

Systolic BP = Systolic Blood Pressure, Diastolic BP = Diastolic Blood Pressure, Fast glucose = Fasting glucose, T Chol = Total Cholesterol, HDL-Chol = High Density Lipoprotein Cholesterol, LDL-Chol = Low Density Lipoprotein Cholesterol, Trig = Triglycerides, PA Index = Physical Activity Index, SD = Standard deviation

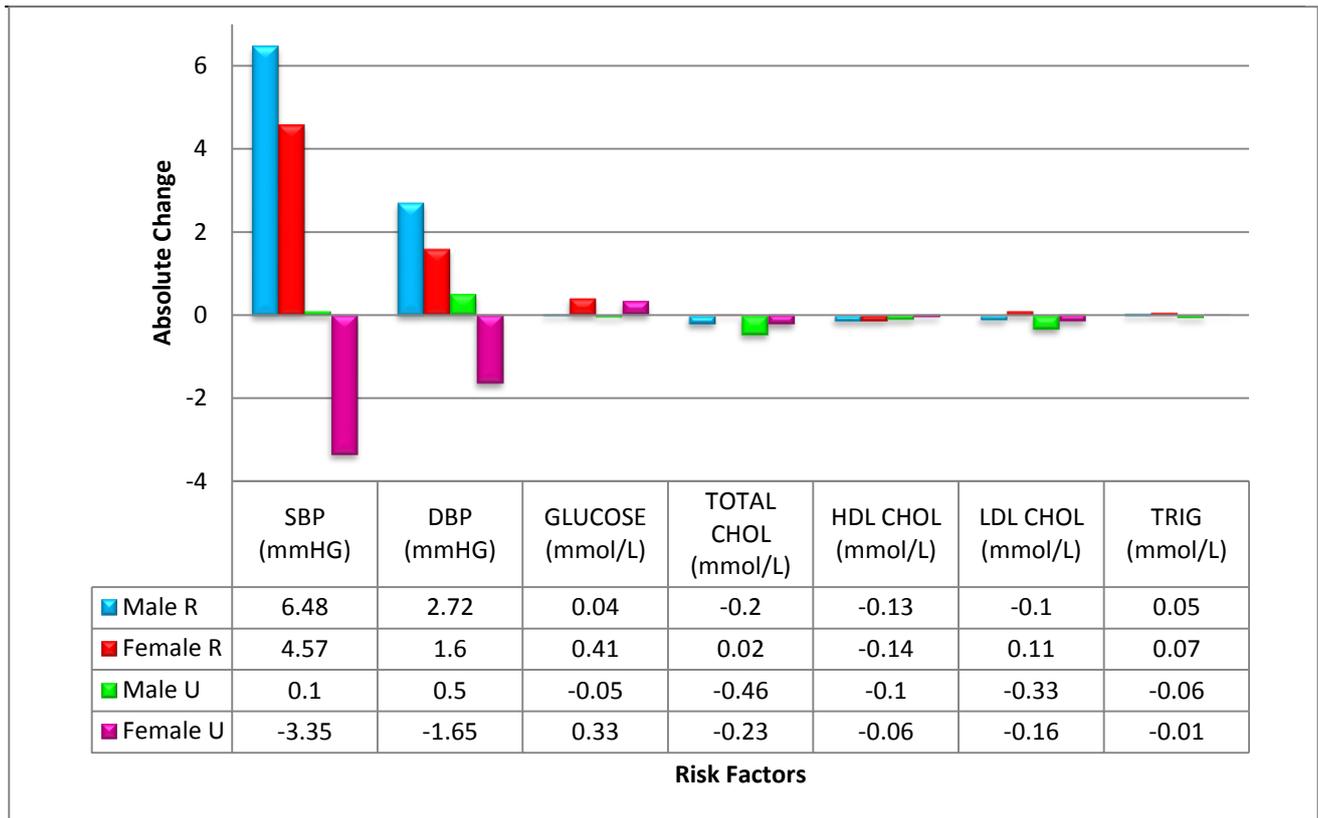


Figure 1: Absolute changes in the biological risk factors from 2005 to 2010

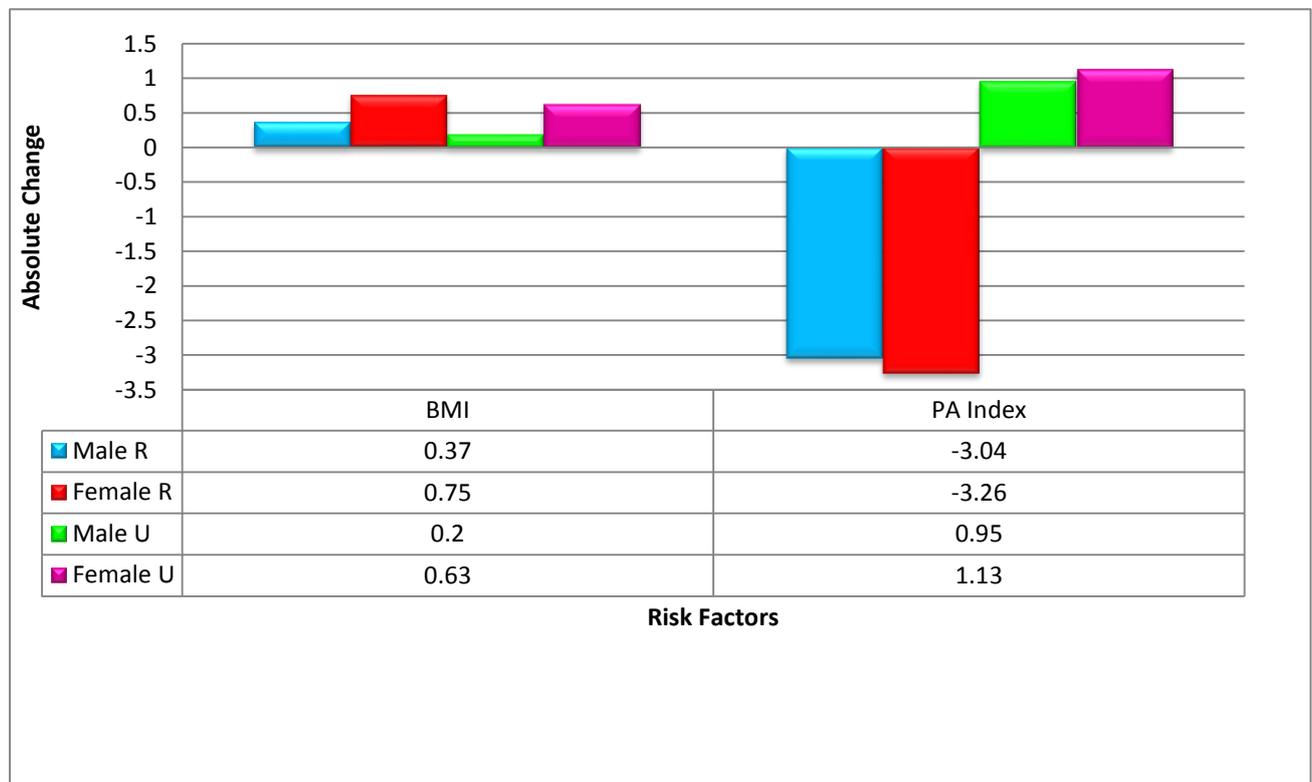


Figure 2: Change in the lifestyle risk factors (BMI & Physical activity) from 2005 to 2010

According to Figure 1 the rural male participants showed a decreased in total cholesterol (-0.2), HDL-cholesterol (-0.13) and LDL-cholesterol (-0.1), while the female rural participants only showed a decreased in HDL-cholesterol from 2005 to 2010. In the urban population the male participants reported a decrease in fasting glucose (-0.05), total cholesterol (-0.46), HDL-cholesterol (-0.1) and LDL-cholesterol (-0.33), where the females showed a decrease in SBP (-3.35), DBP (-1.65), total cholesterol (-0.23), HDL-cholesterol (-0.06), LDL-cholesterol (-0.16) and triglycerides (-0.01) from 2005 to 2010.

In both the male and female population from the rural and urban areas showed an increase in BMI from 2005 to 2010 (Figure 2). Although there was a decrease in the PAI for both the rural male (-3.04) and female (-3.26) participants compared to the increase for both the urban male (0.95) and female (1.13) participants.

Linear regression analyses indicated that a significant inverse relationship was present between PAI and SBP (β -0.96; $p = 0.00$), DBP (β -0.59; $p = 0.00$), total cholesterol (β -0.23; $p = 0.00$), and LDL-cholesterol (β -0.05; $p = 0.00$) (Table 3). The significant contribution of gender to the analyses resulted in the linear regression analyses performed for males and females separately.

