Risk factors of non-communicable diseases, functional performance and physical fitness among female adults in a low-resourced community: B-Healthy study

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DECLARATION

Prof. SJ Moss (supervisor), Dr. GR Oviedo (co-supervisor), and the co-authors of the two articles in this dissertation, hereby give permission to the candidate, Phidza Mashudu, to include these articles as part of her master's dissertation.

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DEDICATION

This dissertation is dedicated to:

My pillar of strength, Namadzavho Julia Phidza, my mom. I don’t even want to imagine how my life would have been if it had not been for you. I love you so much.

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YOUR LOVE IS THE GREATEST BLESSING IN MY LIFE.

ABSTRACT

Lifestyle behaviours that people adopt throughout their lives lead to metabolic changes that result in the development of non-communicable diseases (NCDs) in later life. NCDs are in particular on, the rise in persons from low-middle income countries. The prevalence is increasing significantly in low-resourced communities. Regular physical activity is associated with improved cardiovascular health and improved physical functionality. Therefore, the objectives of the study were to determine the relationship between the risk factors of NCDs and functional performance among females from a low-resourced community; and also, to determine the relationship between functional performance and cardiorespiratory fitness among females from a low-resourced community.

This cross-sectional observational study analysed the data collected during baseline measurements of an overarching B-healthy study. Data from 180 participants, 81 adult females (AF) (48.15 ± 8.30 years) and 98 senior females (SF) (68.58 ± 7.02 years), were analysed from the 200 participants that signed informed consent. The risk factors for NCDs that were determined included body mass index (BMI), hypertension, biochemical analysis for hyperglycaemia, dyslipidaemia, and objective physical activity. Functional performance assessments included sit to-stand (STS), handgrip strength (HGS), timed-up-and-go (TUG), and static balance tests as well as cardiorespiratory fitness (CRF) for maximum oxygen consumption (VO_2max). Descriptive statistics were performed to present participants' characteristics as means with standard deviations. Independent t-tests were used to determine the differences between adults (< 60 years) and seniors (≥ 60 years). Partial correlation analyses were performed to determine the relationship between risk factors for NCDs and FP as well as the relationship between CRF and FP. Data were analysed using the Statistical Package for the Social Sciences (SPSS) (IBM SPSS Statistics v.23, Chicago, IL, USA) with the level of statistical significance set at $p < 0.05$.

A significant difference between the AF and the SF for height ($p < 0.003$), SBP ($p = 0.027$), MVPA ($p = 0.023$), left- and right HG, as well as left- and right single leg stance (SLS) ($p < 0.001$) was observed. The results around risk factors for NCDs and FP showed a significant relationship between BMI and TUG in both groups (AF: $p = .019$; SF: $p = .031$). In AF the waist circumference (WC) correlated significantly with TUG ($r = .348$; $p = .006$). High-density lipoprotein cholesterol (HDL-C) correlated significantly and negatively with right HG ($r = -.301$; $p = .019$). In SF, WC correlated significantly and positively with right HG ($r = .259$; $p = .039$) and negatively with left SLS ($r = -.254$; $p = .042$). Moreover, the adults' STS tests correlated positively with VO2max ($r = 208$; $p \leq .001$**)**. A significant inverse relationship was found in both groups between TUG ($r = -.471$; p **<** 0.001) and VO2max ($r = -.355$; $p = .003$). The left- ($r = .274$; $p = .028$ and $r = .354$; $p =$

.004) and right SLS (r = .261; p = .037 and r = .265; p = .032) correlated significantly and positively with VO2max in AF and SF in this population.

In conclusion, the main finding of the study was the significant relationship in this population between obesity and abdominal obesity as risk factors on the one hand and, on the other, functional ability variables including balance and mobility in conjunction with high levels of physical inactivity. Moreover, physical inactivity was related to a decline in CRF, thus also a reduced functional ability. However, our findings demonstrated that physical function was not confined to CRF but was also related to ageing. Considering the health implications, our results show the importance of engaging community-dwelling adults in activities aimed at improving their overall health, such as their physical fitness and -function.

Keywords: adults, cardiorespiratory fitness, community dwelling, functional limitations, Non-communicable diseases, risk factors, socio-economic status

OPSOMMING

Leefstyl gewoontes wat mense deur hul lewens volg, lei tot metaboliese veranderinge wat aanleiding gee tot die ontwikkeling van nie-oordraagbare siektes (NOS). NOS is veral aan die toeneem in lande met ’n laag-middel inkomste. Die voorkoms is ook meer betekenisvol in areas waar persone met beperkte hulpbronne woon. Gereelde fisieke aktiwiteit word geassosieer met verbeterde kardiovaskulêre gesondheid en verbeterde fisieke funksionaliteit. Die doelstellings van die studie was om die verband tussen die risikofaktore van NAS en funksionele prestasie by vroue uit 'n gemeenskap met 'n lae hulpbron te bepaal; en ook om die verband tussen funksionele prestasie en kardiorespiratoriese fiksheid by vroue uit 'n gemeenskap met 'n lae hulpbron te bepaal.

Hierdie dwarsdeursnit observasie-studie het die data geanaliseer wat gedurende die basislynmetings van die oorkoepelende B-Healthy studie versamel is. Data is geanaliseer van 180 deelnemers, 81 volwasse vroue (VV) (48.15 ± 8.30 jaar oud) en 98 senior vroue (SV) (68.58 ± 7.02 jaar oud) uit die 200 deelnemers wat die ingeligtetoestemmingsvorm onderteken het. Die risikofaktore wat vir NAS bepaal is, het liggaamsmassa-indeks (LMI), hipertensie, biochemiese analise vir hiperglukemie, dislipidemie en objektiewe fisieke aktiwiteit ingesluit. Funksionele prestasie assessering het die sit-tot-staan (STS), handgreepkrag (HGK), “timed-up-and-go” (TUG) en statiese balans toets sowel as kardiorespiratoriese fiksheid (KRF) vir maksimale suurstofverbruik (VO_2max) ingesluit. Beskrywende statistiek is uitgevoer om die deelnemers se eienskappe te rapporteer as gemiddeldes met standaardafwykings. Onafhanklike t-toetse is gebruik om die verskille tussen volwassenes (< 60 jaar oud) en seniors (≥ 60 jaar oud) te bepaal. Gedeeltelike korrelasie-analises is uitgevoer om die verhouding te bepaal tussen risikofaktore vir NAS en FP asook tussen KRF en FP. Data is geanaliseer deur gebruik te maak van die Statistical Package for the Social Sciences (SPSS) [Statistiese Pakket vir die Sosiale Wetenskappe] (IBM SPSS Statistics v.23, Chicago, IL, USA) waar die vlak van statistiese beduidendheid gestel is op $p < 0.05$.

‘n Beduidende verskil was gevind tussen die VV en die SV ten opsigte van lengte ($p < 0.003$), SBD ($p = 0.027$), MIFA ($p = 0.023$), regter- en linker HG, asook regter-en-linker enkel-been-staan (EBS) ($p < 0.001$). Die resultate van die verband tussen die risikofaktore vir NAS en FP het in altwee groepe ‘n beduidende positiewe verhouding getoon tussen LMI en TVB (VV: $p = .019$; SV: $p = .031$). Onder die VV het middelomtrek (MO) beduidend positief gekorreleer met TVB ($r = .348$; $p = .006$). Hoë-digtheid lipoproteïen cholesterol (HDL-C) het beduidend negatief gekorreleer met regter-HG ($r = -.301$; $p = .019$). In SV het MO aansienlik en positief gekorreleer met regter HG ($r = .259$; $p = .039$) en negatief met die linker SLS ($r = -.254$; $p = .042$). Boonop het die STS-toetse

van volwassenes positiewe verband met VO_2max (r = 208; p ≤ .001). 'n Beduidende omgekeerde verhouding is gevind in beide groepe tussen TUG (r = -.471; p <0.001) en VO_2max (r = -.355; p = .003). Die linker- (r = .274; p = .028 en r = .354; p = .004) en regs SLS (r = .261; p = .037 en r = .265; p = .032) het aansienlik gekorreleer en positief met VO_2max in AF en SF in hierdie populasie. Onder SV het MO beduidend en positief gekorreleer met regter-HG (*r* = .259; *p* = .039) en negatief met linker-EBS (*r* = -.254; *p* = .042). Boonop het die STS-toetse van volwassenes het positief gekorreleer met VO_2max (*r* = 208; *p* ≤ .001**)**. 'n Beduidende omgekeerde verhouding is in altwee groepe gevind tussen TVB en VO_2max: (*r* = -.471; *p* < 0.001) en (*r* = -.355; *p* = .003). Die regter- (*r* = .261; *p* = .037 en *r* = .265; *p* = .032) en linker-EBS (*r* = .274; *p*= .028 en *r* = .354; *p* = .004) het in hierdie bevolking onder VV en SV beduidend positief gekorreleer met VO_2max.

Ten slotte is die hoof bevinding van hierdie studie die beduidende verband in hierdie populasie tussen vetsug en abdominale vetsug as risikofaktore enersyds, en funksionele vermoënsveranderlikes, insluitend balans en mobiliteit in samehang met hoë vlakke van fisieke onaktiwiteit. Boonop het fisieke onaktiwiteit verband gehou met die afname in KRF, wat dus ook die funksionele vermoë verminder het. Ons bevindinge het egter getoon dat fisieke funksie nie tot KRF beperk was nie, maar ook verband hou met veroudering. Met inagneming van die gesondheidsimplikasies, toon ons resultate die belangrikheid daarvan om volwassenes in die gemeenskap te laat deelneem aan aktiwiteite wat daarop gemik is om hul algemene gesondheid te verbeter, soos hul fisieke fiksheid en -funksie.

Sleutelwoorde: volwassenes, kardiorespiratoriese fiksheid, gemeenskapsinwoning, funksionele beperkings, Nie-aansteeklike siektes, risikofaktore, sosio-ekonomiese status

TABLE OF CONTENTS

DECLARATION ..... **I**

ACKNOWLEDGEMENTS ..... **II**

DEDICATION ..... **III**

ABSTRACT ..... **IV**

OPSOMMING ..... **VI**

LIST OF ABBREVIATIONS AND ACCRONYMS ..... **XIII**

CHAPTER 1: INTRODUCTION **1**

1.1 Introduction **1**

1.2 Problem statement **1**

1.3 Objectives **3**

1.4 Hypotheses **4**

1.5 Study framework **4**

1.6 Structure of the dissertation **4**

1.7 References **6**

CHAPTER 2: LITERATURE REVIEW: RISK FACTORS OF NON-COMMUNICABLE DISEASES AND FUNCTIONAL PERFORMANCE **1**

2.1 Introduction **1**

2.2 Non-communicable diseases **1**

2.2.1 Cardiovascular diseases (CVDs) **2**

2.2.2 Cancer **3**

2.2.3 Chronic respiratory disease (CRD) **5**

2.2.4 Diabetes Mellitus (DM) **7**

2.2.4.1 Type 1 diabetes **7**

2.2.4.2 Type 2 diabetes **8**

2.3 The burden of disease in South African adults 9

2.4 Socioeconomic status on NCDs 10

2.5 Impact of NCDs on health 12

2.6 Risk factors of NCDs 13

2.6.1 Hypertension **13**

2.6.2 Tobacco smoking **15**

2.6.3 Overweight and obesity **17**

2.6.4 Dyslipidaemia **20**

2.6.5 Physical inactivity **21**

2.6.5.1 Physical inactivity globally **22**

2.6.5.2 Physical inactivity in SA **25**

2.7 Physical inactivity as a modifiable risk factor for NCDs 27

2.8 Physical performance 29

2.8.1 Muscular strength and endurance **30**

2.8.2 Balance **31**

2.9 Cardiorespiratory fitness 33

2.10 Relationship between risk factors of NCDs and functional performance 34

2.11 Summary 35

2.12 References 37

CHAPTER 3: ARTICLE 1 56

ABSTRACT 56

Introduction 57

METHODS **60**

Study design **60**

Participants **60**

Demographic information **60**

Risk factors for non-communicable diseases **61**

Functional performance tests **62**

Statistical analyses **63**

Results **63**

Author contributions **71**

Funding **71**

Acknowledgements **71**

Conflict of interests **71**

Supplementary methods **72**

CHAPTER 4: ARTICLE 2 ..... **80**

ABSTRACT **81**

Background **81**

Methods **81**

Results **81**

Conclusion **81**

Background **82**

METHODS **84**

Study design **84**

Participants **84**

Demographic information **84**

Anthropometry **85**

Cardiorespiratory fitness assessment **85**

Functional performance tests **85**

Statistical analysis **86**

RESULTS **87**

Limitations of the study **90**

Conclusions **90**

CHAPTER 5: SUMMARY, CONCLUSIONS, LIMITATIONS AND RECOMMENDATIONS **98**

5.1 Introduction **98**

5.2 Summary **98**

5.3 Conclusions **100**

5.4 Limitations and recommendations **102**

APPENDIX A: ETHICS APPROVAL LETTER **104**

APPENDIX B: PROOF OF LANGUAGE EDITING **106**

APPENDIX C: INFORMED CONSENT FORM **107**

APPENDIX D: GERIATRIC'S AUTHOR'S GUIDELINES **110**

APPENDIX E: IJBNPA AUTHOR'S GUIDELINES **130**

LIST OF TABLES

Table 2.1: Percentages of individuals aged 15 and above waking up with breathing difficulties and cough attacks according to gender and provinces (SADHS, 2016: 289-290) **7**

Table 2.2: Percentage of deaths due to NCDs by the selected years of death, 1997-2015 (Statistics South Africa, 2017:27) **10**

Table 2.3: Blood pressure classification according to the 2017 ACC/ AHA (Whelton *et al.,* 2018:e138) **14**

Table 2.4: Variation of self-reported family history of hypertension **15**

Table 2.5: Prevalence of cigarette smoking by gender and Province among adults aged 15 years and older, SADHS 2016..... **17**

Table 2.6: BMI classification according to the CDC, 2017 ..... **18**

Table 2.7: Prevalence of obesity among adults, BMI ≥ 30 kg/m^2, aged-standardized estimates by WHO, 2016 ..... **19**

Table 2.8: Highest levels of adult obesity in sub-Saharan Africa (2016), BMI ≥ 30 kg/ m^2 (WHO, 2016)..... **20**

Table 2.9: The frequency of physical inactivity among the WHO Regions (Hallal *et al.,* 2012:248) **23**

Table 2.10: The variation of walking among WHO regions (Hallal *et al.,* 2012:248). **24**

Table 2.11: Variation in vigorous intensity among WHO regions (Hallal *et al.,* 2012:249)..... **25**

Table 2.12: Province specific patterns of inactivity of adult males and females, (SADHS, 2007:292-293) **26**

Table 2.13: Several studies on the effects of aerobic exercise on HDL-C, LDL-C and TG (Wang and Xu, 2017: 3) **28**

LIST OF ABBREVIATIONS AND ACCRONYMS

ACSM	American College of Sports Medicine
ADL	Activities of daily living
AEE	Advanced energy expenditure
BMI	Body mass index
BP	Blood pressure
CDC	Centers for Disease Control and prevention
CPET	Cardiopulmonary exercise test
CRF	Cardiorespiratory fitness
CVDs	Cardiovascular diseases
DBP	Diastolic blood pressure
ECG	Electrocardiogram
HDL-C	High density lipoprotein-Cholesterol
HR	Heart rate
ISAK	International society for the advancement Kinanthropometry
Kg/m^2	Kilogram per metre squared
LDL-C	Low density lipoprotein-Cholesterol
LMICs	Low-middle income countries
Mmol/L	Mill mole per litre

MVPA	Moderate to vigorous physical activity
NCDs	Non communicable diseases
PAL	Physical activity levels
PAR-Q	Physical Activity Readiness Questionnaire
SBP	Systolic blood pressure
SD	Standard deviation
SLST	Single leg stance test
SPSS	Statistical package for the social sciences
TUG	Timed up and go
VO_{2max}	Maximal aerobic capacity
WC	Waist circumference
WHO	World health organization

CHAPTER 1: INTRODUCTION

1.1 Introduction

Research on non-communicable diseases (NCDs) and their detrimental effects on health has a long tradition (WHO,2013). Extensive literature has revealed that the development of NCDs occurs through metabolic changes that result from unhealthy lifestyle behaviours or risk factors that people adopt throughout their lifetime (WHO, 2013:7; Shayo, 2019:7). An additional arising from such lifestyle practices, independently or combined, is that they lead to myriad complications in the musculoskeletal system including chronic pain and functional limitations in adults (Dean and Söderlund, 2015:5). This chapter presents the problem statement on the relationship between the risk factors of NCDs and functional performance among adults as well as the main objectives and hypotheses underpinning the study.

1.2 Problem statement

Non communicable diseases such as cardiovascular diseases, chronic respiratory diseases, cancer and diabetes are the leading causes of mortality, which continues to rise globally (Derman *et al.,* 2008:6; Gowshall and Taylor-Robinson, 2018: 262). It was reported that 73.6 % of deaths are caused by NCDs annually, while 28 million occur in low- and middle-income countries and 16 million before a person reaches the age of 70 years (WHO, 2015). In South Africa, NCDs have been identified as the leading cause of mortality in the year 2000, when it was responsible for 37% of deaths with prevalence among females compared to males (Bradshaw *et al.,* 2003:683). The same trend was found in 2010 when NCDs caused 39% of deaths presenting high prevalence in females (42.6%), more than males (35.4%) while 21.5% of premature deaths occurred between the ages of 49-59 years (Nojilana *et al.,* 2016:478). Kruger *et al.,* (2001:738) reported that females in the North West Province (NW) presented a high level of abdominal obesity which was associated with increased blood pressure, triglyceride concentration and fasting glucose as well as low High-Density Lipoprotein Cholesterol (HDL-C) leading to increased risk of NCDs. This evidence confirms the idea that females, especially in Africa, are exposed to NCDs to a larger extent than males (NCD Alliance, 2011:4).

The global status report on NCDs indicated that globalization and rapid urbanization contributed greatly to the increased prevalence of the risk factors related to NCDs in low- and middle-income countries (LMIC) (Alwan, 2011:2). The transition of infectious diseases to NCDs in LMIC was due to factors such as unhealthy diets, sedentary lifestyles and increased tobacco usage among females (Hancock *et al.,* 2011:2). This was affirmed in a study in the NW which found that leaving the black rural population exposed to changes in the unhealthy quality of food intake from a traditional diet to westernized diets increased the incidence of NCDs (Pisa *et al.,* 2012:376). A

study conducted in China showed lifestyle behaviours including high fats and decreased physical activity as significant factors that affects urbanised people's health (Miao & Wu, 2016:93).

Risk factors around NCDs include modifiable ones such as hypertension, dyslipidaemia, obesity and overweight (WHO, 2018) as well as and non-modifiable ones such as family history, age and gender. Kim *et al.,* (2013:170) suggest modifying these risk factors as a valuable method in reducing the burden of NCDs. Physical inactivity, one of the major modifiable risk factors, is responsible for the burden of NCDs and poor health globally (WHO, 2016), and its continuous rise does not only have negative implications for the health of individuals but also the global economy (Ding *et al.,* 2016:1323). Scarborough *et al.* (2011:532) report that out of £936 million spent on diseases related to physical inactivity in the year 2006-2007, £117 million was spent on stroke, £542 million on heart disease, £65million on colorectal cancer, £54 million on breast cancer and £158 million on type 2 diabetes. In South Africa, lifestyle-related risk factors such as tobacco use, unhealthy dietary habits, excess body mass, intake of alcohol and physical inactivity contributed to the development of chronic diseases such as diabetes, hypertension and abnormal cholesterol levels (Derman *et al.,* 2008:6).

Regular physical activity for 150 minutes per week reduces the risk of coronary artery disease by 14% while participating for more than 150 minutes per week results in a 20% reduction in this respect (Sattelmair *et al.,* 2011:792). Moreover, regular participation in physical activity was demonstrated to be associated with improved cardiovascular and respiratory function, improved body composition and improved weight control (American College of Sports Medicine (ACSM), 2014:10). Thus, physical activity could have an immensely positive effect on various bodily systems and a reduction in overall risk for the development of NCDs and the treatment of those already suffering from it. It has been defined as any bodily movement produced by the contraction of skeletal muscles that result in a substantial increase over resting energy expenditure (ACSM, 2014:2). An individual's ability to perform physical activity and their daily tasks effectively and safely are influenced by their functional mobility, functional lower extremity strength, dynamic balance, postural control and stability and overall endurance (Lusiardi *et al.,* 2003:14). Physical function is a multidimensional concept comprising four related subdomains: mobility (lower extremity function), dexterity (upper extremity function), and axial ability (neck and back function, and ability to carry out activities of daily living) (Patient-Reported Outcomes Measurement Information System (PROMIS), 2014).

Extensive research on gender differences and the functional ability of adults of different ages showed that since females tend to age more than males, their exposure to increased functional limitations is high (Warbutton *et al.,* 2001:230; Ahmed *et al.,* 2016:10; Tomioka *et al.,* 2017: 8). Physical activity also has beneficial effects on the improvement of physical fitness in community adults (Hanson and Jones, 2015:714). A study completed by Sisson *et al.,* (2009:544) in females

aged 45-75 years showed that as the volume of the exercise increased the females were more likely to improve their maximum oxygen consumption. Physical fitness includes cardiorespiratory endurance, muscle strength, endurance, body composition and flexibility (ACSM, 2018), while functional performance includes functional movements such as timed-up-and-go, sit-to-stand (Lusiardi *et al.,* 2003) as well as balance and handgrip strength; components that are essential for healthy ageing. The findings of a study by Cooper *et al.* (2011:382) underlined that participating in leisure-time physical activity throughout adulthood has positive effects in maintaining one's functional performance and quality of life.

A considerable number of studies investigated NCDs and their related risk factors as well as physical activity as a modifiable risk factor that can reduce the rate of NCDs in low-resourced communities (Abegunde *et al.,* 2007:1936; Derman *et al.,* 2008:6; Alwan, 2011) but only limited studies exist regarding the relationship between functional performance and the risk factors related to NCDs in low-resourced communities of South Africa. Low-resourced communities are defined as communities that are characterised by insufficient funds to cover health-care costs on an individual or social basis (Bioengineering team design I, 2014:1). Moreover, such characteristics lead to insufficient access to medical equipment and services, less-developed infrastructure, and less-trained personnel. Against the background of the literature presented, this study aims to answer the question: What is the relationship between functional performance, physical activity and risk factors related to NCDs among African females in a low-resourced community? Females from low-resourced communities require a high level of physical function due to the traditional living arrangements influenced by culture and beliefs (Dong *et al.,* 2014:S37).

The findings of the study will elucidate the health status and well-being of the participants towards developing effective guidelines for the prevention and management of NCDs. The study will present health-care workers with information on the benefits of physical activity and may influence government policies on the need for implementing regular participation in physical activity and exercise interventions to address functional performance and reduction of risk factors related to NCDs among person's dependent on public health care in South Africa.

1.3 Objectives

The objectives of this study are to determine

- The relationship between the risk factors of NCDs and functional performance among females from a low-resourced community.
- The relationship between functional performance and cardiorespiratory fitness among females from a low-resourced community.

1.4 Hypotheses

These following hypotheses underpin the present study:

- A significant inverse relationship between the risk factors of NCDs and functional performance among of females from a low-resourced community will be found.
- A significant positive relationship between functional performance and cardiorespiratory fitness among females from a low-resourced community will be found.

1.5 Study framework

This cross-sectional observational study forms part of an overarching B-Healthy-study and will focus on the data collected during baseline measurements of the B-Healthy study. The aim of the B-Healthy study was to determine the effect of an exercise intervention on the risk factors of NCDs, medicine usage, functional capacity and quality of life among persons from a low-resourced community (Trial number: PACTR201609001771813). The Health Research Ethics Committee for Humans at North-West University approved the study (Ethics number: NWU 00049-15-A1) as well as the North West Province Department of Health.

My contributions in the project included the recruitment of participants and assisting with translations during the completion of demographic information. I also helped in the process of data collection on the assessment of the risk factors of NCDs, functional performance tests and fitness testing.

1.6 Structure of the dissertation

The structure of the dissertation is in the format of five chapters. The research findings including the methods, are presented in article format. The references are presented at the end of each chapter. The reference list is written according to the Harvard style of referencing as adapted by the North-West University for Chapters 1, 2 and 5. Chapters 3 and 4 will be prepared according to the authors guidelines of the journal that the manuscripts are prepared for.

Chapter one will be the introductory chapter consisting of the problem statement, objectives and the hypotheses to be tested. Chapter two will review the detailed literature on the risk factors of NCDs and its relation to functional performance in adults. Chapter three will be the first article titled: “The relationship between the risk factors of NCDs and functional performance among females originating from a low-resourced community: B-Healthy-study”. This article is written according to the author’s guidelines of the *Geriatrics Journal* where it will be submitted for publication. Chapter four, the second article titled: “Relationship between functional performance and among females originating from a low-resourced community B-Healthy Study”. The present

study will be written according to the author's guidelines of the *International Journal of Behavioural Nutrition and Physical Activity* where it will be submitted for publication. The final chapter, Chapter five, will present the summary, conclusions, limitations and recommendations of the study based on the findings and inferences made around the hypotheses tested. A conclusion will be drafted to answer the research question posed above. The limitations and recommendations experienced with the study will be presented as well as future research in the field.

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CHAPTER 2: LITERATURE REVIEW: RISK FACTORS OF NON-COMMUNICABLE DISEASES, PHYSICAL FITNESS AND FUNCTIONAL PERFORMANCE

2.1 Introduction

According to Allender *et al.,* (2010:297) and the non-communicable disease alliance (2011:2), non-communicable diseases (NCDs) are a major contributor to the burden of disease in developed countries. NCDs, defined as chronic medical conditions, which are non-infectious but largely preventable is rapidly increasing in developing countries (Allender *et al.,* 2010:297; WHO, 2017). The risk factors of NCDs include smoking, unhealthy diet, hypertension, obesity, and overweight, age, gender, and dyslipidaemia (Nelson *et al.,* 2015:16; WHO, 2017). Physical inactivity is another associated risk factor that is responsible for the high prevalence of NCDs (WHO, 2017). Individuals who are physically inactive often report low functional limitations, which is defined as the capacity to be able to perform daily activities such as shopping and climbing stairs (Centers for Disease Control and Prevention (CDC), 2018). Regular physical activity was reported to improve the ability to do daily tasks and reduce the risk of falls, which contribute to morbidity and mortality (CDC, 2018).

In this chapter, a review of the literature on the relationship between risk factors of NCDs and functional performance will be presented. The prevalence of NCDs and the associated risk factors of NCDs and their relationship to functional performance will be presented. The review will focus on physical inactivity as a modifiable risk factor for NCDs as well as the consequences of inactivity on mortality and morbidity based on the influence inactivity has on functional performance. The information from this literature review will inform researchers on the current areas where information is lacking

2.2 Non-communicable diseases

Cardiovascular diseases (CVDs), including heart disease and stroke as well as diabetes, cancer and chronic respiratory diseases (CRDs) including, in their turn, chronic obstructive pulmonary disease (COPD) and asthma are considered to be the conditions most dominant in NCDs' mortality and morbidity rates (Allender *et al*., 2010:297; Islam *et al.,* 2014: 2; WHO, 2018). Chronic NCDs accounted for 63% of deaths out of the 57 million people who died in 2008 globally (Alwan *et al.,* 2010). In 2015, out of 56.4 million of all deaths that occurred worldwide, NCDs were responsible for 39.5 million (70%), which is on the increase in low-income countries and their populations (WHO, 2018). The aforementioned evidence shows an increment of 7% of NCD deaths between the years 2008 and 2015. Of these deaths, over 30.7 million occurred in low-

middle-income countries (LMIC) while 48% of deaths in people aged 70 years and the younger group accounted for over 48% deaths.

The leading cause of NCD deaths globally in the year 2008 was CVDs, which accounted for 48% of deaths, while cancers accounted for 21%. Respiratory diseases including asthma and COPD accounted for 4.2 million, deaths and diabetes caused 1.3 million deaths (WHO, 2011:9). The data from the global health observatory (GHO) in 2015, however, reported that the number of deaths attributable to CVDs was 17.7 million (45%), followed by cancers at 8.8 million (22%), respiratory diseases at 3.9 million, and diabetes at 1.6 million (WHO, 2018). Comparing these reports potentially leads to the inference that the deaths attributable to CVDs and respiratory diseases decreased between the years 2008 and 2015, while the number of deaths caused by cancers and diabetes increased. It can be concluded that the increment occurred due to cancers and diabetes.

