Physical activity patterns and aerobic fitness of academic staff at a University of Technology in South Africa

by

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Dissertation submitted in partial compliance with the requirements for the Master's Degree in Technology: Chiropractic at the Durban University of Technology.

I, Valeska Roelofse, do declare that this dissertation is representative of my own work in both conception and execution (except where acknowledgements indicate to the contrary).

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Dedication

I dedicate this dissertation to:

My mom and dad, who are responsible for where I am today. Thank you for helping me to pursue my dreams and for your incredible support, patience, love and encouragement every step of the way. You have always been and continue to be my role models each day and I am so grateful for all the sacrifices and hard work you have made for my education and future.

To God, my Saviour for the strength, vision and determination to complete this study.

To my sister, Danya, thank you for being my biggest supporter throughout my studies and for all the laughs, encouragement and love throughout my studying years.

Acknowledgements

To my supervisors, Prof Julian D Pillay and Prof Firoza Haffejee, thank you for your support and guidance throughout this whole process.

To Tonya Esterhuizen, thank you for your assistance with statistical analysis and your patience.

To all research participants, thank you for your time and participation in this study.

To my classmates, thank you for all the memories and laughs over these past few years. I wish you all the best for the future.

To the Durban University of Technology and my lecturers, thank you for your guidance and allowing me to conduct this research study.

To Thomas Clarke, special thanks for all your support, love, encouragement and help throughout this process and my studies. The shared experience of us both completing our dissertations at the same time has really strengthened our relationship and brought us so much closer and I would not want to share this experience with anyone else.

Abstract

Background: Physical activity (PA) has a significant effect on well-being and should be an essential component of healthy living. An active lifestyle has been found to aid weight management and provide protection against chronic lifestyle diseases. Physical inactivity of white-collar office workers has been shown to decrease work productivity and increase work absenteeism. Consequently, academic staff may experience these effects due to physical inactivity. Despite the many international studies performed on the PA of white-collar office and administration workers, few studies have focussed on office workers in a South African setting. Moreover, studies investigating PA of academic staff in a South African setting are limited. This study therefore aimed to determine the PA patterns and aerobic fitness of academic staff at a university in South Africa (SA).

Objectives: The objectives of this study were: to determine self-reported PA levels of academic staff using the IPAQ; to objectively measure PA patterns of academic staff using pedometers; to compare pedometer-measured data with self-reported data; to establish aerobic fitness through an aerobic fitness assessment; and to determine the association, if any, between the pedometer-measured steps and aerobic fitness.

Method: A cross sectional study in a quantitative paradigm consisted of a descriptive component involving the completion of the IPAQ and 7-day pedometer wear. An experimental component in the form of an aerobic fitness assessment (Harvard Step Test) was performed and measurements including Physical Efficiency Index (PEI) percentage body fat (PBF), Body Mass Index (BMI) and waist-to-hip ratio were taken. This was administered to 61 full-time, non-contract academic staff members at the Durban University of Technology (DUT). IBM SPSS version 25.0 was used to analyse the data. Continuous data was described using median and inter-quartile ranges overall and per group as the variables were not normally distributed. Non-parametric Kruskal-Wallis tests were used to compare medians across physical activity groups at a 0.05 level of significance. Where an overall significant result was obtained, Bonferroni-adjusted multiple comparison tests were performed to identify the groups which differed. Relationships between continuous variables were assessed using Spearman's rank correlation coefficient.

Results: Key findings: 49.1% of participants were classified as being moderately active, 31.9% were classified as highly active and 19.0% were classified as low or physically inactive according to the IPAQ. Participants mostly engaged in moderate-intensity physical activity (MPA) during the week (1800 MET minutes/week). The largest volume of PA was spent performing domestic and gardening/yard activities (1120 MET-minutes/week). A significant difference in self-reported fitness level was found across the PA classifications ($p = 0.003$), with the most significant differences observed between the high and low groups ($p = 0.01$) and moderate and high groups ($p = 0.04$). A trend was found which indicated that as PA measured with the IPAQ increased, so did all the median values of the pedometer measure data.

An overall significant difference between the PA groups (highly active, moderately active and low activity groups) in terms of average aerobic steps ($p = 0.028$) and average aerobic walking time ($p = 0.033$) was present. The majority of participants (62.3%) were classified as having a poor Physical Efficiency Index (PEI), followed by 31.1% of participants having a low-average PEI and only 6.6% were found to have a high-average PEI. Strong negative correlations were found between PEI and Percentage body fat (PBF) ($r = -0.369$, $p = 0.003$). Another negative correlation was present between PEI and Body Mass Index (BMI) ($r = -0.308$, $p = 0.016$). A strong positive correlation was found between BMI and PBF ($r = 0.789$, $p = < 0.001$). BMI was negatively correlated with average daily steps ($r = -0.296$, $p = 0.020$), average daily aerobic steps ($r = -0.244$, $p = 0.059$) and average distance covered ($r = -0.236$, $p = 0.067$). Significant relationships were found between PEI and average kilocalories ($r = 0.295$, $p = 0.021$) as well as with average distance ($r = 0.293$, $p = 0.022$). PBF was negatively correlated with average aerobic steps ($r = -0.416$, $p = 0.001$), average aerobic walking time ($r = -0.409$, $p = 0.001$) and average daily steps ($r = -0.380$, $p = 0.003$). A trend was found where total PA MET-minutes/week increased from Groups A to B to C. There was a significant difference ($p < 0.001$) across the three participation groups regarding PA level where high activity was more likely to be present in Group C and low activity more likely to be present in Group A.

Conclusion: The results of this study revealed that almost half of the participants were at least moderately active according to self-reported data. This is higher than previous studies performed nationally and globally on office workers and healthcare workers. Despite this, most participants exhibited poor aerobic fitness when performing the aerobic fitness assessment and the pedometer data measurements were lower than previous studies conducted. The study therefore illustrates the need for academic staff members to improve their aerobic fitness as well as to improve their step count and aerobic walking time on a daily basis. Additionally, increasing daily step count and aerobic walking time will benefit the health of academic staff. This was seen with the strong negative correlations found between step counts and aerobic walking time with BMI and PBF as well as between PEI and PBF. By increasing step count and aerobic walking time, staff could potentially maintain a healthy BMI and PBF which could reduce risk of co-morbid pathologies. This would contribute to a healthy lifestyle which should be encouraged. Therefore, it is recommended that employers and management of tertiary institutions consider these findings and use them to implement worksite PA programmes in order to improve PA of workers and academic staff which could ultimately positively impact well-being and consequent work performance.

Key words: Physical activity, physical inactivity, work-related musculoskeletal disorders, academic staff, lecturers, aerobic fitness.

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Definitions

Physical activity: Any bodily movement produced by the skeletal muscles of the body resulting in significantly greater expenditure of energy (US Department of Health and Human Services, 1996: 20).

Exercise: A type of physical activity consisting of planned, structured, and repetitive bodily movement done to improve and/or maintain one or more components of physical fitness (Caspersen, Powell and Christenson, 1985:127).

Metabolic equivalents (METS): The ratio of the metabolic rate during work to the metabolic rate when resting. One MET is equal to the caloric intake of 1 kcal/kg/hour and is defined as the energy used when sitting quietly (IARC, 2002: 7).

Sedentary: Actions that do not cause energy expenditure to rise significantly above resting levels. These actions include sitting, watching television and sleeping (Pate, O'Neill and Lobelo; 2008: 174).

Prevalence: The percentage of a population that is affected with a particular disease at a given time (Merriam-Webster Dictionary, 2019: 1).

Abbreviations

The following abbreviations appear in this study:

PA	Physical activity
BMI	Body Mass Index
cm	Centimetre
IPAQ	International Physical Activity Questionnaire
NCD	Non-communicable disease
WHO	World Health Organisation
DUT	Durban University of Technology
WRMSD	Work-related musculoskeletal disorders
Kcal	Kilocalorie
Km	Kilometre
Kg	Kilogram
Min	Minute
METS	Metabolic Equivalents
GPAQ	Global Physical Activity Questionnaire
HDL	High-density lipoprotein
NSAIDS	Non-steroidal anti-inflammatory drugs
FFAs	Free fatty acids
PEI	Physical Efficiency Index
PBF	Percentage body fat
MPA	Moderate-intensity physical activity
VPA	Vigorous-intensity physical activity
LPA	Low-intensity physical activity

Chapter One:
Introduction

1.1 Background

Physical activity (PA) is defined as movement of the body created by skeletal muscle contraction which then increases energy expenditure significantly (Miles, 2007: 318). PA has a substantial impact on health and well-being (Lahti et *al.,* 2010: 246). It has been proven to provide protection against non-communicable diseases (NCD) such as cardiovascular disease, diabetes mellitus, hypertension and cancer, as well as aid in maintaining a healthy weight (Lambert, Bohlmann and Kolbe-Alexander, 2001: 13). Physical inactivity is defined as a condition involving minimal body movement which results in energy expenditure closely resembling that of the resting metabolic rate (IARC, 2002: 7). Chronic diseases result from a sedentary lifestyle and lack of engagement in moderate-to-vigorous PA (Healy *et al*., 2008: 369). Other contributing factors include tobacco use, excessive alcohol use, overeating and unhealthy diets (Cecchini *et al*., 2010: 1775). NCD's are largely responsible for mortality both globally and in low and middle-income countries (Skaal and Pengpid, 2011: 563) and have been recognised as the fourth leading risk factor for global mortality (Hallal e*t al.,* 2012: 247).

Low levels of PA have become a significant public health problem which has been recognised by international and national health organisations as requiring significant intervention (Miles, 2007: 317). It has been recognised by the World Health Organisation (WHO) as the fourth leading risk factor for global mortality and is accountable for 6% of NCD risks (Department of Health, 2016: 17). WHO subsequently developed global activity recommendations which expand on the frequency, intensity, duration, type and amount of activity required to prevent NCD's (WHO, 2010: 7).

In South Africa (SA), PA has been found to be surprisingly low (Lambert, Bohlmann and Kolbe-Alexander, 2001: S12). This is due to the South African population becoming more sedentary with activity levels becoming similar to that of developed countries (Walter *et al*., 2011: 1). Another factor is the demographics of South Africa.

Individuals of Asian or Indian descent as well as African females have been found to be at higher risk of obesity and diabetes and therefore may be less active (Bradshaw *et al.,* 2000: 700-706; Puoane, Steyn and Bradshaw,2002: 1038-1048). Environmental factors such as high crime rates, poor access to facilities (Kruger, Venter and Vorster, 2003: 16–23), lack of PA education in schools (Medical Research Council, 2002) and prolonged television viewing (Medical Research Council, 2002) have been identified as being contributing factors. The Department of Health and the Department of Sports and Recreation in SA aim to combat the rising inactivity and NCD levels through increasing sport participation of citizens through community mass participation programmes and integrated school sports programmes (Department of Health, 2016: 13). This forms part of the strategy for prevention and control of obesity for 2015 to 2020 which uses a guided framework from WHO (Department of Health, 2016: 23).

Low PA levels are commonly seen in office workers due to low physical demands and prolonged sitting. Workers mostly perform monotonous actions which require little effort which promotes sedentariness (Biernat, Tomaszewski and Milde, 2010: 289). This lack of activity can lead to NCD's and low levels of alertness which decreases work productivity (Chia, Chen and Suppiah, 2015: 9) and can contribute to increased sick leave taken by workers (Harcombe e*t al*., 2009: 439). Research on activity levels of office workers is therefore important, as well as beneficial, to government and employers due to the impact on work productivity and public health (Biernat, Tomaszewski and Milde, 2010: 289).

Few studies have focussed on PA of academic staff or lecturers in a university setting. An increase in chronic disease has been found in university lecturers in Sub-Saharan Africa, but the relationship between disease and PA has not been extensively studied, especially in Sub-Saharan Africa (Omondi, Othuon and Mbagaya*,* 2007: 87). The studies that had been performed, reported the majority of participants to have low activity levels (Omondi, Othuon and Mbagaya, 2007: 90) and poor health such as coronary heart disease (Barkhuizen and Rothmann, 2008: 322).

Low activity levels can lead to development of NCD's (Skaal and Pengpid, 2011: 563), musculo-skeletal problems, poor work productivity and attendance (Chia, Chen and Suppiah, 2015: 9). In order to apply effective interventions, knowledge and investigation of lifestyle factors such as PA levels and habits is essential for chronic disease prevention and management (Coopoo, Constantinou and Rothberg, 2008). This study is therefore important as this affects academic staff members at universities. This study could provide insight into physical activity patterns and aerobic fitness levels which could assist the academic staff and institutional management with implementing work wellness programmes and health promotion initiatives to curb absenteeism and low work productivity.

1.2 Aims and Objectives

The aim of this study was to determine PA patterns and aerobic fitness of academic staff at a selected University of Technology in South Africa, with a view to demonstrate how these measures correlate with findings globally and in South Africa and whether interventions are possibly required to improve PA levels of academic staff at the university.

Objectives:

1. To determine self-reported PA levels of academic staff, using the international physical activity questionnaire.
2. To objectively measure PA patterns of academic staff, using pedometers.
3. To compare pedometer-measured data with self-reported data.
4. To establish aerobic fitness through an aerobic fitness assessment.
5. To determine the association, if any, between the pedometer-measured steps and aerobic fitness.
6. Explore and describe the implications of the results and implications on academic practice.

1.3 Rationale

Literature previously published has consisted of cross sectional, observational or intervention studies focussing on PA levels of white-collar office workers in an occupational setting. Many of these studies focus specifically on the impact of physical inactivity and sedentariness on the musculoskeletal system and its impact on work productivity and sick days taken. Other studies focus on the prevalence of NCDs in office workers and the relationship between PA and development of chronic disease. Workplace intervention studies are also common and focus on the effects of introducing healthy lifestyle changes in the workplace on employees and their health benefits. These studies mostly use only one measurement tool such as a survey/questionnaire, accelerometer, pedometer or heart rate monitoring. Therefore, the measurement tools offer either subjective or objective data only and many studies do not offer both. This has led to a lack of studies which offer a comparison between objective and subjective data regarding PA. This study aims to compare pedometer-measured data with self-reported data. Furthermore, this study aims to determine the association between pedometer-measured steps and aerobic fitness. This will allow for a comprehensive set of both subjective and objective data which can be used to illustrate the correlations between PA patterns and aerobic fitness. This study aims to explore and describe the implications of the results and implications on academic practice.

Most PA studies are international, with very few carried out in SA. Even fewer studies focus on PA of academics in a university setting. A cross-sectional and observational study focussing on PA patterns and aerobic fitness of academic staff will contribute valuable insight to the literature. There are currently no known studies focussing on PA of university lecturers in SA. Therefore, this study would provide new and original information in the South African setting. This knowledge of PA levels and fitness can inform and empower the academic staff at the university to make important lifestyle changes which can improve their health and fitness. Furthermore, the university can use this information to establish worksite wellness programmes and incentives to promote PA. This would ultimately benefit the institution as it has been shown that such programmes improve productivity and work-place morale, decrease staff turnover and reduce sick leave (Coopoo, Constantinou and Rothberg, 2008).

1.4 Flow of the thesis

Chapter one provides an introduction and rationale for the study. It introduces the background for the study together with the aims, objectives and study hypotheses.

Chapter two consists of the literature review. This examines and analyses the current literature related to the topic being investigated. This consists of literature regarding PA such as types and definitions of PA, prevalence of PA, barriers and advantages of PA, effects of PA and the management of physical inactivity.

Chapter three discusses the methodology that was carried out to achieve the aims and objectives in the research study. It also describes the statistical tests that were used to acquire the results. Ethical considerations involved in the study are also expanded on.

Chapter four describes the results of the study which are presented through tables, graphs and figures. These are accompanied by written information which allows enhanced understanding of the data.

Chapter five is a critical discussion of the results of the study. This chapter relates the results of the study to the current literature described in the literature review and discusses the results through relation to the aims and objectives of the study. This chapter also explores the role of the chiropractor in promoting wellness and PA within the population, and the importance of doing so, beyond academics.

Chapter six provides a summary and the limitations of the study. It also provides recommendations for future studies.

Chapter Two:
Literature Review

2.1. Introduction

PA has been described as a fundamental aspect of wellness and healthy living (Pedersen and Saltin, 2006: 3). Regular levels of PA at an adequate intensity are vital in maintaining health, bodily functioning and optimal work activity (Lahti *et al.*, 2010: 246). Insufficient PA levels can lead to the development of non-communicable diseases (NCDs), work-related musculoskeletal disorders (WRMSD) (Neuhaus *et al.*, 2014:5) and overall decreased work productivity (Chia, Chen and Suppiah, 2015:9; World Health Organization, 2018: 1). This chapter provides a theoretical framework and overview of literature pertaining to PA within the employed academic sector. It also provides the health and well-being benefits of PA.

Various search engines such as Summon, Google Scholar, EbscoHost ,CINAHL, Web of Science and Medline were used to retrieve articles related to the study. The following search terms were used: “physical activity”, “physical inactivity”, “work-related musculoskeletal disorders”, “academic staff”, “lecturers”, “aerobic fitness”, “pedometers”.

2.2. Definitions and the role of physical activity

PA is described as bodily movement produced by the skeletal muscles of the body resulting in significantly greater expenditure of energy (US Department of Health and Human Services, 1996: 20). The terms ‘physical activity’ and ‘exercise’ are often not well understood, and confusion can occur regarding the definitions of these terms. Exercise has been defined as a type of PA consisting of planned, structured, and repetitive bodily movement done to improve and/or maintain one or more components of physical fitness (Caspersen, Powell and Christenson, 1985:127). Furthermore, they described exercise as a subclass of activity and movement which is prepared and designed to preserve or enhance physical fitness. If the body regularly exercises and remains active, it leads to improvement of musculoskeletal and cardiovascular functioning which increases physical fitness (Miles, 2007: 319). Physical fitness is a complete range of physiological and psychological attributes which enables one to be physically active (Ortega *et al*., 2008: 1). Warburton, Nicol and Bredin (2006:804) describes fitness as a state of wellness physiologically which enables one to meet the requirements of daily living, and/or provides the foundation for sporting performance.