Table 3: Relationship between changes in physical activity index (PAI) and changes in risk factors for NCD for all participants

<i>Change in Risk Factors</i>	<i>Changes in Physical Activity Index</i>		
	β	95% CI	<i>p</i>
Model 1 (crude)			
Systolic BP (mmHg)	-0.96	-1.48 - -0.44	0.00
Diastolic BP (mmHg)	-0.59	-0.90 - -0.28	0.00
Fast glucose (mmol/L)	-0.01	-0.05 – 0.04	0.73
Total Chol (mmol/L)	-0.23	-0.06 - -0.01	0.00
HDL Chol (mmol/L)	0.02	0.01 – 0.04	0.001
LDL Chol (mmol/L)	-0.05	-0.08 - -0.03	0.00
Triglycerides (mmol/L)	-0.01	-0.03 – 0.02	0.64
Model 2 (Gender)			
Systolic BP (mmHg)	-0.99	-1.51 - -0.47	0.00
Diastolic BP (mmHg)	-0.60	-0.91 - -0.30	0.00
Fast glucose (mmol/L)	-0.01	-0.05 – 0.04	0.83
Total Chol (mmol/L)	-0.03	-0.06 - -0.003	0.03
HDL Chol (mmol/L)	0.022	0.01 – 0.04	0.001
LDL Chol (mmol/L)	-0.05	-0.07 - -0.03	0.00
Triglycerides (mmol/L)	-0.01	-0.03 – 0.02	0.62
Model 3 (Setting)			
Systolic BP (mmHg)	0.11	-0.62 – 0.83	0.77
Diastolic BP (mmHg)	-0.34	-0.77 – 0.10	0.13
Fast glucose (mmol/L)	0.02	-0.04 – 0.08	0.45
Total Chol (mmol/L)	0.01	-0.05 – 0.03	0.66
HDL Chol (mmol/L)	0.02	-0.004 – 0.033	0.12
LDL Chol (mmol/L)	-0.03	-0.06 – 0.01	0.10
Triglycerides (mmol/L)	0.01	-0.02 – 0.04	0.63
Model 4 (Change in age)			
Systolic BP (mmHg)	-0.96	-1.49 - -0.42	0.00
Diastolic BP (mmHg)	-0.90	-0.90 - -0.28	0.00
Fast glucose (mmol/L)	-0.01	-0.05 – 0.04	0.733
Total Chol (mmol/L)	-0.04	-0.06 - -0.005	0.021
HDL Chol (mmol/L)	0.02	0.01 – 0.03	0.002
LDL Chol (mmol/L)	-0.05	-0.08 - -0.03	0.00
Triglycerides (mmol/L)	-0.005	-0.03 – 0.02	0.622

Model 1 = Crude analysis; Model 2 = Adjusted for gender; Model 3 = Adjusted for setting (rural vs. urban); Model 4 = Adjusted for change in age; Systolic BP = Systolic Blood Pressure, Diastolic BP = Diastolic Blood Pressure, Fast glucose = Fasting glucose, T Chol = Total Cholesterol, HDL-Chol = High Density Lipoprotein Cholesterol, LDL-Chol = Low Density Lipoprotein Cholesterol, Trig = Triglycerides, PA Index = Physical Activity Index, SD = Standard deviation

Results of the gender separated linear regression analyses reported that males had a significant negative relationship between PAI and DPB (β -0.63; p = 0.02). Conversely the females reported a significant negative relationship between PAI and SBP (β -1.05; 0.002), DBP (-0.59; p = 0.003), Total-cholesterol (β -0.05; p = 0.01) and LDL-cholesterol (β -0.07; p = 0.00). PAI was also significantly positive related to HDL-cholesterol for the females (β 0.02; p = 0.002).

Table 4: Regression analyses of changes in physical activity and changes in risk factors for NCDs

<i>Change in Risk Factors</i>	<i>Changes in Physical Activity Index</i>					
	Males			Females		
<i>Model 1</i>	β	<i>95% CI</i>	<i>p</i>	β	<i>95% CI</i>	<i>p</i>
SBP (mmHg)	-0.88	-1.75 – 0.00	0.51	-1.05	-1.70 - -0.40	0.002
DBP (mmHg)	-0.63	-1.15 - -0.11	0.02	-0.59	-0.98 - -0.20	0.003
Glucose (mmol/L)	-0.04	-0.11 – 0.03	0.30	0.02	-0.04 – 0.07	0.58
T- Chol (mmol/L)	-0.01	-0.06 – 0.04	0.75	-0.05	-0.08 - -0.01	0.01
HDL-Chol (mmol/L)	0.02	-0.01 – 0.04	0.14	0.02	0.01 – 0.04	0.002
LDL-Chol (mmol/L)	-0.02	-0.06 – 0.02	0.44	-0.07	-0.10 - -0.04	0.00
Trig (mmol/L)	-0.02	-0.05 – 0.01	0.14	0.01	-0.02 – 0.03	0.71

Systolic BP = Systolic Blood Pressure, Diastolic BP = Diastolic Blood Pressure, Fast glucose = Fasting glucose, T Chol = Total Cholesterol, HDL-Chol = High Density Lipoprotein Cholesterol, LDL-Chol = Low Density Lipoprotein Cholesterol, Trig = Triglycerides, PA Index = Physical Activity Index, SD = Standard deviation

Discussion

The purpose of this study was to investigate the relationship between changes in physical activity and the changes in the risk factors for NCDs from 2005 to 2010 in a black South African population in transition.

Physical activity

Differences were found in the patterns of PA and obesity among rural and urban dwellers from the North West Province between 2005 and 2010. It was noted that while the overall physical activity index (PAI) decreased from 2005 to 2010, PAI in the urban participants increased, while PAI of the rural participants decreased. These findings are in contrast with a study by Unwin and partners [33], who reported a decrease in the PA of urban participants in Dar es Salaam. The difference in the results may be due to Unwin and partners [33] investigating rural to urban migration, and

determining PA with a specifically developed questionnaire for the local context [33]. Another possible reason could be the lifestyles, habits and economic class of the participants in Dar es Salaam compared to South Africa. Since people in rural areas are still faced with illiteracy, the mastering of the questions in the questionnaire would probably differ to questionnaire completed by persons from the urban settings. The differences observed in the PA patterns in this study may be explained by the increase in active commuting in urban areas in order to travel to and from work. In contrast, the decrease in the PA in rural areas may be due to the increase in unemployment in rural areas, together with factors such as improvement of infrastructure, limiting the need to walk to fetch water [39].

Environmental factors that are likely to prevent South Africans from participating in optimal PA include a lack of safety and high crime rates, as well as a lack of green areas and recreation facilities [48; 49]. Perceptions of PA and the role thereof in health may also be a factor, but this has not been investigated in the South African context.

Both the prevalence of risk factors and the changes observed in these risk factors indicate a high rate of obesity, particularly among women, which is consistent with previous international studies [50; 51] and similar to findings from other South African [52; 53; 54], and African studies [55; 56] reporting a significantly higher prevalence of obesity among females compared to males.

The higher prevalence of physical inactivity in females may contribute to the higher prevalence of overweight/obesity compared to males [57; 49]. Furthermore, the view that large body size in African women is traditionally desirable and indicative of success and happiness may also contribute to the high prevalence of overweight/obesity [58; 49]. This high prevalence, especially among women, demonstrates an urgent need to address levels of obesity in the country, which might also help to stem the rising incidence of non-communicable diseases. This study clearly showed the presence of weight increase and this may be due to tremendous urbanisation and socioeconomic development over the last few decades [59]. Furthermore, the fact that people have entered a stage of the nutrition transition defined by levels of over-nutrition and non-communicable diseases might have contributed to the increase in body weight [35].

Biological risk factors

The increase in blood pressure of the rural population for both males and females is in contrast with the findings reported by Unwin and partners [60] who reported a decrease in blood pressure for both men and women. The possible reasons for this could be that the latter study was cross-sectional, while this study was longitudinal. According to Unwin and partners [60] much of the decrease found in blood pressure was the result of the measurements being taken in the participants' own

surroundings, the familiarity of which may have made them less anxious; this then could be another reason for the differences found between the two studies.

Khan and associates [61] conducted a cross-sectional study on rural Nepali women and reported an increase in fasting glucose over a period of two years, which is in line with the findings from this study, particularly in female rural participants. However, although there was an increase in glucose levels, the participants were still within the normal range.

The stability found in total cholesterol may be as a result of a decrease in the HDL-cholesterol and an increase in the LDL-cholesterol which would be an indication of a deteriorating lipid profile. This may be because of aging and the lack of PA which has been directly associated with low HDL-cholesterol concentrations [62].

The urban participants in this study showed a decrease in total cholesterol, which is in contrast with the findings from a Tanzanian study conducted by Unwin and partners [60] which reported the opposite result. These findings are supported by Snehalatha and Ramachandran [51] who also reported that hypertension and dyslipidaemia were more common among urban residents than rural. The differences found in cholesterol could be attributed to the fact that the participants in studies by both Unwin *et al* [60], and Snehalatha and Ramachandran [51] were younger (30 years and 35 years) compared to the participants (50 - 55 years) in this study. Unwin and partners [60] further reported an increase in HDL-cholesterol in both men and women, contradictory to the decrease in HDL cholesterol reported in this study. A possible reason could be the decrease in the PAI reported, as inactivity contributes to an increase in HDL-cholesterol. A plausible explanation for the mixed differences found in lipid levels of participants in this study might be attributed to changes in diet and eating habits which were not assessed in the current study.