Non-communicable diseases are the main cause of death in most countries in the Americas, the Eastern Mediterranean, Europe, South-East Asia, and the Western Pacific (WHO, 2011:9). Non-communicable disease mortalities are projected to rise by 15 % globally between the years 2010 and 2020. World Health Organisation (2011:9) reported that the WHO regions of Africa, South-East Asia, and the Eastern Mediterranean will face the greatest increase of over 20% by 2020. The African region faces a double burden of disease while there is still more deaths that are caused by infectious diseases, and the prevalence of NCDs is rapidly increasing and is projected to cause almost three-quarters of death, at least as many as other diseases, by the year 2030 (WHO, 2008:22). This brief review therefore indicates that substantial implementation of preventative measures is needed to avert the growing burden of NCDs.

2.2.1 Cardiovascular diseases (CVDs)

Cardiovascular diseases are a group of disorders of the heart and blood vessels or the consequences of poor blood supply (Bloom *et al.,* 2011:8). Such conditions include coronary heart disease, cerebrovascular disease, peripheral arterial disease, rheumatoid heart disease, and congenital heart disease. The most common causes of CVDs include atherosclerosis and hypertension. Cardiovascular diseases leading cause of NCD deaths globally accounted for about 37% of all 17 million premature NCDs deaths in the year 2015, at 82% of deaths occurring in LMIC (WHO, 2017). In the year 2016, CVDs were responsible for an estimated 17.9 million deaths, representing 31% of all global deaths, at 85% of these deaths due to stroke and heart attack (WHO, 2017). Although CVDs are one of the most common causes of death globally, they also are the most preventable diseases since they occur due to modifiable risk factors (Benziger *et al.,* 2016:395-396).

Cardiovascular diseases can be prevented through modifying the behavioural risk factors such as tobacco use, unhealthy diet and obesity, physical inactivity, and harmful use of alcohol (WHO, 2017). Such behaviours are mostly influenced by urbanization, industrialization, and globalization (Fuster *et al.,* 2011:19). It is estimated that heart disease and stroke will be the leading cause of mortality and disability globally by the year 2020, with the number projected to be more than 24 million by the year 2030 (Fuster *et al.,* 2011). The rising prevalence of CVDs worldwide calls for immediate action since it causes a significant economic burden in LMIC (Valentin *et al.,* (2011:1671). The estimation global cost for CVDs in the year 2010 was USD 863 billion, projected to rise to USD 1,044 billion by the year 2030 (Bloom *et al.,* 2011:22). Moreover, about USD 474 billion (55%) is presently due to direct health-care costs, while the remaining 45% is due to loss in productivity resulting from either disability, premature death, or illness.

In South Africa, an estimation of 195 people dies every day due to CVDs, representing about 20% of the daily deaths due to HIV/ AIDS (Maredza *et al*., 2011:48). Cardiovascular diseases are the growing cause of death in South Africa, while heart disease and stroke are the leading causes of death (Heart and Stroke Foundation South Africa (HSFSA), 2016). Cardiovascular diseases were accountable for 17.3% of deaths in South Africa in the year 2014 (Statistics South Africa, 2015). The continuing burden of CVDs in African countries puts the country under pressure since its health systems are already striving to deal with the burdens of infectious, perinatal, and maternal diseases (Mbewu, 2009:5). The HSFSA reported that 80% of deaths before the age of 60 could be prevented by modifying risk factors including unhealthy diets, sedentary lifestyles, and smoking (HSFSA, 2016).

2.2.2 Cancer

Cancer refers to a genetic disease where tumour cells vary from their normal progenitors by genetic modifications that affect growth-regulatory genes (Khan *et al.,* 2010: 133). A cancerous tumour is malignant. These cells can invade surrounding tissues and spread to other organs of the body. Several studies have recognized lifestyle behaviours as the main cause of cancers (Khan *et al.,* 2010: 134; Davies *et al.,* 2011: S70; White *et al.,* 2016: S96). Such modifiable lifestyle behaviours include unhealthy diets, obesity, sedentary lifestyles, excessive alcohol consumption, and smoking. The prevalence of cancer cases and cancer mortality is increasing rapidly globally.

Bloom and associates reported that cancer is the second-largest global cause of mortality accounting for about 13% of all deaths (7.6 million deaths) (Bloom *et al.,* 2011:8). In the year 2018, cancer accounted for about 9.6 million deaths and 18.1 million new cancer cases were reported worldwide (Bray *et al.,* 2018:399). Males accounted for 5.4 million of these deaths and 9.5 million incidences while 4.2 million deaths and 8.6 million incidences were reported for females. Furthermore, the leading country with more cancer mortality (and incidences) was Asia

at 57.3% (48.4%), followed by Europe at 20.3% (23.4%), the Americas at 14.4% (21.0%), Africa at 7.3% (5.8%), and Oceania at 0.7% (1.4%). The global burden of new cases of cancer is projected to rise to 21.5 million by the year 2030 (Bloom *et al.,* 2011:18). Furthermore, the cancers with the most cases globally in the year 2010 were lung cancer at 12.8% of new cases, followed by breast cancer at 10.9%, colorectal cancer at 9.8%, stomach cancer at 7.8%, and prostate cancer at 7.1%. The numbers however changed by the year 2018 where lung cancer cases comprised 11.6% of deaths, breast cancer, and colorectal cancer increased to 11.6% and 10.2% respectively while stomach cancer accounted for 5.7%. Prostate cancer, however, remained constant at 7.1% (Bray *et al.,* 2018:400).

Breast cancer is the most frequently diagnosed and the leading cause of morbidity and mortality in females globally (Torre *et al.,* 2015: 89). Lifestyle changes, including healthy body weight maintenance, regular physical activity, and reducing the amount of alcohol intake are the best strategies for reducing the development of breast cancer (Kushi *et al.,* 2006: 266-267; Schmid and Leitzmann, 2014:1310). Breast cancer accounted for about 1.38 million (10.9%) of all new cases in the year 2008 (Ferlay *et al.,* 2010:2904). In the year 2012, however, the number increased to an estimated 1.7 million new cases according to the WHO report on the International Agency for Research on Cancer (WHO, 2012). Breast cancer was responsible for 6.6% of 9.6 million deaths of all cancer sites in the year 2018 (Bray *et al.,* 2018:398). In South Africa, breast cancer reported 8 230 new cases among females, representing 21.78% of all cancers in the year 2014 (Herbst, 2015:2). Comparing South African and Asian statistics leads to the potential observation that females in South Africa present more cases than Asian females: Asian females reported 465 breast cancer cases, representing 30% of all cancers (Herbst, 2015:2-3).

Lung cancers were reported to be the most commonly diagnosed type in men and the leading cause of mortality among them worldwide and the second cause of death in LMIC of the Americas (Torre *et al.,* 2015:95; WHO, 2008: 11). An estimated 1.8 million new cases of lung cancer occurred in 2012, accounting for 13% of total cancer diagnosis (Torre *et al.,* 2015:95). Lung cancer, the leading cause of mortality in men in the year 2018, accounted for 18.4% deaths at 22.0% deaths in males and 13.8% in females (Bray *et al.,* 2018:400). The American Cancer Society (2019) estimated lung cancer to account for about 228,150 of new cases (116,440 in males and 111,710 in females) in the year 2019 and about 142,670 mortalities (76,650 in males and 66,020 in females). Moreover, lung cancer is reported to be more prevalent in older people (65 years or older) with fewer diagnoses in people aged 45 years and younger. This evidence ties in well with what has been reported by Siegal and associates, where cancer was the leading cause of mortality in adults aged 40-79 years among genders in the United States in the year 2012 (Siegel *et al.,* 2016:21).

Other forms of cancers influenced by lifestyle behaviours include colorectal cancer, prostate cancer, and liver cancer (Khan *et al.,* 2010: 141; American Cancer Society, 2019). Colorectal cancer is the third most commonly diagnosed in males and the second in females and the fourth leading cause of cancer mortality worldwide (Torre *et al.,* 2015:93). Moreover, in the year 2012, colorectal cancer was responsible for 693,900 deaths and about 1.4 million cancer cases globally.

The estimated costs for the 13.3 million new cancer cases in 2010 were USD 290 billion, projected to rise to USD 458 billion by the year 2030 (Bloom *et al.,* 2011:20). Many costs were accounted for by medical costs at USD 154 billion (53% of the total) while non-medical costs accounted for USD 67 billion and income losses accounted for USD 69 billion.

In the year 2012, more than half of all cancers (57%) and cancer deaths (65%) occurred in LMICs, with the numbers projected to rise by the year 2025 (Islam *et al.,* 2014:4). Africa does not differ from other countries since it is also experiencing an increasing health burden of cancer incidences (Torre *et al.,* 2015:89). Most of the LMIC countries already have a health care system that is struggling to meet the increasing demands mostly due to the growing number of cancer cases (Kingham *et al.,* 2013: e165). Moreover, the limitation of cancer care in sub-Saharan Africa is due to issues of cost, infrastructure, an inadequate workforce, and cultural barriers.

It can therefore be concluded that cancer can be prevented or managed by identifying the lifestyle factors that influence its development throughout the life span while implementing necessary intervention programmes to deal with the cancer crisis.

2.2.3 Chronic respiratory disease (CRD)

Chronic respiratory diseases are chronic conditions that affect the airway and other systems of the lungs (Bloom *et al.,* 2011:8). Such conditions, including asthma, COPD, respiratory allergies, and pulmonary hypertension, are responsible for 7% of all deaths globally (4.2 million deaths). The most common CRDs in South Africa are asthma and chronic bronchitis (Steyn & Fourie, 2005:123).

Chronic obstructive pulmonary disease is a term used to describe a group of progressive lung diseases including chronic bronchitis (a condition that is characterized by excessive mucus production in the airways) and emphysema (a condition where there is damage to the gas exchange part of the lung), which hampers breathing (Bloom *et al.,* 2011:8). Asthma is a chronic inflammatory disease of the airways of the lung characterized by reversible airflow obstruction and bronchospasm (Yawn, 2008:138). Asthma and COPD share the same symptoms including wheezing, coughing up phlegm, and breathlessness, which could either be persistent or episodic (South African Demographic Health Survey (SADHS), 2016:270; Viviers and Van Zyl-Smit, 2015:786). Smoking is the primary cause of COPD, a condition that is common in elders (WHO,

2017). Elders who smoke or who used to smoke face challenges due to normal age-related decline in lung function and the loss of lung function they experienced while smoking which, results in the onset of COPD symptoms (Murphy & Sethi, 2002:762-763; Rossi *et al.,* 2017:2604).

Asthma and COPD were responsible for two-thirds of the total 4.7% global disability-adjusted life year (DALY) accounted for by CRDs in the year 2015 (López-Campos *et al.,* 2016:19). Furthermore, CRDs accounted for 6.3% of global years lost due to disability (YLD) with COPD responsible for 29.4 million YLD followed by Asthma at 13.8 million YLD. The prevalence of COPD is increasing worldwide, especially in the United States where the rates of death associated with COPD have increased in the past two decades (Murphy and Sethi, 2002:762). In the year 2015, COPD accounted for about 3.17 million deaths, representing 5% of all deaths worldwide (WHO, 2017). Other modifiable risk factors for COPD include occupational dust and chemicals, air pollution, and lower respiratory infections during childhood. The global cost of illness due to COPD was estimated at USD 2.1 trillion in the year 2010 which is projected to rise to USD 4.8 by the year 2030 (Bloom *et al.,* 2011:24).

Chronic respiratory diseases, especially COPD and asthma, are becoming health issues in Africa, including Sub-Saharan Africa and North African regions (Ahmed *et al.,* 2017:207). After smoking, additional factors, including indoor- and outdoor pollution and occupational dust and chemicals were reported to be the cause of CRDs (Ahmed *et al.,* 2017:207; WHO, 2017). A study performed in South Africa found a high prevalence of CRD symptoms in elders residing close to mine dumps compared with those who were unexposed to mine dumps (Nkosi *et al.,* 2015:7). The prevalence of asthma (17.3%), chronic bronchitis (13.4%), chronic coughing (26.6%), emphysema (5.6%), pneumonia (17.1%) and wheeze (24.7%) differed greatly from those of unexposed areas, where the percentages were 12.1%, 7.5%, 18%, 3.3%, 13.9%, and 19.3%, respectively (Nkosi *et al.,* 2015:5). The prevalence of people who experience difficulties in breathing patterns increased with age (SADHS, 2016:289). In the year 2016, females in the North West Province experienced a higher percentage of waking up with breathing difficulties and cough attacks when compared with men **(Table 2.1)** and when compared with other provinces (SADHS, 2016: 289-290).

Table 2.1: Percentages of individuals aged 15 and above waking up with breathing difficulties and cough attacks according to gender and provinces (SADHS, 2016: 289-290)

Province	Females (%)	Males(%)
Western Cape	17.6%	19.8%
Eastern Cape	24.1%	33.6%
Northern Cape	19.0%	31.1%
Free State	23.1%	30.6%
Kwazulu-Natal	15.2%	23.2%
North-West	30.9%	16.4%
Gauteng	26.4%	26.0%
Mpumalanga	22.6%	40.0%
Limpopo	18.8%	32.8%

2.2.4 Diabetes Mellitus (DM)

Diabetes is a metabolic disorder in which the body is unable to regulate the level of blood glucose appropriately (Bloom *et al.,* 2011:9). This chronic condition occurs when the pancreas cannot produce enough insulin or when the body cannot use the insulin it produces effectively (WHO, 2016:7). Insulin is a hormone produced by the pancreas that regulates blood sugar or glucose. When there is not enough insulin in the body or the cells in the body are unable to respond to insulin, too much blood sugar stays in the bloodstream which results in damage to body organs, especially peripheral blood vessels and the nervous system (CDC, 2019). Two common types of diabetes include type 1 and type 2.

2.2.4.1 Type 1 diabetes

Type 1 diabetes is the form that occurs as a result of the body's failure to produce insulin, requiring a person to frequently inject it or wear an insulin pump to regulate the amount of circulating insulin to control the blood glucose levels (CDC, 2019). This form of DM was previously referred to as 'insulin-dependent diabetes'. The symptoms for type 1 diabetes include excessive urination, excessive thirst, constant hunger, weight loss, vision changes and fatigue (WHO, 2016:11). No exact cause for type 1 diabetes has been found but it is believed that it can occur as a result of a complex interaction between genes and environmental factors (WHO, 2016:12).

2.2.4.2 Type 2 diabetes

Type 2 diabetes, formerly called non-insulin-dependent diabetes, occurs because of the body's inability to utilize the insulin it produces (CDC, 2019). Unlike type 1 diabetes, symptoms of type 2 diabetes are often absent, and the condition can go undiagnosed for a long time until complications arise. The risk factors for type 2 diabetes include race, family history, overweight and obesity, unhealthy diet, physical inactivity, and tobacco use (WHO, 2016:12).

Gan (2003:11) estimated that 194 million people worldwide (5.1 % of the adult population) had diabetes in the year 2003 and this is projected to rise to 333 million (6.3%) by the year 2025. It is believed that, due to the estimated number of 314 million (8.2 in the adult population) of people with Impaired Glucose Tolerance (IGT), the situation could be projected to rise to 472 million (9.0%) by the year 2025. Furthermore, of all cases of diabetes in developing countries, type 2 was responsible for 85-95% and the risk of developing it is in line with the prevalence of obesity. According to data from the Heart disease and stroke statistics, 2017-update report, about 23.4 million adults were diagnosed with diabetes while 7.6 million adults were living with it unknowingly and 33.9% were pre-diabetic (Benjamin *et al.,* 2017: e296). Comparing the data from 1988 to 2010, National Health and Nutrition Examination Survey (NHANES) (2013:2693) reported that the prevalence of diagnosed and undiagnosed DM increased by 45% and the total number of diabetic people increased by 75%. In 2010, diabetes was the seventh leading cause of death in the United States, based on the total number of 234,051 death certificates where it was listed as the cause of death (CDC, 2014:7). Type 2 diabetes accounts for about 90-95% of all diagnosed cases of diabetes with the highest prevalence among United States adults aged 65 years and older (CDC, 2014:9). World Health Organization has estimated an increase in the number of people with diabetes from 347 million in 2008 to 366 million by 2030 (Allender *et al*., 2010:297).

The prevalence of the total population and global costs of diabetes among 180 countries in the year 2015 was estimated at USD 7.25 billion and USD 1.32 trillion respectively, with a gross domestic product (GDP) of USD 73.53 trillion (Bommer *et al.,* 2018:966). These estimations were projected to rise to a total population of 8.39 billion with a GDP) of $ 115.30 trillion by the year 2030, thus presenting an increased burden to the health care systems and the economy of the countries. A systematic review of the costs of diabetes treatment in LMIC reported it as an expensive disease to manage for the patients since most of them are unable to afford health care expenses (Moucheraud *et al.,* 2019:7). Moreover, the median of diabetes care including laboratory tests in these countries was USD 25 billion, ranging from below USD 45 billion to almost USD 200 billion. The annual inpatient costs varied from under USD 20 billion while other countries reported over USD 1000 billion, with medicines ranging from under USD 20 billion per year to above USD 500 billion. The outpatient costs ranged from below USD 3 billion to almost USD 50 billion, at a median of USD 7 billion per visit (Moucheraud *et al.,* 2019:7). These variations in

treatment costs could be the result of the different care sectors or the care practices in various health care systems.

In the year 2010, India reported a high number of people older than 30 years living with diabetes, where 18% was recorded in males and 16% in females (Draper *et al*., 2010:399). The South African Nutrition Health and Nutrition Survey (SANHANES) also found that in South Africa, the Asian/ Indian population had the highest prevalence of diabetes (30.7%), with the brown ethnic group presenting about 13.4% (SANHANES-1, 2013:94). Moreover, diabetes was the highest among rural informal (11.9%) and urban formal (11.3%) residents. In South African adults, diabetes increases with age (SADHS, 2016:272). Results of a glycated haemoglobin (HbA1c) test gives rise to the potential observation that the prevalence (adjusted HbA1c ≥ 6.5%) was high among the females aged 65 years (30%) and older and males aged 55-64 (23%) years (SADHS, 2016:272). The increasing burden of NCDs, especially in LMIC, poses a threat to public health care systems since the risk factors are accompanied by health complications (Islam *et al.,* 2014:2).

Without proper treatment, diabetes can cause many medical complications. Acute complications include hypoglycemia, diabetic ketoacidosis, or non-ketotic hyperosmolar coma. Serious long-term complications include CVDs, chronic renal failure and diabetic retinopathy, nephropathy and neuropathy (Kumar and Shaik, 2015:2). The substantial prevalence and the costs of managing NCDs pose an increasing burden in LMIC.

2.3 The burden of disease in South African adults

South Africa is experiencing a quadruple burden of disease including pre-transitional diseases, chronic diseases, injuries, and HIV/AIDS (Bradshaw *et al.,* 2003:687; Pillay-van Wyk *et al.,* 2016:e651). Chronic NCDs caused an estimated 35 million deaths each year, 60% of all deaths globally, at 80% in LMIC (SANHANES-1, 2013:71). The prevalence of NCDs is expected to rise substantially in the coming decades if the risk factors are not managed (Bloom *et al.,* 2011:6). There are several main behaviours by which the NCD risks factors can be modified including eating a healthy diet, participating in regular physical activity, not using tobacco, and avoiding harmful use of alcohol in South Africa (Bradshaw *et al*., 2011:1). Despite other factors causing the burden of disease in South Africa such as the AIDS pandemic, high rates of injury and other infectious diseases, the rising of NCDs is also affecting the quality of life and increasing health-care expenses at a personal and country-level (Bradshaw *et al.,* 2011).

Rapid urbanisation is a global trend (Malan *et al*., 2008:323; Ritchie and Roser, 2018). The rapid urbanisation of the black South African population in context with globalisation is believed to increase the burden of NCDs since it is accompanied by changes in health patterns (Puoane *et*

al., 2008:74; Maher *et al.,* 2010: 943). Most of these changes include a westernised diet comprised of calorie-dense foods, saturated fat, animal protein and sugar, low fruit and vegetable intake, increased sodium intake, and low levels of physical activity (Miao & Wu, 2016: 93). Urbanisation involves an increase in the urban population of a country or area due to different components of urban population growth (Kok and Collinson, 2006:17, Ritchie and Roser, 2018). Such components include urban natural increase, urban net migration from rural areas, and the reclassification of parts of the rural population into the category 'urban'. The United Nations (2004) reported that while 39% of the African population were living in urban areas by the year 2003, it is anticipated that by the year 2030 the majority of people in the continent would be living in urban areas.

The leading cause of death in South Africa from the year 1997-2003 was due to NCDs, accountable for 44.9%, from the year 2004-2008 more deaths were due to NCDs (statistics South Africa, 2017:27). However, the data from statistics South Africa **(Table 2.2)** showed an epidemiological transition in the main causes of death from the year 2010-2015 from communicable to NCDs (Statistics South Africa, 2017:27). Furthermore, the percentage of deaths attributable to NCDs by age and gender was found to be high in females within the age group of 40-70 years, and in males within the age of 45-80 years (Statistics South Africa, 2017:27).

Table 2.2: Percentage of deaths due to NCDs by the selected years of death, 1997-2015 (Statistics South Africa, 2017:27)

Year of death	% of all total deaths
1997	53.3%
2002	46.0%
2003	44.9%
2009	45.7%
2010	46.6%
2015	55.5%

With the growing burden of NCDs, it is important to examine the socioeconomic distribution of the major risk factors in LMICs.

2.4 Socioeconomic status on NCDs

Socioeconomic determinants play a significant role when it comes to the distribution of NCD risk factors in developed and developing countries (Chimed, 2014:13). Socioeconomic status (SES) factors include sex, age, urban/ rural areas, ethnicity, education and income (WHO, 2010:2). Non-

communicable diseases behavioural risk factors are associated with mortality and they are more prominent in the low SES groups (Stringhini *et al.,* 2010:1164; Allen *et al.,* 2017:e286). A study on the relationship between SES and NCD risk factors in the WHO Western Pacific Region showed with a view to SES an inverse relationship between the risk factors and SES across LMIC that were measured (WHO, 2010:80). Smoking and alcohol consumption reported higher levels in the groups at a lower SES compared to persons at a higher SES. Even though ethnicity, which was measured in Fiji and Malaysia, did show a difference in Fiji, it was considered a complicated factor to analyze since it involves conflicted associations such as social and cultural differences as well as religious laws and customs (WHO, 2010:81). Furthermore, the urban/ rural areas variations in NCD risk factors measured in China, Fiji, and Malaysia showed that Fijian and Chinese adults presented high levels of diabetes, obesity, hypertension, and high cholesterol compared to those of the rural residents. The levels of hypertension, high cholesterol, and diabetes among males and females were however higher in rural residential areas of Malaysia than in the urban residential areas (WHO, 2010:81). The results on the NCD risk factors showed that the smoking rates among the Chinese and among Filipino females and Malaysian males are directly related to age while in China and Fiji and among Filipino males and females smoking is inversely proportional to education levels (WHO, 2010:82). Furthermore, increased alcohol intake showed a direct relationship with age among Chinese men and an inverse relationship among males and females in Fiji with males having higher rates compared to females. Hypertension and cholesterol levels increased with age; however, it showed a periodical relationship with education and income. Diabetes presented higher rates among educated Chinese and Fijian men and among rich Chinese males and females and Filipino men. Half and three quarters of females and males from the former Soviet Union countries presented multiple risk factors consisting of two or more related to NCD (Chimed, 2014:112).

The results found in a systematic review in low-income and lower-middle-income countries reported that individuals from low SES present with higher levels of tobacco use and harmful alcohol use than the group from high SES (Allen *et al.,* 2017:e284). Moreover, the low SES group also reported low fruit-, vegetable-, fish and fibre intake compared to the high SES group (Allen *et al.,* 2017: e284-e285). Furthermore, the high socioeconomic group had high levels of physical inactivity and they consumed more salt, fats, and other processed foods compared to the low socioeconomic group. These findings give a substantial indication that people from low SES environments are more prone to engage in lifestyle habits that increase the risk of developing NCDs. These results emphasise the appropriateness of the prevention and management strategies that government officials and policymakers are currently using to treat NCDs.

South Africa is undergoing an epidemiological transition with the rising of chronic lifestyle diseases, high injury rates, HIV/ AIDS and poverty-related diseases (Steyn *et al.,* 2006: 259).

Furthermore, changes in political-, social-, and economic factors have led to high levels of urbanisation, dietary changes, and poor health behaviours. The Transition and Health during Urbanisation in South Africa (THUSA) study reported that urbanisation, increase of income, and education in the North West Province were associated with increased risk factors of coronary artery disease including high cholesterol in males and females, increased body mass index (BMI) in men, and overweight and obesity in females (Vorster *et al.,* 2007:288). The THUSA study was aimed at determining physical activity levels of black South Africans in the North West Province and assessing the relationship between physical activity and the prevalence of risk factors for CVDs in a cross-sectional study. However, the results also showed that people in higher-income urban groups presented low serum glucose, low systolic blood pressure levels, and low BMI in females while a possible reason could be the improved access to care in urban than in the rural areas. Therefore, it is advisable to inform the population about the ramifications of overweight, obesity, and smoking as well as promoting healthy diets. The Heart of Soweto study showed that the epidemiological transition incidence which has played a role in the increasing levels of CVDs will certainly feed the continuous epidemic of NCDs in the future (Pretorius *et al.,* 2011:112).

2.5 Impact of NCDs on health

The growing prevalence of NCDs impacts health through health care costs, physiological changes in the body, and the functional effects on independent living. For instance, the rapid increase of NCDs in low-income countries leave individuals exposed to increased household costs associated with health care (WHO, 2014). Moreover, it will also affect the poverty reduction programmes thus increasing the burden of risk factors including tobacco use, unhealthy diet, and limitation of access to health service, which can lead to early mortality as compared to people from higher-income countries. The major NCDs do not only lead to NCD-related morbidity and mortality but also to other NCD-related conditions such as musculoskeletal-, neurological-, renal-, endocrine diseases, mental disorders, disability (blindness and deafness), and injuries (Richards *et al.,* 2016:230; WHO, 2015:8). Such impairments have a negative impact on raising the demand for the social and health systems and poverty-stricken people and can reduce productivity.

Non-communicable diseases can also have an impact on the way people spend, which leads to much reduction in non-medical-related spending on food and education, resulting in the withdrawal of wealth and assets to pay for care (Engelgau *et al.,* 2011:76). Tobacco use, for example, when the purchases become too much, can end up displacing money to spend on food and education in the house leading to changes in household spending patterns. In India, costs around NCDs were higher compared to non-NCD-related conditions resulting in high financial risk and a burden on those who were affected and, in the household (Mahal *et al.,* 2010:44). About 40% of almost three-quarters of the expenditures on NCDs are financed by household borrowing and sales of assets indicating a significant level of financial vulnerability to NCD.

Richards *et al.,* (2016:230) emphasise the importance of acquiring information about knowledge and discussions of NCD prevention, control, treatment, and measurements since these are in line with the continuous development goals aimed at establishing healthy lives and well-being. Further, knowledge of NCD-related disability should be taken into consideration in planning NCD policy for the accomplishment of rehabilitation aspects and the identification of cost-effective approaches for better health outcomes.

2.6 Risk factors of NCDs

Any characteristic or attribute of a person that poses as the risk for that person to develop an NCD is considered a risk factor (WHO, 2010:2). Non-communicable diseases share similar modifiable and non-modifiable risk factors (Van Zyl *et al*., 2010:72; WHO, 2018). The modifiable risk factors include high blood pressure, hyperglycaemia, hyperlipidaemia, tobacco smoking, alcohol abuse, overweight and obesity, and physical inactivity while age, gender, and family history fall under non-modifiable risk factors. Additionally, in terms of attributable deaths, the leading risk factor is hypertension which was responsible for 13% of global death followed by tobacco use (9%), raised blood glucose, and physical inactivity , while the latter two factors accounted for 6% and obesity and overweight 5% (WHO, 2009: v).