PA plays a prominent role in energy expenditure within the body and therefore largely affects energy levels and body composition (Department of Health, 1991:12). Energy from PA forms part of total bodily energy expenditure along with dietary-induced thermogenesis and basal metabolic rate (UK Department of Health, 1991: 12). Evidence supporting the beneficial effects of PA is growing (Haskell, Blair and Hill, 2009: 280). These benefits include prevention of chronic disease, improving musculoskeletal functioning and mental well-being (UK Department of Health, 2004: 4).

2.2.1. Types of physical activity

PA occurs in four different settings. Occupational PA occurs during working hours and is related to job performance which occurs during an 8-hour workday (Howley, 2001: S364). This includes activities such as walking around the office, sitting at a desk, desk activities such as typing and writing and talking to colleagues (Ainsworth *et al.*, 2000: S500-S501). Household and domestic activity includes duties such as cleaning, gardening and caring for family (IARC, 2002: 6) (IPAQ research committee, 2002: 4). Activity also occurs in the form of travel to and from places which can be done through driving, cycling or walking (Miles, 2007: 318). Leisure-time PA includes sport, exercise and recreational activities done in free time (IPAQ research committee, 2002: 5). Types of PA can also include various activities and exercises according to intensity and skill demands. This firstly includes endurance activities requiring minimal physical fitness or skills to perform, for example walking or aqua-aerobics. Secondly, this includes endurance activity of vigorous intensity requiring minimal skill, for example jogging or rowing. Thirdly, this includes endurance activities requiring skill to be performed for example swimming or skating. Lastly, recreational sports, for example basketball or soccer (Armstrong *et al.,* 2005:366)

The ACSM (American College of Sports Medicine) formed the FITT-VP principles of Ex R_x (exercise prescription). This stands for the frequency (how often), intensity (how hard), time (duration), type (mode/kind), total Volume (amount) and progression (advancement). PA is also categorized according to intensity. Intensity is described as either the rate at which an activity occurs, or the amount of effort required to perform an activity (WHO, 2018: 1). The overload principle of training states exercise below a minimum intensity/ threshold will not challenge the body sufficiently to cause changes in physiologic parameters, including raised maximal oxygen volume consumed per unit of time (VO_{2max}) (Garber, Blissmer and Deschenes,2011:1338). Aerobic exercise intensity recommendations determined by ACSM state that moderate (40% to 59% heart rate reserve) to vigorous (60% to 89% HRR) intensity aerobic exercise is recommended for most adults, and light (30% to 39% HRR) recommended to deconditioned individuals (ACSM, 2018:233). Absolute intensity is the rate of energy used to perform an activity and is measured in kcal/kg/min or METS (metabolic equivalents). Intensity is commonly expressed as metabolic equivalents (METS). It is the ratio of the metabolic rate during work to the metabolic rate when resting. One MET is equal to the caloric expenditure of 1 kcal/kg/hour and is defined as the energy used when sitting quietly. Intensity can also be expressed as a percentage of VO_2max and maximum heartrate (Miles, 2007: 318-319; IARC, 2002: 7).

Moderate-Intensity PA (MPA) is defined as activity which expresses 3.0 to 6.0 METs, using 3.5 to 7 kcal/min. This type of activity involves moderate effort and speeds up the heartrate noticeably. Vigorous-Intensity PA (VPA) is defined as activity which expresses more than 6 METs, using at least 7 kcal/min. This involves a large amount of effort, leading to fast breathing and a significant increase in heart rate (WHO, 2018: 1).

The quantity of PA done can be described through the characteristics of frequency and duration (Miles, 2007: 319). Frequency describes the number of times the activity has been performed daily, weekly or monthly (Howley, 2001: S365).Frequency recommendations for aerobic exercise include that moderate intensity aerobic exercise be performed at least 5 days a week, vigorous intensity aerobic exercise be performed at least 3 days a week, or a weekly combination of 3-5 days per week (ACSM, 2018:232). Duration is the number of minutes spent doing the activity every time it is performed (Howley, 2001: S365). Aerobic exercise recommendations for frequency state that majority of adults should accumulate 30–60 minutes per day (≥150 minutes per week) of moderate intensity exercise, 20–60 minutes per day (≥75 minutes per week) of vigorous intensity exercise or a combination daily to achieve the recommended exercise volume (ACSM, 2018:243). Exercise volume is the product of

Frequency, Intensity, and Time (duration) or FIT of exercise. Evidence supports the vital role of exercise volume in achieving health/fitness outcomes, particularly with respect to body composition and weight management (ACSM, 2018:245). Recommendations for exercise volume include a recommended target volume of ≥500- 1000 MET-minutes per week for most adults (ACSM, 2018:247). Progression can consist of increasing any of the components of the FITT principle of Ex Rx as tolerated by the individual. This depends on individual response, needs, limitations, and adaptations to exercise as well as evolution of the goals and objectives of the exercise program (ACSM, 2018:248).

The American College of Sports Medicine (ACSM) and American Heart Association (AHA) issued updated recommendations for PA and health in 2007(Haskell *et al*., 2007:) which are illustrated in the tenth edition of ACSM's Guidelines for Exercise Testing and Prescription as the current PA guidelines (ACSM and AHA, 2017:53-54). These included that all healthy adults between ages 18–65 years old should engage in a minimum of 30 minutes of moderate intensity aerobic PA for 5 days a week or for a minimum of 20 minutes of vigorous intensity aerobic PA on 3 days a week (ACSM and AHA, 2017:53-54). Furthermore, a combination of both moderate and vigorous intensity exercise can be used to meet this recommendation (ACSM and AHA, 2017:53-54). The total of 30 minutes of minimum MPA can be met by performing this in short periods of 10 minutes or less (ACSM and AHA, 2017:53-54). Activity that maintains or improves muscular endurance and strength should be performed for a minimum of two days a week (ACSM and AHA, 2017:53-54). Due to the dose-response relationship between PA and health, individuals who want to prevent gain or improve fitness can exceed the minimum PA recommendations (ACSM and AHA, 2017:53-54).

The National Health Service of England (NHS) recommends adults aged 19-64 years should perform at least 150 minutes of MPA or 75 minutes of VPA weekly (NHS,2019:1).Daily PA, performing strengthening activities and reducing sedentary activity is encouraged (NHS,2019:1).

2.3. Benefits of physical activity

The advantages of PA have been well recorded (Low, Lee and Sam, 2015:20-26; Beavis, Smith and Fader, 2016:151-167; Kirkham and Davis, 2016:1-13; Hamasaki, 2016: 243-5; Alves *et al.,* 2016: 575-583). This is supported by growing literature demonstrating that PA can lead to improved general health, psychological well-being, quality of life and improved functional capacity (Penedo *et al.*, 2005: 189).

Being physically active is vital in achieving and maintaining a healthy lifestyle (Macera, Hootman and Sniezek, 2003: 122). PA is a modifiable risk factor for many chronic diseases (Warburton, Nicol and Bredin, 2006: 801). It decreases mortality and disability by having a preventative effect against hypertension, coronary heart disease and diabetes. Disability is reduced through decreased pain and swelling in the joints in arthritic individuals (Macera, Hootman and Sniezek*,* 2003: 122). There is strong evidence supporting PA reducing risk of cancer, specifically colon, breast and prostate cancers (Friedenreich, and Orenstein, 2002: 3457S). Increasing activity levels has formed a major part of public health interventions to combat the widespread obesity in both developing and developed countries (Saris *et al*., 2003: 101). It has been shown to prevent weight gain and regain (Saris *et al.,* 2003: 111) and decrease risk of obesity (Reiner *et al.,* 2013: 814-815). PA also contributes to maintaining bone health by decreasing risk of falls and bone fractures in the elderly (Kohrt *et al*., 2004: 1988) and osteoporosis (Landkammer *et al.*, 2014: 113). Despite these benefits, most adults are not sufficiently physically active and consequently are at risk of developing health problems (Macera, Hootman and Sniezek, 2003: 122).

PA improves psychological well-being and quality of life through preserving independence and physical functioning (Macera, Hootman and Sniezek*,* 2003: 122). Depression and anxiety are treatable with PA which can reduce symptoms (Dunn, Trivedi and O'Neal*,* 2001: S588). Studies have shown other benefits include mood improvement (Sexton, Søgaard and Olstad, 2001: 348), satisfaction with physical appearance (King, Taylor, Haskell, 1989:320), improvement of vitality (Salmon, 2001: 33) and self-confidence (Fox, 2003: 88). PA can also aid in prevention and progression of mental disease such as dementia and Alzheimer’s disease (Reiner *et al*., 2013: 814). It has been found to enhance quality of life of individuals with diseases such as fibromyalgia (Gowans *et al.,* 2001: 527) and peripheral arterial occlusive disease (Gartenmann *et al.,* 2002: 32).

2.4. Barriers to physical activity

It has been estimated that 30 to 60% of the world's population is sedentary or not regularly physically active (De Bourdeaudhuij and Sallis, 2002: 279). Sedentariness is defined as actions that do not cause energy expenditure to rise significantly above resting levels. These actions include sitting, watching television and sleeping (Pate, O'Neill and Lobelo; 2008: 174). Understanding the barriers which cause physical inactivity is vital for improving and forming public health interventions (Sallis , Owen and Fotheringham,2000:295).

An Australian study found that being overweight was a common barrier to PA, especially in women and obese individuals. Other barriers frequently reported were laziness or demotivation, not being a 'sporty' kind of person and suffering from a disability or injury. Less common barriers were poor health and embarrassment when exercising (Ball, Crawford and Owen*,* 2000: 332).

South African studies focussing on PA barriers are scarce (Steyn, Fourie and Temple, 2006: 30). There is a need for more studies to be done, especially within certain cultures which present unique barriers (Coakley, 2007: 672). This was seen in a study focussing on isiXhosa speaking, professional women where the mean of age was 39.9 and 19.8 years old respectively. PA barriers caused by their culture were discussed (Walter and Du Randt, 2011: 143-155). The first barrier identified was a lack of support and interest from family members (Walter and Du Randt, 2011: 146). This meant PA was not encouraged (Walter and Du Randt, 2011: 146). Secondly, a woman exercising was not perceived as being a part of the isiXhosa culture (Walter and Du Randt, 2011: 147). Thirdly, traditional gender roles see girls performing domestic tasks while the boys are allowed to play outside (Walter and Du Randt, 2011: 147-148). This outlook is carried on into adulthood where women take on most domestic tasks (Walter and Du Randt, 2011: 147-148). Other barriers included criticism from the community if women were seen wearing revealing exercise clothing or exercising (Walter and Du Randt, 2011: 148). This was seen as only appropriate when done by children or younger individuals and not women, especially if they were married (Walter and Du Randt, 2011: 148). Another barrier discussed was discouragement by older family members about unwanted weight loss as this is not seen as part of their culture (Walter and Du Randt, 2011: 146-150).

Allender, Cowburn and Foster (2006: 829) found lack of access to facilities, inadequate safety and high cost to be common barriers. The table below displays the barriers to PA that were identified.

Table 2.1: Barriers to participating in physical activity and sport by age (Allender, Cowburn and Foster, 2006: 829)

Age category	**Barriers**
Young children	Activities that are very structured
	Competition in sports
Young women and adolescents	Poor-fitting physical education uniforms
	Negative school encounters
	Disruption by boys in class
	Poor support from teachers
	Peer influence
	Competitive atmosphere
	Wanting to appear feminine
Adults	Anxiety due to unfamiliar environment
	No role models
	Poor social network
	Identity problems
	Negative school encounters
Older adults	No role models of a similar age
	High cost
	Time constraints
	Uncertainty over prescribed activity requirements

Identification of PA barriers present among university staff is important as this can aid work intervention programmes in recognising and resolving certain barriers, especially in the work environment. Leicht, Sealey and Devine identified barriers to PA among university staff (including academic staff) in Queensland, Australia. The most common barriers identified by academic staff were fatigue (21%) and lack of time (41%) due to occupational commitments (Leicht, Sealey and Devine, 2013: 167).

Table 2.2: Barriers to achieving physical activity recommendations identified by academic staff at an Australian university (Leicht, Sealey and Devine, 2013: 167)

Barriers	**Academic staff (%)**
Lack of time because of occupational commitments	41
Fatigue	21
Lack of time because of family commitments	20
Other	12
Lack of company to be active with	8
Not pleasurable	7
Pain	5
Lack of transport	3
No equipment available	3
Lack of funds	3
Poor health	1

2.5. Prevalence of physical activity status

Knowledge regarding the prevalence of PA globally has been somewhat limited in the past. This was due to most studies using different instruments to capture data, resulting in the data being incomparable (Guthold *et al.*, 2008: 486). In the past decade this has been improved through the use of the international physical activity questionnaire (IPAQ) and the global physical activity questionnaire (GPAQ). These are standardised tools which have been used globally to assess the prevalence of PA and have enabled the prevalence in two-thirds of the world's countries to be compared and assessed (Hallal *et al.*, 2012: 247-248).

2.5.1. Global Prevalence of physical activity

In 2012, 31.1% of adults globally were classified as being inactive (Hallal *et al*., 2012:2). Hallal *et al*. (2012) reported this when studying PA prevalence of adults aged 15 years and older from 122 countries as well as adolescents aged between 13 and 15 years old from 105 countries (Hallal *et al.,* 2012:6). Individuals were considered physically inactive if they did not meet the following requirements: 5 days of weekly MPA for 30 minutes, 3 days of weekly VPA for 20 minutes or a combination resulting in 600 MET-minutes per week. These are the current activity recommendations set out by WHO (WHO, 2010: 1). Other findings included that populations of higher-income countries were more inactive. North and South America were found to be the least active with 43.3% closely followed by the eastern Mediterranean with 43.2% not meeting the activity requirements. Southeast Asia was found to be the most active with 83% of the population meeting activity requirements (Hallal *et al*., 2012:3,7).

Guthold *et al*. (2008: 486,487) studied data collected from the World Health Survey which was introduced by the World Health Organisation (WHO) in 2001. This cross-sectional survey was carried out in 70 countries. These were chosen because of varying income levels (low, middle and high) being well-represented across the selection. This study focussed on fifty-one of these countries and used the IPAQ to collect data and activity requirements as previously mentioned. These countries were predominantly middle and low-income countries, and this was done to aid the lack of data in these populations (Bull *et al*., 2004: 790). It was found that 17.7% of all participants were inactive. Mauritania had the highest prevalence of physical inactivity at 62.3%, followed by Swaziland’s prevalence of 52.75%. The United Arab Emirates was third highest at 49.25% prevalence followed by the Dominican Republic at 41.25% inactivity prevalence.

Centers for Disease Control and Prevention use the Behavioural Risk Factor Surveillance System (BRFSS) to collect data from adults living in the United States of America, District of Columbia and associated territories. This system uses telephonic interviews to collect data on health-related risk factors and chronic disease and use of health prevention services. Xu *et al*. (2013: 1) published a summary of the surveillance for certain health behaviours. This surveillance study was carried out in 2011 in the United States and aimed to gather data on health risk behaviours, participation and access to healthcare (Xu *et al*. 2013: 1). Adults were required to meet the 2008 Physical Activity Guidelines for Americans which recommended engaging in at least 150 minutes of MPA weekly or at least 75 minutes of VPA weekly or an equivalent combination of both (U.S. Department of Health and Human Services,2008:vii). It recommended that aerobic activity should be performed in periods of at least 10 minutes and should be spread throughout the week (U.S. Department of Health and Human Services, 2008:vii). It was found that adults who met these government recommendations for aerobic PA and muscle-strengthening activity formed only 8.5%–27.3% in states and associated territories, 11.0%–32.0% in counties and 7.3%–32.0% in Metropolitan/Micropolitan Statistical Areas (MMSAs). The median figure for adults who engaged in activity of moderate intensity for 150 minutes or more weekly or engaged in vigorous activity for 75 minutes weekly per state, was 51.6%. The median figure in MMSAS was slightly higher at 52.1% and per county was found to be 52.9%. Adults who engaged in MPA of 300 minutes or more weekly or engaged in VPA for 150 minutes or more weekly were found to be less prevalent. Median figures per state were 32.0%, per MMSAs was 31.8% and per county was 32.6%. This data determined the median prevalence of adults meeting government activity requirements to be 52% for moderate, and 32% for vigorous aerobic activity. Adults engaging in muscle-strengthening activity only, were found to be 30%. Additionally, the median figure for adults engaging in no PA during leisure time per state was 26.2% (Xu e*t al.*, 2013: 9).

The Health Survey for England 2016 (Scholes *et al.,* 2016: 7) gathered data through a questionnaire where participants were asked about activity at home, walking, occupational activity, sports and exercising. PA was assessed according to the UK recommendations which require MPA of at least 150 minutes weekly in durations of ten minutes or more. Alternatively, 75 minutes of VPA, or an equivalent combination of both MPA and VPA, is adequate (Scholes *et al.,* 2016: 10). It was found that 62% of adults aged 19 years and older were considered physically active by meeting these requirements. Of the individuals aged 19 to 64 years of age, 67% met the aerobic activity requirements (Scholes *et al*., 2016: 14). Prevalence of individuals aged 16 years and older who met activity requirements was 62% (Scholes *et al*., 2016: 15). The highest prevalence of PA in the UK was found to be in London at 65% and the lowest in the West Midlands at 53% (Scholes *et al*., 2016: 16). Prevalence of PA in

2016 for adults aged 19 years and older was found to be similar to findings in 2012, where prevalence was found to be 61% (Scholes *et al*., 2016: 19).

In 2008, Healy *et al.* published a report investigating the associations between PA and sedentariness with metabolic risk in participants which consisted of 169 individuals. The time spent being sedentary or doing MPA and VPA was measured through the use of accelerometers. The findings were that only 4% of their time was spent engaging in MPA or VPA. Participants were found to be sedentary 57% of the time or participating in light-intensity activity for 39% of the time (Healy *et al.,* 2008: 369-371).

Another study by Healy *et al.* in 2007 investigated the independent association between light-intensity activity and 2-h plasma glucose concentration. This study measured time spent doing light, moderate and vigorous activity in 173 Australian men and women through wearing an accelerometer and use of a diary. It was reported that 4.3% of their time was spent engaging in moderate to vigorous activity. Furthermore, 23.8% of time was spent doing light-intensity activity and 56.6% was spent sedentary (Healy *et al.*, 2007: 1387-1388).