In this study, triglycerides for both urban males and female participants decreased as was also found by Unwin and partners [60]. Results from an Indian population [63] however, found that triglyceride levels were significantly higher in the urban population than rural. The reason for the significant higher levels could be that the urban population of the study by De and associates [63] had a much higher alcohol intake and showed results of smoking addiction, whereas in our study a decrease in both smoking and alcohol habits was found.

Life style risk factors

The decrease in smoking and alcohol intake of male and female participants from both rural and urban areas is in contrast with the findings from Peltzer and partners [64], which reported an increase in the use of alcohol in South Africa. They did not however, distinguish between urban and rural respondents and reported data on persons 15 years and older, while the participants in this

study were around 50 years old. The decrease might be as a result of the introduction of tobacco control policies in South Africa, the lack of money, or an awareness that has been created in the community through the continuous involvement of health workers. Although smoking and alcohol intake decreased, the use thereof was still highly prevalent among males, as also reported by Peer and associates [49].

The main findings of the relationship between the changes in the PAI and the risk factors for NCDs revealed a significant inverse relationship for systolic BP, diastolic BP, total cholesterol and LDL-cholesterol. These findings are in line with the findings from Pattyn and associates [65] whose results suggest that dynamic endurance training has a significant lowering effect on blood pressure. In a study conducted by Ferreira de Moraes and partners [66] in Europe and Brazil, PA had a significant effect on systolic and diastolic blood pressure in both genders. This is in contrast with this study as a significant inverse effect on blood pressure was only found in the female population. Reasons for the difference could be that the latter study by Ferreira de Moraes and partners [66] was a cross-sectional study where this study was longitudinal, and further had a smaller sample size compared to Ferreira de Moraes and partners [66] whose sample size consisted of 4 299 participants. Cultural and ethnic differences in lifestyle could also be a reason.

These findings are further supported by a study conducted by Gu and associates [67] in China, who reported that urban women are more physically active than rural women and have a lower prevalence of obesity and hypertension, while urban men are less physically active than rural men and have a higher prevalence of obesity.

The findings from Gu and associates [67] are supported by Millett and partners [68] who reported that people walking or cycling to work were less likely to be overweight or obese than persons traveling by public transport, and that those cycling or walking were less likely to develop hypertension or diabetes. In the population researched in this study, motorised transport was the most prevalent form of commuting.

In general, it has been found that physical activity reduces individual cardiovascular risk by improving blood pressure, plasma triglycerides, blood glucose and low HDL cholesterol levels, as well as the risk of metabolic syndrome in participants with heavy work-related PA levels [69; 70].

The change in the PAI did not result in a significant relationship with the change in the fasting glucose for either the male or the female populations. However, this study found a significant inverse relationship between changes in PAI and changes in total cholesterol and LDL-cholesterol when adjusted for change in age, gender and settings (rural vs. urban). This is supported by Mbalilaki *et al* [62] who found that urban subjects with a significantly and substantially lower PA level reported more unfavourable lipid profiles than their rural counterparts. According to

Mbalilaki *et al* [62] this is probably due to the higher level of daily physical activity among rural individuals working in agriculture or involved in heavy physical activities, while most urban inhabitants have sedentary work and leisure time habits. Our study found that the urban participants had an increase in physical activity, since the participants were mostly performing manual labour and not sedentary jobs.

The major findings of this study is that an increase in the PAI over a five year period in females was related to a significant decrease in the systolic blood pressure, diastolic blood pressure, total cholesterol, and LDL cholesterol, while the HDL-cholesterol increased. This suggests that when daily PA levels decrease over time, the lipid profile of these persons would also become more detrimental to the person, since total cholesterol will increase and HDL-cholesterol will decrease. Together with these changes, particularly in women, even blood pressure will increase during a decrease in PA.

To the best knowledge of the authors this is the first study to investigate the role of changes in PAI on the changes observed in the changes of risk factors for CVD. Interventional studies are required to increase the PA levels in rural areas, particularly in women in order to counter the rise in NCDs, specifically hypertension.

Limitations of the study

Socio-demographic characteristics, such as education, occupation, household size and marital status were not accounted for during this investigation. Future studies should include the prevalence of communicable diseases such as tuberculosis and HIV/AIDs, which have a high prevalence in South Africa and can, influence PA levels due to the physiological demand these conditions place on the body. Where possible, information on physical activity should be gathered with more objective instruments, such as step counters or accelerometers combined with heart rate.

Conclusion

In conclusion, risk factors for NCDs are more prevalent in urban than rural populations of the North West Province, in particular low levels of physical activity. Changes in PA were significantly related to the changes in the risk factors (systolic blood pressure, diastolic blood pressure, total cholesterol, HDL cholesterol and LDL cholesterol) of females. Future studies should include intervention studies aimed at increasing the quantity and intensity of physical activity in order to determine the advantages of PA on risk factors for NCDs in a black South African context.

List of abbreviations

PURE: Prospective Urban to Rural Epidemiological study; BMI: body mass index; BP: blood pressure; NCDs: non-communicable diseases; WHO: World Health Organization; CVD: cardiovascular disease; ISAK: International Society for the Advancement of Kinanthropometry; Fast glucose: fasting glucose; T Chol: total cholesterol; HDL Chol: high density lipoprotein cholesterol; LDL Chol: low density lipoprotein cholesterol; Trig: triglycerides; PA: physical activity; SD: standard deviation; PAI: physical activity index.

Competing interest

The author(s) declare that they have no competing interest.

Authors' contributions

TvN – led the writing; SM – conceived and supervised the study, analysed the data; MM – edited the manuscript assisted with stats and interpretation for critical content; HK – edited the manuscript for critical content; AK – edited the manuscript for critical content. All authors read and approved the final manuscript.

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Author details

¹Physical Activity, Sport and Recreation (PhASRec), Faculty of Health Sciences, North-West University, Potchefstroom, South Africa. ²Centre of Excellence in Nutrition, Faculty of Health Sciences, North-West University, Potchefstroom, South Africa. ³Africa Unit for Trans-disciplinary Health Research (AUTHeR), Faculty of Health Sciences, North-West University, (Potchefstroom Campus), Potchefstroom, South Africa.

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Chapter 6

*Summary, Conclusion, Limitations and
Recommendations*

6 *Summary, Conclusion, Limitations and Recommendations*

6.1 SUMMARY

6.2 CONCLUSION

6.3 LIMITATIONS

6.3 RECOMMENDATIONS

6.1 SUMMARY

Non-communicable diseases (NCDs) in South Africa have become as prevalent as communicable diseases, placing an ever-increasing human and economic burden on South Africans. Knowledge of the factors that play a role in managing NCDs is therefore necessary in order to enable their management. Physical activity is an important modifiable risk factor for NCDs with a positive effect on other life style risk factors of NCDs. Therefore the overarching aim of the study was to investigate the relationship between PA levels and risk factors for NCDs in a black population in transition. In order to reach the aim the following objectives were posed:

- What is the correlation between the adapted Baecke physical activity questionnaire and the IPAQ-Short version?
- What changes in physical activity occurred and how do these changes relate to changes in BMI?
- What is the relationship between changes in physical activity and the changes in the risk factors for NCDs in a South African population?

Chapter One provided a brief introduction and outline of the problem statement which underlies the research questions, objectives and hypotheses that form the basis of this study. This thesis is submitted in article format, as approved by the Senate of the North-West University (Potchefstroom Campus), and therefore includes a literature review (Chapter Two) and three research articles (Chapters Three, Four and Five respectively) which will be presented to accredited peer-reviewed journals.

In order to answer the objectives of this study, recent literature was reviewed in Chapter Two. Chronic non-communicable diseases (NCDs) are medical conditions or diseases which are non-infectious, and they are a major contributor to the burden of disease in developed countries, and increasing rapidly in developing countries. It has been projected that by 2020, NCDs will account for 73% of death and 60% of the disease burden globally. NCDs are the top cause of death worldwide, killing more than 36 million people in 2008, and it is projected that this figure will reach 55 million deaths by 2030.

NCDs are largely due to preventable and modifiable risk factors such as high blood pressure and cholesterol, tobacco smoking, inappropriate use of alcohol, overweight and obesity, and physical inactivity; all health factors which need to be properly managed.

There is an extensive body of empirical evidence which demonstrates the physical and psychological health benefits of physical activity (PA). Studies showed that increased physical activity is associated with a lower waist-to-hip ratio and a higher HDL-cholesterol, and that it is inversely associated with body mass index (BMI) and percentage body fat. Physical activity is also associated with lower mortality rates, a decreased risk of cardiovascular disease mortality in general and coronary heart disease in particular.