2.6.1 Hypertension

Hypertension or high blood pressure is a chronic medical condition where the blood pressure (BP) in the arteries is elevated which requires the heart to work harder than normal to circulate blood through the blood vessels (Belue *et al*., 2009:13). Hypertension is the most common global condition affects people and was also found to be the major risk factor of stroke and CVDs (Mathew *et al.,* 2017). Whelton *et al.,* (2018:e138) defined hypertension as a systolic BP of 140 mmHg or more and a diastolic BP of 90 mmHg or more. In addition, people were considered hypertensive if they were taking hypertensive medication or have been declared hypertensive by a medical doctor at least on two different occasions (Benjamin *et al.,* 2017:e280). Ruivo and Alcântara (2012:152) describe systolic blood pressure and diastolic blood pressure as the product of cardiac output and peripheral vascular resistance. Systolic BP rises as cardiac output increases during exercise while diastolic BP falls as peripheral vascular resistance decreases, thus facilitating perfusion of large muscle groups. **Table 2.3** shows the 2017 American College of Cardiology/ American Heart Association (ACC/ AHA) guidelines around high blood pressure.

Table 2.3: Blood pressure classification according to the 2017 ACC/ AHA (Whelton *et al.,* 2018:e138)

Classification	Systolic pressure(mmHg)	Diastolic pressure(mmHg)
Normal	<120	<80
Elevated	120-129	<80
Stage 1 hypertension	130-139	80-89
Stage 2 hypertension	≥ 140	≥ 90

It has been a known factor before Poulter *et al.,* (2015:802) described BP as a heritable trait, as such, it was estimated that 30% of the variance in BP relates to genetic factors. Risk factors for hypertension include age, race, family history, overweight, insufficient physical activity, smoking, sleep apnoea, and poor dietary patters (Benjamin *et al.,* 2017: e284).

According to the AHA report, approximately 86 million adults (34%) in the United States are affected by hypertension (Benjamin *et al.,* 2017:e280). In the year 2001, hypertension caused approximately 7.6 million of all deaths globally with stroke accountable for 54% of this and 47% of ischemic heart disease, 75% of hypertensive diseases, and 25% of CVDs (Lawes *et al.,* 2008: 1514). Hypertension is a major health concern in all LMIC regions as it accounted for more than 80% attributable burden of diseases with a high percentage at a young age (Lawes *et al.,* 2008: 1516).

On the AHA report on Heart disease and stroke statistics (2018: e287), the National Heart, Lung, and Blood Institute (NHLBI) reported that the prevalence of hypertension between the year 2011to 2014 was 11.6% among individuals aged 20-39 years, 37.3% among those aged 40-59 years, and 67.2% to those aged 60 years and older. The higher percentage of hypertension occurred among females aged 65 years and older when compared to males. The data from the National Health and Nutrition Examination Survey 2013 to 2014 indicated that 15.9% of adults in the United States who were hypertensive were not aware that they suffered from it (Benjamin *et al.,* 2017: e281).

In South Africa, more than 6.5 million people have BP above 140/ 95 mmHg and 3.2 million of these have a BP measurement higher than 160/ 95 mmHg (Norman *et al*., 2007:692). It was estimated that 53 males and 78 females die each day from the impact of hypertension in South Africa--thus females have a significantly higher rate of hypertension than males (South African Health and Nutrition Examination Survey, 2013: 72). The gender difference in hypertension was further noticed in the SADHS report (2016: 268) where 46% of females had hypertension compared to 44% of males. The South African Demographic Health Survey (2007: 197) reported

that the family history of hypertension can also lead to increased NCDs. The self-reported family history of hypertension was high (30.9%) among the four NCDs that were assessed by the SANHANES-1 (2013:71-72) followed by high blood sugar (20.7%), stroke (8.9%), and heart disease (7.6%). However, the levels of hypertension varied among provinces with the Free State presenting a notably high percentage (45.8%) **(Table 2.4).**

The complications arising from high BP include left ventricular hypertrophy (caused by overload pressure) and coronary artery disease (Foëx and Sear, 2004: 73). Left ventricular hypertrophy (LVH) is an independent risk factor of CVDs, one of the major NCDs. Due to an increment in muscle mass and wall thickness but not the ventricular volume, LVH destroys the diastolic function, resulting in the reduction of the ventricular relaxation and thus delaying the filing of the ventricle with blood (Foëx and Sear, 2004: 73). Furthermore, chronic pressure overload increases the risk of having heart failure, while stroke results from thrombosis, thromboembolism, and intracranial haemorrhage which are all complications of hypertension.

Table 2.4: Variation of self-reported family history of hypertension, SADHS, 2007:197

Province	Percentage
Western Cape	38.4%
Eastern Cape	38.6%
Northern Cape	41%
Free State	45.8%
KwaZulu-Natal	36.7%
North West	22.8%
Gauteng	25.7%
Mpumalanga	25.8%
Limpopo	21.8%

2.6.2 Tobacco smoking

Tobacco smoking is the practice of burning tobacco and inhaling the resulting smoke. Tobacco smoking is a global health issue responsible for killing more than 7 million people a year (WHO, 2017). More than 6 million of those deaths are the result of direct tobacco use while around 890 000 are the result of non-smokers being exposed to second-hand smoke. Second-hand smoke fills enclosed spaces including restaurants and offices when people are smoking. Additionally, second-hand smoke can lead to serious cardiovascular and respiratory diseases, including coronary heart disease and lung cancer (WHO, 2017). In 2004, an estimated 20.9% (44.5 million) of United States adults were current smokers; of these, 81.3% (36.1 million) smoked every day

and 18.7% (8.3 million) smoked some days (CDC, 2005:1121). Among those who currently smoked every day, 40.5% (14.6 million) reported that they had stopped smoking for at least 1 day during the preceding 12 months because they were trying to quit. Among the estimated 42.4% (90.2 million) persons who had ever smoked, 50.6% (45.6 million) were former smokers (CDC, 2005:1121).

The WHO (2011:1) reported that cigarette smoking, either directly or passively, causes almost 6 million deaths each year with the number expected to rise to 7.5 million by the year 2020. It is estimated that smoking will be responsible for 71% of lung cancer cases, 42% of CRD cases, and 10% of cardiovascular disease cases. The European region was found to be the highest with an increased prevalence in smoking with the value estimated at 29% while the African region was the lowest at 8% prevalence (WHO, 2011:17). In all regions, males smoked more than females.

The South African Medical Research Council (SAMRC) reported smoking as the sixth leading risk factor of disability and mortality in South Africa in the year 2015 (2017: 550). Out of the 421 102-total number of deaths related to smoking status in the year 2015, the number among people aged 16 years and older was 18.9% while the highest percentage (41.3%) was reported for people who did not smoke (Statistics South Africa, 2015:15). However, about 33.8% of the death forms had incomplete data on smoking status and 6.0% of those who notified the death were not aware of the smoking status of the deceased. The SADHS report on cigarette smoking variations among provinces **(Table 2.5)** and gender shows that the Northern Cape and Western Cape males and females smoke cigarettes at a higher rate when compared to other provinces (SADHS, 2016: 37-38).

Reddy *et al.,* (2015: 653) reported on the SANHANES-1 report that factors such as socio-cultural and demographic elements can also contribute to the prevalence of tobacco smoking. The population assessment of the tobacco health (PATH) study reported that in the year 2014, there were 5.5 million e-cigarette users of which 2.3 million used them daily and 3.2 million used them some days (Rodu & Plurphanswat, 2017:943).

Table 2.5: Prevalence of cigarette smoking by gender and Province among adults aged 15 years and older, SADHS 2016

Province	Gender	
	Males	Females
Western Cape	42.5%	25.1%
Eastern Cape	39.4%	6.8%
Northern Cape	44.2%	17.8%
Free State	39.7%	5.5%
Kwazulu-Natal	34.6%	1.9%
North West	31.6%	3.5%
Gauteng	37.6%	4.5%
Mpumalanga	36.3%	5.2%
Limpopo	25.0%	1.3%

There is a lack of evidence regarding the use of e-cigarettes in South Africa as it remains unregulated. However, a study that was performed on marketing e-cigarettes on South African retail websites pointed out factors such as smoking cessation, environmental friendliness, healthiness, cost-effectiveness, and hedonic value as ways of marketing e-cigarettes in South Africa (Muposhi and Dhurup, 2018:5). The SADHS reported that 2% of females and 3% of males aged 15 years and above used e-cigarettes on a daily basis or during occasions as it remained uncommon in South Africa (SADHS, 2016: 315). These findings highlight a need for scientific studies to further investigate the risks and benefits associated with e-cigarettes in South Africa.

2.6.3 Overweight and obesity

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; Gadde *et al.,* 2018:69). Centers for Disease Control and Prevention define adult obesity as weight that is higher than the required healthy weight for a specific height of an individual (CDC, 2017). The accumulation of body fat is an indication that more energy is stored than the amount of energy needed for cell function and activities of daily living (Bray, 1990:457; The European food information council, 2015:13). Obesity is defined using the cut points of BMI **(Table 2.6)** which is calculated by dividing the subject's mass by the square of the height as measured in metres.

Table 2.6: BMI classification according to the CDC, 2017

Classification	BMI (kg/ m^2)
Underweight	<18.5
Normal	18.5-24.5
Overweight	25-29.9
Class 1 obesity	30-34.5
Class 2 obesity	35-39.9
Class 3 obesity	≥40

A total of 28 million people dies each year due to obesity and overweight globally with an estimated 35.8 million of global DALYs caused by obesity and overweight (WHO, 2011:22). The estimated prevalence of obesity among United States adults between the years 2011 to 2014 was about 36.5%, and 17% in youth (Ogden *et al.,* 2015: 1). The overall prevalence among middle-aged adults aged 40 to 59 was 40.2% and older adults aged 60 and older reached over 37% which was higher than younger adults who rated 32.3% (Ogden *et al.,* 2015: 1-2). In addition, the prevalence of females was higher at 38.3% as opposed to males at and 34.3% overall. About 2.8 million people die each year due to being obese or overweight (WHO, 2011:2).

Around the global status of NCDs, WHO (2011: 23) reported that the global prevalence of obesity and overweight nearly doubled between the years 1980 and 2008. Additionally, 10% of males and 14% of females in the world were obese in 2008 compared with a percentage of 5% in males and 8% for females in 1980. The estimated annual medical cost of obesity in the year 2008 among United States adults was USD 147 billion, less than the medical cost for people with obesity, which was USD 1,429, which is higher than those with normal weight (CDC, 2017).

In 2016, 1.6 billion (39%) adults aged 18 years and older were reported to be overweight and of these, over 650 million (13%) were obese (WHO, 2017). Obesity or overweight, once considered high-income problem, is rising considerably in LMIC with high prevalence in urban settings. Low-to-middle income countries are experiencing a double burden of disease. While LMICs are dealing with problems of infectious diseases and malnutrition, they are also experiencing a rapid increase in obesity and overweight, increasing the risk of NCDs (WHO, 2017).

According to the CDC (2017), obesity was shown to decrease by level of education. Adults without a high school degree or equivalent had the highest self-reported obesity (35.5%), followed by high school graduates (32.3%), adults with some college experience (31.0%), and college graduates (22.2%). Obesity increases the risk of many physical and mental conditions that are visible in metabolic syndrome as well as a combination of medical disorders including DM type 2, high

blood pressure, high blood cholesterol, and high triglyceride levels (De Onis *et al*., 2010:1258). Obesity is influenced by consuming more calories than burning them off, and when energy intake and energy expenditure are not balanced, the excess energy is stored as fat (Gadde *et al.,* 2018:69). Gadde and colleagues report that a person's body shape and size can be used to determine NCDs (2018: 72). Additionally, as adiposity increases, so does the left ventricular mass, leading to thickening of the left ventricular walls (a condition referred to as LVH). The left ventricle is the primary pumping chamber of the heart, and LVH causes poor blood supply which results in cardiac ischemia, heart attack or heart failure (Torpy *et al.,* 2004:2430). Increased plasma levels of free fatty acids, intracellular non-adipose tissue lipids, as well as ectopic adipose tissue depots, also contribute to systemic inflammation and insulin resistance leading to DM over time (Gadde *et al.,* 2018:73).

Africa has also been facing an increasing burden of obesity in adults aged 18 years and above over the years, with high prevalence in females compared to males **(Table 2.7)** (WHO, 2016).

Table 2.7: Prevalence of obesity among adults, BMI ≥ 30 kg/m^2, aged-standardised estimates by WHO, 2016

Year	Males (%)	Females (%)	Total (%)
2016	5.6	15.3	10.6
2015	5.3	14.9	10.3
2014	5.1	14.5	9.9
2013	4.9	14.1	9.6
2012	4.6	13.7	9.3
2011	4.4	13.3	9.0
2010	4.2	12.9	8.7
2009	4.0	12.5	8.4

South Africa is also facing an increasing burden of obesity (Cois and Day, 2015:7). When it comes to obesity in sub-Saharan African countries, South Africa ranks as the highest country **(Table 2.8)** (WHO, 2016).

Table 2.8: Highest levels of adult obesity in sub-Saharan Africa (2016), BMI ≥ 30 kg/ m^2 (WHO, 2016)

Country	Obesity rate (%)
South Africa	28.3
Botswana	18.9
Namibia	17.2
Lesotho	16.6
Eswatini	16.5
Zimbabwe	15.5
Gabon	15.0
Seychelles	14.0
Djibouti	13.5
Mauritania	12.7

South African adults aged 15 years and above report high levels of overweight and obesity based on BMI, with the prevalence high in females (68%) compared to males (31%) (SADHS, 2016:45). Moreover, the severity of obesity was reported as high among black/ African females and Indian/ Asian females while in men the severity was high in the white population group (SADHS, 2016:47).

Obesity and overweight can be managed by limiting energy intake from total fats and sugars; increasing consumption of fruit and vegetables, legumes, and whole grains and nuts and by engaging in regular physical activity (60 minutes a day for children and 150 minutes spread through the week for adults) (WHO, 2017). Addressing issues such as control of sodium intake and increased levels of obesity can be helpful in reducing hypertension in the future (Bradshaw *et al.,* 2011).

2.6.4 Dyslipidaemia

'Dyslipidaemia is a systemic disorder characterized by having abnormal levels of one or more serum lipids' (Shi *et al.,* 2014:33). Raised cholesterol is the major cause of health burden in developing and developed countries as a risk factor for ischemic heart disease and stroke (WHO, 2018). The growing burden of dyslipidaemia is becoming a global health problem (Qi *et al.,* 2015:13461). The prevalence differs according to socioeconomic-, cultural-, and ethnic traits. Factors include unhealthy diets and lack of physical activity, which lead to obesity and overweight, and these contribute to the rising prevalence of diabetes and high blood cholesterol (Bradshaw *et al.,* 2011). Other factors that lead to dyslipidaemia include age, gender, and central obesity (Qi

et al., 2015:13462). According to WHO (2011:2), the estimated death rate due to high cholesterol, which is high in high-income countries, was 2.6 million (45% of total) deaths annually and 29.7 million (2.0% of total) DALYs.

According to the WHO (2018), the global prevalence of raised total cholesterol among adults (≥ 5.0 mmol/L) was 39% (37% for males and 40% for females) in 2008. The WHO region that had the most considerable burden of raised cholesterol in genders was Europe at 54%, followed by the Americas at 48% while the WHO African region and Southeast Asian regions presented the lowest percentages at 22.6% and 29.0% respectively. The results of a study done in China on epidemiology of dyslipidaemia in adults showed that the most frequent type of dyslipidaemia was hypertriglyceridemia with an estimated pool of 17.7%, followed by low levels of blood high-density lipoprotein cholesterol (HDL-C) (11.0%), hypercholesterolemia (TC) (8.8%) and mixed hyperlipidaemia (TC + TG) (5.1%) (Huang *et al.,* 2014:6).

Data from the NHANES 2003-2006 showed an estimation of 53% (105.3M) in the Unites States adult population with at least one lipid abnormality (Tóth *et al.,* 2012:328). Furthermore, 27% (53.5million) have high LDL-C for their cardiovascular risk category, 23% (46.4 million) have low HDL-C, approximately 30% (58.9 million) have high TG levels; and among patients with TG ≥200mg/ dL, 13% (25.7 million) have suboptimal non-HDL-C. It was because of these results that the NHANES 2003-2006 made an emphatic suggestion on the need for medical interventions in treating high LDL-C, non-HDL-C and other forms of dyslipidaemias, improving education about dyslipidaemia, and developing better public health prevention strategies to minimize the risk factors of dyslipidaemia (Tóth *et al*., 2012:328).

High levels of fat, calcium, cholesterol, cellular waste products, and fibrin in the arteries lead to fatty deposits, plaque which results in a condition known as atherosclerosis (the hardening, and narrowing of the arteries) (AHA, 2015; NHLBI, 2018). Atherosclerosis causes damage to the endothelium (a layer that covers the inside layer of the arteries). The plaque increases in size as atherosclerosis progresses, resulting in the blockage of arteries, thus reducing-to-stopping the amount of blood flow and lessening the amount of oxygen and other nutrients in the body cells. Since atherosclerosis can affect any artery in the body, it can result in poor health conditions including coronary heart diseases, stroke, and kidney diseases.

2.6.5 Physical inactivity

Booth *et al.,* (2012: 1144) define physical inactivity as 'physical activity levels less than those required for optimal health and prevention of premature death'. Physical inactivity was found to be the fourth leading risk factor responsible for the burden of NCDs and poor health (WHO, 2016), and its continuous rise has negative implications for the health of individuals and the global

economy (Ding *et al.,* 2016:1323). People who are insufficiently physically active have a 20-30% increased risk of all-cause mortality, compared to those who participate in at least 150 minutes of moderate-intensity physical activity per week, as recommended by WHO (WHO, 2015). Lee *et al*. (2012:219) suggested that even if physical inactivity decreased by only 10-25%, more than a million deaths could be prevented each year. By eliminating physical inactivity, the life expectancy of the world's population is estimated to increase by 0.68 years (WHO, 2015).

In the year 2008, globally approximately 31% of adults aged 15 and over were poorly active (men 28% and females 34%) (WHO, 2017). The prevalence of physical inactivity was high in the American and the eastern Mediterranean regions; females from these WHO regions showed a high percentage of physical inactivity (almost 50%) while the prevalence for men was 40% in the Americas and 36% in the eastern Mediterranean (WHO:2017). Physical inactivity is responsible for a 20-30% chance of increased risk of death. The data from WHO (2011:1) demonstrated that 3.2 million people die each year due to insufficient physical activity. Regular physical activity is associated with reduced CVD risk, including hypertension, diabetes, cancers, and depression.

The global estimations on the burden of inactivity by country from the outcome of the studied cases that was done using the adjustment factors of 1.20, as found by Lee and colleagues, reported 1.20 for coronary heart disease (standard error, 0.03), 1.23(0.05) for type 2 diabetes, 1.05 (0.09) for breast cancer, 1.22 (0.08) for colon cancer, and 1.22 (0.07) for all-cause mortality (2012:222). People who developed type 2 diabetes had the highest prevalence with an overall median of 43% followed by those who were eventually dying at 43% and those who were developing colon cancer, CHD, and breast cancer at overall medians of 43%, 42%, and 41% respectively.

2.6.5.1 Physical inactivity globally

The WHO (2010:10) reported that the rising of physical inactivity levels in many countries is having a major impact on the general health of people and on the prevalence of NCDs. As the level of technology usage and new developments are continuing to rise, it affects the levels of physical activity negatively since it reduces the amount of physical labour needed to carry out people's daily activities (Hallal *et al.,* 2012:247). Changes in occupation, the advent of newer technologies, and the rapid pace of urban life have increasingly resulted in more work that is sedentary involving less energy expenditure (Misra & Khurana, 2008:21). Thus, technology is another source for the reduction in the levels of physical activity globally. Based on collected and compared data from 122 countries, Hallal and colleagues (2012: 247) reported that a third of adults and four out of five adolescents were not active. Furthermore, they added: 'Although the technological revolution has been of great benefit to many populations throughout the world, it

has come at a major cost in terms of the contribution of physical inactivity to the worldwide epidemic of non-communicable diseases.

Even though the benefits of physical activity are recognized worldwide, Giannuzzi *et al.,* (2003:319) reported that sedentary lifestyles are predominant in urban areas globally and are one of the top five major risk factors for NCDs. These findings are consistent with what has been reported by Creber *et al.,* (2010:1), Woodcock *et al.,* (2011:121) and Twinamasiko *et al.* (2018: 5). The frequency of inactivity differed according to the WHO regions (**Table 2.9).**

Table 2.9: The frequency of physical inactivity among the WHO Regions (Hallal *et al.,* 2012:248)

Region	Percentage
America	43.3%
Eastern Mediterranean	43.2%
Europe	34.8%
Western Pacific	33.7%
Africa	27.5%
Southeast Asia	17%

Another source of a familiar, available, and cheap forms of physical activity and a most significant component of total physical activity to the adult population is, apparently simply enough, the act of walking (Murtagh *et al.,* 2014:33). While walking can be used for different purposes such as personal transport or recreation it is frequently responsible for the larger proportion of self-reported physical activity in older adults. In a systematic review of interventions to promote walking, Ogilvie and associates (2007:7) report that interventions to promote walking can be beneficial for improving the levels of inactivity especially to people who live a sedentary lifestyle or those who are willing to change their lifestyles. While 63.3% adults in the UK did not meet the recommended amount of physical activity including a brisk walk for 30 minutes for at least five times a week, or vigorous exercise for 20 minutes three times a week (Boseley, 2012), 64.1% of adults reported walking for at least 10 minutes continuously on 5 or more days a week globally (Hallal *et al.,* 2012:248). The difference in WHO regions, though, were prudent **(**see **Table 2.10**).

Table 2.10: The variation of walking among WHO regions (Hallal *et al.,* 2012:248).

Region	Percentage
America	65.6%
Eastern Mediterranean	66.9%
Europe	66.8%
Western Pacific	65.0%
Africa	57.0%
Southeast Asia	67.2%

Walking should therefore form a foundation in the approaches that promote activity especially for older adults since it is the more familiar reported activity and can also improve physical functioning (Murtagh *et al.,* 2014:38).

The global inactivity prevalence differed by countries: Malta reported 71.9% of adults, while in Serbia the proportion was 68.3%. Additionally, Greece was reported as the most active since it only had 16% of inactive adults while Estonia had 17% and the Netherlands reported 18%; the United States reported 41% and Canada 34%. Females once more presented a higher prevalence of physical inactivity (33.9%) than males (27.9%) in the WHO regions (Hallal, 2012:248). Murtagh *et al.,* (2014:31) reports that on all self-reported physical activity around 5 surveys that were used to estimate the proportion of Irish older adults who meet the recommendations of physical activity, females once again presented lower levels of physical activity across all ages when compared to males. Based on these findings overall, it is inferred that levels of physical activity differ greatly according to countries and gender and that it is high in high-income countries. The results indicate that females are more physically inactive than men in many countries, which leaves them vulnerable to the risk of developing NCDs.

Vigorous-intensity participation in physical activity is a key symbol of physical activity levels and is more effective and reliable than moderate-intensity participation (Hallal *et al.,* 2012:249). Moreover, 31.4% of adults reported vigorous-intensity physical activity on at least three or more days a week; however, large variation existed among the WHO regions **(Table 2.11)** (Hallal *et al.,* 2012:249).

Table 2.11: Variation in vigorous intensity among WHO regions (Hallal *et al.,* 2012:249)

Region	Percentage
America	24.6%
Eastern Mediterranean	43.2%
Europe	25.4%
Western Pacific	35.3%
Africa	38.0%
Southeast Asia	43.2%

2.6.5.2 Physical inactivity in SA

South Africa is experiencing a largely increased number in low levels of active people, with high prevalence in females (Smit *et al.,* 2011:456-4578; Peltzer and Phaswana-Mafuya, 2012: 454; Malambo *et al.,* 2016: 5). An inverse relationship exists between physical activity levels and age (SADHS, 2007:292; Walter *et al.,* 2011: 8). Furthermore, in a comparison between the old population (35-45 years) and the young population (18-25 years), observations showed that even though the younger generation was more active, neither groups reached the recommended Health-Enhancing physical activity levels (Walter *et al.,* 2011:6). Their recommendations were ≥ 7 days of moderate or vigorous activity and ≥ 3000 MET.min/ week. In the North West Province among the Setswana speaking adult population, Onagbiye and colleagues (2017:107) reported that adults aged 34 to 44 years were more active than the old age group, while walking was the preferred type of physical activity A number of existing studies in the broader literature have examined physical activity levels using questionnaires, including the aforementioned literature (Oyeyemi *et al.,* 2016: 8; Kader & Haffejee, 2018: 527). Therefore, future studies are recommended on the measurement of objective assessment of physical activity (Oyeyemi *et al.,* 2016:11; Malambo *et al.,* 2016: 8). In Gauteng Province factors such as access to facilities, traffic, and neighbourhood safety, streets in the neighbourhood, limited places for walking or cycling, and crime, were highlighted as contributing factors to low levels of physical activity (Dhurup & Grobler 2012:423).

In the case of province-specific patterns of activity, KwaZulu-Natal accounted for a high percentage of physical inactivity among males and females, at 66% and 81%, respectively followed by the Northern Cape at 58% and 78% respectively **(Table 2.12)**. The same trend was found on a research done by Muluvhu (2018:138) in a low-resourced community of Limpopo province where females with metabolic syndrome (80%) presented high prevalence of inactivity compared to males (72%).

The data presented above emphasise the implementation of strategies that help to promote healthy lifestyles and call on interventions to enhance physical activity among the residents. Failure to do so can only lead to an increase in the already-considerable burden of NCDs and the associated risk factors. An association between the lifestyle behaviours and physical activity was observed in findings of a study performed by Peltzer and Phaswana-Mafuya (2012:453), participants who reported histories of hypertension, diabetes, obesity, smoking, alcohol use, and unhealthy diets, presented high levels of low physical activity (59.9%, 65.1%, 66.7%, 59.3%, 52.5%, and 57.9%), respectively.

Table 2.12: Province specific patterns of inactivity of adult males and females, (SADHS, 2007:292-293)

Province	Percentage	
	Males	**Females**
KwaZulu-Natal	66	81
Northern Cape	58	78
Gauteng	57	67
Free State	54	67
North West	45	75
Western Cape	37	66
Mpumalanga	31	49
Eastern Cape	25	48
Limpopo	24	35

The perceptions that working females are not able to participate in physical activity revolved around the ideas that most females already have a load to carry when it comes to family commitments, parenting, and working and that they therefore hardly found time to engage in physical activity (Nolan and Surujlal, 2010:356). The high number of physically inactive levels and unfitness poses a considerable burden regarding the health and wellness of South African females, since this plays a significant part in growth and the maintenance of one's health and wellness (Smit *et al.,* 2011:459). Regular physical activity is associated with weight maintenance, reduced risk of degenerative diseases, reduced early mortality risk, and improved quality of life, prevention of falls, and improved strength and endurance due to the nature of regular movements (CDC, 2018). Therefore, a low level of physical activity influences physical performance.

2.7 Physical inactivity as a modifiable risk factor for NCDs

The burden of NCDs can be reduced significantly by modifying the major risk factors including physical inactivity (WHO, 2018; WHO, 2019). There exists a considerable amount of literature on the health benefits of regular participation in physical activity (Giannuzzi *et al.,* 2003:319; Reiner *et al.,* 2013: 8; Lear *et al.,* 2017: 2652; Sheikholeslami *et al.,* 2018: 4). Physical activity is any bodily movement produced by the contraction of skeletal muscles that results in a substantial increase in caloric requirements over resting energy expenditure including playing, household chores, traveling, working, and recreational activities (ACSM, 2014:2). World Health Organization recommends physical activity of 60 minutes of moderate-vigorous intensity daily at least three times per week for children and adolescents aged 5-17 years; 150 minutes of moderate-vigorous physical activity or 75 minutes of vigorous physical activity throughout the week for adults aged 18-64 years. Adults aged 65 and older should engage in at least 150 minutes of moderate intensity aerobic physical activity or 75 minutes of vigorous aerobic physical activity throughout the week or an equivalent combination of moderate-vigorous intensity activity; adults with mobility problems should perform physical activity to enhance balance and prevent falls at least three or more days in a week (WHO, 2019). Moreover, muscle-strengthening activities should be performed two or more days in a week. These recommendations are significant for health outcomes such as improvement in cardiorespiratory and metabolic health, musculoskeletal health, functional health, and prevention of falls.