2.5.2. Prevalence of physical activity in South Africa

Statistics regarding the prevalence and effects of physical inactivity in the South African population have been described as scarce (Dalal *et al.*, 2011: 885). Studies that have been done, revealed that the South African population has largely adopted the sedentary lifestyle of developed, high income countries (Lambert, Bohlmann and Kolbe-Alexander, 2001: 12). This has resulted in a similar disease profile emerging in the form of non-communicable diseases, such as coronary heart disease and type 2 diabetes mellitus (Kunene and Taukobong, 2015: 2). Studies carried out in localised areas of SA have indicated increasing levels of physical inactivity (Joubert e*t al.*, 2007: 726).

From a sample of individuals from a peri-urban community in the Western Cape, 49.7% did not meet the recommended 150 minutes of protective PA against cardiovascular disease. Data was collected using The Stanford Seven Day Physical Activity Recall which was modified and carried out by interviewers. The sample consisted of 976 individuals, 15 years and older, that formed part of the working-class community of Mamre in the Western Cape (Steyn *et al.,* 2004: 234, 235, 237).

Kruger, Venter and Vorster studied the PA levels of individuals from randomly selected sites in the North West province. Participants were required to complete a questionnaire similar to the Baecke questionnaire, which was validated for use in the population. Participants were questioned on occupational and travelling activity, sport involvement, stair climbing and recreational activity. It was found that 29.1% were inactive and 27.9% were moderately active. It was also found that individuals living in rural areas were less active and that only 48.1% participated in sports (Kruger, Venter and Vorster, 2003: 16, 18, 20).

Research has also been carried out on the PA of health professionals in SA. One particular study focussed on activity levels of health professionals working at Estcourt Hospital in KwaZulu-Natal. The majority of the participants were black (82%) and female (83%), with the nursing profession forming more than half (57%) of participants, followed by doctors (14%). The remaining professions together accounted for slightly over a quarter (29%) of the participants. The majority of (60%) participants were in the ≥ 40-years-old category, and 40% were in the < 40-years-old category (Kunene and Taukobong, 2015:3). Participants were required to complete the Global Physical Activity Questionnaire (GPAQ) version 2 of the World Health Organisation (WHO). It was found that 40% of participants had low activity levels with less than 600 MET-minutes/week being performed. Moderately active participants formed 29% of the sample, performing 600 or more MET-minutes/week. Participants classified as highly active, by performing 3000 or more MET-minutes/week, formed 31% of the sample (Kunene and Taukobong, 2015: 2-3). Another study focussed on the effects of implementing the trans-theoretical model to improve activity of hospital healthcare workers in SA. Participants were required to walk for six minutes on a stepping machine while their heartrate was assessed. Their fitness levels were then determined according to their $V0_2$max. It was reported that 81.5% had low fitness levels. It was found that 15.5% were moderately fit and that only 3% of participants had high fitness levels (Skaal and Pengpid, 2012: 386-387).

2.5.3. Prevalence of physical activity in men and women

Developing countries that have been analysed, revealed that 20% of women and 15% of men were physically inactive enough to be considered at risk of developing NCD’s. PA prevalence varied between men and women in African countries, but was comparatively similar in the Western Pacific, Eastern European and Southeast Asian countries. In most developed countries, women had a higher probability of being more inactive than men. (Guthold *et al*., 2008: 486-488).

Worldwide it has been found that 33.9% of women are inactive, which is more than the 27.9% of men who have been found to be inactive. Walking patterns between men and women have been found to be similar due to the walking measurement being divided into the same categories, namely occupational, transport and recreational (Hallal *et al*., 2012:256). Men were found to have a higher probability of engaging in VPA than women, across all age groups (Hallal *et al.,* 2012:256). Men engage in moderate to vigorous-intensity exercise for an average of 35.5 minutes daily, while the average for women is 32 minutes (Hallal *et al*., 2012: 248-250,252,).

Past risk factor studies carried out in SA have emphasised that women are specifically vulnerable to not being physically active on a regular basis (Joubert *et al.,* 2007: 726). This was seen in the working-class community of Mamre in the Western Cape where only 22% of young women participated in protective levels of activity (Steyn *et al.,* 2004: 237). In the North West Province, a similar trend was found where 35.5% of women and only 24% of men were considered physically inactive (Kruger, Venter and Vorster*,* 2003: 19). In contrast, women living on farms were found to be more active than men living on farms. Sport activity participation was higher in men (37.3%) and lower in women (10.8%). Only 18% of men played sport regularly and the most common sport played was soccer. It was found that the most active participants were those living on farms or in informal settlements as they cycled or walked long distances to work (Kruger, Venter and Vorster, 2003: 18-21).

These studies emphasise the low levels of PA of women in particular in SA compared to that of men. Physical inactivity has been found to be significantly and inversely related to both waist circumference and BMI in South African women (Kruger *et al.,* 2002: 18: 422-427). This is seen in the high prevalence of obese and overweight South African women (24.8% and 39.2%) compared to men (0.1% and 10.6%) (Shisana *et al.,* 2014: 135). In turn, this has significant health implications for South African women such as increased risk of chronic lifestyle disease such as type 2 diabetes, ischaemic heart disease and hypertension (Steyn, Fourie and Temple, 2006: 23, 27). This indicates the significant role of PA in prevention of these diseases and the importance of the guidelines being developed by The Ministry of Health for prevention and management of these conditions (Steyn, Fourie and Temple, 2006: 29).

2.5.4. Prevalence of physical activity by age

The decrease of PA levels with age is the most notable factor in PA studies (Caspersen *et al.*, 1994: 74). Although this has been reported in many studies, it is not well understood (Sallis, Prochaska and Taylor, 2000: 1598). Research has shown that PA decreases most significantly during adolescence between the ages of 13 and 18 years of age (Van Mechelen *et al.,* 2000: 1615 -1616; Telama and Yang, 2000: 1620). It has been shown that habits continue from childhood to adulthood (Telama, 2009:193), thus active children are less likely to experience chronic lifestyle diseases resulting from physical inactivity when older (NatCen Social Research, 2017: 25).

It has been found that one is the most physically active during childhood (Anderssen *et al.*, 1996: 354-355 van Mechelen and Kemper, 1995). European studies support this finding, reporting that European children were significantly more active than adolescents, especially in MPA (Riddoch *et al.,* 2004: 90). The Health Survey for England 2008 reported PA in children between the ages of 4 and 15 years to be low - 32% for boys and 22% for girls respectively (The NHS Information Centre, 2008: 10).

Regular PA has been found to be important during the adolescent years, due to its particular health benefits. Despite this, population studies have found that many adolescents do not meet PA recommendations (Sallis, Prochaska and Taylor, 2000: 963). The Global Matrix study found that PA was higher in low-income countries with poor infrastructure. Generally, this study found PA grades worldwide to be poor (Tremblay *et al*., 2014: S119). It has been estimated that globally, four out of every five adolescents between 13 to 15 years old, do not achieve the recommended PA guidelines (Hallal *et al*., 2012: 254).It has been found that physical inactivity gradually rises during adulthood, with the greatest increase occurring from age 50 to 69 (Guthold *et al*., 2008).

Prevalence of physical inactivity in adults (individuals aged 15 years and older) from 122 countries was estimated by Hallal *et al.* As seen in Table 3, the highest prevalence of inactivity is in North and South America as well as the East

Mediterranean countries. The WHO global health observatory data repository was used to obtain these estimates.

Table 2.3: Physical inactivity prevalence by WHO regions (Hallal *et al*., 2012: 248)

WHO Region	**Prevalence (%)**
Africa	27, 5
North and South America	43, 3
East Mediterranean	43, 2
Europe	34, 8
South- East Asia	17, 0
Western Pacific	33, 7

Individuals in urban areas have been shown to be more physically active than those in rural areas. Parks, Housemann and Brownson (2003) found that residents living in suburban areas were more than twice as likely to meet recommended PA guidelines than those living in rural locations (Parks, Housemann and Brownson, 2003: 29). This was supported by Guthold *et al*. (2008) who found that urban men and women were 6.7% and 3.4% more physically active than their rural counterparts (Guthold *et al*., 2008: 492).

Table 2.4: Physical inactivity of men and women according to urbanity (Guthold *et al.*, 2008: 492)

	Prevalence (%)	
Urbanity	**Men**	**Women**
Urban	18,8	21,7
Rural	12,1	18,3

Being physically active should be one of the most important priorities in older adults. This is due to the substantial evidence of the many health benefits in this population, (Nelson *et al*., 2007: 1099, 1102). Despite this, older adults are largely less physically active when compared to younger adults (DiPietro *et al.*, 1993: 69–76).

2.6. Factors influencing physical activity participation

Previous studies have found various factors that influence PA participation. These include cognition, demographics, behaviours and physical and social environment. Perceived barriers and benefits of activity are two cognitive factors which affect activity levels most consistently (Buckworth and Dishman, 1999: 1024). Perceived barriers are one's assessment of possible obstacles which prevent one from participating in health behaviour. Perceived benefits are one's assessment of possible advantages of engaging in health behaviours (Brown, 2005: 107).

De Bourdeaudhuij and Sallis (2002) investigated the effect of various psychosocial variables in three adult population samples and found social variables such as a supportive environment to be an important influence on PA in both genders at every age. This included family and friends believing PA to be important (De Bourdeaudhuij and Sallis, 2002: 285-286). Other factors included family and friends providing direct support and engaging in PA themselves. Self-efficacy, which is the confidence to continue being physically active despite facing challenges or difficulties, was also a notable variable found. Health benefits were the reason for activity in male adults and young females. Opportunities to be competitive were significant in males (De Bourdeaudhuij and Sallis, 2002: 285-286).

Bauman *et al*. (2012: 260) found being male a constant positive determinant between ages four to nine years old. Perceived behavioural control and self-efficacy were found to be determinants in adolescents. Health status, history of PA as an adult and personal activity goals were found to play important roles (Bauman *et al*., 2012: 260).

Environmental factors affecting children include proximity of houses and facilities such as shops. Other factors include traffic capacity and speed, the ability to walk and access to, and closeness to, recreational amenities (Ding *et al.*, 2011: 446). Street formation and the ability to walk easily were important factors found in adults. Transportation settings, attractiveness of the environment and closeness to recreational amenities were also found to be significant factors (Bauman *et al.*, 2012: 262).

Allender, Cowburn and Foster (2006) carried out a systematic review of qualitative research focussing on the reasons for sport and PA participation of children and adults in the United Kingdom. They found that socialising, weight control and pleasure were the most frequently found reasons for participation. The table below summarises the main reasons found for participation in PA by age.

Table 2.5: Main reasons for participating in PA and sport by age (Allender, Cowburn and Foster, 2006: 829)

Age category	**Reason**
Young children	Support from parents
	Experimentation
	Safe surroundings
	Uncommon activities
Young women and adolescents	Support from family
	Weight control
	Participating with peers
	Improved self confidence
	Increased fitness
Adults	Gain skills
	Social support
	Health benefits
	Pleasure
	Feeling of achievement
Older adults	Pleasure
	Social network
	Health advantages

2.7. Physical inactivity and chronic diseases

Many chronic diseases can be prevented by being physically active which aids weight management and lowers the risk of obesity (Miles, 2007: 316). Unfortunately, low PA levels in SA have resulted in widespread obesity and chronic disease (Joubert e*t al*., 2007: 729,730).

2.7.1. Coronary heart disease

Coronary heart disease describes the cardiovascular symptoms caused by narrowing of the coronary arteries, which provide the blood supply to the myocardium (Institute of

Medicine (US) Committee on Social Security Cardiovascular Disability Criteria, 2010: 1-304). The narrowing of arteries is due to atherosclerosis. This is an inflammatory process in the arterial wall whereby lipid-rich deposits accumulate within the intima of the arterial wall and form plaques (Walker *et al*., 2014: 579-580). These lipid-rich deposits can include triglycerides; borderline levels are between 150-200 mg/dL. Raised levels of triglycerides (>200 mg/dl) are associated with an increased risk of atherosclerosis (Wedro, 2019:1).This can cause myocardial necrosis which can lead to angina pectoris, myocardial infarction, arrhythmia and sudden death (Walker e*t al*., 2014: 583).

It has been found that PA, especially that of vigorous intensity, decreases risk of cardiovascular disease.PA reduces risk through increasing high-density lipoprotein (HDL) cholesterol, reducing collateral vessel growth and lowering blood pressure (Walker *et al*., 2014: 581). In South Africa, 29.4 thousand deaths in 2012 were caused by ischaemic heart disease and 39.5 thousand deaths were attributed to strokes (WHO, 2015: 1-3).

2.7.2. Hypertension

Hypertension is accountable for over half of all cases of coronary heart disease and strokes and is the risk factor most responsible for mortality worldwide (Bhagani, Kapil and Lobo, 2018: 509). Hypertension is classified as systolic blood pressure being equal to, or greater than, 140mmHg and diastolic blood pressure equal to, or greater than, 90mmHg (Mancia *et al.,* 2013: 2165).

Primary or essential hypertension is when an exact underlying cause is not found. The pathogenesis is not well understood but it is suspected that a combination of genetic, lifestyle and environmental factors may lead to its development (Walker *et* al., 2014: 607). Secondary hypertension is when an identifiable cause, which can be treated or reversed, is found through assessment of the individual. The causes are classified as neural, vascular, renal and endocrine (Bhagani, Kapil and Lobo, 2018: 510).

Table 2.6: Causes of secondary hypertension according to category (Bhagani, Kapil and Lobo, 2018: 511)

Category	Cause
Neural	Obstructive Sleep Apnoea
	Failure of autonomic system
Vascular	Fibromuscular dysplasia
	Renovascular disorders
	Aorta coarctation
	Renal stenosis
Renal	Monogenic tubular syndromes
	Polycystic kidney disease
	Chronic kidney disease
	Reninoma
Endocrine	Corticosteroid disorders
	Phaeochromocytoma
	Hyper/hypothyroidism
	Acromegaly

Risk factors predisposing an individual to development include smoking, family history, diabetes mellitus, serum cholesterol and pre-developed vascular disorders (Walker *et al*., 2014: 607). PA reduces risk of hypertension by improving elasticity and flexibility of the artery walls and raising production of collagen fibres (Han *et al.,* 2012: 402).

2.7.3. Diabetes mellitus

Diabetes is a collection of metabolic diseases where raised blood glucose levels (hyperglycaemia) are present (American Diabetes Association, 2010: S62). Type I diabetes results from autoimmune destruction of the β cells of the pancreas that secrete insulin. This results in complete insulin deficiency (Walker *et al*., 2014: 800). Type II is the most common and is characterised by insulin resistance and inadequate insulin production to combat this resistance (Walker *et al*., 2014: 800). Criteria for diagnosis include a fasting glucose concentration of ≥ 7.0 mmol/L or a casual or non-fasting glucose concentration of ≥ 11.1 mmol/L (Seino *et al.,* 2010: 212). SA had 1,826,100 cases of reported diabetes in 2017 (International Diabetes Federation, 2018) and it was estimated that 8.3% of the global population had diabetes in 2011 (Walker *et al*., 2014: 800). Genetic and environmental factors have been strongly linked to developing diabetes (Dupuis *et al.*, 2010: 12-13; Chan *et al*., 2009: 2133).

PA increases glucose absorption by skeletal muscle from the bloodstream, thereby decreasing resistance of muscle to insulin and improving glycaemic control and insulin sensitivity (Schrauwen, 2007: 535). Exercise causes muscle cells to release a protein called Fibronectin type III domain-containing protein 5 (FNDC5) which is a precursor to irisin, a hormone which has shown to be protective against obesity and diabetes (Boström *et al*., 2012: 463).

Engaging in PA regularly can delay or prevent the onset of diabetes mellitus type II (Schellenberg *et al*., 2013: 548). The American Diabetes Association recommends that diagnosed individuals should participate in MPA to VPA for 150 minutes or longer, spread over three days weekly (Colberg *et al*., 2016: 2066). It has been found that 150 to 175 minutes of weekly exercise can reduce the risk of diabetes by 40-70% in individuals with reduced glucose tolerance (Church *et al*., 2010: 2261).

2.7.4. Obesity

Obesity has been defined as an excess in body fat which can impair health. Diagnosis requires a BMI of more than or equal to 30 kg/m^2 (WHO, 2018: 1). There is a global increase of obesity with a rising prevalence not only in high-income countries, but in low and middle-income countries too (Swinburn *et al*., 2011: 805).In 2016, the South Africa Demographic and Health Survey revealed that 41% of women and 11% of men 15 years and older were classified as obese (National Department of Health *et al*., 2017: 45-47).

Obesity is the result of a large difference between energy intake and energy output which is too great to be overcome by hypothalamic regulation of basal metabolic rate (Walker *et al*., 2014: 116).

Reduced PA levels and basal metabolic rate support the likelihood of weight gain with ageing (Walker *et al*., 2014: 116). PA has been found to increase eating awareness and evidence may suggest a positive effect on appetite regulation and satiety (Martins, Morgan and Truby, 2008: 1344-1345).

2.7.5. Hypercholesterolemia

Raised plasma cholesterol levels in the form of low-density lipoproteins (LDL's) of > 4.9 mmol/l and > 7.5 mmol/l total cholesterol indicate familial hypercholesterolemia or hyperlipidaemia (Heart UK, 2018: 3). Hypercholesterolemia can be familial or caused by a diet high in saturated fat and obesity (Durrington, 2003: 722). Secondary causes include diabetes mellitus, liver disease and nephrotic syndrome (Soran *et al*., 2018: 14).

Risk factors include family history, smoking, male gender, hypertension, physical inactivity and central obesity (Murray *et al.,* 2003: 227). In SA, 35.5% of individuals aged 25 years and older have an elevated total cholesterol of 5 mmol/L or greater (WHO, 2016). Strong evidence has shown that PA can decrease the risk of cardiovascular disease by up to 30% (Li and Siegrist, 2012: 401), for which high cholesterol is a major risk factor (Stamler *et al*., 2000: 311). Increasing leisure-time PA has been shown to reverse atherosclerosis which can be achieved by walking as little as 25 kilometres weekly (Franklin *et* al., 2003: 118).