As communities become more urbanised, physical activity has declined due to (amongst other things) sedentary employment, limited outdoor space and high rates of street violence. Physical inactivity is the fourth leading risk factor for global death, after high blood pressure, smoking and high blood glucose. In South Africa an overall of 17 037 deaths in 2000 were attributed to physical inactivity.

Assessing physical activity is very important for epidemiological studies in order to examine the relationship between inactivity and/or activity, and the development of NCDs. Developing accurate and reliable tools for quantifying physical activity behaviour continues to be a research priority. A wide range of methods has been used to quantify physical activity behaviour. These methods include subjective measures, such as child and parent self-report questionnaires, and objective measures such as doubly labelled water, heart rate and accelerometry combined (ActiHeart®), accelerometers and pedometers. Both subjective and objective assessment tools have advantages and disadvantages depending on the population being studied and the research question being investigated. In this study it was aimed to contribute to this knowledge base. In research studies

(THUSA) in the North West Province it was found that the adapted Baecke questionnaire to assess PA the results correlated significantly with the IPAQ. Since the IPAQ is the internationally accepted standard questionnaire, it was important to correlate the two questionnaires.

The major determinants of the increasing burden of NCDs are globalisation, urbanisation and economic liberalization. Rapid urbanization is accompanied by unhealthy dietary practices, sedentary lifestyles and obesity, all of which are major risk factors of NCDs. All these risk factors are related to lifestyle and are influenced when changing from a rural to an urban lifestyle.

South Africa is currently experiencing rapid urbanisation, especially of Africans leaving underdeveloped rural areas to seek a better lifestyle in and around cities. Urbanisation in South Africa has led to a significant increase in diseases of lifestyle, like hypertension, diabetes, high cholesterol and cardiovascular diseases. In the context of globalization, the rapid urbanisation in South Africa, accompanied by large shifts in the health patterns of South Africans, is increasing the prevalence of non-communicable diseases.

South Africa is experiencing rapid transition. Vorster and partners (2011:429-441) asked the question whether this transition can be steered in a positive way to avoid the health problems experienced by developed countries. It is concluded that it is possible to steer the nutrition transition into a more positive direction, provided that some basic principles in planning public health promotion strategies, policies and interventions are followed.

In summary, from literature it is clear that PA is acknowledge as a modifier of risk factors for NCDs. However, information on changes in PA levels over time in a black community in transition is limited. Also the need to know which questionnaire to use for reliable PA data in an illiterate community was identified. Since Baecke has been used in studies from the North West Province, instead of the IPAQ it was important to determine correlation.

The results of this study were presented in three research papers.

In chapter three, the research article entitled “Correlation between Baecke physical activity questionnaire and IPAQ-S in a black South African population” by Van Niekerk, T., Moss, S.J., Monyeki, M.A., Kruger, H.S. and Kruger, A. will be presented for publication in the South African journal for research in sport, physical education and recreation. The main purpose of this study was

to determine the relationship between the adapted Baecke physical activity questionnaire and the IPAQ-S in a black South African population.

The second article (chapter four) entitled “Changes in physical activity of a black South African population in transition: The PURE-study” by Van Niekerk, T., Moss, S.J., Monyeki, M.A., Kruger, H.S. and Kruger, A. has been submitted to the South African journal of sports medicine. The aim of this study was to determine the changes in physical activity and how the changes relate to changes in BMI among a black South African population in transition from 2005 to 2010.

The third article (chapter five) entitled “The relationship between changes in physical activity and change in risk factors for cardiovascular disease in a black South African population: The PURE-study” by Van Niekerk, T., Moss, S.J., Monyeki, M.A., Kruger, H.S. and Kruger, A. will be presented for publication in the Journal of Behavioural Nutrition and Physical Activity. The aim of this study was to investigate the relationship between the changes in physical activity and the changes in the risk factors for NCDs in a black South African population in transition.

All manuscripts in this thesis have been written according to the referencing requirement of the journals to which they will be submitted. The font and spacing in this thesis has however been kept the same throughout the thesis. For examination purposes all figures and tables are presented within the text rather than at the end of the article.

6.2 CONCLUSION

The conclusions that are drawn from this research are presented in accordance with the set aims from the research articles and by testing the hypotheses (Chapter One) that were set for this study:

Objective 1: To determine the relationship between the adapted Baecke physical activity questionnaire and the IPAQ-S in a black South African population.

HYPOTHESIS 1: There is a non-significant positive relationship between the adapted Baecke physical activity questionnaire and the IPAQ-S in a black South African population.

CHAPTER 6

The relationship between the PAI as determined with the adapted Baecke physical activity questionnaire and the IPAQ-S were found to be significantly related (Spearman $r = 0.243$; $p = 0.00$) when adjusted for age and BMI.

In conclusion, although the correlation between the adapted Baecke and IPAQ is weak, it was statistically significant, which makes both questionnaires valid tools to use in the South African black community.

Hypothesis 1 is therefore *rejected*.

Objective 2: To determine changes in physical activity (PA) and how the changes in PA relate to changes in BMI among a black South African population in transition.

HYPOTHESIS 2: The PA will decrease significantly from 2005 to 2010 and the changes in PA are significantly inversely related to the changes in BMI in a black South African population in transition.

Physical activity index of the participants showed an overall decrease from 2005 to 2010 (7.3 ± 1.9 to 6.5 ± 1.9). In spite of this overall decrease, the physical activity index in the urban participants increased from 6.4 ± 1.8 to 7.5 ± 1.4 , while in the rural participants, the PAI decreased from 8.2 ± 1.5 to 5.1 ± 1.5 . Change in BMI was significantly inverse associated with change in PAI for the urban population ($\beta = -0.10$; $p = 0.004$) after adjusting for gender, change in age and settings (rural/urban).

In conclusion the overall physical activity levels decreased in this black South African population from 2005 to 2010, while the BMI in the women participants increased. The increase in BMI was related to the decrease in PAI, particularly in rural women.

Hypothesis 2 is therefore *partially accepted*

Objective 3: To determine the relationship between changes in physical activity and changes in the risk factors for NCDs in a black South African population in transition.

HYPOTHESIS 3: There is a significantly inverse relationship between changes in physical activity and the changes in the risk factors for NCDs from 2005 to 2010 in a black South African population in transition.

Significant differences were found for age, weight and BMI in the participants from 2005 when rural participants were compared to their urban counterparts. Rural women gained an average of three kilograms in the five years, compared to the average one kilogram weight gain for urban women.

The rural and urban participants differed significantly with regard to the determined risk factors for NCDs that included resting systolic blood pressure (mmHg) (129.72 ± 23.30 ; 137.33 ± 25.14 ; p 0.00), diastolic blood pressure (mmHg) (86.16 ± 14.48 ; 89.28 ± 14.46 ; p 0.00), fasting glucose (mmol/L) (4.88 ± 1.23 ; 5.10 ± 1.86 ; p 0.01), triglycerides (mmol/L) (1.21 ± 0.64 ; 1.38 ± 0.92 ; p 0.00), and PAI (8.21 ± 1.48 ; 6.40 ± 1.84 ; p 0.00) in 2005.

There were increases in serum HDL and LDL-cholesterol from 2005 to 2010 (HDL: 1.52 ± 0.63 – 1.42 ± 0.59 and LDL: 2.90 ± 1.18 – 2.88 ± 1.12). Although overall the PAI decreased from 2005 (7.30 ± 1.90) to 2010 (6.46 ± 1.85), it was increased in urban participants (6.40 ± 1.84 – 7.50 ± 1.40), but decreased in rural participants (8.21 ± 1.48 – 5.10 ± 1.54). A significant negative relationship between changes in PAI and changes in blood pressure (systolic and diastolic), total cholesterol and LDL-cholesterol was found and a significant positive relationship between changes in PAI and HDL-cholesterol was found when adjusted for gender and changes in age.

When changes in PA and changes in risk factors were split according to gender, a significant negative relationship was found for diastolic blood pressure (β -0.63; p 0.02) in the male population and a significant negative relationship for females in systolic blood pressure (β -1.05; p 0.002), diastolic blood pressure (β -0.59; p 0.003), total cholesterol (β -0.05; p 0.01), and LDL cholesterol (β -0.07; p 0.00), with a significant positive relationship for HDL-cholesterol (β 0.02; p 0.002).

Biological risk factors for NCDs increased from 2005 to 2010 in this black South African population in transition. The increased changes observed in the risk factors, namely, systolic blood pressure, diastolic blood pressure, total cholesterol and LDL-cholesterol were related to the decrease in the physical activity levels.

Hypothesis 3 is therefore *accepted*.