Regular participation in physical activity for diabetic people improves blood glucose tolerance, reduction in diabetic complications, improvement in insulin resistance, reduction in body fat, and cardiovascular benefits (Kabanda & Phillips, 2011:240; American Diabetes Association (ADA), 2017). The effect of physical activity on diabetes differs according to the type of exercise. Seminal contributions have been made by Chimen and colleagues (2012:547) where they reported that aerobic exercises decrease insulin resistance and improve lipid levels in persons with type 1 diabetes. Additionally, for type 2 diabetes, high-intensity interval training is associated with the improvement of insulin resistance and glycaemic control in adults (Jelleyman *et al.,* 2015:955). Resistance training for type 2 diabetes patients is associated with the enhancement of post-exercise energy consumption which leads to decreased adipose tissue mass and improved glucose homeostasis as a result of amplified rates of glycogen fusion (Pesta *et al.,* 2017:3). Additionally, resistance training is also responsible for the mitochondrial oxidative volume of muscles in diabetic patients.

The San Francisco Burden of Disease and Injury Study reported that aerobic physical activity of brisk walking for at least 30 minutes per day in most days of the week results in the reduction of 4-9 mmHg systolic blood pressure (San Francisco Burden of disease and Injury study, 2010). The observations from the findings from a narrative review of 27 randomized controlled trials (RCTs)

on aerobic physical activity effects on hypertension show that medium-to-high intensity aerobic activity reduces BP by 11/5 mmHg (Börjesson *et al.,* 2016:361). Furthermore, the results obtained by examining three RCTs on isometric training using the handgrip, of a submaximal voluntary contraction, performed three times per week, showed a mean reduction of 9.8/1.8 mmHg blood pressure (Börjesson *et al.,* 2016:359). As it is well known that hypertension is associated with LVH (Foëx and Sear, 2004: 73), exercise helps in restoring the hypertensive heart with paradoxical deterioration or prevention of LVH (Hegde & Solomon, 2015: 5). High physical activity index leads to improved cardiac structure and function since it is associated with improved components of cardiac structure and function such as LV mass index, reduced plasma mid-regional prohormone atrial natriuretic peptide (MR pro-ANP), and reduced plasma N-terminal prohormone brain natriuretic peptide (NT pro-BNP) (Kaminura *et al.,* 2017: 622).

A series of studies have indicated that regular physical activity and exercise are associated with improved lipid profiles thus reducing the risk of CVDs (Mann *et al.,* 2014: 219; Hu *et al.,* 2015: 269; Wang and Xu, 2017: 5). Aerobic exercises from different RCTs in males and females had different effects on lipid profiles **(Table 2.13).**

Table 2.13: Several studies on the effects of aerobic exercise on HDL-C, LDL-C and TG (Wang and Xu, 2017: 3)

References	Training time	Frequency	HDL-C	LDL-C	TG
LeMura *et a*l.	16 wk	3 times/wk	↑0.4 mmol/L	↓0.2 mmol/L	↓0.2 mmol/L
Nybo *et al*.	12 wk	150 min/wk	↑0.1 mmol/L	↓0.1 mmol/L	Not reported
Kraus *et al.*	24 wk	14-23 kcal/kg/wk	↑4.3 mg/Dl	↓1.9 mg/dL	↓28.4 mg/dL

Wk = weeks

Resistance training over a period of eight months (three exercise sessions per week for a total of 105 sessions) was associated with improved blood lipid profiles among patients with coronary artery disease (Theodorou *et al.*, 2016: 179). This has also been explored in community-dwelling adults living with Alzheimer's disease by Vital *et al.* (2016: 30). Their findings revealed a significant improvement in lipid profiles from the resistance training that was organized for 60 minutes per session, three times a week for 12 weeks. The results of TC showed improved cholesterol concentrations from 221.6 mg/dL ± 60.5 to 199.9 mg/dL ± 37.1, while HDL and LDL cholesterol improved from 47.2 mg/dL ± 10.3 to 50.5 mg/dL ± 9.5, and 149.2 mg/dL ± 57.1 to 126.6 mg/dL ± 32.9 respectively. However, the combined exercise of aerobics and resistance was encouraged as its effects last long, even after training cessation (Mann *et al.,* 2014: 219; Theorodou *et al.,* 2016:183). It can therefore be concluded that clinicians should encourage regular participation in

physical activity for persons with dyslipidaemia as the reduction in blood lipids is beneficial in preventing and treating it, which results in reducing the risk of CVDs.

Research on smoking as a modifiable risk factor showed an inverse relationship with physical activity in healthy adults aged 30 to 60 years. The study, from Tehran, revealed that people who smoke (71.1%) exercise less compared to non-smokers (29%) (Heydari *et al.,* 2015: 242). A systematic review and meta-analysis of longitudinal studies on the associations of smoking and alcohol consumption with healthy aging showed that out of 27 studies reviewed, 23 reported on the positive relationship between former- or non-smokers and healthy aging (Daskalopoulou *et al.,* 2018:12). Due to the effects that smoking has on health such as severe CRDs including COPD (WHO, 2017), physical ability to perform activities becomes limited. The reduced ability to perform activities is due to ventilatory limitations caused by the imbalance between the reduced ventilatory capacity and the increased demand as a result of dyspnoea sensations (Vogiatzis *et al.,* 2012:8). Several studies show that COPD patients present low levels of physical activity over time (Troosters *et al.,* 2010: 1007; Garcia *et al.,* 2017: 2780; Sievi *et al.,* 2018:4). Some authors have also suggested that participation in physical activity can be implemented as a method of smoking cessation treatment (Vander Weg *et al.,* 2018:58). However, although research has illuminated the acute effects of physical activity in managing nicotine cravings and withdrawal symptoms, it is still not clear if smoking cessation due to physical activity has a long-term effect (Klinsophon *et al.,* 2017: 18; Vander Weg *et al.,* 2018: 58). In short, the literature strongly suggests the encouragement of regular participation in physical activity considering its health benefits and improvement in functionality. Regular participation in physical activity is associated with improved components of functional performance which is essential for healthy future aging.

2.8 Physical performance

The Patient-Reported Outcomes Measurement Information System (PROMIS) (2014) defines a physical function as one's ability to carry out activities that require physical actions ranging from self-care (activities of daily living) to those that are more complex and require a combination of skills, often with a social component or within a social context. Physical function is divided into several related domains: mobility (lower extremity function), dexterity (upper extremity function), balance and coordination, and ability to carry out activities of daily living (ADL). Various factors influence an individual's physical function such as age and gender (Metti *et al.,* 2018:560, adiposity (Schaap and Kirkwood, 2012: 62), and chronic diseases (Wei *et al.,* 2016:361).

In relation to age, Brady and colleagues (2014:444) reported that the process of aging brings a multitude of changes to the musculoskeletal system. The rate of decline in physical function with age was further reported by Peters *et al.* (2013:668) with a high prevalence in females compared to males. This has also been explored in a cross-sectional analysis of international mobility in the

aging study performed on community-dwelling older adults aged 65-74 years (Ahmed *et al.,* 2016:12). Their findings are that females presented a high prevalence of self-reported mobility disability and reduced physical performance compared to males, with high prevalence in low and middle-income countries compared to high-income countries. The same trend was observed in the findings from a study on global Aging and adult health (SAGE) in South African adults aged 50 years and above (Phaswana-Mafuya *et al.,* 2012:75-76). Their findings were that females presented poor levels of physical function based on the ADL and instrumental activities of daily living (IADL), with an accelerating decline after the second and third decades. Moreover, high physical function levels showed a significant relationship with high-rated well-being.

Disparities in SES contribute greatly to health and physical function, especially in older people. Socioeconomic status, defined as a variety of measures covering education, marital status, occupation, and household income, is well associated with the prediction of physical function and all-cause mortality (Signorello *et al.,* 2014:e106). While it has been shown that education significantly influences physical function in participants aged 60-69 years, household income was a significant factor among those aged 70 years and above (Noppert *et al.,* 2018:5). Age-related retirement and the death of a spouse pose a risk of limited income resulting in increased economic disadvantage. Female adults aged 60 years and above with low SES and self-reported loneliness were reported to be at risk of functional decline including difficulties with their upper extremities, mobility, ADL, and the ability to climb stairs (Perissinotto *et al.,* 2012:1080). These findings emphasise the effect of aging on functional limitations and highlight the importance of examining the factors that lead to functional limitations throughout the course of life as most of the branches from the behaviours that people adopt in middle age. Physical function is associated with physical fitness and physical performance.

2.8.1 Muscular strength and endurance

'Muscular fitness is composed of the functional parameters of strength, endurance, and power, and each improves consequently to an appropriately designed resistance-training regimen' (Garber *et al.,* 2011:1343). The CDC (2015) defines muscular strength as the performance component of physical fitness with the capacity of a muscle or a muscle group to apply force. Muscle strength and endurance are associated as the endurance requiring a certain volume of strength to perform repetitive contractions against resistance (Gacesa *et al.,* 2013:808). Past research shows that muscle strength is influenced by age (Keller and Engelhardt, 2013:349). Sarcopenia (loss of skeletal mass and strength due to aging) is associated with loss of skeletal muscle performance (Tieland *et al.,* 2018: 4). The emanated effects of muscle aging include decreased muscle fibre size, strength, power, and reduction in muscle elasticity (Miljkovic *et al.,* 2015:157). A study by Keller and Engelbrecht (2013:349) shows that the adult groups with the mean age of 31 and 54 years reported a declining range of 16.6% and 40.9% of muscle strength.

Therefore, preserving muscle strength and endurance throughout the life course is beneficial for healthy aging. The handgrip test is commonly used for testing muscle strength in the upper extremities (Leong *et al.,* 2016: 541).

Grip strength is defined as the maximum strength determined by the combination of extrinsic and intrinsic hand muscle contraction resulting in the flexion of the hand joint (Mitsionis *et al.,* 2009:715). Several determinants of handgrip strength include older age, gender (Musalek and Kirchengast, 2017:5), low levels of physical activity, nutritional status, and upper extremity strength (Leong *et al.,* 2015:269). In their study on gender differences in the association between grip strength and mortality, Arvandi *et al.,* (2016:4) report that grip strength is associated with all-cause mortality in older adults at a mean age of 76 years with a high prevalence in females. However, their findings are reported independent of age, nutritional status, chronic diseases, physical activity levels. A cohort study by Strand *et al.* (2016:1216) reported a linear mortality risk increment with low levels of grip strength and mortality due to CVDs and respiratory diseases in adults aged 50-80 years. One infers from these findings that grip strength is a significant indicator of fundamental aging and age-related diseases.

2.8.2 Balance

Balance is a performance-related component of physical fitness involving the ability to maintain the human body's stability while standing or moving (CDC, 2015). Balance impairment is associated with risks of falling. Falls are common incidences in the adult population with many consequences including death, injuries, and physical and emotional complications (Pasquetti *et al.,* 2014:222). The WHO (2018) reports that an estimated 646 000 deaths due to falls occur each year, at over 80% of fall-related mortalities occurring in low-and middle-income countries. Moreover, older adults (60 years and above) are at increased risk of death or injuries related to falls. The fundamental factors that are associated with falls include older age, muscle weakness, gait and balance problems, visual and cognitive impairment, depression, medical conditions (neurological and cardiac conditions), and high levels of physical inactivity (Rubenstein & Josephson, 2002:154; Ward *et al.,* 2015:319; WHO, 2018).

According to Brown (2017:12), bad posture also has a negative impact on balance, falling, and pain. The maintenance of postural stability is due to the combination of problems around sensory input (visual and vestibular system), central nervous system, and motor co-ordination, followed by outputs to the musculoskeletal system (Iwasaki and Yamasoba, 2015:39; De Villiers and Kalula, 2015:705). Moreover, aging results in ≤ 40% of decreased vibration and position sense and common vestibular impairments, reduced central processing, and muscle atrophy, which lead to postural instability. A flexed posture is characterized by back pain, impaired vision due to impaired neck flexion, and muscular impairments and motor function limitations (Balzini *et al.,*

2003:1425). The deterioration of balance results in loss of independence in older adults, thus hindering the ability to perform ADL.

Functional performance tests are built around postural actions and movements which people adopt in their everyday activities. The one leg stance test is one of the functional performance tests used for predicting frailty and fall risks in the elderly population (Michikawa *et al.,* 2009:683). Moreover, it is advantageous since it only takes a minute to complete the test and it shows high reliability because the use of a stopwatch provides precise criteria for stopping the timed test (Mancini and Horak, 2010:241). Factors that affect the balance and mobility in elders include foot malalignment, large body and fat mass, older age, and lower limb strength and muscle endurance (Mohd Said *et al.,* 2015:5).

The timed up and go test (TUG) were used to access the measure of functional stability and mobility in older adults (Lusiardi *et al.,* 2003; Yoon *et al.,* 2009; Benavent-Caballer *et al.,* 2016:126). Functional mobility is associated with motor skills that are necessary for independent living including moving around, walking, and changing direction while walking. Mousa *et al.,* (2016:51) used the TUG test to determine muscle strength, balance, and gait as well as to assess the risk of falls since they are essential factors in preventing osteoporosis fractures. The findings showed that a TUG time of more than 20 seconds, which represented poor mobility, was associated with reduced lumbar spine- and femur neck bone mineral density which may bring forward the risk of the onset of osteoporosis fracture by ten years. Benavent-Caballer *et al.,* (2016:125) report that the TUG time scores are directly proportional to age. Their findings were that participants aged 65-75 years reported a mean TUG time of 8.6 seconds and a mean time of 12.4 and 17.2 seconds for those aged 76-85 years and greater than 85 years respectively.

Rising from a seated to a standing position is one of the most common tasks of everyday living. The primary problem of age-related loss of lower limb strength and power is the reduced ability to perform functional activities (Nakano *et al.,* 2014: 585), thus reduced ability to perform ADL including walking, sitting, and standing. The chair stand test, fast and easy to use in a busy setting, is one of the effective methods used to determine lower extremity muscle strength performance in the risk stratification for injurious falls (Rikli and Jones, 1999; Ward *et al.,* 2015:319). Reid and Fielding (2012:8) reported that lower extremity muscle power is a significant predictor of functional performance in older adults. Therefore, assessment of the chair stand test is essential for lower extremity functionality. The performance of the chair standing test is influenced by the peak power of the ankle flexors (Suzuki *et al.,* 2001:1167). A study conducted by Tsuji *et al.,* (2015:114) in community-dwelling healthy older adults aged 65-75 years found that the ground reaction force parameters in a sit-to-stand movement were associated with isokinetic strength and power in the ankles and knees.

2.9 Cardiorespiratory fitness

Cardiorespiratory fitness (CRF), a major component of physical fitness, refers to the ability of the heart and lungs to carry oxygen to working muscles during a continuous physical activity (Ross *et al.,* 2016:e654). Cardiorespiratory fitness reflects the combined effectiveness of the lungs, heart, and vascular system, and muscles in the transportation and usage of oxygen. Typically, it is associated with the combined function of various body systems under physiological stress conditions reflecting the body function and general health of an individual (Laukkanen and Kujala, 2018: 2293). Cardiorespiratory fitness is measured by maximum oxygen consumption (VO_2max) expressed in millilitres of oxygen per kilogram of body mass per minute (mL/kg/min) (Ross *et al.,* 2016:e654-e655). Determining factors associated with the levels of CRF include age (Schneider, 2013:455), gender, and smoking (Zeiher *et al.,* 2019:16) as well as sedentary lifestyle (Després, 2016: 508). Physical inactivity and sedentary behaviours lead to the body's accumulation of additional adipose tissues and chronic inflammation that are responsible for the development of NCDs (Hingorjo *et al.,* 2017:659-660). Although CRF can be determined by genetic factors, physical activity is the main modifiable factor towards improving it.

High levels of CRF are associated with reduced mortality risk (Imboden *et al.,* 2018:2290, de Lannoy *et al.,* 2019:555). However, a study done by Lu *et al.* (2018:1134) among Chinese older adults established that physical activity and CRF were inversely related with the risk of all-cause mortality. These findings suggest that high CRF does not inevitably confer low mortality risk in physically inactive older adults. It is well documented that aging leads to reduced physical activity levels. Therefore, it is essential for elders to engage an active lifestyle. Aging is associated with a decline in the structure and functioning of pulmonary circulation which is characterized by an increase in pulmonary stiffness as well as pulmonary vascular pressure and resistance; leading to pulmonary hypertension (Lam *et al.,* 2009:2667). One problem with the structural and mechanical changes in pulmonary vasculature as a result of pulmonary hypertension is that it increases the right ventricular afterload (Wang and Chesler, 2011:213). Moreover, the right ventricular afterload is the primary cause of pulmonary hypertension deaths as it leads to heart failure. A systematic and a meta-analysis of controlled trials focused on patients with pulmonary arterial hypertension found that an exercise training programme is beneficial towards improving physical- and functional capacity (Buys *et al.,* 2015:4). Therefore, regular participation in physical activity is essential for improved fitness since high levels of aerobic capacity is inversely proportional to pulmonary vascular resistance in healthy individuals at maximum exercise (Lalande *et al.,* 2012:4286).

Studies that examine the effect of chronological aging on CRF in adults are well documented (Kolher *et al.,* 2016:609; Jakovljevic, 2018:72; Pandey *et al.,* 2019:4) and it is also commonly acknowledged that CRF in adults is a significant predictor of independent living and also of the

ability to perform ADLs that require involvement of large muscle groups for long periods. Fleg and colleagues (2005:677) indicated that the decline in CRF varies according to age at 3 to 6% decline per decade in individuals aged 20 to 30 years but more so at greater than 20% decline from the age of 70 years and above in males and females. As has been reported in extant literature, even though aging brings inevitable decline in CRF, physical activity can alleviate it. This statement is supported by Kohler *et al.* (2005:608) where inactive females reported a CRF decline of 14.3% while 10% at those who were insufficiently active, and while, in turn, 8.0% was observed at sufficiently active persons over a period of 6 years. These findings emphasise that the CRF is determined by physical activity, gender, and chronological aging.

2.10 Relationship between risk factors of NCDs and functional performance

The rapid growth of risk factors of NCDs is a global burden. A challenging problem that arises in this domain is the detrimental effects of these risk factors on the physiological systems of the body including the musculoskeletal system (Barbat-Artigas *et al.,* 2012:817; Li *et al.,* 2015:5). The WHO reports similar risk factors of musculoskeletal conditions and NCDs including physical inactivity, obesity, smoking, and poor nutrition (WHO, 2019). Li *et al.* (2015:7) report the association of muscle mass and chronic conditions on physical performance among adults aged 65 years and older. They found that participants who had low muscle mass and the presence of chronic conditions reported low grip strength, slower gait, and lower TUG scores compared to those with low muscle mass and chronic conditions. Moreover, consistent with previous studies (Nakano *et al.,* 2014:585; Makizako *et al.,* 2017:611), their findings showed that physical performance declines with increased age.

One primary problem with reduced physical performance is the decline in the ability to perform functional activities including ADL and physical activity, which turn out to be problematic because high levels of physical inactivity are associated with myriad problems in the skeletal system. High levels of physical inactivity are associated with reduced muscle strength and endurance due to age-related loss of muscle mass in adults (Knight, 2012:329), thus affecting physical performance. The findings from a study done by Tomás *et al.* (2018:5) on Portuguese community-dwelling adults (60 years and older) led to a similar conclusion where participants who presented low levels of physical inactivity presented poor results on functional performance tests compared to those who were active. Moreover, after a three-year follow-up, the observations on body composition showed that while male participants had reduced BMI, females showed loss of skeletal muscle mass and a significantly increased waist to hip ratio. These led to a decline in functional fitness and reduced ability to perform functional activities, thus increasing dependence.

South Africa was reported to have a high percentage of older people at about 7.6% of the population over the age of 60 years in the year 2010 (Statistics South Africa, 2010:8). However,

the 2019 statistical report indicates that the number of older people was 9%, an increment of 1.4% from the year 2010 (Statistics South Africa, 2019:9). Extant literature reports that rapid increase in aging is associated with reduced physical function, thus increased risk of disabilities in the geriatric population. Furthermore, as the population is continuing to rise, maintaining physical function becomes vital since a lack of it leads to reduced ability of performing functional activities. Community-dwelling females require a high amount of physical function due to traditional living arrangements influenced by culture and beliefs (Dong *et al.,* 2014: S37; Idang, 2015: 108-109).

2.11 Summary

Research on NCDs and their associated risk factors enjoys a long and illuminating tradition. The literature reviewed here centres on the major group of NCDs and their associated risk factors including their impact on health. The epidemiological transition of NCDs is rapidly increasing in developing countries including South Africa. The major group of NCDs including CVDs, cancer, CRDs, and diabetes is the leading cause of morbidity and mortality globally. The literature reveals that physical inactivity, one of the major risk factors of NCDs, is responsible for a high prevalence of NCD-related deaths. Modifying physical inactivity does not only have health benefits of reducing the burden of NCDs but is also associated with an improved ability to perform functional activities. Increase in the geriatric's population increases the risk of limitations in physical function. The literature examined here discusses major changes that are associated with aging including loss of muscle mass, reduced muscle strength and endurance as well as poor cardiovascular health. These changes reduce functionality in older adults and impact negatively on their health since they lead to poor quality of life and reduced ability to perform functional activities including ADL and physical activity. Consequently, CRF also decreases which increases the risk of early disability and dependence in community-dwelling adults.

The traditional living arrangements influenced by cultural beliefs require high levels of physical function in community-dwelling females to perform their functional activities within their households. The literature also indicates that low levels of CRF and physical activity are associated with an increase of risk factors around NCDs. With South Africa facing a growing burden of its geriatrics population and the burden of NCDs, maintaining physical function becomes important for healthy aging. Moreover, the literature shows that there is enough evidence around the risk factors of NCDs, and evidence on physical function in the elderly population. However, it is important to track these factors that lead to functional limitations throughout the course of life since most of them branches from the behaviours that people adopt in the middle age. Therefore, further research should be done in comparison to these factors from middle-aged adults to the geriatric population.

Future studies should embark on addressing the lacuna in extant South African literature regarding relationships between risk factors of NCDs and functional performance. This will develop a better understanding of the management of risk factors for NCDs and independent living. To address this lacuna, the reviewed literature will form a base for the analyses of a baseline data from B-Healthy study in this dissertation aimed to determine the relationship between the risk factors of NCDs, physical activity, and functional performance among African females in a low-resourced community. The findings are reported here in the format of two independent articles.

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CHAPTER 3: ARTICLE 1

The relationship between risk factors of non-communicable diseases and functional performance in females from a low-resourced community: B-Healthy-study

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Abstract

Risk factors due to non-communicable diseases (NCDs) often lead to persons avoiding physical activity, which will result in a decrease in functionality. This study aimed to determine the relationship between the risk factors of NCDs and functional performance in females from a low-resourced community. The data was gathered by analysing 81 adult females (AF) (48.15 ± 8.30 years) and 99 senior females (SF) (68.58 ± 7.02 years) in this cross-sectional study. Risk factors of NCDs and functional performance were assessed with a view to the following activities: sit to stand, handgrip (HG), timed up and go (TUG) and static balance.

The results showed a significant relationship between BMI and TUG in both groups (AF: p = .019; r =.303; SW: p = .031; r =.271). In the AF the waist circumference (WC) correlated with TUG (r =.348; p = .006). High-density lipoprotein cholesterol (HDL-C) correlated inversely with the right HG (r = -.301; p = .019). WC correlated positively with the right HG (r = .259; p = .039) and inversely with the left single leg stance (SLS) (r = -.254; p = .042) in the SW.

The conclusion can be therefore drawn that an increase in obesity as a risk factor related to NCDs corresponds with a reduction in balance and handgrip strength. Future interventions should aim at addressing obesity in individuals with NCDs to ensure improved balance as a key factor in functional ability related to fall risk.

Keywords: Non-communicable diseases, risk factors, functional ability, socio-economic status

Introduction

Non-communicable diseases (NCDs), also known as chronic diseases of lifestyle, are the leading cause of morbidity and mortality globally [1]. The development of NCDs occurs due to a combination of genetic, physiological, environmental and behavioural factors. NCDs were responsible for 41 million, or 71%, of all deaths globally in the year 2015 [1]. Of these deaths, the leading cause was cardiovascular diseases (CVD), responsible for 17.9 million deaths, followed by cancers (9 million), respiratory diseases (3.9 million) and diabetes with 1.6 million deaths per year [2]. The major risk factors that were responsible for these deaths included unhealthy diets, which accounted for about 12 million deaths, followed by smoking tallying 6.5 million, alcohol and drug use adding up to 1.8 million and physical inactivity, which accounted for 1.6 million deaths [3]. The World Health Organization (WHO) reported that over 31.5 million NCD deaths occurred in low- and middle-income countries (LMIC) where 46% deaths occurred before the age of 70 years [2].

The number of deaths related to NCDs in LMIC is projected to rise more rapidly if necessary actions are not taken [4]. Such actions include modifying risk factors, which can be efficient towards reaching the target of reducing the NCD mortality rate by 25% between the years of 2010 – 2025 [5]. The rapid growth of the epidemiological transition in LMIC is the leading cause of the increasing rate of NCD-related deaths resulting from infectious diseases such as HIV/AIDS and Tuberculosis [6].

The areas likely to be affected include Africa, the eastern Mediterranean and Southeast Asia. Africa alone is projected to face the largest increase in deaths, of 46%, related to global NCD incidences by the year 2030 [7]. Evidence gathered by tracing Africa's progress towards implementing the NCDs global action plan 2013-2020 showed that its commitment to succeeding when it came to WHO recommendations for confronting NCDs, which were set to be achieved by the year 2015 and 2016, seems to have failed [8]. The national strategic plan for NCDs in South Africa (SA) has highlighted the need for community-based strategies around prevention, control and management of NCDs to complement facility-based health services to help in tackling the NCD burden [9]. The ageing of the population, lifestyle changes, lack of access to affordable medication and health care systems are the main contributors to NCD deaths in LMIC [10], while these have resulted in increased household care expenditures, increased risk of poverty and disability [11].

Since NCDs develop over a long period, they can lead to deterioration in a person's quality of life and, eventually, death. Therefore, it is essential that risk factors are detected as early as possible to alleviate negative effects, especially in old age [12]. An inverse relationship exists between physical inactivity and functional ability [13]. A study conducted on Portuguese

community-dwelling adults confirms the relationship between physical activity and functional performance, since physically active participants reported better results in performance tests [13]. Although the evidence in the study demonstrated that functional ability deteriorates slowly in correlation with ageing, it declined more rapidly in correlation with physical inactivity, which led to a premature decline of health in individuals, reducing years of life relative to average lifespan and increasing the percentage of population disability [14].

The process of ageing is defined by the biological changes in the body systems; however, it is also subjected to constructions created by society, which differs in different countries. In this respect, the WHO reported that chronological time played a significant role in defining the process of ageing, especially in developed countries including Africa [15]. Moreover, elderly age was classified as 60 years and above, which corresponds with retirement ages in most developed countries. The Parliament of the Republic of South Africa defined an older person as one who was 60 years old and above in females and 65 years old and above in males [16], while the word "older" is used interchangeably with "senior."

The process of ageing is associated with adaptations in body systems including cardiorespiratory endurance, changes in the musculoskeletal- and metabolic systems as well as growth in geriatric syndromes and chronic diseases [17,18]. Adaptations prompted by ageing include loss of bone mineral density and reduced muscle strength and size, leading to decreased functional performance, thus affecting the quality of life negatively as well as increasing dependence and risk of falls [19].

The main cause of disability in the elderly population is the decline of health as a result of chronic diseases, which leads to challenges in performing activities of daily living (ADL) [20,21] such as walking, taking a bath and moving from bed to chair. Females tend to be more intensely influenced by age when compared to men, leaving them more exposed to the risk of disabilities due to age [22].