2.8. Physical inactivity and the work environment

Physical inactivity and sedentariness are largely prevalent in office-based occupations which involve sitting for most of the day. Hildebrandt *et* al*.* (2000: 514-515) revealed that 60% of workers with inactive lifestyles reported low back pain symptoms and those sedentary and inactive workers were found more likely to have low back pain symptoms and prolonged sick leave (Hildebrandt *et al*.,2000: 514-515). This leads to the development of WRMSD's and poorer sleep quality, which can decrease productivity during work (Chia, Chen and Suppiah*,* 2015: 8). It can be assumed that research on the teaching profession will be similar to the lecturer population. Research has shown that poor physical health and high levels of stress are associated with teaching. Neck, back and upper limb musculoskeletal disorders are most prevalent in teachers (Erik and Smith, 2011: 1). These are due to prolonged standing, overhead writing and sitting with a head-down posture (Chiu and Lam, 2007: 20). This knowledge is significant for chiropractors as they diagnose, treat, manage and prevent disorders of the musculoskeletal system (CASA, 2020:1) and can aid management of patients who are in professions like lecturing where these specific work conditions can lead to similar musculoskeletal injury and disorders. This would also give chiropractors and other healthcare practitioners valuable insight where improved treatment, postural advice and exercises can be prescribed to help prevent injury and disorders in the workplace (CASA, 2020:1).

Jacobson *et al*. (2001: 1019) found one day of exercise weekly was related to decreased sick leave and two days related to even less sick leave. "Meta-Analysis of Workplace Physical Activity Interventions" by Conn *et* al*.* (2009: 334) revealed that interventions caused a lower mean absenteeism, lower job stress and significantly greater job satisfaction. Seat cycles used for 22.8 minutes daily on average by office workers in Singapore, led to lower systolic blood pressure levels, less lower back pain, better sleep quality and decreased episodes of sleepiness in workers (Chia, Chen, and Suppiah*,* 2015: 8).

2.8.1 Workplace physical activity interventions

Studies have revealed that white collar workers spend between 66% and 82% of working hours being sedentary (Clemes, O'Connell and Edwardson, 2014: 302). It has also been shown that these workers do not balance this by improving their PA involvement or by decreasing sedentariness after working hours (Chau *et al*., 2012: 54: 199; Tigbe, Lean and Granat, 2011: 53: 51). This highlights the need for inventions in the workplace, not only for improving health but to also increase work productivity.

It has been proposed that interventions should aim to decrease sitting time and increase PA of office workers (Puig-Ribera *et al.,* 2015: 72). Malik, Blake and Suggs (2014) identified three types of workplace activity intervention programmes which had been implemented in recent years. The first type was PA or exercise interventions such as exercise classes, promoting use of stairs and active travelling. Another type of intervention was offering counselling or support to workers through peer support, telephone coaching, motivational talks and group counselling. The third type included providing health-promoting information to workers through flyers, email messages, health screenings and posters (Malik, Blake and Suggs, 2014: 155). Exercise interventions such as a workplace walking program significantly increased workers' daily step count and PA levels (Gilson *et al*., 2009: 43; von Thiele Schwarz, Lindfors and Lundberg*,* 2008: 183). Offering counselling or support showed some improvement in PA levels of workers, with phone counselling and face-to-face mentoring producing the largest increase in activity (Campbell *et al*., 2002: 319, van Wier *et al*., 2009: 6;). Sending email interventions led to a significant increase in leisure-time activity in workers (Hager *et al.*, 2002: 333). Walking interventions were found to be the most successful in causing a significant rise in PA levels from the PA intervention studies.

This was attributed to workers being able to walk during working hours which possibly removed the barrier of lack of time to exercise due to work (Dugdill *et al.*, 2008: 27). These workplace interventions are aligned with the principles of chiropractic practice and care, which consist of a holistic outlook and promotion of a healthy lifestyle by encouraging a proper diet and regular exercise CASA, 2020:1).Therefore it is common for chiropractors to encourage patients to be more active throughout their daily life, such as using stairs instead of a lift or taking regular breaks from sitting at a desk in order to encourage more activity at the workplace.

The studies included in this review by Malik, Blake and Suggs (2014) used a variety of methods to assess PA levels of workers. These methods fall into two categories and can be either subjective or objective. Subjective methods require the individual to record their activity levels or to recall their activity participation. Examples of this used in the reviewed studies included questionnaires, interviewing the individuals and filling in a PA diary. Objective methods include use of devices which can directly measure and monitor biosignals and other measures of activity. Examples of this include indirect calorimetry, accelerometers, heart rate monitors and pedometers (Blake and Suggs, 2014: 156, Strath *et al.*, 2013: 2262, 2265; Malik,).

Wearable devices have become increasingly popular and one of the most commonly used is pedometers. Pedometers measure steps taken and determine the distance walked over a period of time (Strath *et al.*, 2013: 2268). Studies have provided sufficient evidence for convergent and construct validity, supporting their use in practice and research (Tudor-Locke e*t al*., 2002: 808; Tudor-Locke *et al*., 2004: 282). Schneider *et al.* found the reliability of commonly used pedometers to be good (> 0.80) and found the intra-model reliability for most models to be significantly high (Schneider *et al.,* 2003: 1782). Advanced pedometers can record walking behaviour and measure time spent in different intensity categories during regular gait cycles (Bassett and Strath, 2002: 163-164; Strath *et al.*, 2013: 2268). Therefore, pedometers measure a cumulative number of steps (volume of activity) and walking behaviour (Tudor-Locke and Myers, 2001: 95-96; Corder, Brage and Ekelund, 2007: 598). Measurement of activity intensity contributes to aerobic fitness which is important in preventing cardiovascular disease and maintaining good health (Eisenmann, Laurson and Welk, 2011: S106).

2.8.2 Aerobic fitness

Aerobic fitness measures/estimates the ability of the body to transport oxygen to muscle tissue and produce energy when exercising (Armstrong and Welsman, 2007: 5). Studies have found that higher aerobic fitness contributes to a lowered risk of mortality and disease and therefore it is important for maintaining a healthy lifestyle (Laukkanen, Lakka and Rauramaa, 2001:825; Swain, 2005: 55, Williams, 2001:754).Aerobic fitness, or cardiorespiratory fitness, is the ability to perform large muscle, dynamic, moderate-to vigorous intensity exercise for prolonged periods of time. Performing at this level of physical exertion is dependent on the integrated physiologic and functional conditon of the respiratory, cardiovascular, and musculoskeletal systems (ACSM, 2018:146).

Aerobic fitness can be measured by a few methods. Heart rate monitors can measure resting and maximum heart rate which indicates the cardiorespiratory stress experienced by an individual during exercise (Strath *et al*., 2013: 2265). Indirect calorimetry is considered the most accurate process for energy-expenditure measurement in controlled conditions (Strath *et al*., 2013: 2265). This involves an open-circuit system in which oxygen and carbon dioxide volumes expired are measured and analysed (Strath *et al*., 2013: 2265). Another method is the doubly labelled water method which measures energy expended over one to three weeks (Strath *et al*., 2013: 2265).This method uses the removal rate of two isotopes which are ingested in water to determine the carbon dioxide production over the measured time (Strath *et al*., 2013: 2265).

2.8.2.1 Measuring aerobic fitness

An important indicator of aerobic fitness is maximal oxygen uptake (VO_2 max). VO_2 max is the maximum rate of the cardiovascular, pulmonary and muscular systems to absorb, transport and utilise oxygen per minute during incremental exercise (Poole, Wilkerson and Jones, 2008: 403). VO_2 max can be directly measured but the process is performed in a laboratory setting which is expensive. It is, therefore, common for VO_2 max to be estimated using physiological measurements such as heart rate values measured during submaximal exercise (Uth *et al*., 2004: 111). VO_2 max uses assessments such as the Harvard step test, Beep test and the twelve-minute run and walk test (Gayen, Bandyopadhyay and Mitra, 2013: 102). These tests can be performed intermittently (submaximal), continuously to exhaustion (maximal) or in the form of a walking/running test (Wood, 2008: 1).

Submaximal tests include the step tests such as the Harvard step test which is one of the most popular tests due to minimal equipment and space needed (Yuan *et al*., 2008: 139). This test is based on the assumption that fitter individuals will have smaller increases in heart rate while stepping onto and off a step for five minutes and will be able to recover more quickly. These results can then be correlated with maximal oxygen consumption (Burnstein, Steele and Shrier, 2011: 506). Cycle ergometer tests are also submaximal tests. An example is the Astrand-Rhyming test which involves cycling for 6 minutes at a specific workload while heart rate is measured. The goal is to maintain a steady-state heart rate in the range of 125 and 170 bpm which, together with the workload, is used to estimate the VO_2 max (Wood, 2008: 1).

Maximal tests are performed until exhaustion and include $V0_2$ max field tests which are commonly used. An example is the multi-stage 20 m shuttle run test which involves running back and forth between two lines which are 20 metres apart. Running speed is then indicated to the individual through a CD audio beep which increases the speed every minute (Aandstad *et al.*, 2011: 514).

Walking/running tests are popular as they can be used by individuals of all ages and fitness groups, the tests are simple to perform and many people can be tested at once (Wood, 2008: 1). Examples include Cooper's 12-minute run test which involves individuals running as many laps as possible in twelve minutes. The laps completed and distance covered are then used to estimate VO_2 max (Penry, Wilcox and Yun, 2011: 5). For less fit or elderly individuals, the Rockport Walking test or six-minute walk test can be used. The Rockport test involves walking as quickly as possible for a mile (1,6 kilometres) after which heart rate and time of walking is recorded. $V0_{2max}$ is then calculated using these measurements along with weight and age (Wood, 2008: 1). The six-minute walk test is an adaptation of Cooper's 12-minute run test and is used on the elderly. This involves walking as quickly as possible for six minutes in a rectangular area of 45.72m (Wood, 2008: 1). Beacons are placed to signal distance walked (Wood, 2008: 1). The aim is to cover as much distance as possible in the six-minute time frame. Individuals are then scored using equations set out by Jenkins *et* *al*. (2009: 516-517). These include the walking distance, age and height of the individual (Jenkins *et al.*, 2009: 516-517).

2.9. Summary

Interventions can be developed and implemented to improve employee health and fitness which may consequently contribute to improved work productivity (Chia, Chen and Suppiah, 2015: 5-10). If high levels of inactivity are found, measures can be taken to educate employees about the importance of exercise. Few studies have been done on PA levels of office workers in SA (Ferreira and Strydom, 2016: 118-119). Most research focusses on health-care workers. Inactivity contributes to the high levels of obesity and co-morbid pathology (Skaal and Pengpid, 2011: 563). Therefore, more studies need to be done in this area of PA. Additionally, PA data of university staff will give insight into the health of employees and steps can be taken to improve PA uptake. This study therefore aims to determine the PA patterns and aerobic fitness of academic staff at the DUT to expand the knowledge in this area.

Chapter Three:
Methodology

3.1 Background

This chapter describes the methodology that was applied to the research question and hypotheses. This chapter will consist of the study design, the ethical considerations used, the study setting, the study population, participant recruitment, the sample size, inclusion and exclusion criteria, the measurement tools used, research procedure, limitations that were experienced in the study, data synthesis and the statistical analysis used.

3.2 Study design

The study was designed as a cross-sectional study in a quantitative paradigm. It consisted of a descriptive component, involving the completion of the IPAQ and 7-day pedometer wear and an experimental component in the form of an aerobic fitness assessment. The study was conducted at DUT from which academic staff were recruited. DUT gave the researcher permission to conduct the study (Appendix D). Individuals were required to complete the questionnaire, wear the pedometer for a consecutive seven-day period and to perform an aerobic fitness assessment. Approval to conduct the study was obtained from the Institutional Research Ethics Committee (IREC) (IREC Reference Number: REC 37/18) (Appendix H).

3.3 Study setting

The aerobic fitness test and other measures (such as anthropometric measures), as well the issuing and return of the pedometer, were undertaken in the rehabilitation room located in the DUT chiropractic clinic in Durban, KwaZulu-Natal. Following informed consent by participants, the questionnaires were provided to participants either through delivery by the researcher to their offices or by email for them to fill out. The method of receiving the questionnaire was the choice of the participants. The participants completed the questionnaires in their own time and then either emailed them back to the researcher or the researcher collected them once completed. Pedometers were used by participants throughout their daily activities at work and during leisure time.

3.4 Study population

The study population was 472 full-time, non-contract academic staff members at DUT at the Ritson, ML Sultan and Steve Biko campuses.

3.5 Permission to conduct research

Full ethical approval to conduct research was granted by the Institutional Research Ethics Committee (IREC) (Appendix H) at DUT. In order to grant full ethical approval, IREC also required gatekeeper permissions. These permissions were granted by the DUT Chiropractic Clinic Director (Appendix E) and DUT (Appendix D). Full ethical approval indicated that the research study followed the principles of the Declarations of Helsinki of 1964, and Nuremburg and Belmont of 1947.

3.6 Inclusion and exclusion criteria

The following criteria were used to determine those eligible for inclusion in the study:

1. Full-time academic employees at the university.

2. Signed Informed consent (Appendix A).

3. Willingness to wear a pedometer during waking hours for seven consecutive days and additionally be willing to perform an aerobic fitness test if randomly selected.

The following criteria were used to determine those not eligible for inclusion into the study:

1. The supervisors of the research project. The supervisors were involved and invested in the research project which could lead to bias in the results.

2. Participants not willing to wear a pedometer. The pedometer was required for complete data collection in the study therefore participants needed to agree to wear them.

3. Participants performing non-ambulatory activity (such as swimming and cycling) that may not be captured or may be inaccurate through the pedometer reading. This could lead to inaccurate pedometer data collection which would not show a true reflection of the participant’s PA levels.

4. Participants that did not sign the informed consent. This was required for ethical reasons and ensured the participants were fully informed about the study and what was required of them.

5. Participants who were not full-time academic staff members. This was chosen to ensure consistency in the results as all participants had similar working hours.

6. Participants that reported any known health problems, for example injury or cardiac disease, that would have prevented them from performing the fitness assessment. This was to protect participants health and to not put them at risk of negatively affecting their health e.g. worsening an injury or symptoms of an injury or disease.

3.7 Sampling

Sampling included participant recruitment and sample size.

3.7.1 Participant recruitment

The participants were full-time, non-contract academic staff members at DUT. Permission was given to the researcher by the DUT Institutional Research Ethics Committee (IREC) allowing the academic staff to participate in the study (Appendix D). Academic staff were recruited by the researcher through emails and phone calls made by the researcher. Participation in the study was voluntary.

3.7.2 Sample size

The Department of Management Information Systems at DUT was contacted to supply the number of full-time academic staff members employed by the university, which was 472. The initial sample size calculated by a statistician was 213 participants for completion of the questionnaires and pedometer wear (Singh, 2017). The sample size which was initially calculated for the fitness assessments was 40 participants. These sample sizes accounted for the possibility of drop-outs and lost data. They were randomly selected from the participants who had already completed both the questionnaire and pedometer wear (Singh, 2017). After five months of data collection, the researcher requested a sample size reduction due to low response rate, limited pedometer numbers and time constraints. This reduction was approved (Appendix I) and the reduced sample size determined after consultation with a statistician for completion of the questionnaire and pedometer study was 61 staff members. This same sample size was determined for the fitness assessment participants in order to increase the validity of the results. Thus, the sample size required for the aerobic fitness assessment was 61 staff members. A power analysis using ANOVA tests was conducted in G-POWER to determine a sufficient sample size. ANOVA (Analysis of Variance) is a statistical method that evaluates potential differences in a scale-level dependent variable by a nominal-level variable having 2 or more categories (Statistics Solutions., 2013:1).G-POWER is a widely used tool to compute statistical power analyses for many different t tests, F tests, $\chi2$ tests, z tests and some exact tests. It can also be used to compute effect sizes and to display graphically the results of power analyses (Buchner *et al*., 2020:1). These statistical tools and programs were selected and used at the discretion of the statistician and were sufficient in determining the sample size for the study.

3.8 Measurement tools

3.8.1 The International Physical Activity Questionnaire

This was the self-administered format and included an additional page with questions on socio-demographics (age and gender), a subjective fitness rating, types of sport involvement, leisure-time exercise and recreational activities engaged in. This page also included questions on whether the participant was physically fit enough to participate in the step test and did not have any health problems or injuries preventing them from participating (Appendix C). The IPAQ consisted of five parts and the questions were close ended.

The questionnaire included the following five parts:

- Part 1: Job-related PA
- Part 2: Transportation PA
- Part 3: Housework, house maintenance and caring for family
- Part 4: Recreation, sport and leisure-time PA
- Part 5: Time spent sitting

The questions in these five parts focused on the intensity of activity; whether moderate or vigorous (IPAQ research committee, 2002: 1-5). Metabolic equivalent of task (MET)-minutes per week were then calculated using prescribed MET values from the Compendium by Ainsworth *et al*. (2000: 498-504) and were applied to time variables according to the intensity of activity (IPAQ research committee, 2005: 5). This questionnaire did not require permission for use and was found to be valid when assessing PA patterns and levels in healthy adults by Hagstromer, Oja and Sjostrom (2005: 755-762). Mäder *et al*. (2006: 1255-1266) found the reliability of the short format of IPAQ to be good where a Spearman correlation produced a coefficient range of 0.43-0.68 for continual data measures.

3.8.2 Pedometer wear

Participants wore a blinded pedometer, the Omron HJ 720 ITC. This was a piezoelectric pedometer which recorded the intensity and number of steps taken. Pedometers were calibrated for each participant which required their weight (kg), height (cm) stride length (cm),date and time to be entered before the pedometer was worn. This was then uploaded electronically. Information displayed included number of steps taken daily, number and duration of "manufacturer-defined aerobic steps" (>60 steps/minute, minimum duration of 10 minutes) (OMRON Healthcare, 2007: 1). This provided aerobic time, which is complete time spent accumulating steps in minutes per day (minutes/day). Calories burned and distances covered were also displayed. This brand and model of pedometer has been shown to be valid and reliable by Holbrook, Barreira and Kang (2009: 669-673) for various mounting positions under prescribed and self-paced walking conditions in both healthy and overweight adults. Hasson *et al*. in 2009 stated it was a valid assessment of steps taken in different BMI groups during constant- and variable-speed walking.