To conclude, the findings in the presented study show that in a black South African population both the Baecke and IPAQ-S physical activity questionnaire can be used to determine the level of physical activity within the black South African context. The correlation reported was significant, but very low. The findings from this study are supported by the same weak correlation between the Baecke and IPAQ-S questionnaires that was found in a European population. The questionnaires are based on different constructs to recall physical activity, which make it difficult to compare findings. In South Africa the Baecke have been used in the majority of studies that recorded physical activity in the North West Province. Researchers from the Western Cape have applied the IPAQ-S questionnaire in the majority of the research. The IPAQ-S asks the participant to recall time spent in the different activities while the Baecke questionnaire recall physical activity based on work, commute, sport, stairs and leisure. The Baecke therefore report on the type of activities involved in during engaging with physical activity. Although the relationship between Baecke and IPAQ-S is significant, the questions in IPAQ-S that asks the participant to recall time, instead of types of activity, poses a problem for the majority of South Africans.

There is debate regarding how best to define and measure the types and levels of physical activity which can help protect against risk factors for NCDs. Self-report using a questionnaire such as the Baecke or IPAQ is a commonly used measurement method, but it has been shown that this measures something quite different from the more objective methods such as an accelerometer. Instruments such as IPAQ appear to result in over and under reporting physical activity. It is important to find a measurement that is ideal for the population being measured, that they understand and interpret it correctly so that correct results can be obtained. The findings from this study indicate that although the relationship is statistically present, the Baecke questionnaire should be considered as the subjective questionnaire of choice, since an understanding of the sedentary behaviour that IPAQ-S report on can also be determined, as well as information on commute, sport and leisure activities are reported with Baecke. The implementation of objective determined

physical activity levels is however needed for the South African population before the advantages of regular physical activity can truly be understood.

Knowledge of the true levels of physical activity would be of importance in the fight against the risk factors for NCDs. The most prevalent risk factors for NCDs in South Africa are obesity and hypertension. Obesity has reached epidemic proportions globally. The prevalence rate of obesity is a problem in both the developed and developing world and affects people regardless of gender across the whole life spectrum and is influenced by the lifestyle, environment and socio-economic status of an individual or population. Across the world overweight and obesity is combated through the introduction of physical activity in combination with nutritional interventions.

When overall physical activity levels were examined over a period of five years in this presented study, a decrease was found in this black South African population investigated. The results showed that the BMI of the women increased over this period of time while the physical activity of the women from rural area specifically decreased. This is in contrast with what we found in the literature, where it has been well documented that people living in rural areas had much higher levels of activity and a lower risk of obesity. Although there was an overall decrease in physical activity the urban population showed an increase in physical activity while the rural participants showed a decrease. The differences that were found could be explained by the lack of work in the rural areas, while the urban areas presented with more opportunity to be involved in a job with related physical activity. The recent improvement in infrastructure in the rural areas, such as tap water and sanitation, may have also resulted in the decrease in physical activity in the rural areas, since the population do not need to walk for water. Motorised transport is also more readily available in the rural areas for commuting, which may be a reason for the reduction in the physical activity.

The significant relationship between the increase in BMI and decrease in physical activity might also be explained by the view that big body size in African women is traditionally desirable and indicative of success and happiness. The change in dietary intake may have assisted in the increase in body size as determined with BMI. The increased BMI on the other hand resulted in the women in particular to be less active, since persons with larger BMI find it more difficult to be physically active. The majority of the population appears to have adopted less active lifestyles as the use of motorised transport, employment of mechanised equipment to perform occupational and domestic tasks, and time spent watching television and using computers have increased. The less active

lifestyle is supported by what we found that the PA levels in rural and urban settings of the North West Province declined over a period of 5 years, while the BMI of the participants increased significantly.

The decrease in physical activity in general, combined with the increase in BMI are to variables that are part of the risk factors for non-communicable diseases, also known as chronic diseases of lifestyle or silent killers, and are defined as diseases of long duration and slow progression. The group of illnesses that share similar risk factors as a result of exposure, over many decades to unhealthy diets, smoking, lack of regular exercise, and possibly stress, classified as NCDs, impact substantially globally and in South Africa particularly due to urbanisation. The risk factors for NCDs include overweight and obesity, dislipidemia, hyperglycemia, hypertension, inactivity, smoking habit and alcohol consumption.

The present study indicate that an increase in the biological risk factors for NCDs from 2005 to 2010 in this black South African population, and that this increase in the risk factors was related to the changes observed in the change of their physical activity levels. Rural and urban participants differed significantly with regard to resting systolic and diastolic blood pressure, fasting glucose, triglycerides and PAI. Possible reasons for the differences found could be due to different lifestyles, habits and economic class of the different populations. Diverse eating habits from the rural and urban population may also be a reason for the differences found, as urban populations are more likely to consume unhealthy diets rich in processed foods comprising cholesterol ‘unfriendly’ unsaturated fats and salts. The increase in blood pressure of the rural population for both males and females are in contrast with the findings reported in the literature. This could be due to the decrease reported in their physical activity levels and the increase in their BMI. The increase reported in fasting glucose for the rural participants are supported with the literature, this could be supported by the increase in their BMI. The urban participants in this study showed a decrease in serum total cholesterol which is in contrast with the findings from the literature, but could be supported with the decrease in their BMI and increase in their physical activity levels reported. This study reported a decrease in serum triglycerides in both urban males and female participants which could be due to the decrease in both smoking and alcohol habits reported.

The decrease in physical activity may be due to unemployment of the rural participants as with work becoming more computerized and machine-orientated, so there are less work opportunities for the participants. A decrease in PAI inactively contributes to an increase in HDL, which was found

in the results. Cultural and ethnic differences in lifestyle are also a possible reason for the differences found. The urban participants reported an increase in PA, and that could be why they reported a decrease in blood pressure, fasting glucose, total cholesterol and triglycerides. This is supported by what is reported in the literature.

The presented study in conclusion indicate that physical activity questionnaires are not ideal to measure physical activity in a South African population, although questionnaires are recommended for large populations. The IPAQ-S is recommended internationally but is difficult to use in South Africa because of the lack of good time perception. In South Africa the adapted Baecke questionnaire is used, because different domains can be determined and it is less time consuming. With the Baecke questionnaire the influence of the different domains influencing physical activity can be determined. The general decrease in PA and consequent increase in NCDs in the rural and urban population, support the findings from research performed in other Western Countries. In South Africa the decrease in physical activity affects the female population most regarding an increased in BMI as well as an increase in the risk factors for NCDs. The indicated increase in BMI over a five-year period was related to the decrease observed in the physical activity levels. The decreased levels of physical activity on the other hand were significantly related to the increase in systolic and diastolic blood pressure. South Africans should be made aware of the benefits of physical activity and by increasing the quantity and intensity of physical activity the health outcomes will improve through a lowering of risk factors of NCDs.

The results on serum risk factors, BMI and PA that become more favourable in urban setup than rural from this study may be used as evidence for the possibility to steer urbanisation into more health people.

CONTRIBUTION OF THE THESIS

The research performed for the thesis; contribute the following new knowledge to the current body of knowledge in the literature.

- The relationships between Baecke and IPAQ-S questionnaires have not previously been investigated in a South African population. The presented study found a significant but low correlation between the two questionnaires for a black South African population. Validity studies between physical activities determined with questionnaires and objective measurements of physical activity are needed in South Africa.
- Changes in the physical activity levels of black South Africans of rural and urban areas over a period of 5 years have not been investigated to the knowledge of the author. The present study is the first to prove that PA in rural areas is decreasing and the increase in BMI is contributing to the decrease. Future studies should investigate the reasons for the changes in PA in rural areas in order to implement strategies to prevent further decrease in physical activity or rural dwellers.
- The present study is the first study to observe that the changes in physical activity is significantly related to the increase in the systolic and diastolic blood pressure observed in this population over a 5-year period.

6.3 LIMITATIONS

There are several limitations of this study that may have influenced the outcomes:

- 6.3.1 Physical activity was not determined by means of an objective instrument of measure.
- 6.3.2 The knowledge and perceptions of physical activity and risk factors for NCDs are not known for this population and could have influenced the answers to the questionnaire-based physical activity measurements.
- 6.3.4 Questionnaire-based physical activity data are known to present a bias toward over reporting physical activity levels. The use of questionnaire-based physical activity measurements can be considered a limitation of this study.

6.4 RECOMMENDATIONS

The results of and subsequent recommendations made in this thesis will be disseminated to health professionals through publications in peer-reviewed research journals, to wit, the South African Journal of Research in Sport, Physical Education and Recreation, the South African Journal of Sports Medicine, and the Journal of Behavioural Nutrition and Physical Activity.

The following recommendations are proposed for future research:

- 6.4.1 In the future physical activity should be determined by more objective measurements in order to prevent biases in the reporting thereof.
- 6.4.2 Patients should be clearly educated about risk factors for NCDs and the definition of physical activity prior to completing questionnaires.
- 6.4.3 The level of agreement between the IPAQ-S and the objective ActiHeart measurements for activity energy expenditure should be determined for a South African population in order to collect more reliable data on physical activity.
- 6.4.4 Randomized controlled trials of exercise on blood pressure in community settings

The findings from this study contribute to the current body of knowledge in that currently changes in physical activity have not been tracked in South Africans in transition in such a large sample size as in this study. This knowledge contributes to the understanding of the relationship between changes in PA and the changes in the risk factors for NCDs. Once these relationships are known, the implementation of appropriate intervention programs should be performed. The changes related to a structured exercise intervention on the outcome of the risk factors for NCDs will direct the appropriateness of implementing intervention programs in impoverished communities.