Prior research shows that strength, endurance, balance, bone mineral density and flexibility decline at about 10% every decade, regardless of whether a person is healthy and active [23], while these declines correlate with declination in a person's functionality [24]. Strengthening the musculoskeletal system is beneficial for improving overall health and reducing the risk of cardiovascular diseases, thus promoting healthy ageing [25]. A series of studies have reported that a decline in physical function as ageing progresses is engendered by adverse NCD risk factors [26]. Understanding the relationship between NCDs and functional abilities will therefore assist with the development of interventions to improve the health and wellness of older persons [27]. For instance, a relation between functional limitation and diabetes mellitus, as related further to lower-body mobility and function, was reported in studies conducted in high-income countries

such as the United States, Hong Kong and the UK [28,29,30]. The overall findings of these studies show that diabetes is associated with a wide range of disabilities.

Ample evidence is available to demonstrate the prevalence and long-term effects of NCDs and their risk factors on health outcomes [2,5,32,33], but limited evidence is available on the relationship between risk factors around NCDs and functional performance, especially as found among adults and senior females who are dependent on public health care and live in low-resourced communities of SA. In the present study, the relationship between the risk factors of NCDs and functional performance in femles from a low-resource community in Potchefstroom, SA was examined. The information obtained will inform health care practitioners about strategies that could be implemented to manage risk factors that arise around NCDs and functional ability. The information presented will contribute to the development of effective exercise interventions to address risk factors around NCDs as well as functional performance, thus, to improve the general quality of life in low-resourced communities.

Methods

Study design

The study is a cross-sectional observational study which is part of an overarching B-Healthy study. The data collected during the baseline measurement of the B-Healthy study will be used. The B-healthy study aimed to determine the effect of an exercise intervention on the risk factors of NCDs, medicine usage, functional capacity and quality of life of persons from a low-resourced community (Trial number: PACTR201609001771813). The Health Research Ethics Committee for Humans at North -West University approved the study (Ethics number: NWU 00049-15-A1). Permission to conduct the study was received from the Department of Health.

Participants

A total number of 200 residents between 35 to 89 years old were recruited from the surrounding areas of two public health clinics, Steve Tswete- and Lesego clinics in Ikageng. These participants were dependent on treatment at either of these two clinics. From the 200 participants (both males and females) that gave informed consent, the data of 180 females were included in this study due to the small number of male participants. Participants were recruited by means of information flyers and word of mouth at the healthcare clinics and community gatherings in the areas of the two clinics. The inclusion criteria state persons to be included that are able to perform exercise tests, persons depending on public health clinics for care, persons who were at moderate to low risk for physical activity based on the Physical Activity Readiness Questionnaire (PAR-Q) [34] and also participants who presented at least one cardiovascular risk factor. The exclusion criteria included pregnancy and/ or lactation, any absolute contraindications to exercise testing as indicated by the ACSM [35], orthopaedic and/or mental limitations and participants with known cardiovascular risk and at high risk for physical activity participation according to the PAR-Q [35].

Demographic information

The collected demographic data of the participants included the date of birth, age, ethnicity and reporting any chronic conditions for which they are prescribed medication. This process was carried out upon arrival after signing the informed consent and filling out necessary questionnaires.

Risk factors for non-communicable diseases

Age

Participants over the age of 55 years were classified as having a risk for NCDs [35].

Overweight and Obesity

Height was measured to the nearest 0.1 cm using a stadiometer calibrated to the nearest 0.1 cm (Seca 225, Seca, Hamburg, Germany). Weight was measured to the nearest 0.1 kg on a digital scale (Seca 861, Hamburg, Germany) with the subject wearing lightweight clothing and no shoes. The height and weight measurements were taken three times and following the guidelines of the International Society for the Advancement of Kinanthropometry (ISAK) (ISAK, 2011). Body mass index (BMI) was calculated as weight in kilograms divided by height in meters squared kg/m^2 and, accordingly, participants were classified into normal (BMI < 25 kg/m^2), overweight (BMI: 25-29.9 kg/m^2) and obese (BMI ≥ 30 kg/m^2) [35]. Waist circumference (WC) was measured by using a flexible steel tape (Lufkin W606PM, Creative Health Products, MI, USA) to the nearest 0.1 cm. The WC measurements were categorised into normal (WC< 88 cm) and elevated (WC ≥ 88 cm) [34]. Measurements were taken with participants standing, on the midpoint between the lower edge of the costal border and the upper edge of the iliac crest. All measurements were taken three times by the same trained person with the mean of the two closest assessments used for the analysis.

Hypertension

Blood pressure was measured with a sphygmomanometer (Omron Xinxiang Golden Elephant Sci-Tech Co., Ltd., China) using the Riva-Rocci/ Korotkoff method on the left arm [36]. Participants had to refrain from smoking cigarettes and to ingest caffeine, for 30 min before measurement. Two measurements were taken 5 minutes after arrival, following a 5-minute rest between each measurement. The average for the heart rate, systolic and diastolic blood pressure in mmHg was used for data analyses. The blood pressure cut off points used for analysis were assessed according to guidelines of the American college of cardiology/ American heart association (ACC/AHA) where normal BP was considered as <120/80 mmHg, prehypertension as 120-139/ 80-89 mmHg, stage 1 hypertension as 140-159/90-99 mmHg and stage 2 hypertension as ≥ 160/ ≥ 100 mmHg [37]. Participants who were taking medication were considered hypertensive.

Biochemical analysis for hyperglycaemia and dyslipidaemias

A peripheral blood sample was collected to determine the levels of fasting glucose, cholesterol, HDL-C and LDL-C and the values were recorded in millimoles per liter (mmol/L) according to the manufacturer ‘s user manual [38] by employing Accutrend glucose and

cholesterol monitors (Accutrend, Roche Diagnostics, Germany). These processes were completed before the participants continued with the physical activity calibration step test. Fasting glucose levels of ≥ 5.5 mmol/L were classified as prediabetes while dyslipidemia levels were as follows: LDL-C ≥ 3.37 mmol/L, HDL-C < 1.04 mmol/L and TC ≥ 5.18 mmol/L. Persons taking anti-glycaemic medication were also classified as diabetic [34].

Habitual objective physical activity

Physical activity levels were determined objectively using the combined heart rate (HR) and accelerometer device (ActiHeart, CamNtech Ltd, Cambridge, UK), a chest-worn monitoring device. Time spent in different categories of physical activity was measured as minutes per day in light (1.5 – 2.99 METs), moderate (3 – 5.99 METs), vigorous (≥ 6 METs) and MVPA (≥ 3 MET) [35]. The device was calibrated using an 8-min step test on a 21.5 cm step box [39]. Data were collected for seven consecutive days at 30-sec epochs. All participants were required to sit for 5 minutes before any measurements were taken and sit quietly again at the end of the steps test for a 2-minute recovery period. Instruction for wearing the accelerometer including placement, wearing time and when to return the device (8 days later) was provided to the participants. The ActiHeart was attached to the chest by means of two ECG pads.

Functional performance tests

To determine the participants' functional performance, the following tests were assessed: lower extremity muscle endurance, mobility, upper extremity muscle strength and static balance.

Lower extremity muscle endurance

The sit-to-stand test for determining lower extremity strength was performed with a 30-second Chair Stand Test [40]. Participants in a seated position on a chair with standard height (44-45 cm) and arms folded across the chest were instructed to complete as many full stands as possible in 30 seconds. Two trials were performed where the number of full stands within 30 seconds was counted. The participants rested for 10 seconds between the measurements. The best value of two measurements was used for analyses.

Mobility

The timed up and go test was applied to test mobility and fall risks [40]. The advantages of the test are that it is simple, requires simple tools, is quick to perform and can be performed by participants who use assisting devices such as a walker, cane or crutches. Participants were asked to get up from a seated position (seat height of 46 cm) without using their arms, walk nine meters, turn and return to their seated position. The participants performed the test three times and the best result was recorded to the nearest 0.1 seconds.

Upper extremity muscle strength

The handgrip test was used to assess muscle strength in the upper extremities. The grip strength was measured using a hand-held dynamometer (5030 Jamar-Hydraulic Hand Dynamometer, Sammons Preston Rolyan, Bolingbrook, Illinois, USA). The assessments were conducted three times on each hand in an alternating fashion with a 30-sec pause between attempts. The test was conducted with the participant seated holding the upper arm alongside the trunk and elbow at 90° of flexion. The participants were asked to squeeze the device as hard as possible for at least 10 seconds. The best results were recorded to the nearest 0.1 kilograms (kg).

Static balance assessment

The single-leg stance (SLS) test measured the static standing ability using a stopwatch [41]. Participants were asked to stand on one leg up to a maximum of 60 seconds on a flat surface, shoes off and on one bended knee. The balance was measured as the longest time depending on how long the participant stood without stumbling or feet touching the ground.

Statistical analyses

Descriptive statistics were performed to present participant's characteristics as means with standard deviations. To test the normality of the variables, the Kolmogorov–Smirnov test was utilized. Partial correlation analysis between risk factors for NCDs and functional performance variables was performed to determine the relationship between risk factors for NCDs and functional performance variables.

The total group of females were then categorised according to age as adult (AF) and senior females (SF). Adult females were younger than 60 years and SF were ≥ 60 years. A one-way ANOVA with Bonferroni posthoc comparisons was used to analyze group differences. Partial correlation analysis was performed between risk factors for NCDs and functional performance of the two categories separately and adjustment for age was made.

The level of statistical significance was set at 5% ($p < 0.05$). Data were analysed using the Statistical Package for the Social Sciences (SPSS) (IBM SPSS Statistics v.23, Chicago, IL, USA)

Results

Table 1 represent the characteristics of the participants and their NCD risk factors according to their age group. The results indicate that the overall mean age of the participants was 59.38 ± 12.71 years, with an average waist circumference larger than the 88 cm guideline and BMI at the level of obesity (32.1 ± 7.75 kg/m^2). The overall blood pressure's classification for

the participants was hypertensive (135/83 mmHg). The average cholesterol and glucose concentrations for the group were reported to be normal. We described the results of MVPA, which show the overall mean of 39.86 ± 58.47 minutes of MVPA performed daily amounting to an average of 239 minutes per week, the adult group reporting more time than the senior females. There was a significant age difference related to height ($p < 0.003$), SBP ($p = 0.027$) and MVPA ($p = 0.023$).

Table 1: Descriptive characteristics of the participants

Variables	All n = 180	< 60 y (adults) n = 81	≥ 60 y (seniors) n = 99	*p*-value
	Mean ± SD	Mean ± SD	Mean ± SD	
Age (years)	59.38 ± 12.71	48.15 ± 8.30	68.58 ± 7.02	<0.001*
Weight (kg)	78.6 ± 18.52	78.36 ± 19.95	76.35 ± 17.35	0.719
Height (m)	1.54 ± .06	1.56 ± .74	1.53 ± .06	0.003*
Metabolic variables				
BMI (kg/m^2)	32.07 ± 7.75	31.62 ± 8.20	32.44 ± 7.39	0.485
Waist C (cm)	92.41 ± 14.10	91.32 ± 15.03	93.35 ± 13.27	0.344
SBP (mmHg)	135.29 ± 21.63	131.37 ± 18.87	138.5 ± 23.25	0.027*
DBP (mmHg)	83.18 ± 13.80	84.67 ± 12.30	81.95 ± 14.87	0.189
Glucose (mmol/L)	5.42 ± 2.97	5.38 ± 3.14	5.45 ± 2.84	0.878
TC (mmol/L)	4.22 ± .99	4.19 ± .99	4.24 ± .98	0.730
LDL-C (mmol/L)	1.99 ± .89	1.99 ± .92	1.99 ± .88	0.995
HDL-C (mmol/L)	1.46 ± .45	1.48 ± .41	1.44 ± .49	0.614
ActiHeart variables				
MVPA (min/week)	39.86 ± 58.47	51.20 ± 73.37	29.13 ± 37.00	0.023*
Accelerometer wearing time (day)	6.01 ± .67	5.91 ± .63	6.11 ± .71	0.087

BMI=Body mass index; DBP=Diastolic blood pressure; HDL-C= High-density lipoprotein cholesterol; LDL-C= Low-density lipoprotein cholesterol; MVPA= Moderate to vigorous physical activity; SBP= Systolic blood pressure; TC= Total cholesterol. * = statistically significant ($p < 0.05$); SD= Standard deviation

Table 2: Descriptive statistics of the participants' functional performance test results

Variables	All n = 180	< 60 y n = 81	≥ 60 y n = 99	*p*-value
	Mean ± SD	Mean ± SD	Mean ± SD	
Right HG (kg)	24.15 ± 6.13	25.90 ± 6.41	22.70 ± 5.51	0.001*
Left HG (kg)	23.82 ± 5.27	25.36 ± 5.22	22.58 ± 5.00	0.001*
Sit to Stand Test (n)	12.02 ± 4.43	12.55 ± 4.73	11.54 ± 4.10	0.153
TUG test (30 seconds)	19.51 ± 8.09	18.5 ± 7.82	20.41 ± 8.27	0.136
SLS-Right (seconds)	21.26 ± 19.54	29.54 ± 20.97	13.60 ± 14.46	<0.001*
SLS-Left (seconds)	20.42 ± 18.64	27.50 ± 20.16	13.70 ± 14.22	<0.001*

HG = Handgrip strength; SLS = Single leg stance; TUG= Timed up and go. * Statistically significant ($p < 0.05$); SD= Standard deviation

Table 2 represents the characteristics of the participants and functional performance measurement according to their age groups. The results indicate that the females scored just above the recommended average level of the right HG, but the left HG was below the average [42]. Out of 180 participants, 158 reported the right-hand as their dominant side, 13 reported the left-hand as their dominant side and 9 participants did not specify this. Both the right- and left HG strength differed significantly among the age groups ($p < 0.001$). Overall, the participants showed poor performance on the number of repetitions in the sit to stand test (12.02 ± 4.43 reps) while the timed up and go test was just above the recommended average values (19.51 ± 8.09 sec). The left- as well as right single leg stance differed significantly between the two groups ($p < 0.001$), since the senior group presented lower values compared to the adult group. Overall, the senior group reported poor performance on all the tests when compared to the adult group.

Table 3: Correlation of the risk factors of NCDs and functional performance adjusted for age in females from a low-resourced community

Variables		Right HG (kg)	Left HG (kg)	Sit to Stand (n)	TUG Test (sec)	SLS-Right (sec)	SLS-Left (sec)
BMI (kg/m^2)	*r*	.048	.029	-.080	.123	-.120	-.154
	p	.621	.762	.407	.203	.214	.111
Waist C (cm)	*r*	.053	.032	-.034	.093	-.216	-.219
	p	.584	.741	.726	.334	.024*	.022*
SBP (mmHg)	*r*	-.067	.119	.149	-.032	.158	.082
	p	.492	.218	.123	.740	.100	.396
DBP (mmHg)	*r*	-.126	-.007	.094	.078	.120	.043
	p	.192	.944	.331	.421	.212	.658
Glucose (mmol/L)	*r*	-.078	-.130	-.059	-.176	.035	.024
	p	.418	.176	.542	.067	.716	.801
TC (mmol/L)	*r*	.058	.014	.203	-.129	.029	.015
	p	.550	.886	.035*	.180	.768	.873
LDL- C (mmol/L)	*r*	.122	.046	.204	-.135	.080	.045
	p	.207	.634	.033*	.163	.406	.640
HDL- C (mmol/L)	*r*	-.221	-.090	.039	-.060	-.026	.002
	p	.021*	.353	.684	.539	.790	.987
MVPA (min/week)	*r*	-.009	-.004	-.078	-.025	-.015	-.151
	p	.916	.958	.351	.763	.859	.068

BMI = Body mass index; DBP = Diastolic blood pressure; HDL-C = High-density lipoprotein cholesterol; HG = Handgrip strength; LDL-C = Low-density lipoprotein cholesterol; MVPA = Moderate to vigorous physical activity; SBP = Systolic blood pressure; SLS = Single leg stance; TC = Total cholesterol; TUG = Timed up and go. * Statistically significant ($p < 0.05$)

Table 3 indicates that a significant inverse relationship was observed between the waist circumference and right- (r = -.216; p = .024) as well as left single leg stance (r = -.219; p = .022) and between HDL-Cholesterol and RHG (r = -.221; p = .021). A significant positive relation was observed between the sit to stand test and LDL-Cholesterol (r = .204 p = .033) as well as total cholesterol respectively (r = .203; p = .035).

Table 4: Correlation of the risk factors of NCDs and functional performance of the adult female group of a low-resourced community adjusted for age.

		Right HG (kg)	Left HG (kg)	Sit to Stand Test (repetitions)	TUG Test (sec)	SLS-Right (sec)	SLS-Left (sec)
BMI (kg/m^2)	*r*	-.034	.019	-.144	.303	-.167	-.130
	p	.794	.886	.271	.019*	.202	.324
Waist C (cm)	*r*	-.148	-.050	-.147	.348	-.251	-.206
	p	.258	.704	.263	.006*	.053	.113
SBP (mmHg)	*r*	-.116	.110	.139	-.096	.099	.080
	p	.377	.403	.291	.467	.451	.542
DBP (mmHg)	*r*	-.227	-.072	.146	-.110	.161	.135
	p	.081	.586	.264	.403	.220	.303
Glucose (mmol/L)	*r*	-.115	-.187	.047	-.066	.173	.200
	p	.382	.153	.719	.616	.186	.126
Cholesterol	*r*	-.045	-.063	.345	-.140	-.047	-.042
(mmol/L)	*p*	.732	.632	.007*	.285	.721	.748
LDL- C (mmol/L)	*r*	.066	.014	.355	-.173	.005	.016
	p	.619	.918	.005*	.187	.970	.902
HDL- C (mmol/L)	*r*	-.301	-.214	.054	.038	-.088	-.106
	p	.019*	.101	.682	.771	.505	.419
MVPA (min/week)	*r*	.102	.137	-.068	.039	.058	-.165
	p	.438	.295	.606	.770	.662	.208

BMI = Body mass index; DBP = Diastolic blood pressure; HDL-C = High-density lipoprotein cholesterol; HG = Handgrip strength; LDL-C = Low-density lipoprotein cholesterol; MVPA = Moderate to vigorous physical activity; SBP = Systolic blood pressure; SLS = Single leg stance; TC = Total cholesterol; TUG = Timed up and go. * Statistically significant ($p < 0.05$).

Table 5: Correlation of the risk factors of NCDs and functional performance for the senior female group from a low-resourced community adjusted for age

Variables		Right HG (kg)	Left HG (kg)	Sit to Stand Test (repetitions)	TUG Test (sec)	SLS-Right (sec)	SLS-Left (sec)
BMI (kg/m^2)	*r*	.185	.119	.040	.271	-.126	-.245
	p	.144	.350	.753	.031*	.321	.051
Waist C (cm)	*r*	.259	.110	.130	.063	-.204	-.254
	p	.039*	.388	.305	.623	.106	.042*
SBP (mmHg)	*r*	-.060	.096	.130	.109	.167	.109
	p	.639	.449	.305	.390	.187	.393
DBP (mmHg)	*r*	-.094	-.006	-.086	.185	.067	-.022
	p	.460	.961	.500	.142	.598	.865
Glucose (mmol/L)	*r*	-.055	-.070	-.230	-.065	-.158	-.160
	p	.668	.584	.068	.608	.212	.207
TC (mmol/L)	*r*	.083	.007	.085	-.150	.083	.116
	p	.512	.953	.506	.236	.516	.362
LDL- C (mmol/L)	*r*	.054	-.079	-.007	-.093	.106	.102
	p	.670	.534	.956	.464	.407	.423
HDL- C (mmol/L)	*r*	-.121	.034	.052	-.128	.086	.139
	p	.341	.791	.686	.312	.500	.274
MVPA (min/week)	*r*	-.070	-.137	-.123	-.081	-.140	-.139
	p	.584	.279	.333	.525	.268	.275

BMI = Body mass index; DBP = Diastolic blood pressure; HDL-C = High-density lipoprotein cholesterol; HG = Handgrip strength; LDL-C = Low-density lipoprotein cholesterol; MVPA = Moderate to vigorous physical activity; SBP = Systolic blood pressure; SLS = Single leg stance; TC = Total cholesterol; TUG = Timed up and go. * Statistically significant ($p < 0.05$)

Table 4 indicate a partial correlation as found between the risk factors of NCDs and functional performance in adult females. The results show a significant relationship between BMI and TUG in both groups (AF: $r = .303$; $p = .019$ and SF: $r = .271$; $p = .031$). A significant relationship was observed between WC and TUG ($r = .348$; $p = .006$) while total cholesterol and LDL-C correlated significantly with the sit to stand test ($r = .345$; $p = .007$) and ($r = .355$; $p = .005$) in the adult group. Furthermore, HDL-C correlated inversely with the right HG ($r = -.301$; $p = .019$).

Table 5 indicate a partial correlation as found between the risk factors of NCDs and functional performance in seniors where the results shows that WC correlated positively with the right HG (r = .259; p = .039) and inversely with the left SLS (r = -.254; p = .042).

Discussion

The main purpose of the study was to determine the relationship between the risk factors of NCDs and functional performance among females from a low-resourced community. The main overall findings of this study were that risk factors of NCDs related to obesity, such as waist circumference and cholesterol concentrations, were significantly inverse related to the functional performance of balance in this cohort of females from a low-resourced community. The results also indicated that participants presented low values of functional performance according to age-specific norms [40].

These results dovetail well the previous evidence where age was associated with a great risk of exposure to the risk factors for chronic conditions as well as functional limitations [35,43,44]. The inverse relationship between WC and balance (Tables 3 and 5) is an important finding since it illuminates an understanding of the risk factors for chronic conditions that are associated with balance among the adult population. Balance is very important among the old population since it relates to maintaining body posture, reduction of falls and the performance of daily activities and independent living. Contrary to the previous findings, which examined the relationship between balance and obesity mostly with a view to the assessment of BMI [45,46,47], we did not find a significant relationship between BMI and balance in this study. Our results, therefore, cast a new light on to the association of abdominal obesity and balance. A high prevalence of abdominal obesity (WC > 88cm) in females was observed in epidemiological studies in China [48,49,50] and SA [51,52], including the current study with a percentage of 65.5% of participants reporting a WC of greater than 88 cm. These results demonstrate that abdominal obesity is associated with various health outcomes; however, previous studies highlighted that little is known about the association between abdominal obesity and balance in the older population.

This study demonstrated that 35.6% and 32.4% of participants reported SBP of over 140 mmHg and DBP over 90 mmHg overall, with a high prevalence of diastolic hypertension reported in the adult female group (33.3%) compared to 31.6% of the senior female group. The report from Statistics South Africa [53] showed that 56.7% of females aged 60 years and older were diagnosed with hypertension in the year 2016, while in our study the prevalence was 79.8%. Furthermore, the black African population accounted for a higher prevalence of hypertension compared to the white and coloured populations. Systolic BP was significantly elevated in the senior group compared to the adult group. The participants' glucose and cholesterol concentration

levels were normal according to the cut-off norms for both groups. However, it should be taken into consideration that some participants in our study were taking antihyperglycemic and lipid-lowering medications.

The findings around muscle strength show better results on the right-hand grip compared to the left. This could be due to the fact most participants reported the right-hand side as their dominant hand, which was preferred for activities of daily living. A significant difference in muscle strength between the two groups was observed: seniors accounted for low values compared to the adult group. This confirms the findings of Barbosa and colleagues [54], who reported a decline in muscle mass in females aged 60 years and above and a more significant decline in individuals aged 72 years and above. Loss of muscle mass has been associated with a decline in muscle strength [55], and our study confirms these findings around the effect of ageing on muscle strength. Research indeed shows a relationship between muscle strength and cardiovascular health in both children and adults [56,57,58]. These findings have demonstrated that muscle strength is an important predictor of cardiovascular health. Contrary to the results of these findings, however, our results did not report the same relationship of HDL-Cholesterol correlated inversely with RHG, while LDL-C and TC correlated directly with the sit to stand test. This is counterintuitive, as it has been reported in previous studies that HDL-C was associated with better functional performance [59,60]; the results from our study, therefore, pose an argument around the role that HDL-C plays on the musculoskeletal system.

At this stage, we speculated that the possible explanation for our results could be that some of the participants were taking medication for lowering their dyslipidaemia levels. However, it is important to note that these speculations are in accordance with the findings of other previous studies [61,62,63]. The findings share a similar pattern since they accentuate that cholesterol-lowering medication has detrimental effects on the skeletal muscle, thus reducing functional ability and performance [42,64].

Another finding from our results among adults and senior groups was a significant relationship between BMI and the TUG test, which is an important finding when it comes to understanding the role of BMI in relation to functional mobility in adults. We did not find a significant relationship between BMI and balance in this study, however, our results indicated that the seniors reported poor mobility compared to the adult group. These results are in accordance with a study conducted in Brazil where elderly females with a mean age of 68.7 years, varying between 60 and 84.92 years, reported low fitness in all functional tests according to their BMI levels [65]. Furthermore, obesity was more prevalent in their study as it was in the current study. Together, these findings share the light on the importance of managing obesity in the elderly population as its negative impact on performance activities may lead to functional limitations in individuals.

A further novel finding in our study centred on the participants' objective physical activity levels. Overall, there was a significant difference in MVPA of the two groups with the mean accelerometer wearing time of ≈ 6 days in a week. Our results showed that 55.6% of the adult group did not meet the physical activity recommendations, while the senior group accounted for 72%. This suggests that physical activity levels decline with age, which dovetails with findings of previous studies [66,67]. However, when comparing our results with the previous literature, it must be noted that the earlier studies assessed physical activity levels by means of self-report questionnaires. Therefore, our study emphasizes the recommendation of objective assessment of physical activity in future.

Conclusions

Despite the limits around risk factors and functional performance, there was a significant relationship between obesity as a risk factor among the female population from a low-resourced community of NCDs when it came to functional ability as related to balance and mobility. The most prevalent risk factor for NCDs in the sample was physical inactivity. High levels of physical inactivity were in conjunction with high levels of obesity and, in particular, abdominal obesity. The seniors in this study presented with lower functional performance in accordance with age indicated norms. It can therefore be concluded that interventions addressing obesity in females should be implemented to improve functional performance, and balance in this population.

Author contributions

PM developed the objectives, assisted in the process of data collection, capturing and analyses and drafted and approved the finalisation of the article as part of her master's degree. SJM conceptualised and was the principal investigator of the B-Healthy study. SJM and GRO contributed to the interpretation of the results, assisted in drafting the article and approved the final draft.

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Conflict of interests

The authors declare no conflict of interest.

Supplementary methods

The datasets that support the findings of our study are available from the authors upon a reasonable request and permission from the authors.

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CHAPTER 4: ARTICLE 2

Relationship between functional performance and cardiorespiratory fitness among females from a low-resourced community: B-healthy study

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Abstract

Background

Ageing is associated with physiological changes that affect a person's cardiorespiratory fitness and physical function. A primary problem of ageing is a decline in muscle strength that results in reduced functional fitness engendering reduced ability to perform activities of daily living. Community-dwelling adults require high levels of physical functioning due to their family tasks and responsibilities. This study aimed to determine the relationship between functional performance (FP) and cardiorespiratory fitness of females from a low-resourced community.

Methods

The study is a cross sectional observational study which is a part of an overarching B-Healthy study. The baseline data collected in the larger B-Health project was used. Our sample included 180 females (81 adults and 99 seniors) aged between 35 and 89 years. The FP tests including sit to stand, handgrip (HG), timed up and go (TUG) and static balance and cardiorespiratory fitness test for maximum oxygen consumption (VO_2max) were assessed. FP and VO_2max variables were summarised using mean ± SD. A partial correlation was performed with adjustment of age.

Results

The results showed a significant relationship between VO_2max ($p < 0.001$) and both right and left HG ($p < 0.001$). The adult's sit to stand test correlated positively with VO_2max ($p \leq .001$). A significant inverse relationship was reported between the TUG and VO_2max in both groups: ($r = -.471$; $p < 0.001$) and ($p = .003$) respectively. The right- and left single leg stance correlated with VO_2max in adult and senior groups: ($r = .261$; $p = .037$ and $r = .274$; $p = .028$) and ($r = .265$; $p = .032$ and $r = .354$; $p = .004$).