3.8.3 Aerobic fitness

The Harvard step test was used to measure aerobic fitness of participants. It is based on the theory that individuals with higher aerobic fitness levels experience smaller increases in heart rate when stepping up and down a 44 cm step for five minutes and have faster physical recovery times (Burnstein, Steele and Shrier, 2011: 505-513).

Heart rate was measured prior to beginning the step test. Participants were required to step up and down the step continuously for five minutes or for as long as they were able to. Participants were advised to stop as soon as they experienced any discomfort while performing the test. After five minutes they were instructed to sit down and be as quiet and still as possible. Heart rate was then measured at 30 second intervals up to five minutes, beginning one minute after stepping had stopped. Cardiorespiratory endurance was determined using the Physical Efficiency Index (PEI) formula (Lee, Roh and Kim, 2016: 641-645):

$PEI = D/(2 \times P) \times 100$

D: Duration of the exercise (s)

P: First phase (60–90 s) + Second phase (120–150 s) + Third phase (180–210 s) Heart rates (Lee, Roh and Kim, 2016: 641-645)

Burnstein, Steele and Shrier (2011: 505-513) found this test to be reliable and valid for fitness in occupational and sport settings. BMI was calculated using the participant's height and weight with the formula of kg/m^2. PBF was measured and waist circumference measured with a measuring tape.

3.8.4 OMRON BF511 Body Composition Monitor

The Omron BF511 body composition monitor uses bioelectrical impedance analysis to determine specific variables including weight, BMI, PBF, skeletal muscle percentage and visceral fat level. This is achieved through sending a very weak electrical current through the body. An example is the calculation of PBF. Due to body fat having low electrical conductivity, this electrical impedance is used to determine the fat tissue percentage. Information such as gender, height and age were entered into the profile on the monitor, which assisted with calculation of the variables (Omron Healthcare, 2017: 1,3). The variables recorded were weight (kg), BMI (kg/m^2) and PBF (%). This device has been clinically validated and found to provide accurate information for field studies and its eight-electrode arrangement (positioned on both hands and feet) was preferred for public and personal use (Bosy-Westphal *et al*., 2008: 320, 324).

3.9 Research procedure

3.9.1 Initial approach to prospective participants and completion of questionnaires

The researcher randomly selected departments at DUT using the RANDBETWEEN function as a random number generator in Excel. The departments included were those situated on the Ritson, Steve Biko and M.L. Sultan campuses. The researcher requested participation through phone calls and emailing the staff members and department secretaries a Letter of Information and Informed consent (Appendix A) and the questionnaire (Appendix C). The Letter of Information and Informed Consent (Appendix A) consisted of a detailed explanation of the study which stated that it was completely voluntary and staff members could withdraw from the study at any time. The email also asked staff members to complete the questionnaires and email them back or to contact the researcher to collect them from the department. Separate ballot boxes were used to store the Letter of Information and Informed Consent (Ballot box A) and the questionnaires (Ballot box B), which ensured confidentiality. After receiving the written informed consent, the staff members were assessed to determine whether they met the inclusion criteria of the study.

3.9.2 Handing out of pedometers and completion of pedometer wear

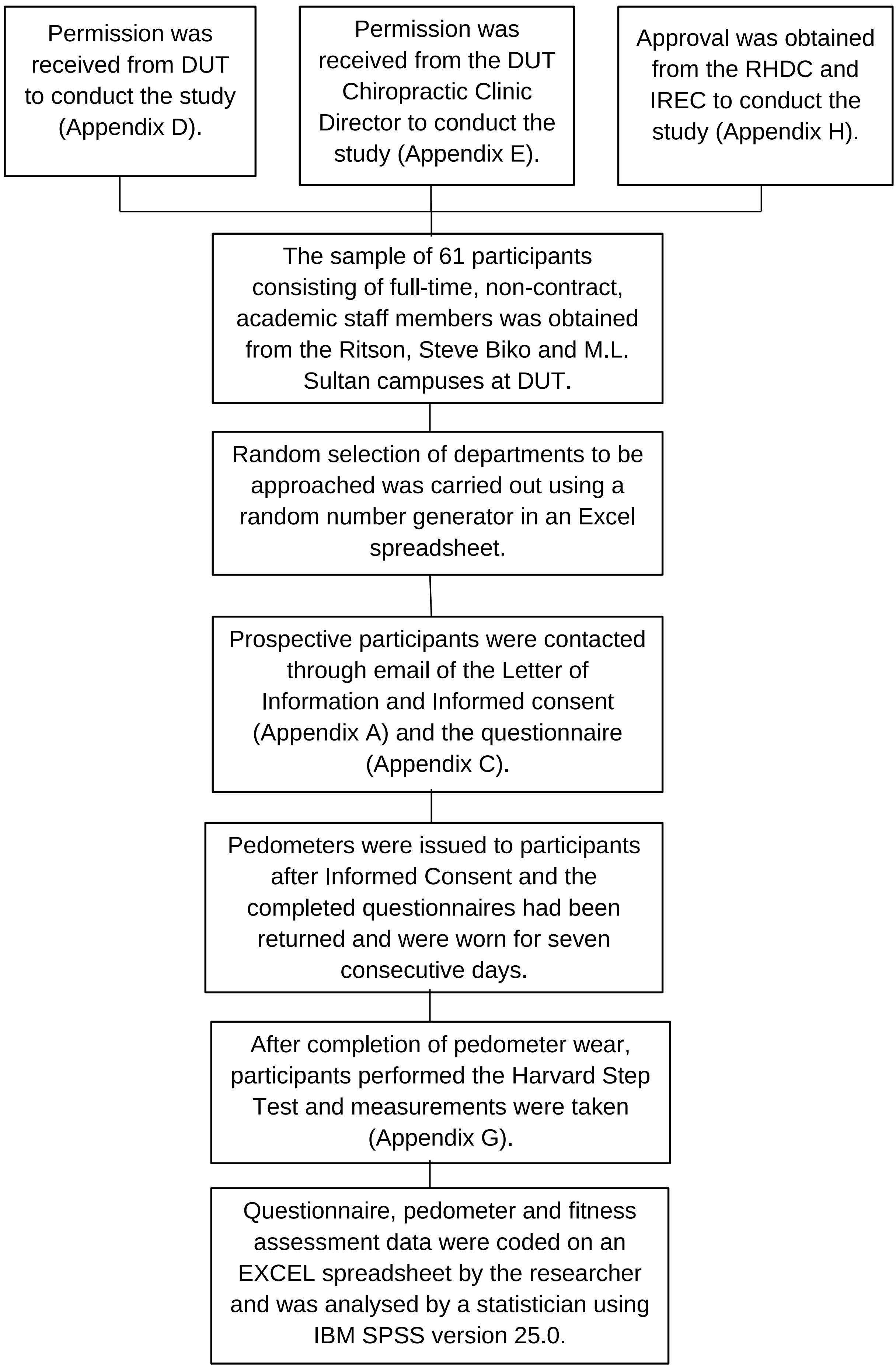
Staff members were asked to wear a pedometer daily for seven consecutive days after returning the completed questionnaire to the researcher. This was to ensure a five-consecutive-day protocol to increase the likelihood of attaining at least three days of pedometer readings. This is the minimum criteria for estimating daily ambulatory physical activity (Tudor-Locke *et al*., 2004: 281-291; Rowe *et al*., 2007: 435-447; Hart *et al*., 2011: 62-69). The researcher aimed to receive pedometer data over seven consecutive days for all 61 participants and continued data collection until this was achieved.

Staff members were required to wear the pedometer on the right or left hip, throughout the day, and to follow their usual daily activity routine. They were informed of the date on which pedometers would be collected and by which they needed to have worn the pedometer consistently for a week. The researcher also informed the staff members that they could only remove the pedometer when sleeping, showering or bathing. The pedometer screen was covered to prevent staff members from seeing their daily steps which could have influenced their levels of physical activity. Staff members were emailed reminders to wear their pedometers and to obey the protocol. Staff members were also informed that they would be able to receive their daily results at the end of the study.

3.9.3 Fitness assessment

The staff members were instructed to bring their pedometers to the fitness assessment to return them to the researcher. Reminders for dates and times of returning the pedometers and the fitness assessment were sent to participants. The researcher met with the staff member in the rehabilitation room in the DUT chiropractic clinic. The staff member than performed the Harvard Step Test. This consisted of the researcher recording the stepping time up to five minutes. The heart rate was measured at 30 second intervals up to five minutes, beginning exactly one minute after stepping had stopped. Weight, BMI and PBF were determined using the Omron BF511 body composition monitor. Height was determined using a tape measure. Waist and hip circumferences were measured to determine the waist-hip ratio. Waist circumference was measured in the mid-axillary line halfway between the lower margin of the last palpable rib and the top of the iliac crest. Hip circumference was measured at the widest circumference of the buttocks (WHO, 2011: 20). These measurements were all recorded on the data collection sheet (Appendix G). Collection of the pedometers and performance of fitness assessments were done over the duration of a month from administering the questionnaires.

3.10 A summary of the research procedure


Permission was received from DUT to conduct the study (Appendix D).
Permission was received from the DUT Chiropractic Clinic Director to conduct the study (Appendix E).
Approval was obtained from the RHDC and IREC to conduct the study (Appendix H).
The sample of 61 participants consisting of full-time, non-contract, academic staff members was obtained from the Ritson, Steve Biko and M.L. Sultan campuses at DUT.
Random selection of departments to be approached was carried out using a random number generator in an Excel spreadsheet.
Prospective participants were contacted through email of the Letter of Information and Informed consent (Appendix A) and the questionnaire (Appendix C).
Pedometers were issued to participants after Informed Consent and the completed questionnaires had been returned and were worn for seven consecutive days.
After completion of pedometer wear, participants performed the Harvard Step Test and measurements were taken (Appendix G).
Questionnaire, pedometer and fitness assessment data were coded on an EXCEL spreadsheet by the researcher and was analysed by a statistician using IBM SPSS version 25.0.

3.11 Ethical considerations

- Permission was received from the DUT to conduct the study (Appendix D).
- Permission was received from the DUT Chiropractic Clinic Director to conduct the study (Appendix E).
- Approval for this study was obtained from the RHDC and the IREC of DUT (IREC Reference Number: REC 37/18) (Appendix H).
- Participants were given a letter of information and consent to inform them of the study (Appendix A) and the lecturers were required to sign the letter of consent (Appendix A).
- The researcher and each participant signed a letter of confidentiality. This stated that the information was to be kept private between the researcher and the participant and that the participant's identity was to be kept anonymous in the research process (Appendix B).
- The participants were informed that participating in the research was entirely voluntary and that they should not feel compelled to participate.
- No remuneration was given to the participants due to participation being voluntary.
- All information obtained was only seen and utilised by the researcher, the statistician and the supervisor. It was kept in safe storage during the research study.
- Justice was ensured throughout as the study was fair and impartial. There was no direct benefit for participation and each participant was treated the same.
- Non-maleficence was ensured as participants did not suffer any harm from the research.
- The data will be stored safely at the DUT – Chiropractic Programme for five years after which it will be shredded and disposed of.

3.12 Data Synthesis and Analysis

3.12.1 International Physical Activity Questionnaire data

The data was captured in an EXCEL spreadsheet to be coded and cleaned using the Guidelines for Data Processing and Analysis of the IPAQ – Short and Long Forms manual found on the IPAQ website (IPAQ research committee, 2005: 1-15). The data was coded as a continuous measure and as median MET-minutes. Interquartile ranges and median values were worked out for low-intensity PA (LPA), moderate-intensity PA (MPA) and vigorous-intensity PA (VPA) according to the specific domains (transportation, work, home, yard and leisure). These were then calculated by using the formulas and MET values present in the analysis guide. Total PA scores were calculated using the formula of Total PA MET-minutes/week = sum of Total Work + Total Transport + Total Domestic and Garden + Total Leisure-Time MET-minutes/week scores. Categorical scores were then applied and classified populations as either ‘low’, ‘moderate’ or ‘high’. The question on sitting was an additional indicator variable and was not included in the PA score. Minutes were used as the indicator instead of MET-minutes because the latter represented energy spent. The data was cleaned using the guidelines set out in the analysis guide. An example of an analysis plan was present in the guide which was followed by the researcher (IPAQ research committee, 2005: 1-15). The complete time doing PA during the week and the activity intensity were used and compared to WHO recommendations for PA per week. This advised 150 minutes of MPA or 75 minutes of VPA or an equivalent combination of both, accumulating at least 600 MET minutes weekly. The formula that was used was: (MET value) × (time of activity in minutes per day) × (days of activity per week) = MET-minutes per week (IPAQ research committee, 2005: 1-15).

3.12.2 Pedometer data

Data was uploaded onto the Omron Health Management Manager Software Protocol (Incorporated Omron Health Management. Instruction manual: Pocket pedometer-model HJ-720ITC, 2007: 1). Participants’ data was analysed if the pedometer was worn for at least seven consecutive days. The variables of daily steps, aerobic steps, aerobic walking time, calories burned, and distance covered were then exported into an EXCEL spreadsheet for data analysis.

Tudor-Locke and Bassett (2004:6-7) described the normal steps-per-day categories and classification system.

Table 3.1: Steps-per-day categories and classification system (Tudor-Locke and Bassett, 2004:6-7)

Steps per day	Classification
<5000	Sedentary lifestyle
5000–7499	Physically inactive
7500–9999	Moderately active
≥10,000	Physically active
≥12,500	Very active

3.12.3 Fitness assessment data

The PEI for each participant was compared to this classification table (Chegg Inc., 2019: 1).

Table 3.2: Physical Efficiency Index Classification (Chegg Inc., 2019: 1)

Physical Efficiency Index	Classification
Below 55	Poor
55 to 64	Low average
65 to 79	High average
80 to 89	Good
90 and above	Excellent

The physical efficiency/fitness index (PEI/PFI) measures the physical fitness for muscular work and the ability to recover from the work (Parmar and Vaghela, 2015:1076).

The BMI (kg/m^2) was compared to the ranges specified by WHO and classified accordingly.

Table 3.3: Body mass index and corresponding nutritional status (WHO, 2019: 1)

Body Mass Index (BMI)	Nutritional Status
Below 18.5	Underweight
18.5–24.9	Normal weight
25.0–29.9	Pre-obesity
30.0–34.9	Obesity class I
35.0–39.9	Obesity class II
Above 40	Obesity class III

PBF was compared to the classification table which was based on the research of McCarthy *et al*. (2006: 598) and Gallagher *et al*. (2000: 694-701), found in the instruction manual of the Omron BF511 body composition monitor. This table classified participants according to gender and age into the categories of low, normal, high or very high PBF (Omron Healthcare, 2017: 30).

The waist and hip circumference measurements were used to determine the waist-hip ratio (waist circumference/hip circumference). This was then compared to a classification table of risk according to waist-to-hip ratio for disease associated with being overweight.

Table 3.4: Waist-to-hip ratio and disease risk (Burgess, 2017: 1)

Disease risk	Women	Men
Low	0.80 or below	0.95 or below
Moderate	0.81–0.85	0.96–1.0
High	0.86 or above	1.0 or above

The participants' data from the IPAQ, the pedometers and the fitness assessment was then classified into three groups according to their participation in the study. Group A consisted of participants who only completed the IPAQ questionnaire in the study. Group B consisted of participants who completed the IPAQ questionnaire and pedometer wear. Group C consisted of the participants who completed all three data sets. This comparison of data allowed for possible correlations between trends in the data and the level of study participation which might have shown significant correlations that would have provided further insight in the study.

3.13 Statistical analysis

IBM Statistical Package for the Social Sciences (SPSS) version 25.0 was used to analyse the data. Continuous data was described using median and inter-quartile range overall and per group, as the variables were not normally distributed. Median values were reported, and non-parametric tests were performed due to the skewness of the data (Esterhuizen, 2019: 1). The median is less influenced by skewed data and outliers than the mean and thus is a preferred measure of central tendency with asymmetrical data (Australian Bureau of Statistics, 2013: 1). Nonparametric Kruskal-Wallis tests were used to compare medians across PA groups at a 0.05 level of significance. Where an overall significant result was found, Bonferroni adjusted multiple comparison tests were done to try and identify the groups which differed. Relationships between continuous variables were assessed using Spearman's rank correlation coefficient (Esterhuizen, 2019: 1).

3.14 Limitations

The researcher had difficulty contacting the staff members through email as many staff members did not reply. The researcher only sent emails for the first two months of data collection as there was a very low response rate from the staff members. At the beginning of the third month, the researcher began phoning staff members to inform them of the study and to ask them if they were willing to participate. This resulted in an improvement but the response rate per department was still relatively low. A limited number of pedometers were available to the researcher to give to participants. This resulted in a longer time being required for data collection as each pedometer was with each participant for a week at a time during the data collection period. In the fourth month of data collection, DUT experienced a suspension of the academic programme due to student protests. The staff members recruited during that month were not lecturing and spent most of the day in their offices. This meant that the PA data from the questionnaires and pedometers did not reflect their usual daily activity routine during work hours. Thus, due to low response rate, human resource, time and financial constraints, the sample size was reduced to 61 participants (Appendix I).

Limitations in the methodology included the use of the IPAQ as there have been limitations reported. It has been reported that there may be a possible limitation regarding the high prevalence estimates produced, where 75% of many populations satisfy or succeed 600 MET-minutes (Bauman *et al.,* 2009:8).Another limitation is that participants struggle to differentiate between moderate and vigorous activity, this can lead to PA being overestimated (Sallis and Saelens, 2000:1). IPAQ assesses multiple domains of PA which could cause increased overall PA estimates than other surveys that only capture leisure-time activity (Health and Human Services, US,2008:1-61).Another possible limitation is misreporting PA due to recall problems or cross-cultural differences (Bauman *et al.,* 2009:S6). No premeasurement criterion was communicated to participants before using the OMRON BF511 Body Composition Monitor, as the researcher was not aware of these criteria (Beestone, 2018:1). When performing the Harvard Step test, a metronome was not used to ensure a rate of 30 steps per minute which has been used in other studies (Hiremath, Parwati and Goudar, 2018:2; Sharma *et al.,* 2014:259*).*

Chapter Four:
Results

4.1 Introduction

This chapter presents the findings and analysis of data collected in the study. These results are linked to the hypotheses and the research question, which influenced the study. It consists of the following: participation rate; demographics of participants; self-reported PA levels using the IPAQ; PA patterns using pedometer data; comparison of pedometer-measured data with self-reported data; aerobic fitness assessment measurements; comparison of pedometer-measured data with aerobic fitness; comparison of pedometer measured data with fitness assessment measurements, self-reported fitness level and IPAQ PA.