Future research should therefore focus on the barriers to physical activity, knowledge and perceptions of communities in transition about physical activity and risk factors for NCDs.

Appendices

Appendix A Guidelines for Authors

Appendix B Informed consent

Appendix C Questionnaires

Appendix D Language editing

Appendix A

Guidelines for Authors

- South African Journal of Research in Sport, Physical Education and Recreation
- The South African Journal of Sports Medicine
- Journal of Behavioral Nutrition and Physical Activity

South African Journal of Research in Sport, Physical Education and Recreation

The *South African Journal for Research in Sport, Physical Education and Recreation* is published by Stellenbosch University. Contributions from the fields of Sport Science, Physical Education, Recreation/Leisure Studies, Exercise Science and Dance Studies will be considered for publication. The articles submitted will be administered by the appropriate Subject Review Editor and evaluated by two or more referees. The decision as to whether a particular article is to be published or not, rests with the Editorial Board.

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<i>Top:</i>	3.56
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<i>Gutter:</i>	0.0

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Authors are also requested to name three (3) potential referees, of which one (1) **must** be an international referee (the journal is not bound to use these referees). Complete information regarding the referees (name, surname, e-mail address and telephone numbers) must be provided in the cover letter.

We discourage the practice of parts of one study in different journals. Authors who submit a manuscript from a study of which some data has been or will be published elsewhere, must provide a strong justification in an accompanying letter to the Editor. The justification for not publishing all the data together in one paper must also be motivated in the covering letter.

Should the article be taken from a master's thesis or doctoral dissertation, academic ethic requires that the student will be the first author.

The author should also ensure that the ***LANGUAGE*** of the manuscript has been thoroughly edited at the time of submission (English [UK]). The name, address and telephone number of the person who has done the language editing must be provided. Any expenses incurred by the journal dealing with language editing will be added to the author's page fees.

The manuscript must have an ***ETHICAL CLEARANCE NUMBER*** that was supplied by authentic ethical committee of a specific institution. The process that was followed to obtain ethical clearance must be described in the manuscript under the heading **Ethical clearance**. No manuscript can be published without this declaration.

Any uncertainty regarding the **STATISTICAL PROCEDURES** that arise during the assessment of the manuscript will be referred to a local statistician. Any expenses incurred by the journal dealing with statistical procedures will be added to the author's page fees.

PREPARATION OF MANUSCRIPT

Manuscripts must be presented in a format that is compatible with *Microsoft Word for Windows (PC)*. Tables, all figures (illustrations, diagrams, etc.) and graphs are also regarded as text and must be presented in a format that is compatible with *Word*. Photographs must be presented in *jpg* format.

Original manuscripts must contain the following sections in the following sequence: Title page, Abstract, Introduction, Methodology, Results, Discussion, Practical application, Conclusions, Acknowledgements and References.

Title page

The first page of each manuscript should indicate the *title* in English and Afrikaans (will be translated for foreign authors), the *names (title, first name in full and other initials, surname)* of the author(s), the *telephone numbers (work & home [Mobile – for local authors]), facsimile number, e-mail address (if available) and the field of study*. The **complete mailing address** of the first named author and the institution where the work was conducted should be provided in full. When more than one author and/or authors from various departments are involved the **'author(s)** must be numbered according to their **'department(s)**. If any of the above-mentioned information should change during the review process, please inform the subject editor. A **short title**, of not more than **45 characters** including the spaces, should be provided for use as a running head.

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Each manuscript must be accompanied by an abstract of approximately 150-200 words in *English* and should be set on a *separate page* as a **SINGLE** paragraph (one and a half spacing). A list of three to seven **key words** in *English* is required for indexing purposes and should be typed below the abstract. Articles in Afrikaans must include an **additional** extended summary (500-1000 words) in English. This summary must start on a new page (just before the reference list) and also provide the English title of the article at the beginning.

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Start the text on a new page with the title of the article (centered and *without* the names of the authors). Follow the style of the most recent issue of the journal regarding the use of headings and subheadings. Use only **one space** after a paragraph. Only make use of *section breaks* and not *page breaks*.

Tables and figures

Tables and figures should be numbered in *Arabic* numerals (1, 2, etc.). Tables require the heading at the *top* while figures a legend *below* and both separate from the table/figure. **Note:** Use the decimal POINT (**not** the decimal comma). The site where the table or figure must be placed in the text must be indicated clearly in the manuscript. *Tables and figures are placed after the reference list with each on a separate page.*

References

In the *text* the Harvard method must be adopted by providing the author's surname and the date placed in parentheses. *For example:* Daly (1970); King and Loathes (1985); (Botha & Sonn, 2002); McGuines *et al.* (1986) or (Daly, 1970:80) when Daly is not part of the sentence. More than one reference must be arranged **chronologically** (Daly, 1970; King & Loathes, 1985). Note that *et al.* (italics) is used in the body of the text when there are **more than two authors**, but never in the list of references.

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Only the references cited in the text should be listed alphabetically according to surname (last name) of authors (capitals) after the body of text under the heading, **References** (capitals) starting on a new page. In the case where the TITLE of an article, book, etc., is in any other language than English, the author must also provide an English translation of the title in parentheses.

In the case of articles published in **JOURNALS**, references listed should include the surnames and initials (capitals) of all authors, the date of the publication in parentheses, the full title of the article, the full title of the journal (italics), the volume number, the serial number in parentheses (omitted **only** if the said journal does not use issue numbers), followed by a colon and a space with the first and last page numbers separated by a hyphen.

Example:

VAN WYK, G.J. & AMOORE, J.N. (1995). A practical solution for calculating instantaneous values of tension in the extensor muscles of the knee joint during extension and flexion. *South African Journal for Research in Sport, Physical Education and Recreation*, 18(1): 77-97.

If the reference is a **BOOK**, the surname (last name) and initials of the author or editor (Ed.) must be given, followed by the date of publication in parentheses, the title of the book (italics) as given on the title page, the number of the edition (ed.) in parentheses, the city (and abbreviation for the state in the case of the USA OR the country [in curved parentheses]) where published, followed by a colon, a space and the name of the publisher.

Example:

JEWETT, A.E.; BAIN, L.L. & ENNIS, C.E. (1995). *The curriculum process in Physical Education* (2nd ed.). Madison, WI: WCB Brown & Benchmark.

For a **CHAPTER** from a book, the page numbers of the chapter cited must be provided in parentheses (not italics) after the title of the book. For further details, authors should consult the most recent publication of this Journal for other examples.

Example:

DE RIDDER, J.H. (1999). Kinanthropometry in exercise and sport. In L.O. Amusa, A.L. Toriola, I.U. Onyewadume (Eds.), *Physical Education and sport in Africa* (235-263). Ibadan (Nigeria): LAP Publications.

If the reference is a **THESIS** (master's level) or **DISSERTATION** (doctoral level), italics is **not** used in the title as it is an unpublished work.

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CRAVEN, D.H. (1978). The evolution of major games. Unpublished PhD dissertation. Stellenbosch: Stellenbosch University.

For **ELECTRONIC SOURCES**, all references start with the same information that would be provided for a printed source (if available). The web page information follows the reference. It will

usually contain the name of the author(s) (if known), year of publication or last revision, title of complete work in inverted commas, title of web page in italics, Uniform Resource Locator (URL) or access path in text brackets (do not end the path statement with a full stop) and date of access. See "*How to cite information from the Internet and the Worldwide Web*" at <http://www.apa.org/journals/webref.html> for specific examples. When citing a web site in the text, merely give the author and date (in this case: Ackermann, 1996).

Example of Web Page:

ACKERMANN, E. (1996). "Writing your own Web Pages. "*Creating Web Pages*. [<http://www.mwc.edu/ernie/writeweb/writeweb.html>]. Retrieved on 22 October 1999.

When referencing an article in a **NEWSPAPER** the key word of the newspaper is typed in capitals, as this is how **it will appear in the alphabetical references**, namely *The CAPE ARGUS* will appear under "C" or *Die BURGER* will appear under "B".

Example:

CAPE ARGUS (The) (1980). 10 January, p.4.

INTERVIEWS

Example:

POTGIETER, J.R. (2003). Personal interview with the Chairperson of the Department of Sport Science. 31 January. Stellenbosch: Stellenbosch University.

CORRESPONDENCE

Example:

POTGIETER, J.J.J. (2003). Personal correspondence of the Director of the Sport Bureau, 5 February. Stellenbosch: Stellenbosch University.