Conclusion

Broadly translated, our findings endorse the existing literature which suggests that improved functional performance is associated with high levels of aerobic capacity. Our results demonstrate a strong effect of engaging community-dwelling adults in activities aimed at improving their functional abilities throughout adulthood. Comparing the adults and seniors also elucidates the trend in which functional abilities start to decline.

Keywords: cardiorespiratory fitness, functional ability, community-dwelling, adults, aerobic fitness, physical function.

Background

Physical function is a major predictor of healthy ageing (1). Health comprise 5 factors including genetics (30%), social habits (15%), environment (5%), access to health care (10%) and behavioral factors that accumulate 40% of a person's health (2). Behavioral factors are widely considered to play a significant role in maintaining physical health throughout adulthood (3). The process of ageing is associated with a predictable decline of physical capacities and degenerative diseases (4). Ageing is strongly associated with sarcopenia, the loss of muscle mass, which leads to decreased muscle strength (5). The decrease in muscle contraction due to sarcopenia results in compromised balance, muscle stiffness and reduced mobility. Activities of daily living (ADLs) and functional ability become compromised (6–8). One of the counteractive ways of preserving muscle tissues and reducing the detrimental effects of ageing on skeletal muscles is engaging in regular physical activity (9). Regular participation in physical activity is associated with improved physical fitness and physical health status through adulthood (10). The American College of Sports Medicine (ACSM) defines physical fitness as the ability to carry out daily tasks with vigour and alertness, without undue fatigue and with ample energy to enjoy leisure-time pursuits and meet unforeseen emergencies (11). The association between physical fitness and functional performance is significant when it comes to understanding the factors associated with functional ability in adults (12).

Evidence shows that the world's population is ageing, consequently engendering increased numbers of old persons (13–16). The Department of Economic and Social Affairs (DESA) reports that the number of the population aged 60 years and above is proliferating compared to other ages (17). The number of adults aged 60 and above was 841 million in the year 2013, which is projected to rise to more than 2 billion by the year 2050 (18). South Africa (SA) had the highest prevalence of older people with about 7.6% of the population over the age of 60 years in southern Africa in the year 2010 (19). In the year 2016, the mid-year population in SA was 55.91 million of which approximately 28.53 million (51%) of the population were females (20). This leaves an increment of 8% in the population between the years 2010 and 2016. As the elderly population continues to rise, maintaining functional ability and prevention of disability will become increasingly important for independent living (21).

The rapid increase in ageing is concomitant with an increase in the risk of disabilities in the elderly population, which results in an increased demand for healthcare facilities and medical expenditures (22). Even though there may be healthcare facilities to use in low-middle-income countries, many elders still face barriers to access and afford care compared to persons living in high-income countries (23). In SA, major reasons for adults' dissatisfaction in healthcare facilities includes long waiting hours, poor communication and autonomy (24). The traditional living arrangements, mostly influenced by culture, female labour force participation, as well as

individualistic lifestyle, require a high level of physical function for community-dwelling females (25). Physical functioning depends on both physiological and cognitive influences. A decline in age-related cognitive function leads to difficulties in carrying out ADL and instrumental activities of daily living (IADL) (26,27). The findings of a study conducted in among SA's community-dwelling adults' aged 65 years and older showed that functional performance tests including grip strength and functional reach were associated with cognitive performance (28). Moreover, females presented low values for most functional and cognitive tests compared to men.

Functional limitations also engender significant implications for emotional distress such as anxiety and depression (29,30). South African adults aged 50 years and older with functional disabilities and low quality of life presented with symptoms of depression (31). Furthermore, the African black population where female numbers are more dominant than those of males presented even more symptoms. Such problems amplify challenges and difficulties in performing ADL, IADL and mobility. These findings were consistent with those reported by Tomita and Burns (32). One primary problem with the barriers of functional limitations is that it leads to increased levels of physical inactivity (33,34).

Cardiorespiratory fitness (CRF), expressed in maximum oxygen uptake (VO_2max), is an effective method used for evaluating physical fitness (35,36). Furthermore, VO_2max is expressed in millilitres of oxygen per kilogram of body mass per minute (mL/kg/min). An inverse relationship exists between CRF and age (37–39). It was reported that CRF declines by at least 10% in the 10 years after the age of 30 among inactive individuals, and 5% in 10 years in those who are active (40). Another factor that affects VO_2max is gender, whereby females presented with lower levels of VO_2max than men (41). Similar and interchangeably concepts used around CRF include aerobic fitness, aerobic endurance, cardiovascular fitness, aerobic capacity, aerobic power, maximal aerobic power, aerobic work capacity and physical work capacity (42).

CRF is an important factor in functional limitations and frailty (35,43). The inverse relationship between CRF and frailty results from the characteristics of frailty, which include low walking speed, low grip strength and reduced levels of physical activity (44). Poor muscle strength, one of the components of physical fitness, is associated with increased risk of mortality (45,46) due to adverse health outcomes around it including frailty and sarcopenia that lead to disability (47). Wolff and colleagues (48) observe the relationship between skeletal muscle function and VO_2max. They found that the training on the single-leg knee extension exercise is associated with increased VO_2max as well as increased skeletal muscle size in young sedentary individuals (48).

A challenging problem that arises in this domain centres on functional limitations associated with age and gender. These barriers lead to myriad problems for community-dwelling females, as

their duties to live independently require their physical strength throughout adulthood. Physical activity is associated with increased levels of CRF in relation to functionality and healthy ageing; however, limited evidence exists on the relationship between functional performance and CRF among African females from a low-resourced community.

Methods

Study design

This is a cross-sectional observational study which is a part of an overarching B-Healthy-study. The data collected during the baseline measurement will be used forms part of an overarching B-Healthy study and will focus on data collected during baseline measurements of the B-Healthy-study. The B-healthy-study aimed to determine the effect of an exercise intervention on the risk factors of NCDs, medicine usage, functional capacity and quality of life of persons from a low-resourced community (Trial number: PACTR201609001771813). The Health Research Ethics Committee for Humans at North-West University approved the study (Ethics number: NWU 00049-15-A1). Permission to conduct the study was received from the Department of Health.

Participants

A total number of 200 residents between 35 and 89 years old were included in the study from the surrounding areas of two public health clinics, the Steve Tswete- and Lesego clinics in Ikageng. These participants were dependent on treatment at either of these two clinics. From the 200 participants (males and females) that gave informed consent, the data of 180 females were included in this study considering that the male participants were very few. The recruitment process was done by the means of distributing flyers and word of mouth though the healthcare workers from the two clinics. The inclusion criteria designated persons that were able to perform exercise tests, persons depending on public health clinics for care, persons who were moderate to low risk for physical activity based on a Physical Activity Readiness Questionnaire (PAR-Q) (49) and also participants who presented at least one cardiovascular risk factor. The exclusion criteria included pregnancy and/ or lactation, any absolute contraindications to exercise testing as indicated by the ACSM (50), orthopaedic and/ or mental limitations and participants with known cardiovascular risk as well as risk for physical activity participation according to the PAR-Q (50).

Demographic information

The collected demographic data of the participants included the date of birth, age, ethnicity and gender. Participants first provided an informed consent form prior to following the process of filling out necessary questionnaires.

Anthropometry

Height was measured to the nearest 0.1 cm using a stadiometer calibrated to the nearest 0.1 cm (Seca 225, Seca, Hamburg, Germany). Weight was measured to the nearest 0.1 kg on a digital scale (Seca 861, Hamburg, Germany) with the subject wearing lightweight clothing and no shoes. The height and weight measurements were taken three times following the guidelines of the International Society for the Advancement of Kinanthropometry (ISAK) (ISAK, 2011). Body mass index (BMI) was calculated as weight in kilograms divided by height in meters squared kg/m2. Waist circumference (WC) was measured by using a flexible steel tape (Lufkin W606PM, Creative Health Products, MI, USA) to the nearest 0.1 cm. Measurements were taken on the midpoint between the lower edge of the costal border and the upper edge of the iliac crest, with participants standing. All measurements were taken three times by the same trained person with the mean of the two closest assessments used for analysis.

Cardiorespiratory fitness assessment

To examine the CRF of the participants, a cardiopulmonary exercise test (CPET) was performed with a portable metabolic measurement system (MetaMax II (MM), CORTEX Biophysik GmbH, Leipzig, Germany) to determine the peak oxygen consumption (VO2peak) of each participant. A graded 8-minute step test determined the cardiorespiratory fitness of the participants. The MM employs a small mixing chamber and provides respiratory values in each case 10 seconds before and during the test. All participants who showed three or more cardiac risk factors were constantly monitored by a twelve-lead electrocardiogram (ECG). CRF was expressed in millilitres of oxygen per kilogram of body mass per minute (mL/kg/min.

During the test, the participant was informed to step in time to the drumbeats/ voice prompt on a 21, 5 cm step box, accompanied by colour prompts showing that the participant should step. At the end of the test, the participant had to sit still for a two-minute recovery period. The participant could stop the test anytime if he or she felt uncomfortable. Functional performance tests followed the cardiorespiratory fitness step test.

Functional performance tests

In order to determine the participants' functional performance, we performed the following tests: lower extremity muscle endurance, mobility, upper extremity muscle strength and static balance.

Lower extremity muscle endurance

We performed the sit to stand test used for lower extremity strength using a 30-second Chair Stand Test (51). Participants in a seated position on a chair with standard height (44-45

cm) and arms folded across the chest were instructed to complete as many full stands as possible in 30 seconds. The test recorded the number of full stands for two trials within 30 seconds. The participants rested for 10 seconds between the measurements. The best value of two measurements was used for analyses.

Mobility

The timed up and go test assessed mobility and fall risks (52). The advantages of the test are that it is simple, requires simple tools, and is quick to perform and can be performed by participants who use assisting devices such as a walker, cane or crutches. Participants got up from a seated position (seat height of 46 cm) without using the arms, walk nine meters, turn and return to their seated position. The participants performed the test three times and the best result was recorded to the nearest 0.1 seconds.

Upper extremity muscle strength

The handgrip test assessed muscle strength in the upper extremities. The grip strength was measured using a hand-held dynamometer (5030 Jamar-Hydraulic Hand Dynamometer, Sammons Preston Rolyan, Bolingbrook, Illinois 60440, USA). The assessments were conducted three times on each hand in an alternating fashion with a 30 second pause between attempts. The test was conducted with the participant seated with the upper arm alongside the trunk and elbow at 90° of flexion. The participants were asked to squeeze the device as hard as possible for at least 3 s. The best results were recorded to the nearest 0.1 kilograms (kg).

Static balance assessment

The single leg stand test (SLST) was used to measure the static standing ability using a stopwatch (53). Participants were asked to stand on one leg up to a maximum of 60 s on a flat surface, shoes off and on one bended knee. The balance was measured as the longest time standing, depending on how long the participant stood, or a maximum of 60 seconds without stumbling or feet touching the ground.

Statistical analysis

Descriptive statistics were performed to present participant's characteristics as means and standard deviations in terms of functional performance and VO_2max variables. To test the normality of the variables, the Kolmogorov–Smirnov test was utilized. To analyze the differences between the adults (< 60 years) and seniors (≥ 60 years), an independent t-test was used. Partial correlation analysis between functional performance and VO_2max variables was performed to determine the relationship between FP and CRF. An adjustment was made for age. Data were analyzed using the Statistical Package for the Social Sciences (SPSS) (IBM SPSS Statistics v.23, Chicago, IL, USA). The level of significance was set at 5% ($p < 0.05$).

Results

The characteristics of the participants as presented in **Table 1** showed a significant difference in VO_2max between the adult group (20.33 ± 4.77 mL/kg/min) and the senior group (16.07 ± 3.75 mL/kg/min) (*p* **<** 0.001**)**. The right- and left HG was significantly different between the two groups with mean values of 25.36 ± 6.41 kg and 25.36 ± 5.22 kg respectively for adults and 22.58 ± 5.00 kg and 22.70 ± 5.51 kg for the seniors' group. The sit to stand test showed poor performance in adult as well as senior groups with mean values of 12.55 ± 4.73 and 11.54 ± 4.10. The senior group took longer to complete the timed up and go test (20.41 ± 8.27 sec) when compared to the adult's group (18.50 ± 7.82 sec). The right- and left single leg stance test reported poor values for both adult and senior groups, respectively, (29.54 ± 20.97 sec and 27.50 ± 20.16 sec) and (13.60 ± 14.46 sec and 13.70 ± 14.22 sec).

Table 1: Descriptive characteristics of the participants as mean and SD for the functional performance and cardiorespiratory fitness

Variables	All n = 180	< 60 y (adults) n = 81	≥60 y (seniors) n = 99	*P*-value
	Mean ± SD	Mean ± SD	Mean ± SD	
Age	59.38 ± 12.71	48.15 ± 8.30	68.58 ± 7.02	<0.001*
Biological variables				
BMI (kg/m^2)	32.07 ± 7.75	31.62 ± 8.20	32.44 ± 7.39	0.485
WC (cm)	92.41 ± 14.10	91.32 ± 15.03	93.35 ± 13.27	0.344
CRF variables				
VO_2max (ml/kg/min)	18.92 ± 5.35	20.33 ± 4.77	16.07 ± 3.75	< 0.001*
Performance variables				
Right HG (kg)	24.15 ± 6.13	25.90 ± 6.41	22.70 ± 5.51	0.001*
Left HG (kg)	23.82 ± 5.27	25.36 ± 5.22	22.58 ± 5.00	0.001*
Sit to Stand Test (N)	12.02 ± 4.43	12.55 ± 4.73	11.54 ± 4.10	0.153
TUG (seconds)	19.51 ± 8.09	18.50 ± 7.82	20.41 ± 8.27	0.136
SLST-Right (seconds)	21.26 ± 19.54	29.54 ± 20.97	13.60 ±14.46	< 0.001*
SLST-Left (seconds)	20.42 ± 18.64	27.50 ± 20.16	13.70 ±14.22	< 0.001*

BMI: Body mass index; CRF: Cardiorespiratory fitness; HG = Handgrip strength; SLST = Single leg stance test; TUG= Timed up and go; VO_2max = Maximum oxygen consumption; WC = Waist circumference. * Statistically significant (*p* < 0.05); SD= Standard deviations

The partial correlation analysis results between functional performance and maximum aerobic capacity variables for both adult and senior groups as depicted in **Table 2,** indicate a significant positive relationship between the sit to stand test and VO_2max (*r* = .208; *p* < 0,01). A

significant inverse relationship was reported between the timed up and go test and VO_2max in both adults (r = -.471; p < 0,01) and senior groups (r = -.355; p = .003) respectively. A significant positive relationship was observed between both right and left single leg test and VO_2max and in both adult (Right: r = .261; p = .037 and Left: r = .274; p = .028) and senior (Right: r = .265; p = .032 and Left: r = .354; p = .004) groups respectively.

Table 2: Correlation between functional performance and VO_2max of adult and senior females from a low resourced community adjusted for age

		VO_2max (ml/min/kg)		
		All	< 60 y (adults)	≥ 60 y (seniors)
Right handgrip (kg)	*r*	.145	.209	-.044
	p	.135	.097	.724
Left handgrip (kg)	*r*	.183	.192	.044
	p	.058	.129	.727
Sit to Stand Test (N)	*r*	-.097	.208	.196
	p	.318	.100*	.116
Timed Up and Go test (seconds)	*r*	-.003	-.471	-.355
	p	.979	<.001**	.003*
Single-Leg Stand test- Right (sec)	*r*	.079	.261	.265
	p	.415	.037*	.032*
Single-Leg Stand test- Left (sec)	*r*	-.055	.274	.354
	p	.571	.028*	.004*

VO_2max = Maximum oxygen consumption. * statistically significant (p < 0.05). ** Statistically significant (p < 0.001)

Discussion

The purpose of the study was to determine the relationship between cardiorespiratory fitness and functional performance among females from a low-resourced community. The results indicated that the mean VO_2max for females older than 60 years were significantly lower than the VO_2max for the females younger than 60 years. Confirming findings reported by Ades and Toth (54), the present findings showed an inverse relationship between age and VO_2max. Their findings showed that the decline of aerobic fitness was observed from the age of 40, but more so

as the individuals reach the ages of 60 and 70 years old. In our study, 55% of the seniors and 45% of the adult group reported low aerobic capacity. The ability of the body to consume oxygen and its distribution to the working muscles affects the VO_2max (55). Moreover, due to the age-decline in maximum heart rate, the aerobic capacity also declines. Therefore, it is essential for adults to keep an active lifestyle, as high levels of PA are associated with improved aerobic fitness.

Our results further indicate a significant inverse relationship between the VO_2max and the TUG test for the total group. The timed up and go test challenges the agility and muscle strength. Studies have shown that age-related decline in aerobic fitness and muscle strength results in poor functional mobility (56,57). Limitations in elder's mobility lead to a pre-clinical intermediate stage in the pathway to disability (58). A larger portion (34.1%) of the females older than 60 years from our study took significantly longer to complete the TUG compared to the portion of adult females (22.4%). A study conducted on Brazilian community-dwelling adults aged 60 years and older reported that the TUG of greater than 12.47 seconds was associated with the prediction of falls (59). In our study, the seniors reported a mean time of 20.41 seconds in the TUG test. These results suggest that poor mobility is associated with compromised balance. Ferruci and colleagues (60) reported that the rate of decline in lower extremity mobility increases from the age of 60 to 70 years. A number of physiological systems in the body including sensory input and organization, motor co-ordination and musculoskeletal function synchronizes a person's balance (61). Age-related decline in the neuro-musculoskeletal system function results in increased risk of falling in older adults (62). Our results demonstrated that the process of aging is associated with a decline in balance between the two groups, which is in accordance with the findings from a contemporary review reported by Osoba and colleagues (63). Their findings showed that the age-related decline in sensory and visual systems in older adults aged 60 years and above leads to reduced ability in maintaining good posture and balance. A study performed on risk factors of predicting falls in South African community-dwelling adults aged 65 years and above showed that participants with increased time to complete the TUG test were at risk of falls (64). Balance impairment results in compromised ability to perform functional activities. Another novel finding from our study was a positive relationship between VO_2max and the SLS tests. Our results viewed in terms of those of Mertz and colleagues (65) strongly suggest that CRF is an important predictor of balance and dependence in the elderly population.

Our results demonstrated a significant difference in upper body muscle strength between the two groups. Our findings share light on the existing literature that muscle strength declines with increased age (66,67). The rate of muscle mass decline begins with 1 to 2% per year past the age of 50 years, resulting in 25% of sarcopenia individuals below the age of 70 and 40%

above the age of 80 years (68). The seniors from our study reported low grip strength mean values compared to the adults. Our findings, viewed in terms of findings made by Lino and colleagues (69), show that the reduction in grip strength is a common condition in the population aged 60 years and above, which leads to impairments in performing ADL (70). The double responsibilities of family and work encountered by the middle-aged females limit them from exercise activities, which consequently leads to deterioration in functional fitness (71).

The sit to stand test correlated directly with VO_2max in the adult group. This is an important finding in understanding the effect of lower extremity muscle strength in the ability to perform functional tasks. According to the results from Lee *et al* (72), the decline of lower extremity muscle strength begins in adults aged 44 to 55 years. Muscle strength and aerobic capacity are strong predictors of functional limitations in adults (37). These findings highlight the importance of comparing the differences between the adult and senior groups in order to observe the degree of deterioration in functional abilities in preparation for future aging.

Limitations of the study

The findings of this study should be interpreted against its limitations. The availability sampling methods applied for the study prevents generalisation of the findings around the entire population. The inclusion of only females limits the findings to females from this low-resourced community.

Conclusions

The findings of this study engender the conclusion that physical function is not confined to cardiorespiratory fitness only but is related to the process of aging. Moreover, since aerobic capacity decreases naturally with age, it is important for community-dwelling adults to live an active lifestyle for future aging. Broadly translated, our findings endorse the notion that improved functional performance is associated with high levels of aerobic capacity as found in extant literature. Comparing the adults and seniors also gives elucidates the trend in which functional abilities start to decline. Overall, our results demonstrate a strong effect of engaging community-dwelling adults in activities aimed at improving their functional abilities throughout adulthood.

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CHAPTER 5: SUMMARY, CONCLUSIONS, LIMITATIONS AND RECOMMENDATIONS

5.1 Introduction

Non-communicable diseases (NCDs) are the leading cause of morbidity and mortality globally. The rapid growth of these diseases is influenced by behavioural factors that affect the health of the individuals and their functionality (WHO, 2018). This chapter presents a summary of the study, embracing risk factors of NCDs, functional performance, and cardiorespiratory fitness among female adults in a low-resourced community. This was experimentally investigated by analysing the baseline data collected in a B-Healthy study. A summary of the dissertation will be presented; thereafter, the conclusions based on the hypotheses will be posed. Finally, the chapter will draw an overarching conclusion and present the limitations against which the data should be interpreted with recommendations for future research.

5.2 Summary

In the past several decades, infectious/communicable diseases have played a crucial role in determining the individual's health status. However, recent research findings have revealed that unhealthy lifestyle behaviours that people adopt throughout their lifetime lead to metabolic system changes in the body which results in NCDs at a later stage (Shayo, 2019:7). These unhealthy behaviours including hypertension, dyslipidaemia, and overweight and, obesity do not only have negative implications for health but due to the detrimental adaptations in physiological processes of the body together with aging, they also lead to compromised functional ability in adults (Dean and Söderlund, 2015:5). As the world's population is aging, it is important to investigate the possible aging changes that are associated with the developments of NCDs and functional limitations.

Chapter 1 outlines a brief introduction to the development of NCDs and the associated risk factors, as well as their implication on health. It was observed that the increasing burden of the risk factors of NCDs in developed countries is influenced by urbanization which results in changes in dietary patterns and sedentary lifestyles which, in turn, results in functional limitations in adults.

To address the outlined problem, this study therefore aimed to answer the following research question: What is the relationship between the risk factors of NCDs, physical activity and functional performance in African females in a low-resourced community?

The literature reviewed in **Chapter 2** that focused on the risk factors of NCDs and its relation to functional performance in adults, indicated that the burden of NCDs is rapidly increasing globally,

especially in low-middle-income countries. Major NCDs include cardiovascular diseases, cancer, chronic respiratory diseases, and diabetes mellitus. The literature further revealed that the increasing burden of NCDs in LMIC is due to urbanization and globalization, which results in unhealthy lifestyle behaviours including unhealthy dietary patterns, low levels of physical activity and increased tobacco usage. It was reported that NCD's behavioural risk factors, especially physical inactivity, are associated with high rates of mortality and morbidity.

The literature shows that modifying physical inactivity has positive effects on body systems including musculoskeletal system. Aging, as a non-modifiable risk factor, also impacts health and is associated with body changes including loss of muscle mass, reduced muscle strength, muscle endurance, and poor cardiovascular health in the geriatric population compared to adults. These physiological changes have a negative effect on health as it increases the risk of falls due to an increased lack of physical function. Limitations in functionality result in poor quality of life and reduced ability to perform functional activities including ADL, IADL, and physical activity, which increase the risk of early disability and dependence in community-dwelling adults.

With South Africa facing a growing burden of old population increment, so the risk of disability and age-related conditions increases. These conditions become a problem since traditional living arrangements, mostly influenced by culture, female labour force participation, and an individualistic lifestyle, require a high level of physical function among community-dwelling females. However, these are not the only difficulties that SA females encounter, since disparities in socioeconomic status including education, marital status, occupation, and household income contribute to the prediction of physical function and mortality.

The literature further revealed that NCD risk factors are more prominent in the low SES groups, which results in an increased risk of morbidity and mortality. In view of the challenges that community-dwelling females experience due to the risk factors of NCDs and functional limitations, it seemed fitting to achieve the objectives of this study by determining the factors that lead to functional limitations throughout the life course as most of these branch from lifestyle behaviours that people adopt in middle age.

To investigate the relationships, the baseline data of the B-Healthy-study was analysed. The findings of the analysis were prepared and presented in two separate chapters as research papers for publication purposes.

In the first article, **Chapter 3,** entitled “The relationship between risk factors of NCDs and functional performance in females in a low-resourced community: B-Healthy-study”, the relationship was determined between risk factors around NCDs and functional performance. The results indicated that there was a significant inverse relationship between obesity as a risk factor

for NCDs and functional ability as related to balance and mobility among female participants in a low-resourced community.

The second article, **Chapter 4,** entitled "Relationship between functional performance and cardiorespiratory fitness among females in a low-resourced community: B-healthy study", determined the relationship between functional performance and cardiorespiratory fitness among adults and seniors. The results indicated that physical function is not confined to cardiorespiratory fitness only but, instead, is influenced to a greater extent by the process of aging. We also found that comparing adults with seniors illuminates the trend in which functional abilities start to decline.

5.3 Conclusions

The conclusions of this study are based on the hypotheses stated in **Chapter 1** and will be presented as follows:

Hypothesis 1: A significant inverse relationship between the risk factors for NCDs and the functional performance of females in a low-resourced community will be found.

The results showed a significant relationship between BMI and TUG in adult and senior female groups (AF: p = .019; r = .303; SF: p = .031; r = .271). The waist circumference of the adult group correlated positively with the TUG (r =.348; p = .006). High-density lipoprotein cholesterol correlated inversely with the right HGS (r = -.301; p = .019). Waist circumference correlated positively with the right HGS (r = .259; p = .039) and inversely with the left single leg stance (SLS) (r = -.254; p = .042) in the senior group. An increased TUG time is interpreted as the participant taking longer to complete the test, which means that the larger the BMI, the longer the participants took to complete the test, which brings about an inverse relationship. Based on these findings, hypothesis 1 can therefore be **accepted.**

Hypothesis 2: A significant positive relationship between functional performance and cardiorespiratory fitness among females in a low-resourced community will be found.

The results showed that the adult group's sit to stand test correlated positively with VO_2max (r = .208; $p \leq .001$**)**. A significant inverse relationship was reported between the TUG and VO_2max in the adult and senior groups: (r = -.471; $p <$ 0.001) and (r = -.355; p = .003). An inverse relationship in TUG and VO_2max means that the greater the time taken to complete the test, the lower the VO_2max recorded for the participants. The right and left single leg stance correlated with VO_2max in adult (r = .261; p = .037) and senior groups: (r = .265; p = .032), and (r = .274; p= .028 and r = .354; p = .004). Based on these findings hypothesis 2 can therefore be **partially accepted.**

The findings of the current study indicate that the risk factors of NCDs related to obesity, such as waist circumference and cholesterol concentrations, were significantly and inversely associated with the functional performance of the participants. These findings are an indication that the amount of energy that is required to perform functional activities is surpassed by the energy stored within the body. It is common knowledge that when the energy intake is not equal to the energy expenditure for a long period of time then the body goes to energy imbalance. This results in an increase in body weight, which on the long-term will lead to obesity. The observation of the inverse relationship between obesity and functional performance indicate that obese persons from this community have a lack of balance when they are obese. This may lead to an increase in the risk of falls.

According to the literature, the most significant variable that affects energy expenditure is physical activity. Regular participation in physical activity has been reported to have positive health outcomes including bodyweight management, primary and secondary prevention of chronic conditions, and improved cardiorespiratory and physical function.

A high prevalence of physical inactivity was found among African women of the low-resourced community with the seniors (≥ 60 years) accounting for higher percentages compared to adults (< 60 years). In addition, these findings provided additional information from which it can be inferred that the rate of obesity among women was influenced by a lack of physical activity.

The literature review indicates that low levels of physical activity and sedentarism reduce cardiorespiratory fitness, which leads to reduced ability to perform daily living activities. When the latter are reduced, various physiological changes occur. It is common knowledge that ageing causes the increment of fatty substances inside the cell which leads to abnormal functioning of many cells and enlargement of body cells which, in turn, results in the inability of cells to divide and multiply. Since they lead to an increased physical burden on the body, these changes lead to impaired muscle metabolism, which results in myriad complications in the body's systems, including those of the musculoskeletal and cardiovascular system. A strained body contributes to poor performance in functional activities.

Our results proved this to be true. Comparison of the aerobic capacity and functional performance between the two groups showed that the seniors performed poorly compared to the adults. A sedentary lifestyle plays a significant role in unhealthy ageing. However, our results also demonstrate that physical function is not confined to cardiorespiratory fitness only but centres to a greater extent on the process of ageing. Therefore, it is important that adults maintain their physical function throughout adulthood for healthy ageing.