Median values were reported, and non-parametric tests were performed for the results that follow due to the skewness of the data (Esterhuizen, 2019). The median is less influenced by skewed data and outliers than the mean and thus is a preferred measure of central tendency with asymmetrical data (Australian Bureau of Statistics, 2013: 1).

4.2 Participation rate

Sixty-one full-time, permanent academic staff members from DUT participated in the study. A total of 218 questionnaires were sent out to full-time, permanent academic staff members on Ritson, Steve Biko and M L Sultan campuses over a five-month period. Of the 218 questionnaires distributed, 116 were completed and returned. Of these, 55 were excluded as 27 participants only filled in the questionnaire and did not complete the pedometer wear or fitness assessment. A further 28 participants completed the questionnaire and pedometer wear but did not perform the fitness assessment. These 55 participants were excluded due to either a change of mind and not wanting to participate in pedometer wear and perform the fitness assessment, or the researcher was unable to contact them after completion of the questionnaire to complete the rest of the study. Another 5 participants were excluded for not completing the questionnaire completely or failing to complete the informed consent form. The final sample number of the study was thus 61 (n = 61). The final response rate was 27.9%. Participants were required to complete the IPAQ, wear a pedometer for seven consecutive days, perform the Harvard step test and have measurements including BMI, PBF, body height, body weight and waist-to-hip ratio recorded.

4.3 Demographics

4.3.1 Age

The mean age of participants was 44.1 ± 9.5 years. The oldest participant was 63 years old and the youngest participant was 25 years old.

4.3.2 Gender

The majority of the sample (67.2%) consisted of females (*n* = 41).

4.3.3 Department and Faculty

Table 4.1 shows that the largest number of participants was from the Information Technology department at 37.7% (*n* = 23) and that the Nursing department had the lowest number of participants at 1.6% (*n* = 1).

Table 4.1: Participation of participants according to department

Department	Frequency (n)	Percentage (%)
Applied Law	2	3.3
Auditing and Taxation	2	3.3
Community Health Studies	4	6.6
Dental Sciences	3	4.9
Entrepreneurial Studies and Management	2	3.3
Financial Accounting	4	6.6
Food and Nutrition Consumer Sciences	2	3.3
Hospitality and Tourism	8	13.1
Information and Corporate Management	3	4.9
Information Technology	23	37.7
Management Accounting	7	11.5
Nursing	1	1.6

The faculty of Accounting and Informatics made up the largest portion of the sample at 63.9% (*n* = 39). This was followed by Management Sciences at 19,7% (*n* = 12). Applied Sciences comprised the smallest portion at 3.3% (*n* = 2).

4.3.4 Sports participation

The most popular exercise was walking (45.9%), followed by going to the gym (37.7%) and running (23%). Other forms of exercise performed were yoga (14.8%), soccer (6.6%) and cricket (3.3%).

4.3.5 Recreational activity involvement

The most popular activity was shopping (44.3%), followed by dancing (16.4/%) and playing with their children (13.1%). Other activities such as gardening (6.6%) and walking the dog (3.3%) were also mentioned.

4.4 Self-reported physical activity levels

Self-reported physical activity was determined using the IPAQ.

4.4.1 Physical activity classification

To be classified as moderately active, participants needed to perform a minimum of 20 minutes of VPA on three or more days (IPAQ research committee, 2005: 5, 6). Alternatively, performing MPA or walking for at least 30 minutes for five days or more, were also included in this classification of moderately active. A third alternative requirement was a combination of activity to accumulate 600 MET minutes a week (IPAQ research committee, 2005: 5, 6). To be considered highly active, participation in VPA on at least three days to accumulate at least 1500 MET-minutes/week is required (IPAQ research committee, 2005: 5, 6). Alternatively, seven or more days of a combination of activity resulting in at least 3000 MET-minutes/week can be achieved (IPAQ research committee, 2005: 5, 6). Low or physically inactive participants have less than 600 MET-minutes/week (IPAQ research committee, 2005: 5, 6). Of the participants who completed the questionnaire, pedometer wear and fitness assessment, most were classified as being moderately active (49.1%), while 31.9% were highly active and 19.0% were classified as low or physically inactive according to the IPAQ data.

4.4.2 Types of physical activity intensity performed by participants

The median for total physical activity was 4018.5 MET minutes per week (360.0-29100.0). Participants spent the most time engaging in MPA during the week at 1800

MET minutes/week (360.0-28620.0). The least amount of time was spent engaging in VPA during the week at 720 MET minutes/week (0 -12720).

4.4.3 Physical activity undertaken across specific domains

Most physical activity was spent performing domestic and gardening/yard activities at 1120.0 MET-minutes/week (0.0-28560.0). Participants were least physically active in the transport domain when travelling between places at 594.0 MET minutes/week (0.0-7920.0). At work, 1050.0 MET-minutes/week (0.0- 19020.0) of PA were performed and during leisure-time 794.0 MET-minutes/week (0.0-6426.0) were performed.

4.4.4 Sedentary activity

Participants spent a weekly median time of 37 hours (2.3-100) sitting. The average sitting time per day was 5.29 hours (0.3-14.29).

4.4.5 Sedentary activity according to physical activity classification

No significant relationship was present ($p = 0.640$) between the median total sitting minutes per week and the physical activity classification groups.

4.4.6 Self-reported fitness level

Of all participants, 19.7% rated their level of fitness out of ten as six ($n = 12$). The second most common ratings were three ($n = 11$) and five ($n = 11$) out of ten which were both rated by18% of participants respectively. The 25 and 75 percentiles were 3.50 and 6.50 respectively.

4.5 Self-reported fitness level and IPAQ physical activity classification

The median self-reported fitness level for moderately active participants was five out of ten (3 - 6). Highly active participants reported six out of ten (5 - 7) and low activity participants reported 3 out of ten (1 - 3).The 25 percentiles were 3 (moderately active), 5 (highly active) and 1 (low activity) respectively and the 75 percentiles were 6 (moderately active), 7 (highly active) and 3 (low activity).Please see in Table 4.2 below.

Table 4.2: Self-reported fitness level and IPAQ physical activity classification

		IPAQ Physical activity classification		
		Low	Moderate	High
Self-reported fitness level out of ten	Median	3	5	6
	Percentile 25	1	3	5
	Percentile 75	3	6	7

There was a significant difference in self-reported fitness level across the three PA groups (*p* = 0.003). Post hoc tests showed that the significant differences were between the high and low groups (*p* = 0.01) as well as the moderate and high groups (*p* = 0.04). This shows that the low activity group rated themselves much lower than those in the high activity group and the high activity group rated themselves higher than the low activity group. The moderate activity group also generally rated themselves lower than the highly active group and the highly active group rated themselves higher than the moderate activity group. Therefore, participants rated their fitness level correctly across the groups. Please see in Table 4.3 below.

Table 4.3: Post hoc tests for self-reported fitness level and PA groups

Sample 1-Sample 2	**Test statistic**	**Std. Error**	**Std. Test Statistic (2-sided tests)**	**Sig.**	**Adj.Sig.**
Low-Moderate	-19.753	10.602	-1.863	.062	.187
Low- High	-31.167	10.671	-2.921	.003	.010
Moderate-High	-11.414	4.616	-2.473	.013	.040

4.6. Average daily pedometer values

The median number of daily steps taken by participants was 4824.43 steps (565.86-15098.57). A median distance of 3.6 kilometres (0.31-11.89) was covered daily. Participants walked a median number of 586.29 daily aerobic steps (0.00-5830.43) and burned a median amount of 83 kilocalories (6.14-450.71) every day. The median aerobic walking time was six minutes (0.00-52.86).

4.7 Comparing pedometer-measured data with IPAQ physical activity classification

A trend was present which indicated that as self-reported physical activity increased, so did all the median values of the pedometer-measured data. This is demonstrated in Figures 4.1 to 4.5 below.

The median step count was the highest in the high activity group (6001,71 steps), followed by the moderate activity group (4627,57 steps) and lastly the low activity group (4182,86 steps) (Figure 4.1).

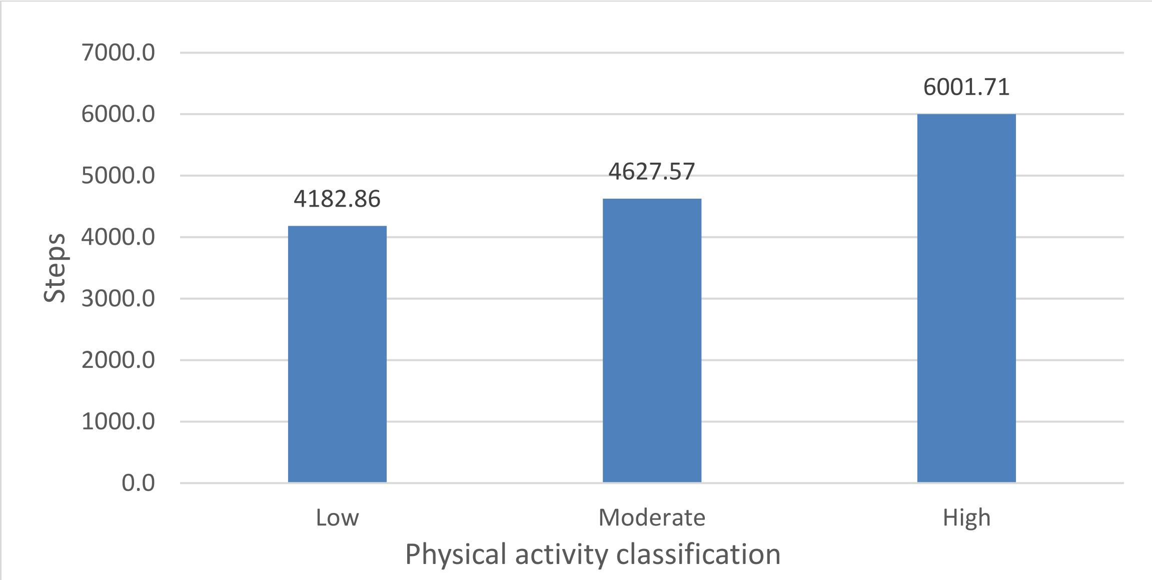


Figure 4.1: Median steps according to physical activity classification

The median aerobic step count was highest in the high activity group (1114,57 aerobic steps), followed by the moderate activity group (213,14 aerobic steps) and lastly the low activity group (0 aerobic steps) (Figure 4.2). Aerobic steps differ from normal steps as it is a more rigorous style of walking and is detected when more than 60 steps per minute are taken and walking occurs for more than 10 minutes continuously (OMRON Healthcare, 2007: 1).

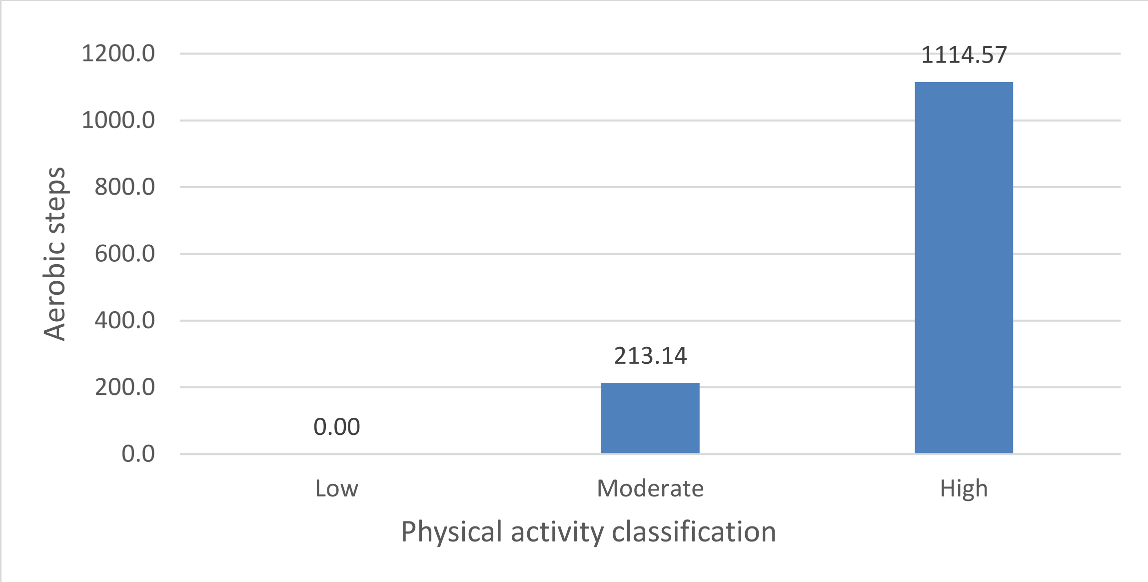


Figure 4.2: Median aerobic steps according to physical activity classification

The median aerobic walking time was the highest in the high activity group (10 minutes), followed by the moderate activity group (2,14 minutes) and lastly the low activity group (0 minutes) (Figure 4.3). Aerobic walking time is the time accumulated when performing aerobic steps (OMRON Healthcare, 2007: 1).

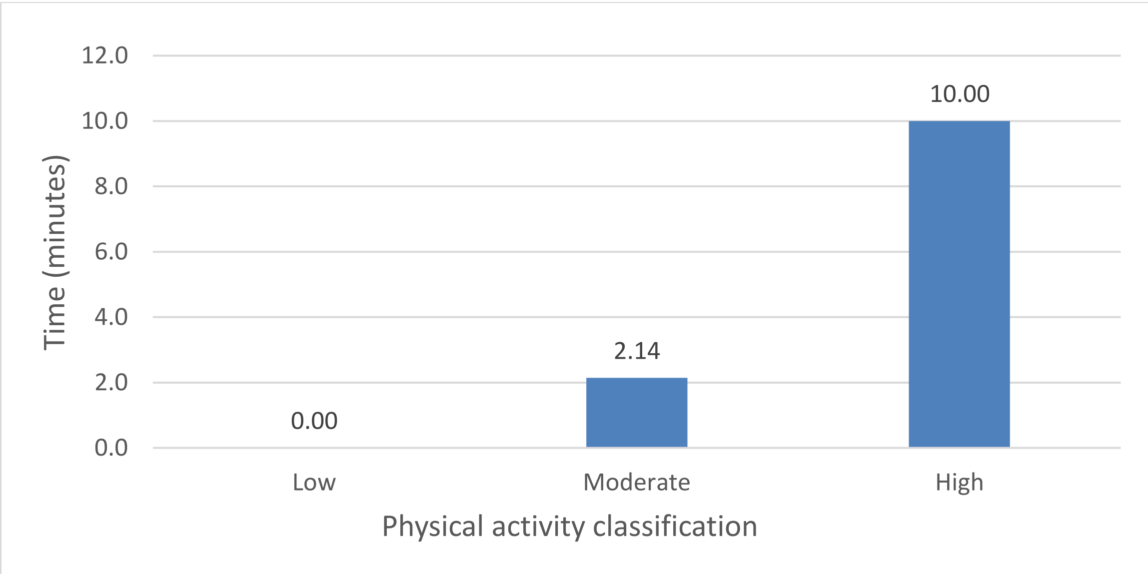


Figure 4.3: Median aerobic walking time according to physical activity classification

The median energy expended was the highest in the high activity group (123,71 kilocalories), followed by the moderate activity group (62,86 kilocalories) and lastly the low activity group (57,57 kilocalories) (Figure 4.4).A kilocalorie (Kcal) represents a unit of energy containing 1,000 calories, therefore average kilocalories are the energy burned throughout the day (Mckenzie, 2020:1).

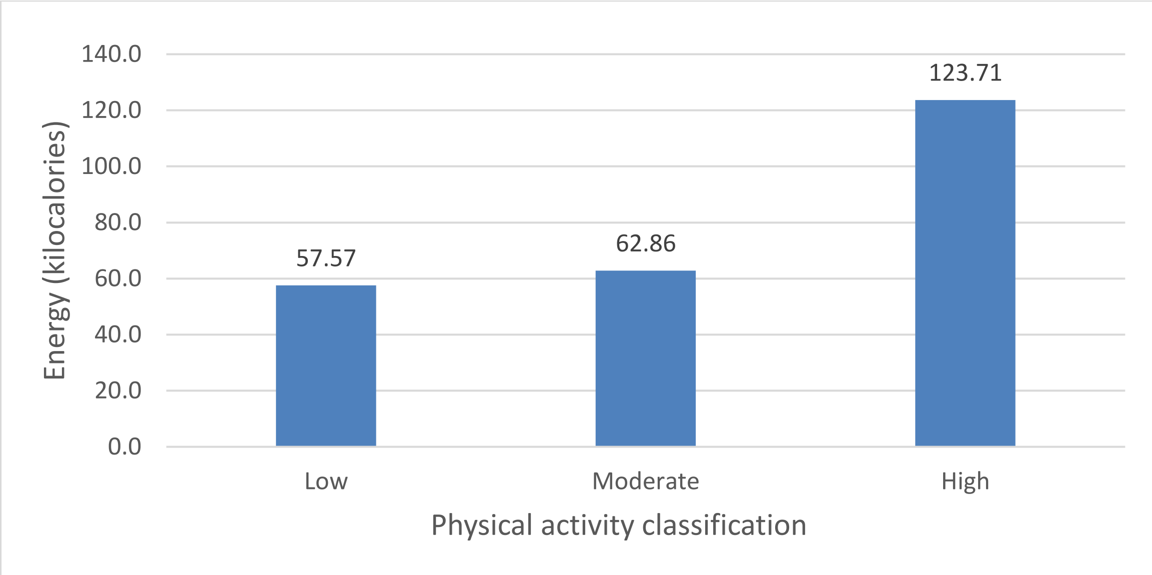


Figure 4.4: Median energy expended according to physical activity classification

The median distance covered was the highest in the high activity group (4,37 kilometres), followed by the moderate activity group (3,44 kilometres) and lastly the low activity group (3,01 kilometres) (Figure 4.5).