CONGRESS PROCEEDINGS

Example:

RENSON, R. (Ed.) (1976). *The history, the evolution and diffusion of sport and games in different cultures*. Proceedings of the 4th International HISPA Congress, Leuven, Belgium, 1-5 April 1975. Brussels (Belgium):

When referring to a paper presented in the above-mentioned proceedings, it must be presented as follows:

REES, R. (1976). Organization of sport in nineteenth century Liverpool. In R. Renson (Ed.), *The history, the evolution and diffusion of sport and games in different cultures* (237-247). Proceedings of the 4th International HISPA Congress, Leuven, Belgium, 1-5 April 1975. Brussels (Belgium): B.L.O.S.O.

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If authors honor the rules and specifications for the submission of manuscripts, unnecessary delays would be avoided. A manuscript that does not meet the requirements, as set out above, will be returned to the author without being evaluated. Requesting copying right concerning figures or photographs is the responsibility of the authors and should be indicated.

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The South African Journal of Sports Medicine

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References to ethnic classification must indicate the rationale for this.

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Shorter items are more likely to be accepted for publication, owing to space constraints and reader preferences.

Original articles not exceeding 3 000 words, with up to 6 tables or illustrations are usually observations or research of relevance to sports medicine and exercise science. References should be limited to 15. Please provide a structured abstract not exceeding 250 words, with the following recommended headings: Background, Objectives, Methods, Results, and Conclusion.

Short reports, Commentaries or Case Studies, should be 1500 words or less, with 1 table or illustration and no more than 6 references. Please provide an accompanying abstract not exceeding 150 words.

Editorials, Opinions, etc. should be about 1000 words and are welcome, but unless invited, will be subjected to the SAJSM peer review process.

Review articles are rarely accepted unless invited.

Letters to the editor, for publication, should be about 400 words with only one illustration or table, and must include a correspondence address.

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Book references:

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Journal of Behavioural Nutrition and Physical Activity

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IJBNPA will not edit submitted manuscripts for style or language; reviewers may advise rejection of a manuscript if it is compromised by grammatical errors. Authors are advised to write clearly and simply, and to have their article checked by colleagues before submission. In-house copyediting will be minimal. Non-native speakers of English may choose to make use of a copyediting service.

Help and advice on scientific writing

The abstract is one of the most important parts of a manuscript. For guidance, please visit our page on [Writing titles and abstracts for scientific articles](#).

Tim Albert has produced for BioMed Central a [list of tips](#) for writing a scientific manuscript. [American Scientist](#) also provides a list of resources for science writing. For more detailed guidance on preparing a manuscript and writing in English, please visit the [BioMed Central author academy](#).

Abbreviations

Abbreviations should be used as sparingly as possible. They should be defined when first used and a list of abbreviations can be provided following the main manuscript text.

Typography

Please use double line spacing.

- Type the text unjustified, without hyphenating words at line breaks.
- Use hard returns only to end headings and paragraphs, not to rearrange lines.
- Capitalize only the first word, and proper nouns, in the title.
- All lines and pages should be numbered. Authors are asked to ensure that line numbering is included in the main text file of their manuscript at the time of submission to facilitate peer-review. Once a manuscript has been accepted, line numbering should be removed from the manuscript before publication. For authors submitting their manuscript in Microsoft Word please do not insert page breaks in your manuscript to ensure page numbering is consistent

between your text file and the PDF generated from your submission and used in the review process.

- Use the *IJBNPA* reference format.
- Footnotes are not allowed, but endnotes are permitted.
- Please do not format the text in multiple columns.
- Greek and other special characters may be included. If you are unable to reproduce a particular special character, please type out the name of the symbol in full. **Please ensure that all special characters used are embedded in the text, otherwise they will be lost during conversion to PDF.**

Units

SI units should be used throughout (liter and molar are permitted, however).

Appendix B

- Informed consent
- Check list

Informed Consent



YUNIBESITHI YA BOKONE-BOPHIRIMA
NORTH WEST UNIVERSITY
NOORDWES UNIVERSITEIT

POTCHEFSTROOM CAMPUS

INFORMED CONSENT FORM

PURE-SA PROJECT
PURE-PROJECT (PROSPECTIVE URBAN AND RURAL EPIDEMIOLOGY)

INFORMED CONSENT

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. I indemnify the University, also any
employee or student of the University, of any liability against myself, which may arise during the
course of the project.

I will not submit any claims against the University regarding personal detrimental effects due to
the project, due to negligence by the University, its employees or students, or any other
subjects.

I agree to be tested for HIV :

YES

NO

I want to know my HIV-status:

YES

NO

I agree to give a blood sample

YES

NO

(The HIV testing and other measurements will only be done during September-December 2005.
You have the right to change your mind and at that time you will be asked to sign an inform
consent again on HIV testing)

.....
(Signature of the subject)

Signed at on

PART 2

To the subject signing the consent:

You are invited to participate in a research project. It is important that you read/listen to and understand the following general principles, which apply to all participants in our research project:

1. Participation in this project is voluntary.
2. It is possible that you personally will not derive any benefit from participation in this project, although the knowledge obtained from the results may be beneficial to other people.
3. You will be free to withdraw from the project at any stage without having to explain the reasons for your withdrawal. However, we would like to request that you would rather not withdraw without a thorough consideration of your decision, since it may have an effect on the statistical reliability of the results of the project.
4. The nature of the project, possible risk factors, factors which may cause discomfort, the expected benefits to the subjects and the known and the most probable permanent consequences which may follow from your participation in this project, are discussed in Part 1 of this document.
5. We encourage you to ask questions at any stage about the project and procedures to the project leader or the personnel, who will readily give more information. They will discuss all procedures with you.
6. The University staff will use standardised procedures and take all possible precaution to protect the subject from risks. 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.
8. 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.
9. All information will be kept CONFIDENTIAL.
10. The blood samples and other measurements will only be done between September and December 2005 an appointment with yourself.

INFORMATION TO COMMUNITIES

Dear Participant

Thank you for being willing to help us in this very important project. We are sure that the project will contribute to improve health of all the people of the North West Province.

The aim of the project is to get enough information regarding the development of chronic diseases like Diabetes, Stroke, Lung disease and heart disease with urbanisation to plan appropriate health and nutrition intervention strategies.

For this study we need 2 000 subjects whom we can follow for 12 years. The baseline survey will be done from April 2005 to November 2005. The subjects must be from rural as well as urban communities. Therefore, 500 subjects from 4 different levels of urbanisation will be needed. Ganyesa and Tlaskgameng were chosen for the rural and semi-rural areas because they are still under tribal law with a good infrastructure and stability. Chief M. Letlhogile and the mayor Mr E. Tladinyane are informed about the study. Ikageng and the Informal Ikageng were chosen as it is convenient and near the University. Cllr GG Megalanyane and Cllr Mahesh Roopa are informed about the study.

You are one of the 2000 people (250 men and 250 women from all four sites (Ganyesa, Tlaskgameng, Ikageng, and the Informal Ikageng) that are selected from the previous questionnaires to be asked to proceed with the study. You should be

- Older than 35 years
- Healthy – which means that they must not be aware of any disease and do not take any chronic medication

You will be asked to participate voluntarily and to fill out the adult questionnaire, the food frequency questionnaire, the health questionnaire and the physical activity questionnaire. We will also make an appointment with you to take some measurements such as weight, height, skinfold thickness, ECG (test for heart abnormalities), lung functions, blood pressure, blood glucose, blood samples and a urine sample. You should understand that participation is voluntarily.

It is very important that we gather quality data and knowledge. Because HIV/AIDS is such a devastating illness and affects almost all aspects of health, it is necessary to know if HIV is absent before we analyse the data. Therefore we will ask questions about your HIV status which you are allowed not to answer.

It is also very important to us that you feel free to participate in this study and that you understand what the study is all about. The fieldworker will ask you to sign this form after you have read and understood it.

Kind regards

Dr ANNAMARIE KRUGER

Contact details:

082 7715778/ 018 2994037(W)

018 2997024(H)

Check List



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

POTCHEFSTROOM CAMPUS: FACULTY OF HEALTH SCIENCES

CHECK LIST
PURE-SA PROJECT
(PROSPECTIVE URBAN AND RURAL EPIDEMIOLOGY)

CHECK LIST

NAME:..... **NUMBER:**.....
DATE:.....

WHAT DID YOU DRINK THIS MORNING?:.....

WHAT DID YOU EAT THIS MORNING?:.....

STATION	INSTRUCTIONS	SIGNATURE
1. Recruitment	1 HIV Counselling 2 Informed consent	M Watson..... A Kruger.....
2. Blood sample	OGGT : <input type="checkbox"/> Y <input type="checkbox"/> N Time of sample..... Problems experienced <input type="checkbox"/> Y <input type="checkbox"/> N Name the problem.....	Signature:
3. Spirometry	<input type="checkbox"/> Y <input type="checkbox"/> N	
4. Hand grip	<input type="checkbox"/> Y <input type="checkbox"/> N	
5. Anthropometry	Weight..... Height.....	
6. ECG	<input type="checkbox"/> Y <input type="checkbox"/> N	
7. BP	<input type="checkbox"/> Y <input type="checkbox"/> N	
8. Urine sample	<input type="checkbox"/> Y <input type="checkbox"/> N	
9. Physical activity	Questionnaire <input type="checkbox"/> Y <input type="checkbox"/> N	
10. Referral letter	<input type="checkbox"/> Y <input type="checkbox"/> N	
11. check out		A Kruger.....