The two articles combined with the reviewed literature show that ageing as an unmodifiable risk factor of NCDs is associated with uncountable changes in the body including loss of mass strength and mass which lead to compromised ability to perform functional activities. Our results demonstrate a strong effect of engaging community-dwelling adults in activities aimed at improving their overall health as well as physical function. Therefore, to answer our research question, we concluded that regular participation in physical activity can significantly attenuate the risk factors of NCDs and may lead to improved physical function in this specific population.

5.4 Limitations and recommendations

The findings of this study should be interpreted against the limitations that were experienced which should, in turn, be addressed in future research. The available sampling methods applied in the study prevent the findings from being generalized for the entire population. The inclusion of only females limits the findings to females in this low-resourced community. Moreover, some of the participants included in the current study already presented one or more risk factors of NCDs even though they were on medication: the results, therefore, limit the healthy population.

5.5 Future research

Future research should include younger age groups to trace the trend in which functional abilities start to decline since most of these are adopted throughout the lifespan. Furthermore, males and females of different ethnic- and cultural backgrounds should also be recruited in future studies to determine whether the relationships analysed in the present study apply to them or not.

References

1. World Health Organization. 2018. Non-communicable diseases. https://www.who.int/news-room/fact-sheets/detail/noncommunicable-diseases. Date of access: 15 June 2020.

2. Dean, E. & Söderlund, A. 2015. What is the role of lifestyle behaviour change associated with non-communicable disease risk in managing musculoskeletal health conditions with special reference to chronic pain? *Biomed central musculoskeletal disorders*, *16*(1):1-7.

3. Shayo, F.K. 2019. Co-occurrence of risk factors for non-communicable diseases among in-school adolescents in Tanzania: an example of a low-income setting of sub-Saharan Africa for adolescence health policy actions. *BMC public health*, 19(1): 1-8.

APPENDIX A: ETHICS APPROVAL LETTER

Private Bag X1290, Potchefstroom
South Africa 2520

Tel: 086 016 9698
Web: http://www.nwu.ac.za/

North-West University Health Research Ethics Committee (NWU-HREC)

Tel: 018 299-1206
Email: Ethics-HRECApply@nwu.ac.za (for human studies)

4 December 2019

ETHICS APPROVAL LETTER OF STUDY

Based on approval by the North-West University Health Research Ethics Committee (NWU-HREC) on 04/12/2019, the NWU-HREC hereby approves your study as indicated below. This implies that the NWU-HREC grants its permission that, provided the general conditions specified below are met and pending any other authorisation that may be necessary, the study may be initiated, using the ethics number below.

Study title: Risk factors of non-communicable disease, functional performance and physical fitness among female adults in a low-resourced community: B-Healthy study
Principal Investigator/Study Supervisor/Researcher: Prof SJ Moss
Student: M Phidza-27074250

Ethics number:

N	W	U	-	0	0	0	4	9	-	1	5	-	A	1	-	0	1
Institution				Study Number						Year			Status		Sub-study		

Status: S = Submission; R = Re-Submission; P = Provisional Authorisation; A = Authorisation

Application Type: Sub-study
Commencement date: 04/12/2019
Expiry date: 28/02/2021

Risk: **Minimal**

Approval of the study is provided for a year, after which continuation of the study is dependent on receipt and review of an annual monitoring report and the concomitant issuing of a letter of continuation. A monitoring report is due at the end of February annually until completion.

General conditions:

While this ethics approval is subject to all declarations, undertakings and agreements incorporated and signed in the application form, the following general terms and conditions will apply:

- *The principal investigator/study supervisor/researcher must report in the prescribed format to the NWU-HREC:*
  - *Annually on the monitoring of the study, whereby a letter of continuation will be provided annually, and upon completion of the study; and*
  - *without any delay in case of any adverse event or incident (or any matter that interrupts sound ethical principles) during the course of the study.*
- *The approval applies strictly to the proposal as stipulated in the application form. Should any amendments to the proposal be deemed necessary during the course of the study, the principal investigator/study supervisor/researcher must apply for approval of these amendments at the NWU-HREC, prior to implementation. Should there be any deviations from the study proposal without the necessary approval of such amendments, the ethics approval is immediately and automatically forfeited.*
- *Annually a number of studies may be randomly selected for active monitoring.*
- *The date of approval indicates the first date that the study may be started.*
- *In the interest of ethical responsibility, the NWU-HREC reserves the right to:*

- *request access to any information or data at any time during the course or after completion of the study;*
- *to ask further questions, seek additional information, require further modification or monitor the conduct of your research or the informed consent process;*
- *withdraw or postpone approval if:*
  - *any unethical principles or practices of the study are revealed or suspected;*
  - *it becomes apparent that any relevant information was withheld from the NWU-HREC or that information has been false or misrepresented;*
  - *submission of the annual monitoring report, the required amendments, or reporting of adverse events or incidents was not done in a timely manner and accurately; and/or*
  - *new institutional rules, national legislation or international conventions deem it necessary.*

- *NWU-HREC can be contacted for further information via Ethics-HRECApply@nwu.ac.za or 018 299 1206*

The NWU-HREC would like to remain at your service and wishes you well with your study. Please do not hesitate to contact the NWU-HREC for any further enquiries or requests for assistance.

Yours sincerely,

Digitally signed by
Prof Petra Bester
Date: 2019.12.05
13:54:26 +02'00'

Chairperson NWU-HREC

Current details:(23239522) G:\My Drive\9. Research and Postgraduate Education\9.1.5.4 Templates\9.1.5.4.2_NWU-HREC_EAL.docm
20 August 2019

File Reference: 9.1.5.4.2

APPENDIX B: PROOF OF LANGUAGE EDITING

cumlaude
language practitioners

Director: CME Terblanche - BA (Pol Sc), BA Hons (Eng), MA (Eng), TEFL
22 Strydom Street
Baillie Park, 2531
Tel 082 821 3083
cumlaudelanguage@gmail.com

DECLARATION OF LANGUAGE EDITING

I, Christina Maria Etrecia Terblanche, hereby declare that I edited the research study titled:

Risk factors of non-communicable diseases, functional performance and physical fitness among female adults in a low-resourced community: B-Healthy study

for **Ms Mashudu Phidza** for the purpose of submission as a postgraduate research study. Changes were indicated in track changes and implementation was left to the author.

Regards,

CME Terblanche

Cum Laude Language Practitioners (CC)

South African Translators Institute accr nr: 1001066

Full member of the Professional Editors Guild

1

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

Health Research Ethics Committee
Faculty of Health Sciences
NORTH-WEST University
(Potchefstroom Campus)
2015 -08- 31
HREC Stamp

PARTICIPANT INFORMATION LEAFLET AND CONSENT FORM FOR persons who visit Public Health Clinics in Ikageng in the Kenneth Kaunda District of the North West Province (NWP).

TITLE OF THE RESEARCH PROJECT: **Physical activity intervention at a primary health care clinic for optimal health: the B-Healthy project**

REFERENCE NUMBERS:

PRINCIPAL INVESTIGATOR: **Prof SJ Moss**

ADDRESS: **Faculty of Health Sciences, Physical Activity, Sport and Recreation. Building K3, Room 106. North-West University - Potchefstroom**

CONTACT NUMBER: **018 299 1821**

You are being invited to take part in a research project that forms part of the **B-Healthy project**. Please take some time to read the information presented here, which will explain the details of this project. Please ask the researcher any questions about any part of this project that you do not fully understand. It is very important that you are fully satisfied that you clearly understand what this research entails and how you could be involved. Also, your participation is **entirely voluntary** and you are free to decline to participate. If you say no, this will not affect you negatively in any way whatsoever. You are also free to withdraw from the study at any point, even if you do agree to take part.

This study has been approved by the **Health Research Ethics Committee of the Faculty of Health Sciences of the North-West University (NWU-00049-15-A1)** and will be conducted according to the ethical guidelines and principles of the international Declaration of Helsinki and the ethical guidelines of the National Health Research Ethics

Council. It might be necessary for the research ethics committee members or relevant authorities to inspect the research records.

What is this research study all about?

- *This study will be conducted at the Lesego and Steve Tshwete Health clinics in Ikageng, Kenneth Kaunda District of the North West Province and will involve information collected about your health, your knowledge of risk factors for disease, and physical activity. Measurements will be taken of your blood pressure, blood sugar and cholesterol, body composition and level of fitness with experienced health researchers trained in Biokinetics and Exercise science. A total of 200 participants will be included in this study.*

The objectives of this research are:

- *To determine the effect of a PA on perception and knowledge of PA and risk factors for heart disease in community dwelling persons and 6 months after the intervention.*
- *To determine the effect of a PA intervention on the Quality of life in community dwelling persons and 6 months post intervention.*
- *To determine the effect of a PA intervention on PA levels, fitness and activities of daily living in community dwelling persons and 6 months post intervention.*
- *To determine the effect of a PA intervention on risk factors for NCDs and medication prescription in community dwelling persons and 6 months post intervention*

Why have you been invited to participate?

- *You have been invited to participate because you are part of the Ikageng community and we are promoting physical activities and health care education with the main objective is to improve your community health.*

- *You have also complied with the following inclusion criteria:*
  Males and females with stable clinical condition.
  You are between 35-65 years old.
  Present at least one cardiovascular risk factor (E.g. Hypertension, cholesterol, overweight/obesity, tobacco use, lack of physical activity and diabetes).
  Not orthopedically impaired.
  Moderate to low risk for PA participation based on a PAR-Q screen.
  Ability to perform exercise testing and exercise intervention.
  A primary health clinic is your point of referent for health care.

- *You will be excluded if:*
  Pregnancy and lactation
  Any absolute contraindications to exercise testing
  Orthopaedic limitations.
  Mental limitations.
  Relationships with any of the members of the research team.
  Access to private health care.

- *Participation will be voluntary and participants will be allowed to withdraw at any stage of the study.*

What will your responsibilities be?

- *You will be expected to give information as requested from the questionnaires, asked to attend assessments spread over two days during which we will measure your cholesterol and glucose levels from a finger prick, attend one exercise session or support group meeting per week and perform the given exercises on two more days of the week by yourself. Participation in this study will be for 12 months.*
- *You will also be expected to take part in a focus groups discussion on your perceptions about non-communicable diseases and physical activity. You will however be invited for the focus groups after completion of the assessment as mentioned above. These focus group discussions will be held on different dates and groups will be divided into female and male groups.*
- *Even though you might have agreed to participate in the focus group it might happen that you don't have to participate or attend the focus groups.*

Will you benefit from taking part in this research?

- *The direct benefits for you as a participant will be that you will know your risk factors for lifestyle diseases, your fitness level, and you will learn how to perform physical activity that will improve the management of your risk factors.*
- *The indirect benefit will be that new knowledge will be generated on the effect a regular physical activity intervention may have on the management of risk factors for lifestyle diseases in low resources communities.*

Are there risks involved in your taking part in this research?

- *The risks in this study are that you may become bored during the focus group discussion, or while completing the questionnaire. You would be allowed to take a break. During the testing you may become a little tired and fatigued. The exercises that you will do might lead to moderate muscle soreness initially, which will later disappear. You will be able to rest between the measurements to recover.*
- *During the finger prick to measure your cholesterol and glucose you may feel a little pain or tenderness afterwards. This will only be for a short time. There is a risk of infection although the researchers will clean your finger with alcohol before the finger prick to prevent this.*
- *Considering the possible social, psychological and privacy risks associated with focus group discussions, no personally sensitive questions will be asked nor any questions that will make you feel uncomfortable or emotional. If the focus group discussion or the questions asked might make you feel emotionally uncomfortable you can withdraw from the study without any consequences and an independent counselor as well as independent professional health worker will be available, if you would like to talk with either of them. Risks will further be reduced by having a competent and experienced facilitator lead the focus group discussion.*
- *At this stage the researchers would also like to tell you that only partial confidentiality can be guaranteed during the focus group discussions. This is because members of the focus group may decide to share private and confidential information discussed during the focus groups after the focus group discussion with other community members (e.g. their family members or friends). We will ask all members of the group that they do not talk about the group to their friends or family but it is a risk. The researchers would therefore like to remind you that you do not have to share any personal or confidential information during the focus group discussion. It is entirely up to you what information you are willing and comfortable in sharing.*
- *Your information that will be captured during the focus group discussion will be treated as the group's information and not as individual information.*
- *The benefits outweighs the risk*

What will happen in the unlikely event of some form of discomfort occurring as a direct result of your taking part in this research study?

- *Should you have the need for further discussions after feeling tired and fatigued during testing or the intervention an opportunity will be arranged for you to rest, have your blood pressure, heart rate and blood glucose checked. Any abnormal responses will be referred to the nurse to arrange for a consultation with the medical doctor at the clinic.*

Who will have access to the data?

- *Anonymity will be ensured by allocating a number to each participant. Confidentiality will be ensured by securing the data sheets. Partial confidentiality will only be possible in the situation of the focus group discussions. Reporting of findings will be anonymous by reporting the data of the groups and not the individuals. Only the principle investigator will have access to the personal data. Data will be kept safe and secure by locking hard copies in locked cupboards in the researcher's office and for electronic data it will be password protected. Data from the focus groups will be transferred from the voice recorder to a digital compact disk within 24 hours after the focus group discussion for both security and transcribing purposes as these compact disks (CD's) will be locked away with the other raw data. Data will be stored for seven years after which the information will be shredded and e-copies deleted.*

What will happen with the data/samples?

- *This is a once off collection and data will be kept at the NWU and analysed at the NWU.*

Will you be paid to take part in this study and are there any costs involved?

You will not be paid to take part in the study but refreshments will be available after the testing and interventions. Travel expenses will be paid for those participants who have to travel to the site. There will thus be no costs involved for you, if you do take part.

Is there anything else that you should know or do?

- You can contact Hanlie Moss at 018 299 1821 if you have any further queries or encounter any problems.
- You can contact the Health Research Ethics Committee via Mrs Carolien van Zyl at 018 299 2089; carolien.vanzyl@nwu.ac.za if you have any concerns or complaints that have not been adequately addressed by the researcher.
- You will receive a copy of this information and consent form for your own records.

How will you know about the findings?

- The findings of the research will be shared with you by presenting you with a feedback report with all the data.

Declaration by participant

By signing below, I ..... agree to take part in a research study titled: **B-Healthy project**

I declare that:

- I have read this information and consent form and it is written in a language with which I am fluent and comfortable.
- I have had a chance to ask questions to both the person obtaining consent, as well as the researcher and all my questions have been adequately answered.
- I understand that taking part in this study is voluntary and I have not been pressurised to take part.
- I may choose to leave the study at any time and will not be penalised or prejudiced in any way.
- I may be asked to leave the study before it has finished, if the researcher feels it is in my best interests, or if I do not follow the study plan, as agreed to.

Signed at (*place*) ..... on (*date*) ..... 20....

....
Signature of participant **Signature of witness**

Declaration by person obtaining consent

I *(name)* ..... declare that:

- I explained the information in this document to .....
- I encouraged him/her to ask questions and took adequate time to answer them.
- I am satisfied that he/she adequately understands all aspects of the research, as discussed above
- I did/did not use an interpreter.

Signed at (*place*) ..... on (*date*) ..... 20....

....
Signature of person obtaining consent **Signature of witness**

Declaration by researcher

I *(name)* ..... declare that:

- I explained the information in this document to .....
- I encouraged him/her to ask questions and took adequate time to answer them.
- I am satisfied that he/she adequately understands all aspects of the research, as discussed above
- I did/did not use an interpreter.

Signed at (*place*) ..... on (*date*) ..... 20....

....
Signature of researcher **Signature of witness**

APPENDIX D: GERIATRIC'S AUTHOR'S GUIDELINES

Submission Checklist

Please.read the Aims & Scope to gain an overview and assess if your manuscript is suitable for this journal;use the Microsoft Word template or LaTeX template to prepare your manuscript; make sure that issues about publication ethics, research ethics, copyright, authorship, figure formats, data and references format have been appropriately considered; ensure that all authors have approved the content of the submitted manuscript.

Manuscript Submission Overview

Types of Publications

Geriatrics has no restrictions on the length of manuscripts, provided that the text is concise and comprehensive. Full experimental details must be provided so that the results can be reproduced. *Geriatrics* requires that authors publish all experimental controls and make full datasets available where possible (see the guidelines on Supplementary Materials and references to unpublished data).

Manuscripts submitted to *Geriatrics* should neither been published before nor be under consideration for publication in another journal. The main article types are as follows:

Articles: Original research manuscripts. The journal considers all original research manuscripts provided that the work reports scientifically sound experiments and provides a substantial amount of new information. Authors should not unnecessarily divide their work into several related manuscripts, although Short *Communications* of preliminary, but significant, results will be considered. Quality and impact of the study will be considered during peer review.

Reviews: These provide concise and precise updates on the latest progress made in a given area of research. Systematic reviews should follow the PRISMA guidelines.

Case reports: Case reports present detailed information on the symptoms, signs, diagnosis, treatment (including all types of interventions), and outcomes of an individual patient. Case reports usually describe new or uncommon conditions that serve to enhance medical care or highlight diagnostic approaches.

Submission Process

Manuscripts for *Geriatrics* should be submitted online at susy.mdpi.com The submitting author, who is generally the corresponding author, is responsible for the manuscript during the

submission and peer-review process. The submitting author must ensure that all eligible co-authors have been included in the author list (read the criteria to qualify for authorship) and that they have all read and approved the submitted version of the manuscript. To submit your manuscript, register and log in to the submission website. Once you have registered, click here to go to the submission form for *Geriatrics*. All co-authors can see the manuscript details in the submission system, if they register and log in using the e-mail address provided during manuscript submission.

Accepted File Formats

Authors must use the Microsoft Word template or LaTeX template to prepare their manuscript. Using the template file will substantially shorten the time to complete copy-editing and publication of accepted manuscripts. The total amount of data for all files must not exceed 120 MB. If this is a problem, please contact the editorial office geriatrics@mdpi.com. Accepted file formats are:

Microsoft Word: Manuscripts prepared in Microsoft Word must be converted into a single file before submission. When preparing manuscripts in Microsoft Word, the *Geriatrics* Microsoft Word template file must be used. Please insert your graphics (schemes, figures, *etc.*) in the main text after the paragraph of its first citation.

LaTeX: Manuscripts prepared in LaTeX must be collated into one ZIP folder (include all source files and images, so that the Editorial Office can recompile the submitted PDF). When preparing manuscripts in LaTeX, please use the *Geriatrics* LaTeX template files. You can now also use the online application writeLaTeX to submit articles directly to *Geriatrics*. The MDPI LaTeX template file should be selected from the writeLaTeX template gallery.

Supplementary files: May be any format, but it is recommended that you use common, non-proprietary formats where possible (see below for further details).

Cover Letter

A cover letter must be included with each manuscript submission. It should be concise and explain why the content of the paper is significant, placing the findings in the context of existing work and why it fits the scope of the journal. Confirm that neither the manuscript nor any parts of its content are currently under consideration or published in another journal. Any prior submissions of the manuscript to MDPI journals must be acknowledged. The names of proposed and excluded reviewers should be provided in the submission system, not in the cover letter.

Note for Authors Funded by the National Institutes of Health (NIH)

This journal automatically deposits papers to PubMed Central after publication of an issue. Authors do not need to separately submit their papers through the NIH Manuscript Submission System (NIHMS, http://nihms.nih.gov/).

Manuscript Preparation

General Considerations

Research manuscripts should comprise:

Front matter: Title, Author list, Affiliations, Abstract, Keywords

Research manuscript sections: Introduction, Materials and Methods, Results, Discussion, Conclusions (optional).

Back matter: Supplementary Materials, Acknowledgments, Author Contributions, Conflicts of Interest, References.

Review manuscripts should comprise the front matter, literature review sections and the back matter. The template file can also be used to prepare the front and back matter of your review manuscript. It is not necessary to follow the remaining structure. Structured reviews and meta-analyses should use the same structure as research articles and ensure they conform to the PRISMA guidelines.

Case reports should include a succinct introduction about the general medical condition or relevant symptoms that will be discussed in the case report; the case presentation including all of the relevant de-identified demographic and descriptive information about the patient(s), and a description of the symptoms, diagnosis, treatment, and outcome; a discussion providing context and any necessary explanation of specific treatment decisions; a conclusion briefly outlining the take-home message and the lessons learned.

Graphical abstract: Authors are encouraged to provide a graphical abstract as a self-explanatory image to appear alongside with the text abstract in the Table of Contents. Figures should be a high quality image in any common image format. Note that images displayed online will be up to 11 by 9 cm on screen and the figure should be clear at this size.

Abbreviations should be defined in parentheses the first time they appear in the abstract, main text, and in figure or table captions and used consistently thereafter.

SI Units (International System of Units) should be used. Imperial, US customary and other units should be converted to SI units whenever possible

Accession numbers of RNA, DNA and protein sequences used in the manuscript should be provided in the Materials and Methods section. Also see the section on Deposition of Sequences and of Expression Data.

Equations: If you are using Word, please use either the Microsoft Equation Editor or the MathType add-on. Equations should be editable by the editorial office and not appear in a picture format.

Research Data and supplementary materials: Note that publication of your manuscript implies that you must make all materials, data, and protocols associated with the publication available to readers. Disclose at the submission stage any restrictions on the availability of materials or information. Read the information about Supplementary Materials and Data Deposit for additional guidelines.

Preregistration: Where authors have preregistered studies or analysis plans, links to the preregistration must be provided in the manuscript.

Guidelines and standards: MDPI follows standards and guidelines for certain types of research. See https://www.mdpi.com/editorial_process for further information.

Front Matter

These sections should appear in all manuscript types

Title: The title of your manuscript should be concise, specific and relevant. It should identify if the study reports (human or animal) trial data, or is a systematic review, meta-analysis or replication study. When gene or protein names are included, the abbreviated name rather than full name should be used.

Author List and Affiliations: Authors' full first and last names must be provided. The initials of any middle names can be added. The PubMed/MEDLINE standard format is used for affiliations: complete address information including city, zip code, state/province, and country. At least one author should be designated as corresponding author, and his or her email address and other details should be included at the end of the affiliation section. Please read the criteria to qualify for authorship.

Abstract: The abstract should be a total of about 200 words maximum. The abstract should be a single paragraph and should follow the style of structured abstracts, but without headings: 1) Background: Place the question addressed in a broad context and highlight the purpose of the study; 2) Methods: Describe briefly the main methods or treatments applied. Include any relevant preregistration numbers, and species and strains of any animals used. 3) Results: Summarize the article's main findings; and 4) Conclusion: Indicate the main conclusions or interpretations.

The abstract should be an objective representation of the article: it must not contain results which are not presented and substantiated in the main text and should not exaggerate the main conclusions.

Keywords: Three to ten pertinent keywords need to be added after the abstract. We recommend that the keywords are specific to the article, yet reasonably common within the subject discipline.

Research Manuscript Sections

Introduction: The introduction should briefly place the study in a broad context and highlight why it is important. It should define the purpose of the work and its significance, including specific hypotheses being tested. The current state of the research field should be reviewed carefully and key publications cited. Please highlight controversial and diverging hypotheses when necessary. Finally, briefly mention the main aim of the work and highlight the main conclusions. Keep the introduction comprehensible to scientists working outside the topic of the paper.

Materials and Methods: They should be described with sufficient detail to allow others to replicate and build on published results. New methods and protocols should be described in detail while well-established methods can be briefly described and appropriately cited. Give the name and version of any software used and make clear whether computer code used is available. Include any pre-registration codes.

Results: Provide a concise and precise description of the experimental results, their interpretation as well as the experimental conclusions that can be drawn.

Discussion: Authors should discuss the results and how they can be interpreted in perspective of previous studies and of the working hypotheses. The findings and their implications should be discussed in the broadest context possible and limitations of the work highlighted. Future research directions may also be mentioned. This section may be combined with Results.

Conclusions: This section is not mandatory, but can be added to the manuscript if the discussion is unusually long or complex.

Patents: This section is not mandatory, but may be added if there are patents resulting from the work reported in this manuscript.

Back Matter

Supplementary Materials: Describe any supplementary material published online alongside the manuscript (figure, tables, video, spreadsheets, etc.). Please indicate the name and title of each element as follows Figure S1: title, Table S1: title, etc.

Acknowledgments: All sources of funding of the study should be disclosed. Clearly indicate grants that you have received in support of your research work and if you received funds to cover publication costs. Note that some funders will not refund article processing charges (APC) if the funder and grant number are not clearly and correctly identified in the paper. Funding information can be entered separately into the submission system by the authors during submission of their manuscript. Such funding information, if available, will be deposited to FundRef if the manuscript is finally published.

Author Contributions: Each author is expected to have made substantial contributions to the conception or design of the work; or the acquisition, analysis, or interpretation of data; or the creation of new software used in the work; or have drafted the work or substantively revised it; AND has approved the submitted version (and version substantially edited by journal staff that involves the author's contribution to the study); AND agrees to be personally accountable for the author's own contributions and for ensuring that questions related to the accuracy or integrity of any part of the work, even ones in which the author was not personally involved, are appropriately investigated, resolved, and documented in the literature.
For research articles with several authors, a short paragraph specifying their individual contributions must be provided. The following statements should be used "Conceptualization, X.X. and Y.Y.; Methodology, X.X.; Software, X.X.; Validation, X.X., Y.Y. and Z.Z.; Formal Analysis, X.X.; Investigation, X.X.; Resources, X.X.; Data Curation, X.X.; Writing – Original Draft Preparation, X.X.; Writing – Review & Editing, X.X.; Visualization, X.X.; Supervision, X.X.; Project Administration, X.X.; Funding Acquisition, Y.Y.", please turn to the CRediT taxonomy for the term explanation. For more background on CRediT, see here. "Authorship must include and be limited to those who have contributed substantially to the work. Please read the section concerning the criteria to qualify for authorship carefully".

Conflicts of Interest: Authors must identify and declare any personal circumstances or interest that may be perceived as inappropriately influencing the representation or interpretation of reported research results. If there is no conflict of interest, please state "The authors declare no conflict of interest." Any role of the funding sponsors in the choice of research project; design of the study; in the collection, analyses or interpretation of data; in the writing of the manuscript; or in the decision to publish the results must be declared in this section. *Geriatrics* does not publish studies funded by the tobacco industry. Any projects funded by pharmaceutical or food industries must pay special attention to the full declaration of funder involvement. If there is no role, please state "The sponsors had no role in the design, execution, interpretation, or writing of the study".

References: References must be numbered in order of appearance in the text (including table captions and figure legends) and listed individually at the end of the manuscript. We recommend preparing the references with a bibliography software package, such

as EndNote, ReferenceManager or Zotero to avoid typing mistakes and duplicated references. We encourage citations to data, computer code and other citable research material. If available online, you may use reference style 9. below.

Citations and References in Supplementary files are permitted provided that they also appear in the main text and in the reference list.

In the text, reference numbers should be placed in square brackets [ ], and placed before the punctuation; for example [1], [1–3] or [1,3]. For embedded citations in the text with pagination, use both parentheses and brackets to indicate the reference number and page numbers; for example [5] (p. 10). or [6] (pp. 101–105).

The reference list should include the full title, as recommended by the ACS style guide. Style files for Endnote and Zotero are available.

References should be described as follows, depending on the type of work:

Journal Articles:

1. Author 1, A.B.; Author 2, C.D. Title of the article. *Abbreviated Journal Name* Year, *Volume*, page range.

Books and Book Chapters:

2. Author 1, A.; Author 2, B. *Book Title*, 3rd ed.; Publisher: Publisher Location, Country, Year; pp. 154–196.
3. Author 1, A.; Author 2, B. Title of the chapter. In *Book Title*, 2nd ed.; Editor 1, A., Editor 2, B., Eds.; Publisher: Publisher Location, Country, Year; Volume 3, pp. 154–196.

Unpublished work, submitted work, personal communication:

4. Author 1, A.B.; Author 2, C. Title of Unpublished Work. status (unpublished; manuscript in preparation).
5. Author 1, A.B.; Author 2, C. Title of Unpublished Work. *Abbreviated Journal Name* stage of publication (under review; accepted; in press).
6. Author 1, A.B. (University, City, State, Country); Author 2, C. (Institute, City, State, Country). Personal communication, Year.