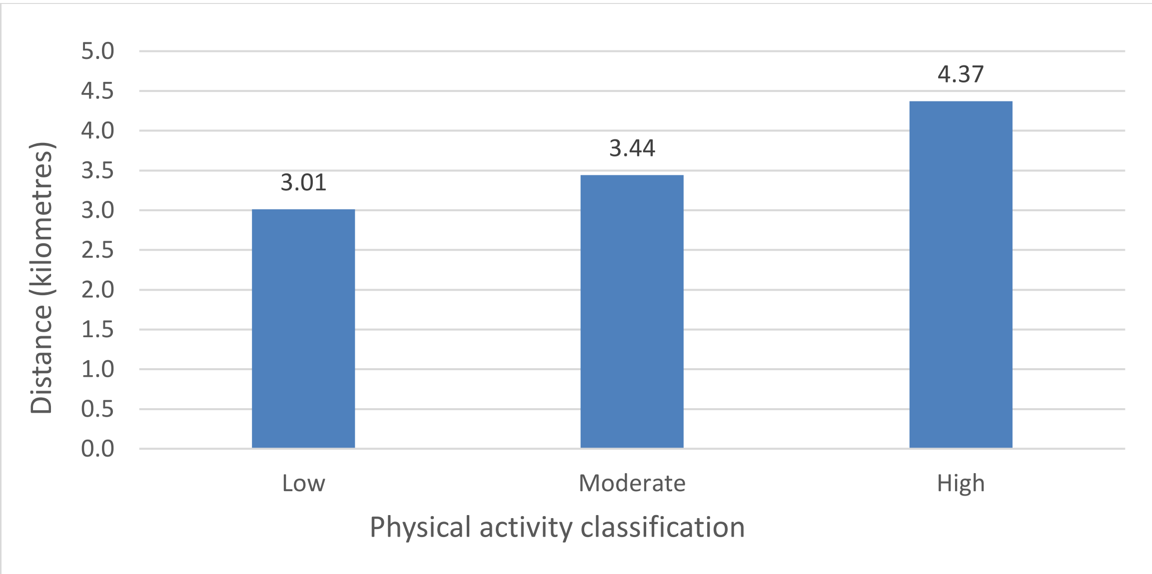


Figure 4.5: Median distance covered according to physical activity classification

The Kruskal-Wallis tests showed an overall significant difference between the physical activity groups in terms of average aerobic steps (p = 0.028) and average aerobic walking time (p = 0.033). A significant difference in aerobic step count was found between the low activity group and high activity group (p = 0.019) (Table 4.4). A significant difference in aerobic walking time was also present between the low activity group and high activity group (p = 0.059) (Table 4.5). Aerobic steps differ from normal steps as it is a more rigorous style of walking and is detected when more than 60 steps per minute are taken and walking occurs for more than 10 minutes continuously (OMRON Healthcare, 2007: 1). Aerobic walking time is therefore the time accumulated when performing aerobic steps (OMRON Healthcare, 2007: 1). However, post hoc tests for these two variables showed that none of the pairwise comparisons between individual groups reached statistical significance due to small sample sizes and thus low power, especially in the low physical activity group. The low versus high groups showed the largest differences in each case, but the difference did not quite reach statistical significance (p = 0.056 and 0.059, respectively).

Table 4.4: Post hoc tests for aerobic steps and physical activity groups

Sample 1 – Sample 2	Std. Error	Std. Test Statistic (2-sided tests)	Sig.	Adj. Sig.
Low-moderate	10.480	-1.598	.110	.330
Low-High	10.548	-2.354	.019	.056
Moderate-High	4.562	-1.773	.076	.228

Table 4.5: Post hoc tests for average aerobic walking time and physical activity groups

Sample 1 – Sample 2	Std. Error	Std. Test Statistic (2-sided tests)	Sig.	Adj. Sig.
Low-moderate	10.479	-1.618	.106	.317
Low-High	10.547	-2.332	.020	.059
Moderate-High	4.562	-1.675	.094	.282

4.8 Measurements performed at the aerobic fitness assessment

The measurements performed at the aerobic fitness assessment included: PEI, BMI, waist-to-hip ratio and PBF.

4.8.1 Physical Efficiency Index

The median PEI for participants was 50. This is classified as poor according to the classification by Chegg Inc. (2019:1).The 25 and 75 percentiles were 47 and 56 respectively. Most participants (62.3%, *n* = 38) were classified as having a poor PEI. This was followed by 31.1% (*n* = 19) of participants having a low-average PEI classification. Only 6.6% (*n* = 4) were classified as having a high-average PEI.

4.8.2 Body Mass Index

The median BMI of participants was 27.3 kg/m^2, which is in the pre-obese BMI category. The 25 and 75 percentiles were 23 and 32.3 respectively. The most common BMI classification was of normal weight at 34.4% (*n* = 21). To be classified as pre-obese, a participant needs to have a BMI between 25.0–29.9 kg/m^2. To be classified in obesity class I, a BMI of 30.0–34.9 kg/m^2 is required. Obesity class II requires a BMI of 35.0–39.9 kg/m^2. To be classified in obesity class III requires a BMI above 40 kg/m^2 (WHO, 2019: 1). Just over a third of participants were classified as pre-obese at 31.1% (*n* = 19) and 18% (*n* = 11) were categorised in obesity class I. Figure 4.6 shows the BMI classifications and their respective percentages below.

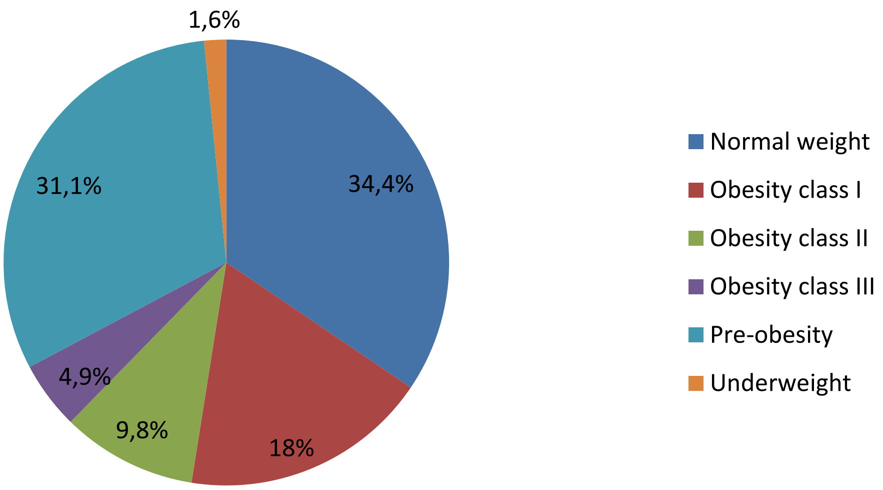


Figure 4.6: Proportion of participants according to body mass index classification

4.8.3 Waist-to-hip ratio

The median waist-to-hip ratio was 0.83. The 25 and 75 percentiles were 0.77 and 0.87 respectively. The waist-to-hip ratio of most participants was classified as being low risk (65.6%, *n* = 40). Low risk categorisation requires women to have a ratio of 0.80 or below and men to have a ratio of 0.95 or below (Burgess, 2017: 1). This was followed by 18% (*n* = 11) of participants falling into the high-risk category. To be considered high risk requires women to have a ratio of 0.86 or above and men to have a ratio of 1.0 or above (Burgess, 2017: 1). Participants who were considered at moderate risk only constituted 16.4% (*n* = 10) of the sample. To be considered at moderate risk, women are required to have a ratio of 0.81–0.85 and men to have a ratio of 0.96–1.0 (Burgess, 2017: 1).

4.8.4 Percentage body fat

The median PBF was 38.3%. Over half of participants were classified as having a very high PBF (52.5%, *n* = 32). The 25 and 75 percentiles were 28.3 and 45.5 respectively. Participants considered to have normal PBF constituted 23% (*n* = 14) of the sample. PBF classifications and their proportions are seen in Figure 4.7 below.

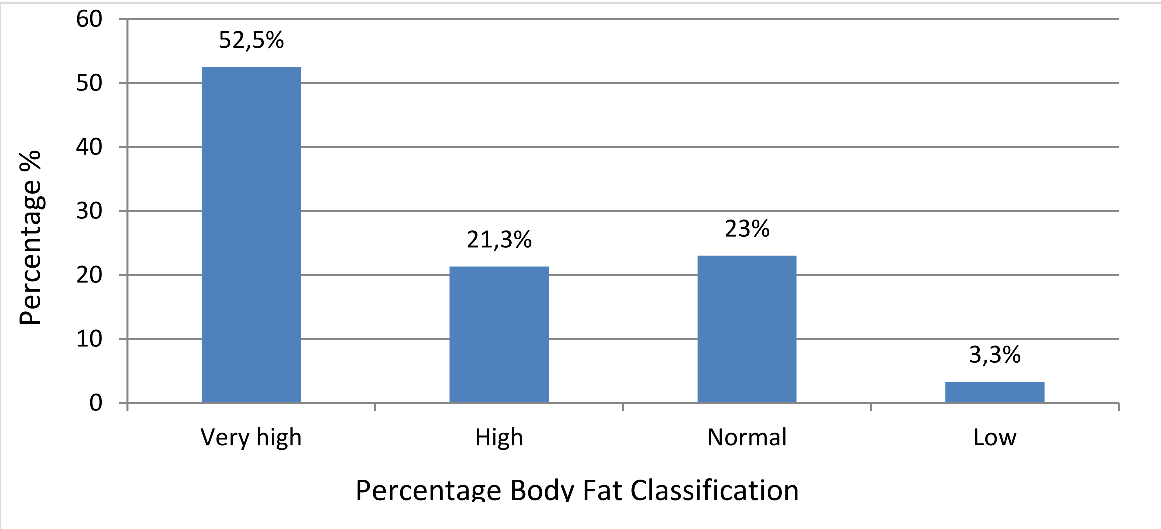


Figure 4.7: Proportion of percentage body fat classifications

4.9 Comparing body mass index, percentage body fat, waist-to-hip ratio and Physical Efficiency Index

Negative correlations were found between PEI and PBF (r = -0.369, p = 0.003). Another negative correlation was present between PEI and BMI (r = -0.308, p = 0.016). A strong positive correlation was found between BMI and PBF (r = 0.789, $p < 0.001$).

4.10 Comparing pedometer-measured data with aerobic fitness

Significant relationships were found between PEI and average kilocalories (r = 0.295, p = 0.021) as well as with average distance (r = 0.293, p = 0.022). This is seen in Table 4.6 below.

Table 4.6: Correlations between pedometer measured data and Physical Efficiency Index

Correlations			
			Physical efficiency index
Spearman's rho	**Average steps**	**Correlation Coefficient**	.250
		Sig. (2-tailed)	.052
		N	61
	Average aerobic steps	**Correlation Coefficient**	.244
		Sig. (2-tailed)	.058
		N	61
	Average walking time	**Correlation Coefficient**	.251
		Sig. (2-tailed)	.051
		N	61
	Average kilocalories	**Correlation Coefficient**	.295*
		Sig. (2-tailed)	.021*
		N	61
	Average distance	**Correlation Coefficient**	.293*
		Sig. (2-tailed)	.022*
		N	61

* Indicates significant values

4.11 Comparing pedometer measured data with aerobic fitness assessment measurements

BMI was negatively correlated with all the pedometer measurements. These correlations were weak to moderate in strength. The strongest negative relationship was with average steps (*r* = -0.296, *p* = 0.020) which was low to moderate in strength. The correlations between the pedometer data and BMI are seen in Table 4.7 below.

Table 4.7: Correlations between pedometer-measured data and body mass index

Correlations			
			Body Mass Index (kg/m²)
Spearman's rho	**Average steps**	**Correlation Coefficient**	-.296*
		Sig. (2-tailed)	.020
		N	61
	Average aerobic steps	**Correlation Coefficient**	-.244
		Sig. (2-tailed)	.059
		N	61
	Average walking time	**Correlation Coefficient**	-.224
		Sig. (2-tailed)	.082
		N	61
	Average kilocalories	**Correlation Coefficient**	-.116
		Sig. (2-tailed)	.373
		N	61
	Average distance	**Correlation Coefficient**	-.236
		Sig. (2-tailed)	.067
		N	61

*Indicates significant values

Negative relationships were present between PBF and all pedometer measurements with the strongest negative relationship being with average aerobic steps (*r* = -0.416, *p* = 0.001) which was low to moderate in strength. This was followed by average aerobic walking time (*r* = -0.409, *p* = 0.001) and average steps (*r* = -0.380, *p* = 0.003). Other significant negative relationships were present with average kilocalories (*r* = -0.280, *p* = 0.029) and average distance (*r* = -0.343, *p* = 0.007). The negative correlations are seen below in Table 4.8.

Table 4.8: Correlations between pedometer measured data and percentage body fat

Correlations			
			Percentage body fat
Spearman's rho	**Average steps**	**Correlation Coefficient**	-.380*
		Sig. (2-tailed)	.003
		N	61
	Average aerobic steps	**Correlation Coefficient**	-.416*
		Sig. (2-tailed)	.001
		N	61
	Average walking time	**Correlation Coefficient**	-.409*
		Sig. (2-tailed)	.001
		N	61
	Average kilocalories	**Correlation Coefficient**	-.280*
		Sig. (2-tailed)	.029
		N	61
	Average distance	**Correlation Coefficient**	-.343*
		Sig. (2-tailed)	.007
		N	61

*Indicates significant values

4.12 Comparisons of physical activity level between groups of participants according to completion of the study

Group A consisted of participants who only completed the IPAQ questionnaire in the study. Group B consisted of participants who completed the IPAQ questionnaire and pedometer wear. Group C consisted of the participants who completed all three data sets. Group A contained the largest percentage of individuals of low activity level at 40.7% (n = 11). Only 11, 1% (n = 3) were considered to be highly physically active. Group B contained a higher percentage of highly active individuals at 25% (n = 7). Group C had the highest percentage of highly active individuals at 44.3% (n = 27). There was a significant difference ($p < 0.001$) across the three groups regarding physical activity level where high activity was more likely to be present in Group C and low activity more likely to be present in Group A. No significant difference ($p = 0.172$) in total PA MET-minutes/week was found across the groups. However, there was a trend towards increasing values from Groups A to B to C. The comparisons between the groups regarding PA level and total PA MET-minutes/week can be seen in Table 4.9 below.

Table 4.9: Comparisons between the groups regarding physical activity level and total physical activity MET-minutes/week

			Groups			
			A	**B**	**C**	**Total**
Physical activity level	**High**	**Count**	3	7	27	37
		Column N %	11.1%	25.0%	44.3%	31.9%
	Low	**Count**	11	8	3	22
		Column N %	40.7%	28.6%	4.9%	19.0%
	Moderate	**Count**	13	13	31	57
		Column N %	48.1%	46.4%	50.8%	49.1%
Total physical activity MET-minutes/week	**Median**		2916.0	3590.0	4018.5	3796.3

4.13 Comparisons of pedometer-measured data between groups of participants according to completion of the study

No significant differences were found between Groups B and C in terms of any of the outcomes. The median number of daily steps was slightly higher in Group C (4,824.4 steps) than Group B (4,477.9 steps). Median number of average kilocalories expended increased from 65.5 in Group B to 83.0 in Group C. The comparisons can be seen in Table 4.10 below.

Table 4.10: Comparisons of pedometer-measured data between groups of participants

		Groups		
		B	**C**	**Total**
Average steps	**Median**	4,477.9	4,824.4	4,804.7
Average aerobic steps	**Median**	.0	586.3	358.9
Average walking time	**Median**	.0	6.0	3.4
Average kilocalories	**Median**	65.5	83.0	80.7
Average distance	**Median**	3.3	3.6	3.6

In summary, key findings included that 49.1% of participants were classified as being moderately active, 31.9% were classified as highly active and 19.0% were classified as low or physically inactive according to the IPAQ. Participants mostly engaged in MPA during the week (1800 MET minutes/week). The largest volume of physical activity was spent performing domestic and gardening/yard activities (1120 MET-minutes/week). A significant difference in self-reported fitness level was found across the PA classifications (p = 0.003), with the most significant differences being present between the high and low groups (p = 0.01) and moderate and high groups (p = 0.04). A trend was found which indicated that as PA increased, so did all the median values of the pedometer-measured data.

An overall significant difference between the PA groups in terms of average aerobic steps (p = 0.028) and average aerobic walking time (p = 0.033) was present. The majority of participants (62.3%) were classified as having a poor PEI, followed by 31.1% of participants having a low-average PEI and only 6.6% were found to have a high-average PEI. Strong negative correlations were found between PEI and PBF (r = -0.369, p = 0.003). Another negative correlation was present between PEI and BMI (r = -0.308, p = 0.016). A strong positive correlation was found between BMI and PBF (r = 0.789, p = <0.001). BMI was negatively correlated with average daily steps (r = -0.296, p = 0.020), average daily aerobic steps (r = -0.244, p = 0.059) and average distance covered (r = -0.236, p = 0.067). Significant relationships were found between PEI and average kilocalories (r = 0.295, p = 0.021) as well as with average distance (r

= 0.293, p = 0.022). PBF was negatively correlated with average aerobic steps (r = -0.416, p < 0.001), average aerobic walking time (r = -0.409, p < 0.001) and average daily steps (r = -0.380, p = 0.003). A trend was found where total PA MET-minutes/week increased from Groups A to B to C. There was a significant difference (p < 0.001) across the three participation groups regarding PA level where high activity was more likely to be present in Group C and low activity more likely to be present in Group A.

Chapter five:
Discussion

5.1 Introduction

This chapter provides insight into the PA patterns and aerobic fitness of the academic staff at DUT in the context of current documented literature. Particular reference is made to the PA classification of the staff, the type of activity that was engaged in, self-reported fitness levels and their correlations with actual fitness, correlations between self-reported PA and pedometer measured data, correlations among BMI, PBF, PEI and between these measurements and pedometer data and trends present across the different participation groups in the study in the light of our findings.