Appendix C

Questionnaires

- Adapted Baecke Physical Activity Questionnaire
- International Physical Activity Questionnaire

20. If you play a second sport, which is it?
- | | | |
|--|---|--------------------|
| low level: bowling, golf, billiards | 1 | 0.76 ^{*1} |
| middle level: tennis, athletics, cycling | 2 | 1.26 |
| high level: soccer, rugby, netball, boxing | 3 | 1.76(27) |
21. How many hours per week do you practice? <1/ 1-2/ 2-3/ 3-4/ >4
0.5, 1.5, 2.5, 3.5, 4.5^{*2} (28-30)
22. How many months per year? <1/ 1-3/ 4-6/ 7-9/ >9
0.04, 0.17, 0.42, 0.67, 0.92^{*3} (31-33)
23. During leisure time I watch TV/ do sitting activities (read, needle-work, play cards) (34)
- | | | | | |
|---------|---------------|------------------|---------|---------------|
| 1.never | 2.sel-
dom | 3.some
-times | 4.often | 5.al-
ways |
|---------|---------------|------------------|---------|---------------|
24. During leisure time I walk/ do standing activities (gardening, housework) (35)
- | | | | | |
|---------|---------------|------------------|---------|---------------|
| 1.never | 2.sel-
dom | 3.some
-times | 4.often | 5.al-
ways |
|---------|---------------|------------------|---------|---------------|
25. Other leisure-time activities:..... (36)
(leisure-time = time off from work/ school)
- | | | | | |
|--|---------------|------------------|---------|---------------|
| | 2.sel-
dom | 3.some
-times | 4.often | 5.al-
ways |
|--|---------------|------------------|---------|---------------|

International Physical Activity Questionnaire

INTERNATIONAL PHYSICAL ACTIVITY QUESTIONNAIRE

(August 2002)

SHORT LAST 7 DAYS SELF-ADMINISTERED FORMAT

FOR USE WITH YOUNG AND MIDDLE-AGED ADULTS (15-69 YEARS)

The International Physical Activity Questionnaires (IPAQ) comprises a set of 4 questionnaires. Long (5 activity domains asked independently) and short (4 generic items) versions for use by either telephone or self-administered methods are available. The purpose of the questionnaires is to provide common instruments that can be used to obtain internationally comparable data on health-related physical activity

Background on IPAQ

The development of an international measure for physical activity commenced in Geneva in 1998 and was followed by extensive reliability and validity testing undertaken across 12 countries (14 sites) during 2000. The final results suggest that these measures have acceptable measurement properties for use in many settings and in different languages, and are suitable for national population-based prevalence studies of participation in physical activity.

Using IPAQ

Use of the IPAQ instruments for monitoring and research purposes is encouraged. It is recommended that no changes be made to the order or wording of the questions as this will affect the psychometric properties of the instruments.

Translation from English and Cultural Adaptation

Translation from English is supported to facilitate worldwide use of IPAQ. Information on the availability of IPAQ in different languages can be obtained at www.ipaq.ki.se. If a new translation is undertaken we highly recommend using the prescribed back translation methods available on the IPAQ website. If possible please consider making your translated

version of IPAQ available to others by contributing it to the IPAQ website. Further details on translation and cultural adaptation can be downloaded from the website.

Further Developments of IPAQ

International collaboration on IPAQ is on-going and an *International Physical Activity Prevalence Study* is in progress. For further information see the IPAQ website.

More Information

More detailed information on the IPAQ process and the research methods used in the development of IPAQ instruments is available at www.ipaq.ki.se and Booth, M.L. (2000). *Assessment of Physical Activity: An International Perspective*. *Research Quarterly for Exercise and Sport*, 71(2):s114-20. Other scientific publication and presentations on the use of IPAQ are summarized on the website.

INTERNATIONAL PHYSICAL ACTIVITY QUESTIONNAIRE

We are interested in finding out about the kinds of physical activities that people do as part of their everyday lives. The questions will ask you about the time you spent being physically active in the **last 7 days**. Please answer each question even if you do not consider yourself to be an active person. Please think about the activities you do at work, as part of your house and yard work, to get from place to place, and in your spare time for recreation, exercise of sport.

Think about all the **vigorous** activities that you did in the **last 7 days**. **Vigorous** physical activities refer to activities that take hard physical effort and make you breath much harder than normal. Think *only* about those physical activities that you did for at least 10 minutes at a time.

1. During the **last 7 days**, on how many days did you do **vigorous** physical activities like heave lifting, digging, aerobics or fast bicycling?

_____ **days per week**

No vigorous physical activities  **skip to question 3**

2. How many times did you usually spend doing **vigorous** physical activities on one of those days?

_____ **hours per day**

_____ **minutes per day**

Don't know/Not sure

Think about all the **moderate** activities that you did in the **last 7 days**. **Moderate** activities refer to activities that take moderate physical effort and make you breath

somewhat harder than normal. Think only about those physical activities that you did for at least 10 minutes at a time.

3. During the **last 7 days**, on how many days did you do **moderate** physical activities like carrying light loads, bicycling at a regular pace, or doubles tennis? Do not include walking.

_____ **days per week**

No moderate physical activities  **Skip to question 5**

4. How much time did you usually spend doing **moderate** physical activities on one of those days?

_____ **hours per day**

_____ **minutes per day**

Don't know/Not sure

Think about the time you spent **walking** in the **last 7 days**. This includes at work and at home, walking to travel from place to place, and any other walking that you have done solely for recreation, sport, exercise or leisure.

5. During the **last 7 days**, on how many days did you **walk** for at least 10 minutes at a time?

_____ **days per week**

No walking  **Skip to question 7**

6. How much time did you usually spend **walking** on one of those days?

_____ **hours per day**

_____ **minutes per day**

Don't know/Not sure

The last question is about the time you spent **sitting** on weekdays during the **last 7 days**. Include time spent at work, at home, while doing course work and during leisure time. This may include time spent sitting at a desk, visiting friends, reading, or sitting or lying down to watch television.

7. During the **last 7 days**, how much time did you spend **sitting on a week day**?

_____ **hours per day**

_____ **minutes per day**

Don't know/Not sure

Appendix D

Language editing



Functions for Fun CC. CK/2001/067655/23 t/a Functionality

PO Box 130211 Bryanston 2021
Tel Nr. (083) 639-1960 Fax nr. (086)555-7982
e-mail lswylde@mweb.co.za

10 December 2013

To Whom it May Concern

This serves to certify that I, Lesley Wyldbore, have completed a language and grammar edit on the Ph.D. thesis entitled "**THE RELATIONSHIP BETWEEN PHYSICAL ACTIVITY AND RISK FACTORS OF NON-COMMUNICABLE DISEASES OF A POPULATION IN TRANSITION: THE PURE STUDY**" submitted by Tershia Van Niekerk to the Potchefstroom Campus of North West University, of South Africa.

Kind regards

Lesley Wyldbore
(083) 639-1960



Private Bag X6001, Potchefstroom
South Africa 2520

Tel: 018 299-1111/2222
Web: <http://www.nwu.ac.za>

Hypertension in Africa Research Team (HART)
Tel: 018 2992444
Fax: 018 2991053
Email: alta.schutte@nwu.ac.za

7 April 2014

To whom it may
concern

Use of Blood Pressure Data as Part of PhD thesis: T van Niekerc

Herewith I would like to give consent that the blood pressure data collected by scientists from the Hypertension in Africa Research Team as part of the Prospective Urban Rural Epidemiology study, may be used as part of the PhD thesis of Mrs. T van Niekerc (Student nr. 12431648), entitled: *The relationship between physical activity and risk factors for non-communicable diseases of a population in transition: The PURE-study.*

Yours
sincerely

Prof. AE
Schutte
Hypertension in Africa
Research Team

SAJSM Submission Acknowledgement

Prof Sarah J Moss/Tershia van Niekerk:

Thank you for submitting the manuscript, "Changes in physical activity of a black South African population in transition: The PURE-study" to South African Journal of Sports Medicine. With the online journal management system that we are using, you will be able to track its progress through the editorial process by logging in to the journal web site:

Manuscript URL:

<http://www.sajsm.org.za/index.php/sajsm/author/submission/545>

If you have any questions, please contact me. Thank you for considering this journal as a venue for your work.

Prof Mike Lambert

South African Journal of Sports Medicine

South African Journal of Sports Medicine

www.sajsm.org.za

Editor: Professor Mike Lambert

mike.lambert@uct.ac.za