Conference Proceedings:

7. Author 1, A.B.; Author 2, C.D.; Author 3, E.F. Title of Presentation. In *Title of the Collected Work* (if available), Proceedings of the Name of the Conference, Location of Conference, Country,

Date of Conference; Editor 1, Editor 2, Eds. (if available); Publisher: City, Country, Year (if available); Abstract Number (optional), Pagination (optional).

Thesis:

8. Author 1, A.B. Title of Thesis. Level of Thesis, Degree-Granting University, Location of University, Date of Completion.

Websites:

9. Title of Site. Available online: URL (accessed on Day Month Year). Unlike published works, websites may change over time or disappear, so we encourage you create an archive of the cited website using a service such as WebCite. Archived websites should be cited using the link provided as follows:
10. Title of Site. URL (archived on Day Month Year).
See the Reference List and Citations Guide for more detailed information.

Preparing Figures, Schemes and Tables

File for Figures and Schemes must be provided during submission in a single zip archive and at a sufficiently high resolution (minimum 1000 pixels width/height, or a resolution of 300 dpi or higher). Common formats are accepted, however, TIFF, JPEG, EPS and PDF are preferred.

Geriatrics can publish multimedia files in articles or as supplementary materials. Please contact the editorial office for further information.

All Figures, Schemes and Tables should be inserted into the main text close to their first citation and must be numbered following their number of appearance (Figure 1, Scheme I, Figure 2, Scheme II, Table 1, *etc.*).

All Figures, Schemes and Tables should have a short explanatory title and caption.

All table columns should have an explanatory heading. To facilitate the copy-editing of larger tables, smaller fonts may be used, but no less than 8 pt. in size. Authors should use the Table option of Microsoft Word to create tables.

Authors are encouraged to prepare figures and schemes in color (RGB at 8-bit per channel). There is no additional cost for publishing full color graphics.

Supplementary Materials, Data Deposit and Software Source Code

Data Availability

In order to maintain the integrity, transparency and reproducibility of research records, authors must make their experimental and research data openly available either by depositing into data repositories or by publishing the data and files as supplementary information in this journal.

Computer Code and Software

For work where novel computer code was developed, authors should release the code either by depositing in a recognized, public repository or uploading as supplementary information to the publication. The name and version of all software used should be clearly indicated.

Supplementary Material

Additional data and files can be uploaded as "Supplementary Files" during the manuscript submission process. The supplementary files will also be available to the referees as part of the peer-review process. Any file format is acceptable, however we recommend that common, non-proprietary formats are used where possible.

Unpublished Data

Restrictions on data availability should be noted during submission and in the manuscript. "Data not shown" should be avoided: authors are encouraged to publish all observations related to the submitted manuscript as Supplementary Material. "Unpublished data" intended for publication in a manuscript that is either planned, "in preparation" or "submitted" but not yet accepted, should be cited in the text and a reference should be added in the References section. "Personal Communication" should also be cited in the text and reference added in the References section. (see also the MDPI reference list and citations style guide).

Remote Hosting and Large Data Sets

Data may be deposited with specialized service providers or institutional/subject repositories, preferably those that use the DataCite mechanism. Large data sets and files greater than 60 MB must be deposited in this way. For a list of other repositories specialized in scientific and experimental data, please consult databib.org or re3data.org. The data repository name, link to the data set (URL) and accession number, doi or handle number of the data set must be provided in the paper. The journal Data also accepts submissions of data set papers.

Deposition of Sequences and of Expression Data

New sequence information must be deposited to the appropriate database prior to submission of the manuscript. Accession numbers provided by the database should be included in the submitted manuscript. Manuscripts will not be published until the accession number is provided.

New nucleic acid sequences must be deposited in one of the following databases: GenBank, EMBL, or DDBJ. Sequences should be submitted to only one database.

New high throughput sequencing (HTS) datasets (RNA-seq, ChIP-Seq, degradome analysis, …) must be deposited either in the GEO database or in the NCBI's Sequence Read Archive.

New microarray data must be deposited either in the GEO or the ArrayExpress databases.The "Minimal Information About a Microarray Experiment" (MIAME) guidelines published by the Microarray Gene Expression Data Society must be followed.

New protein sequences obtained by protein sequencing must be submitted to UniProt (submission tool SPIN).

All sequence names and the accession numbers provided by the databases should be provided in the Materials and Methods section of the article.

References in Supplementary Files

Citations and References in Supplementary files are permitted provided that they also appear in the reference list of the main text.

Research and Publication Ethics

Research Ethics

Research Involving Human Subjects

When reporting on research that involves human subjects, human material, human tissues, or human data, authors must declare that the investigations were carried out following the rules of the Declaration of Helsinki of 1975 (https://www.wma.net/what-we-do/medical-ethics/declaration-of-helsinki/), revised in 2013. According to point 23 of this declaration, an approval from an ethics committee should have been obtained before undertaking the research. At a minimum, a statement including the project identification code, date of approval, and name of the ethics committee or institutional review board should be cited in the Methods Section of the article. Data relating to individual participants must be described in detail, but private information identifying participants need not be included unless the identifiable materials are of relevance to the research (for example, photographs of participants' faces that show a particular symptom). Editors reserve the right to reject any submission that does not meet these requirements.

Example of an ethical statement: "All subjects gave their informed consent for inclusion before they participated in the study. The study was conducted in accordance with the Declaration of

Helsinki, and the protocol was approved by the Ethics Committee of XXX (Project identification code)."

A written informed consent for publication must be obtained from participating patients who can be identified (including by the patients themselves). Patients' initials or other personal identifiers must not appear in any images. For manuscripts that include any case details, personal information, and/or images of patients, authors must obtain signed informed consent from patients (or their relatives/guardians) before submitting to an MDPI journal. Patient details must be anonymized as far as possible, e.g., do not mention specific age, ethnicity, or occupation where they are not relevant to the conclusions. A template permission form is available to download. A blank version of the form used to obtain permission (without the patient names or signature) must be uploaded with your submission.

You may refer to our sample form and provide an appropriate form after consulting with your affiliated institution. Alternatively, you may provide a detailed justification of why informed consent is not necessary. For the purposes of publishing in MDPI journals, a consent, permission, or release form should include unlimited permission for publication in all formats (including print, electronic, and online), in sublicensed and reprinted versions (including translations and derived works), and in other works and products under open access license. To respect patients' and any other individual's privacy, please do not send signed forms. The journal reserves the right to ask authors to provide signed forms if necessary.

Ethical Guidelines for the Use of Animals in Research

The editors will require that the benefits potentially derived from any research causing harm to animals are significant in relation to any cost endured by animals, and that procedures followed are unlikely to cause offense to the majority of readers. Authors should particularly ensure that their research complies with the commonly-accepted '3Rs':

Replacement of animals by alternatives wherever possible,

Reduction in number of animals used, and

Refinement of experimental conditions and procedures to minimize the harm to animals.

Any experimental work must also have been conducted in accordance with relevant national legislation on the use of animals for research. For further guidance authors should refer to the Code of Practice for the Housing and Care of Animals Used in Scientific Procedures [1].

Manuscripts containing original descriptions of research conducted in experimental animals must contain details of approval by a properly constituted research ethics committee. As a minimum,

the project identification code, date of approval and name of the ethics committee or institutional review board should be cited in the Methods section.

Geriatrics endorses the ARRIVE guidelines (www.nc3rs.org.uk/ARRIVE) for reporting experiments using live animals. Authors and reviewers can use the ARRIVE guidelines as a checklist, which can be found at www.nc3rs.org.uk/ARRIVEchecklist.

1. Home Office. Animals (Scientific Procedures) Act 1986. Code of Practice for the Housing and Care of Animals Used in Scientific Procedures. Available online: http://www.official-documents.gov.uk/document/hc8889/hc01/0107/0107.pdf.

Research Involving Cell Lines

Methods sections for submissions reporting on research with cell lines should state the origin of any cell lines. For established cell lines the provenance should be stated and references must also be given to either a published paper or to a commercial source. If previously unpublished *de novo* cell lines were used, including those gifted from another laboratory, details of institutional review board or ethics committee approval must be given, and confirmation of written informed consent must be provided if the line is of human origin.

An example of Ethical Statements:

The HCT116 cell line was obtained from XXXX. The $MLH1^{+}$ cell line was provided by XXXXX, Ltd. The DLD-1 cell line was obtained from Dr. XXXX. The DR-GFP and SA-GFP reporter plasmids were obtained from Dr. XXX and the Rad51K133A expression vector was obtained from Dr. XXXX.

Research Involving Plants

Experimental research on plants (either cultivated or wild) including collection of plant material, must comply with institutional, national, or international guidelines. We recommend that authors comply with the Convention on Biological Diversity and the Convention on the Trade in Endangered Species of Wild Fauna and Flora.

For each submitted manuscript supporting genetic information and origin must be provided. For research manuscripts involving rare and non-model plants (other than, e.g., *Arabidopsis thaliana, Nicotiana benthamiana, Oriza sativa*, or many other typical model plants), voucher specimens must be deposited in an accessible herbarium or museum. Vouchers may be requested for review by future investigators to verify the identity of the material used in the study (especially if taxonomic rearrangements occur in the future). They should include details of the populations sampled on the site of collection (GPS coordinates), date of collection, and document the part(s)

used in the study where appropriate. For rare, threatened or endangered species this can be waived but it is necessary for the author to describe this in the cover letter.

Editors reserve the rights to reject any submission that does not meet these requirements.

An example of Ethical Statements:

Torenia fournieri plants were used in this study. White-flowered Crown White (CrW) and violet-flowered Crown Violet (CrV) cultivars selected from 'Crown Mix' (XXX Company, City, Country) were kindly provided by Dr. XXX (XXX Institute, City, Country).

Arabidopis mutant lines (SALKxxxx, SAILxxxx…) were kindly provided by Dr. XXX, institute, city, country).

Publication Ethics Statement

Geriatrics is a member of the Committee on Publication Ethics (COPE). We fully adhere to its Code of Conduct and to its Best Practice Guidelines.

The editors of this journal enforce a rigorous peer-review process together with strict ethical policies and standards to ensure to add high quality scientific works to the field of scholarly publication. Unfortunately, cases of plagiarism, data falsification, image manipulation, inappropriate authorship credit, and the like, do arise. The editors of *Geriatrics* take such publishing ethics issues very seriously and are trained to proceed in such cases with a zero tolerance policy.

Authors wishing to publish their papers in *Geriatrics* must abide to the following:

Any facts that might be perceived as a possible conflict of interest of the author(s) must be disclosed in the paper prior to submission.

Authors should accurately present their research findings and include an objective discussion of the significance of their findings.

Data and methods used in the research need to be presented in sufficient detail in the paper, so that other researchers can replicate the work.

Raw data should preferably be publicly deposited by the authors before submission of their manuscript. Authors need to at least have the raw data readily available for presentation to the referees and the editors of the journal, if requested. Authors need to ensure appropriate measures are taken so that raw data is retained in full for a reasonable time after publication.

Simultaneous submission of manuscripts to more than one journal is not tolerated.

Republishing content that is not novel is not tolerated (for example, an English translation of a paper that is already published in another language will not be accepted).

If errors and inaccuracies are found by the authors after publication of their paper, they need to be promptly communicated to the editors of this journal so that appropriate actions can be taken. Please refer to our policy regarding publication of publishing addenda and corrections.

Your manuscript should not contain any information that has already been published. If you include already published figures or images, please obtain the necessary permission from the copyright holder to publish under the CC-BY license. For further information, see the Rights and Permissions page.

Plagiarism, data fabrication and image manipulation are not tolerated.

Plagiarism is not acceptable in *Geriatrics* submissions.

Plagiarism includes copying text, ideas, images, or data from another source, even from your own publications, without giving any credit to the original source.

Reuse of text that is copied from another source must be between quotes and the original source must be cited. If a study's design or the manuscript's structure or language has been inspired by previous works, these works must be explicitly cited.

If plagiarism is detected during the peer review process, the manuscript may be rejected. If plagiarism is detected after publication, we may publish a correction or retract the paper.

Image files must not be manipulated or adjusted in any way that could lead to misinterpretation of the information provided by the original image.

Irregular manipulation includes: 1) introduction, enhancement, moving, or removing features from the original image; 2) grouping of images that should obviously be presented separately (e.g., from different parts of the same gel, or from different gels); or 3) modifying the contrast, brightness or color balance to obscure, eliminate or enhance some information.

If irregular image manipulation is identified and confirmed during the peer review process, we may reject the manuscript. If irregular image manipulation is identified and confirmed after publication, we may correct or retract the paper.

Our in-house editors will investigate any allegations of publication misconduct and may contact the authors' institutions or funders if necessary. If evidence of misconduct is found, appropriate action will be taken to correct or retract the publication. Authors are expected to comply with the best ethical publication practices when publishing with MDPI.

Reviewer Suggestions

During the submission process, please suggest three potential reviewers with the appropriate expertise to review the manuscript. The editors will not necessarily approach these referees. Please provide detailed contact information (address, homepage, phone, e-mail address). The proposed referees should neither be current collaborators of the co-authors nor have published with any of the co-authors of the manuscript within the last five years. Proposed reviewers should be from different institutions to the authors. You may identify appropriate Editorial Board members of the journal as potential reviewers. You may suggest reviewers from among the authors that you frequently cite in your paper.

English Corrections

To facilitate proper peer-reviewing of your manuscript, it is essential that it is submitted in grammatically correct English. Advice on some specific language points can be found here.

If you are not a native English speaker, we recommend that you have your manuscript professionally edited before submission or read by a native English-speaking colleague. This can be carried out by MDPI's English editing service. Professional editing will enable reviewers and future readers to more easily read and assess the content of submitted manuscripts. All accepted manuscripts undergo language editing, however an additional fee will be charged to authors if very extensive English corrections must be made by the Editorial Office: pricing is according to the service here.

Preprints and Conference Papers

Geriatrics accepts articles that have previously been made available as preprints provided that they have not undergone peer review. A preprint is a draft version of a paper made available online before submission to a journal.

MDPI operates *Preprints*, a preprint server to which submitted papers can be uploaded directly after completing journal submission. Note that *Preprints* operates independently of the journal and posting a preprint does not affect the peer review process. Check the *Preprints* instructions for authors for further information.

Expanded and high quality conference papers can be considered as articles if they fulfil the following requirements: (1) the paper should be expanded to the size of a research article; (2) the conference paper should be cited and noted on the first page of the paper; (3) if the authors do not hold the copyright of the published conference paper, authors should seek the appropriate permission from the copyright holder; (4) authors are asked to disclose that it is conference paper in their cover letter and include a statement on what has been changed compared to the original conference paper. *Geriatrics* does not publish pilot studies or studies with inadequate statistical power.

Authorship

MDPI follows the International Committee of Medical Journal Editors (ICMJE) guidelines which state that, in order to qualify for authorship of a manuscript, the following criteria should be observed:

Substantial contributions to the conception or design of the work; or the acquisition, analysis, or interpretation of data for the work; AND

Drafting the work or revising it critically for important intellectual content; AND

Final approval of the version to be published; AND

Agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

Those who contributed to the work but do not qualify for authorship should be listed in the acknowledgements. More detailed guidance on authorship is given by the International Council of Medical Journal Editors (ICMJE).

Any change to the author list should be approved by all authors including any who have been removed from the list. The corresponding author should act as a point of contact between the editor and the other authors and should keep co-authors informed and involve them in major decisions about the publication. We reserve the right to request confirmation that all authors meet the authorship conditions.

Reviewers Recommendation

Authors can recommend potential reviewers. Journal editors will check to make sure there are no conflict of interests before contacting those reviewers, and will not consider those with competing interests. Reviewers are asked to declare any conflicts of interest. Authors can also enter the names of potential peer reviewers they wish to exclude from consideration in the peer review of

their manuscript, during the initial submission progress. The editorial team will respect these requests so long as this does not interfere with the objective and thorough assessment of the submission.

Editors and Journal Staff as Authors

Editorial independence is extremely important and MDPI does not interfere with editorial decisions.

Editorial staff or editors shall not be involved in the processing their own academic work. Submissions authored by editorial staff/editors will be assigned to at least two independent outside reviewers. Decisions will be made by other editorial board members who do not have conflict of interests with the author. Journal staff are not involved in the processing of their own work submitted to any MDPI journals.

Conflict of Interests

According to The International Committee of Medical Journal Editors, “Authors should avoid entering into agreements with study sponsors, both for-profit and non-profit, that interfere with authors’ access to all of the study’s data or that interfere with their ability to analyze and interpret the data and to prepare and publish manuscripts independently when and where they choose.”

Authors must identify and declare any personal circumstances or interest that may be perceived as inappropriately influencing the representation or interpretation of reported research results. If there is no conflict of interest, please state "The authors declare no conflict of interest." Any role of the funding sponsors in the design of the study; in the collection, analyses or interpretation of data; in the writing of the manuscript; or in the decision to publish the results must be declared in this section. If there is no role, please state “The founding sponsors had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, and in the decision to publish the results”.

Editorial Procedures and Peer-Review

Initial Checks

All submitted manuscripts received by the Editorial Office will be checked by a professional in-house *Managing Editor* to determine whether they are properly prepared and whether they follow the ethical policies of the journal, including those for human and animal experimentation. Manuscripts that do not fit the journal's ethics policy or do not meet the standards of the journal will be rejected before peer-review. Manuscripts that are not properly prepared will be returned to the authors for revision and resubmission. After these checks, the *Managing Editor* will consult

the journals' *Editor-in-Chief* or *Associate Editors* to determine whether the manuscript fits the scope of the journal and whether it is scientifically sound. No judgment on the potential impact of the work will be made at this stage. Reject decisions at this stage will be verified by the *Editor-in-Chief*.

Peer-Review

Once a manuscript passes the initial checks, it will be assigned to at least two independent experts for peer-review. A single-blind review is applied, where authors' identities are known to reviewers. Peer review comments are confidential and will only be disclosed with the express agreement of the reviewer.

In the case of regular submissions, in-house assistant editors will invite experts, including recommendations by an academic editor. These experts may also include *Editorial Board members* and Guest Editors of the journal. Potential reviewers suggested by the authors may also be considered. Reviewers should not have published with any of the co-authors during the past five years and should not currently work or collaborate with any of the institutions of the co-authors of the submitted manuscript.

Optional Open Peer-Review

The journal operates optional open peer-review: *Authors are given the option for all review reports and editorial decisions to be published alongside their manuscript. In addition, reviewers can sign their review, i.e., identify themselves in the published review reports.* Authors can alter their choice for open review at any time before publication, however once the paper has been published changes will only be made at the discretion of the *Publisher* and *Editor-in-Chief*. We encourage authors to take advantage of this opportunity as proof of the rigorous process employed in publishing their research. To guarantee an impartial refereeing the names of referees will be revealed only if the referees agree to do so, and after a paper has been accepted for publication.

Editorial Decision and Revision

All the articles, reviews and communications published in MDPI journals go through the peer-review process and receive at least two reviews. The in-house editor will communicate the decision of the academic editor, which will be one of the following:

Accept after Minor Revisions:

The paper is in principle accepted after revision based on the reviewer's comments. Authors are given five days for minor revisions.

Reconsider after Major Revisions:

The acceptance of the manuscript would depend on the revisions. The author needs to provide a point by point response or provide a rebuttal if some of the reviewer's comments cannot be revised. Usually, only one round of major revisions is allowed. Authors will be asked to resubmit the revised paper within a suitable time frame, and the revised version will be returned to the reviewer for further comments.

Reject and Encourage Resubmission:

If additional experiments are needed to support the conclusions, the manuscript will be rejected and the authors will be encouraged to re-submit the paper once further experiments have been conducted.

Reject:
The article has serious flaws, and/or makes no original significant contribution. No offer of resubmission to the journal is provided.

All reviewer comments should be responded to in a point-by-point fashion. Where the authors disagree with a reviewer, they must provide a clear response.

Author Appeals

Authors may appeal a rejection by sending an e-mail to the Editorial Office of the journal. The appeal must provide a detailed justification, including point-by-point responses to the reviewers' and/or Editor's comments. The *Managing Editor* of the journal will forward the manuscript and related information (including the identities of the referees) to the Editor-in-Chief, Associate Editor, or Editorial Board member. The academic Editor being consulted will be asked to give an advisory recommendation on the manuscript and may recommend acceptance, further peer-review, or uphold the original rejection decision. A reject decision at this stage is final and cannot be reversed.

In the case of a special issue, the *Managing Editor* of the journal will forward the manuscript and related information (including the identities of the referees) to the *Editor-in-Chief* who will be asked to give an advisory recommendation on the manuscript and may recommend acceptance, further peer-review, or uphold the original rejection decision. A reject decision at this stage will be final and cannot be reversed.

Production and Publication

Once accepted, the manuscript will undergo professional copy-editing, English editing, proofreading by the authors, final corrections, pagination, and, publication on the www.mdpi.com website.

Clinical Trials Registration

Registration

Authors are strongly encouraged to pre-register clinical trials with an international clinical trials register or and to cite a reference to the registration in the Methods section. Suitable databases include clinicaltrials.gov, the EU Clinical Trials Register and those listed by the World Health Organisation International Clinical Trials Registry Platform.

CONSORT Statement

Geriatrics requires a completed CONSORT 2010 checklist and flow diagram as a condition of submission when reporting the results of a randomized trial. Templates for these can be found here or on the CONSORT website (http://www.consort-statement.org) which also describes several CONSORT checklist extensions for different designs and types of data beyond two group parallel trials. At minimum, your article should report the content addressed by each item of the checklist. Meeting these basic reporting requirements will greatly improve the value of your trial report and may enhance its chances for eventual publication.

APPENDIX E: IJBNPA AUTHOR'S GUIDELINES

Research

Criteria

- Cover letters must include the names and emails of at least 4 potential reviewers. These must be from a different institution to the first author and not have published with any member of the writing group in the previous 3 years.

- Cover letters must contain a rationale for how the manuscript is novel, why it is relevant to the journal, and how the research contributes to the field or advances the evidence base.

- All studies testing the effect of an intervention have to be registered with a trials registry to be eligible for peer review. We STRONGLY recommend prospective registration but will consider retrospectively registered trials with appropriate justification.

- For completed randomized controlled trials, IJBNPA requires the submission of a populated CONSORT checklist and flow diagram. The flow diagram should be included in the main body of the text and the checklist should be provided as an additional file. Both the flow diagram and the checklist should be referenced in the text. Submissions received without these elements will be returned to the authors as incomplete. A Word file of the checklist and flow diagram can be downloaded here.

- For all intervention components, authors are required to use the TIDieR Checklist, which should be provided as an additional file. The TIDieR Checklist is available to download as a PDF and a Word file.

- For observational studies, IJBNPA requires the submission of a populated STROBE checklist (http://strobe-statement.org/index.php?id=available-checklists) along with the manuscript. For observational studies that focus on nutrition, the checklist should be modified to reflect the revised STROBE-nut guidelines (http://journals.plos.org/plosmedicine/article?id=10.1371/journal.pmed.1002036).The completed checklist should be provided as an additional file.

- For all empirical studies, info regarding how the sample was recruited, how representative the sample was of the target group, how the analysed sample differed from the recruited sample and how any missing data were handled should be made available to editors/reviewers; these materials should be uploaded as an addtional file at the time of submission.

- There is no specific word limit, but articles should be as concise as possible. Articles that exceed 5000 words are rarely published.

- If an article is accepted for publication, the submitting author will be asked to provide at least one tweet of about 100 characters, together with your (or an institute) Twitter name which will be used to help publicise the paper at the point of publication.

- More general formatting guidelines can be found here.

International Journal of Behavioral Nutrition and Physical Activity strongly encourages that all datasets on which the conclusions of the paper rely should be available to readers. We encourage authors to ensure that their datasets are either deposited in publicly available repositories (where available and appropriate) or presented in the main manuscript or additional supporting files whenever possible. Please see Springer Nature's information on recommended repositories. Where a widely established research community expectation for data archiving in public repositories exists, submission to a community-endorsed, public repository is mandatory. A list of data where deposition is required, with the appropriate repositories, can be found on the Editorial Policies Page.

Preparing your manuscript

The information below details the section headings that you should include in your manuscript and what information should be within each section.

Please note that your manuscript must include a 'Declarations' section including all of the subheadings (please see below for more information).

Title page

The title page should:

- present a title that includes, if appropriate, the study design e.g.:

o "A versus B in the treatment of C: a randomized controlled trial", "X is a risk factor for Y: a case control study", "What is the impact of factor X on subject Y: A systematic review"

o or for non-clinical or non-research studies a description of what the article reports

- list the full names and institutional addresses for all authors

o if a collaboration group should be listed as an author, please list the Group name as an author. If you would like the names of the individual members of the Group to be searchable through their individual PubMed records, please include this information in the "Acknowledgements" section in accordance with the instructions below

- indicate the corresponding author

Abstract

The Abstract should not exceed 350 words. Please minimize the use of abbreviations and do not cite references in the abstract. Reports of randomized controlled trials should follow the CONSORT extension for abstracts. The abstract must include the following separate sections:

- Background: the context and purpose of the study
- Methods: how the study was performed and statistical tests used
- Results: the main findings
- Conclusions: brief summary and potential implications
- Trial registration: If your article reports the results of a health care intervention on human participants, it must be registered in an appropriate registry and the registration number and date of registration should be in stated in this section. If it was not registered prospectively (before enrollment of the first participant), you should include the words 'retrospectively registered'. See our editorial policies for more information on trial registration

Keywords

Three to ten keywords representing the main content of the article.

Background

The Background section should explain the background to the study, its aims, a summary of the existing literature and why this study was necessary or its contribution to the field.

Methods

The methods section should include:

- the aim, design and setting of the study
- the characteristics of participants or description of materials
- a clear description of all processes, interventions and comparisons. Generic drug names should generally be used. When proprietary brands are used in research, include the brand names in parentheses
- the type of statistical analysis used, including a power calculation if appropriate

Results

This should include the findings of the study including, if appropriate, results of statistical analysis which must be included either in the text or as tables and figures.

Discussion

This section should discuss the implications of the findings in context of existing research and highlight limitations of the study.

Conclusions

This should state clearly the main conclusions and provide an explanation of the importance and relevance of the study reported.

List of abbreviations

If abbreviations are used in the text they should be defined in the text at first use, and a list of abbreviations should be provided.

Declarations

All manuscripts must contain the following sections under the heading 'Declarations':

- Ethics approval and consent to participate
- Consent for publication
- Availability of data and materials
- Competing interests
- Funding
- Authors' contributions
- Acknowledgements
- Authors' information (optional)

Please see below for details on the information to be included in these sections.

If any of the sections are not relevant to your manuscript, please include the heading and write 'Not applicable' for that section.

Ethics approval and consent to participate

Manuscripts reporting studies involving human participants, human data or human tissue must:

- include a statement on ethics approval and consent (even where the need for approval was waived)
- include the name of the ethics committee that approved the study and the committee’s reference number if appropriate

Studies involving animals must include a statement on ethics approval.

See our editorial policies for more information.

If your manuscript does not report on or involve the use of any animal or human data or tissue, please state “Not applicable” in this section.

Consent for publication

If your manuscript contains any individual person’s data in any form (including any individual details, images or videos), consent for publication must be obtained from that person, or in the case of children, their parent or legal guardian. All presentations of case reports must have consent for publication.

You can use your institutional consent form or our consent form if you prefer. You should not send the form to us on submission, but we may request to see a copy at any stage (including after publication).

See our editorial policies for more information on consent for publication.

If your manuscript does not contain data from any individual person, please state “Not applicable” in this section.

Availability of data and materials

All manuscripts must include an ‘Availability of data and materials’ statement. Data availability statements should include information on where data supporting the results reported in the article can be found including, where applicable, hyperlinks to publicly archived datasets analysed or generated during the study. By data we mean the minimal dataset that would be necessary to interpret, replicate and build upon the findings reported in the article. We recognise it is not always possible to share research data publicly, for instance when individual privacy could be compromised, and in such instances data availability should still be stated in the manuscript along with any conditions for access.

Data availability statements can take one of the following forms (or a combination of more than one if required for multiple datasets):

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