5.2 Physical activity classification

Our findings of 19.0% of physically inactive participants in this study were lower than previous studies conducted (Hallal *et al.,* 2011:249; Guthold *et al*., 2008:489; Xu *et al*. (2014:9). Hallal *et al.* (2011) found global inactivity to be 31.1% based on the WHO global health data repository from 122 countries (2011: 248). To be considered low-activity, participants did not meet the criteria for moderate or highly active classifications (IPAQ research committee, 2005: 5, 6). Interestingly, the 31.9% of highly active participants in this study was similar to the 31.4% highly active individuals found globally in the same study (Hallal *et al.,* 2011: 249). This indicates that the proportion of highly active individuals in this study is, to an extent, representative of the global proportion of highly active individuals which could possibly indicate the PA characteristics between the populations are similar. These highly active participants engaged in VPA on at least 3 days to accumulate at least 1500 MET-minutes/week. Alternatively, they did a combination of activity resulting in at least 3000 MET-minutes/week (IPAQ research committee, 2005: 5, 6). Almost half of the sample (49.1%) in this study was found to be moderately active which was larger than the 37.5% of the global population determined in the same study (Hallal *et al.*, 2011). This is most likely attributed to the age range of the population which was higher and included individuals of 60 years old or older, whereas in our study there were very few people over 60 years of age. Studies have found that physical inactivity rises during adulthood with age, with the largest increase occurring from age 50 to 69 years of age (Guthold *et al*., 2008). Therefore, it was likely that the global population study may have included a larger group of older participants in their late sixties, seventies or eighties. However, a study by Guthold *et al*. (2008) produced the most similar result where only 17.7 % physical inactivity prevalence was found in a population of 51 mostly low- and middle-income countries. Interestingly, Xu *et al.* (2014) found a similar prevalence to this study, finding moderately active adults in the United States to be 52% and vigorously active adults to be 32%. The standard Behavioural Risk Factor Surveillance System (BRFSS) questionnaire which includes questions on leisure-time physical activity which was defined as nonparticipation in any physical activities (other than what is done during one's regular job) or exercises, such as running, calisthenics, golf, gardening, or walking during the preceding month (Xu *et al.,*2014:6,7).To be classified as moderately active, participants needed to perform a minimum of 20 minutes of VPA on 3 or more days (IPAQ research committee, 2005: 5, 6). Alternatively, performing MPA or walking for at least 30 minutes for 5 days or more, was also included in this classification. A third alternative requirement was a combination of activity to accumulate 600 MET minutes a week (IPAQ research committee, 2005: 5, 6). These form the current physical activity recommendations stated by WHO to be classified as sufficiently physically active (WHO, 2011).

Previous studies performed have revealed that the South African population has largely adopted the sedentary lifestyle of developed, high income countries (Lambert, Bohlmann and Kolbe-Alexander, 2001: 12). These studies have indicated rising levels of physical inactivity (Joubert *et al*., 2007: 726). The results of this study contradict this, with the result of the low-activity proportion of 19.0%. This contradiction is not supported in a study performed by Steyn e*t al.* (2004: 237) that found that 49.7% of a working-class community in Mamre, Western Cape did not meet the recommended PA levels to protect against cardiovascular disease. A possible explanation for this, is participants of 45 years or older in this study were overrepresented by 11% and those between 15 and 29 years old were under-represented by 10% in the sample (Steyn *et al*., 2004: 235). Kruger, Venter and Vorster (2003) also found increased prevalence of inactivity of 29.1% in the North West Province, with only 27.9% of individuals being moderately active. Possible explanations for the varying results could be the differing sample size and demographics of both studies. The study by Kruger, Venter and

Vorster (2003) had a much larger sample (*n* = 1 854) than this study's sample (*n* = 61). Additionally, all participants in the study by Kruger, Venter and Vorster were African and the sample included individuals living in rural settings (Kruger, Venter and Vorster, 2003: 17), whereas this study only included individuals in an urban setting and of different demographics. Individuals in rural settlements have been found to be more inactive which was also seen in the study by Kruger, Venter and Vorster (2003: 20).

Few studies have been done on PA levels of office workers in SA (Ferreira and Strydom, 2016: 119). Most research focusses on health-care workers (Lela and Frantz, 2012; Kunene and Taukobong, 2015; Puoane *et al*., 2005; Skaal and Pengpid, 2012). Both studies by Kunene and Taukobong (2015) and Skaal and Pengpid (2012) found higher inactivity prevalence in healthcare workers in SA than the 19.0% in this study. Of the sample of health professionals in Estcourt Hospital in Kwa-Zulu Natal, 40% had low activity levels, 29% were moderately active and 31% were highly active (Kunene and Taukobong, 2015: 2-3). In a hospital in Pretoria, 81.5% of healthcare workers had low fitness levels, 15.5% were moderately fit and only 3% were considered highly fit (Skaal and Pengpid, 2012: 386-387). An explanation could be the samples of these studies being 109 (Kunene and Taukobong, 2015: 2) and 200 (Skaal and Pengpid, 2012: 564) respectively which is higher than the sample (*n* = 61) in this study. Furthermore, previous studies have found healthcare workers to be particularly inactive (Singh and Purohit, 2012) and to have unhealthy lifestyles when compared to the general population (Jonsdottir, Börjesson and Ahlborg, 2011).

5.3 Types of physical activity intensity performed by participants

Previous studies conducted reported similar results to our findings that MPA was mostly performed during the week (1800 MET minutes/week) and VPA was the least engaged in (720 MET minutes/ week). Biernat, Tomaszewski and Milde (2010: 291, 292) found that office workers in Poland participated in MPA for 180 minutes or longer more frequently than VPA. Additionally, Kunene and Taukobong (2015: 4) found that nearly half (49.5%) of the sample of healthcare workers participated in MPA and only 38.5% engaged in VPA.

5.4 Physical activity undertaken across specific domains

Similar results were seen in white collar workers in Denmark when compared to our findings, that the largest volume of PA was spent performing domestic and gardening/yard activities (1120 MET-minutes/week) and the least amount of PA was spent travelling between places (594 MET minutes/week). This may be due to the population being white collar workers who rely on using cars for transport and therefore seldom walk for transport. The Danish study found that moderately active workers spent the most MET-minutes/week (620 MET-minutes/week) performing domestic activities and the least during transportation (497 MET-minutes/week) (Hansen e*t al.,* 2010: 147). Household and domestic activity includes duties such as cleaning, gardening and caring for family (IARC, 2002: 6) (IPAQ research committee, 2002: 4). Therefore, it can be expected that these results can vary according to the cultures and demographics of the sample and socio-economic status of the population. For example, in the isiXhosa culture, women are expected to do most domestic tasks and duties at home (Walter and Du Randt, 2011: 147-148) and therefore a study including this population will spend a large amount of activity performing domestic activities.

5.5 Sedentary activity

To date, there are no well-accepted parameters for sedentary data and its classification (IPAQ research committee, 2005: 6). Additionally, previous studies have not defined or measured sedentary behaviour consistently (Rosenberg *et al*., 2008: S30). Current epidemiological studies have not been adequately developed to establish sitting parameters that can determine adverse health effects (Bauman *et al.*, 2011: 231). Therefore, only a comparison of this study's results of a median sitting time of 37 hours (2220 minutes) weekly and 317.14 minutes daily can be made with other studies. No significant relationship was present (p = 0.640) between the median total sitting minutes per week and the PA classification groups. Very similar results were reported from a study by Bauman *et al*. (2011) that investigated sitting times of participants from twenty countries. The median sitting time was 300 minutes or five to six hours per day (Bauman *et al.*, 2011: 230). The average daily sitting time of 317.14 minutes in this study was lower than the 417 minutes of mean sitting time found from a study on well-educated countries by Rosenberg *et al*. (2008: S36-37). The average daily sitting time of this study was also found to be over 30% lower than the daily sitting time of full-time Australian workers which was reported to be 492 minutes by Brown, Miller and Miller (2003: 1343-1344).

5.6 Self-reported fitness level and IPAQ physical activity classification

The most frequently rated fitness level out of ten was six (19.7%, *n* = 12) followed by three (18%, *n* = 11) and five (18%, *n* = 11) with the median fitness level being reported as five out of ten (Table 4.4). This indicated that the sample underestimated their fitness levels as over half (50,8%, *n* = 31) were classified as moderately active and 44.3% (*n* = 27) as highly active according to the IPAQ classification. This was contradicted by a study conducted by Mikkelsson *et al*. (2005: 329) on 40-year-old women and men in Finland to determine how accurately they could estimate their fitness level. The correlation between estimated fitness and measured physical fitness was found to be 0.54 and it was determined that the sample was able to estimate their physical fitness at group level moderately well (Mikkelsson *et al*., 2005: 329). An explanation for this could be the demographic of the sample as all individuals in the study by Mikkelsson *et al.* (2005: 329) were 40 years old, whereas in this study the age ranged from 25 years old to 63 years of age. Despite the result, some participants in the study were found to be poor at estimating their physical fitness (Mikkelsson *et al*., 2005: 329)

The findings in this study indicated that participants rated their fitness level accurately across the physical activity groups. A significant difference in self-reported fitness level was found across the PA classifications ($p = 0.003$) (Table 4.5). Participants in the low activity group rated themselves much lower than those in the high activity group and the high activity group rated themselves higher than the low activity group which was seen with the significant differences being present between the high and low groups ($p = 0.01$) (Table 4.5). The moderate activity group also generally rated themselves lower than the highly active group and the highly active group rated themselves higher than the moderate activity group. This was indicated by the significant difference between the moderate and high groups ($p = 0.04$) (Table 4.5). These results are supported by a study conducted in the United States by Gerrard (2012: 1873) which found that the more educated individuals are, the more accurately they can report their physical fitness levels. We can assume the sample in this study was well-educated as all participants had achieved tertiary qualifications.

5.7 Average daily pedometer values

Tudor-Locke *et al.* (2011: 14) determined that healthy adults typically take a range of between 4000 and 18 000 steps/day. Therefore, the daily average of 4824.43 steps found in this study falls into this range, albeit in the lower end of the range. It was also determined that 10000 steps/day was an achievable target for adults in good health (Tudor-Locke *et al.* (2011: 14). The average daily step count was also much lower than the 8818 average daily steps found to be taken by Australian working adults reported by Miller and Brown (2004). An explanation for this could be that the sample of Australian workers included many different occupations such as chemists, laboratory technicians, librarians and cleaners (Miller and Brown, 2004: 220) whose activity levels would differ from academic staff and could possibly account for the higher average daily step count.

Sitthipornvorakul, Janwantanakul and van der Beek (2014: 2, 3) reported that 65.6% of a sample of office workers in Bangkok walked between 5000-9999 steps/day and only 6.2% walked less than 5000 steps per day. However, the sample of the study was much larger than this study at 320 office workers which could explain the contradictory results. The mean age of the participants was also lower than this study at 34.8 years old, therefore participants were generally younger which could account for higher activity and more daily steps being walked (Sitthipornvorakul, Janwantanakul and van der Beek, 2014: 1, 3). Compared to a study conducted in a South African setting, the daily average steps in this study are almost a third lower than the mean steps per day of a working population which was found to be 6,574 steps per day (Pillay *et al.,* 2015: 5). The average of 586.29 aerobic daily steps in this study was similar to that of the working South African population, which was found to be 694 average daily aerobic steps per day (Pillay *et al*., 2015: 5).

The average of 83 kilocalories expended daily was significantly lower than previous studies conducted on office workers. Coopoo, Constantinou and Rothberg (2008: 41) reported that employees within a South African, medium-sized financial corporation expended a mean of 1 974 kilocalories daily. A study performed on 290 workers and students of a Japanese university, found office workers to have the lowest energy expenditure of 2103 kilocalories per day for both males and females (Matsuura *et al*., 1993: 89).

5.8 Comparing pedometer-measured data with IPAQ physical activity classification

A trend was found which indicated that as PA increased, so did all the median values of the pedometer measure data (Figures 4.1 to 4.5). This indicated that PA classification by the questionnaire correlated with the pedometer data. An overall significant difference between the PA groups in terms of average aerobic steps (p = 0.028) and average aerobic walking time (p = 0.033) indicated the questionnaire data was most strongly correlated with these two variables. The low versus high groups showed the largest differences in each case (p = 0.056 and 0.059 respectively) which indicated there was a large distinction between these two groups in terms of pedometer data ranges.

Varying results have been found by previous studies which both contradict and support these results. Contradicting results were found by Sitthipornvorakul, Janwantanakul and van der Beek (2014: 3) who studied the correlation between the GPAQ and pedometer PA data and found no correlation between them (p = 0.15). However, when stratifying by age, a low but significant correlation (p = 0.01) was found in participants of 20–29 years of age (Sitthipornvorakul, Janwantanakul and van der Beek 2014: 3). Supporting evidence was found by Soo, Wan Abdul Manan and Wan Suriati (2015), De Cocker *et al*. (2008) and Cleland *et al.* (2011). When comparing the Bahasa Melayu version of the GPAQ with pedometer data, Soo, Wan Abdul Manan and Wan Suriati (2015: NP189) found a low but significant correlation (p = 0.013) between average daily steps recorded by the pedometer and total PA time spent weekly. Despite this, no significant correlation was found (p = 0.717) regarding PA classification between pedometers and the GPAQ-M (Soo, Wan Abdul Manan and Wan Suriati, 2015: NP189). De Cocker *et al.* (2008: 76) found step counts from pedometer wear to be moderately correlated (r_s = 0.37) with total PA and moderate activity classification (r_s = 0.31) reported from the IPAQ. A study conducted on young

Australian adults reported a moderate and significant correlation ($p < 0.001$) between the self-reported activity levels determined by IPAQ and daily steps recorded by pedometers over a seven-day period (Cleland *et al*., 2011: 498).

The IPAQ utilised self-reported data and therefore was a subjective tool to obtain the physical activity classification of participants (Hagstromer, Oja and Sjostrom, 2006:755). Subjective methods may introduce self-reporting bias which can occur due to factors such as social desirability, selective recall or sampling approach (Althubaiti, 2016: 212). Self-reporting bias is a common aspect of research studies and if used correctly can provide a wider variety of responses than other types of data collection tools (Althubaiti, 2016: 212). It has been found that individuals using the IPAQ tend to overestimate time spent performing high-intensity activity and underestimate time performing low and moderate-intensity activities (Hagstromer, Oja and Sjostrom, 2006:759). This contradicts the findings of this study where PA classification by the questionnaire correlated with the pedometer data.

5.9 Physical Efficiency Index

Similar results have been found by Lee, Roh and Kim (2016) and Sengupta, Chaudhuri and Bhattacharya (2013) where PEI was slightly higher, despite the samples of both studies consisting of different demographics to this study. Lee, Roh and Kim (2016: 643) investigated elementary school students and found that overweight/obese students and students of normal weight had a median PEI of 55.2 and 57.5 respectively as determined by the Harvard step test. The PEI of the elementary students was slightly higher than the median PEI of 50. The majority of participants (62.3%) in this study had a poor PEI, as the median of 50 is classified as poor, and 55 to 64 is classified as low-average PEI. Therefore, fewer students (31.1%) were considered as having low-average PEI in this study. Only 6.6% were found to have a high-average PEI in this study. An explanation for this could be the much younger age of the participants. Lee, Roh and Kim (2016) studied elementary students and it is known that during childhood, one is the most physically active (Anderssen *et al*., 1996: 352.; van Mechelen and Kemper, 1995: 135-158). Sengupta, Chaudhuri and Bhattacharya (2013) used the physical fitness index (PFI) to determine aerobic fitness which utilised the same equation as the PEI. They reported the median PFI to be

57.60 (Sengupta, Chaudhuri and Bhattacharya, 2013: 520). This could be due to the sample being young adults and thus much younger than this sample's study. It has been found that physical inactivity gradually rises during adulthood (Guthold *et al*., 2008: 489), which explains the lower PEI values of this study's older sample group.

5.10 Body Mass Index

Employees of a financial corporation in SA had similar results to our findings of the median BMI of participants being 27.3. The mean BMI of female employees was 29.4 and the male employees had a mean BMI of 27.1 (Coopoo, Constantinou and Rothberg, 2008: 41). The majority of the participants had BMI values that were classified as overweight and the female employees were bordering on obesity (Coopoo, Constantinou and Rothberg, 2008: 42) which is similar to the third (31.1%) of participants classified as pre-obese and the 18% categorised in obesity class I (Figure 4.6) in this study. A study conducted on healthcare workers in a public hospital in Pretoria revealed much higher BMI classifications among both medical and administration employees (Skaal and Pengpid, 2011: 566). Most of the healthcare workers were obese (37.5%) and 26.5% were overweight. Only 26.5% were of normal weight and 9.5% were severely obese (Skaal and Pengpid, 2011: 565). This is higher than our findings where the most common BMI classification was normal weight at 34.4% of the sample (Figure 4.6). An explanation for this could be the age range within the sample where most of the participants were 40 years of age or over (Skaal and Pengpid, 2011: 566) and it has been shown that metabolic rate lowers with age which can contribute to weight gain and increased BMI (Baum and Ruhm, 2009: 635; Guthold *et al*., 2008: 489). A study based on data from the South African National Health and Nutrition Examination Survey (SANHANES-1) conducted in 2012 revealed 42.1 % of the South African sample was of normal weight with 27.8% and 23.0% found to be obese and overweight respectively (Mchiza *et al*., 2015: 994). These results are similar to this study with regard to obese and overweight proportions with the exception of the higher proportion of participants of a normal weight. This could be attributed to the much larger sample of 6 411 South Africans than the sample of 61 in this study which could have led to the difference in results (Mchiza *et al*., 2015: 993).

5.11 Waist-to-hip ratio

Can *et al.* (2016: 940) reported waist-to-hip ratio of office workers in Turkey to be 0.8 across 20 to 29 years of age and 0.7 across 30 to 49 years of age. The 0.8 across 20 to 29 years of age is similar to the median waist-to-hip ratio of 0.83 found in this study. Despite the sample consisting of only women (Can *et al*., 2016: 938), the waist-to-hip ratios were very similar to this study across the age groups. 70% were considered at low risk for cardiovascular disease and diabetes (WHO, 2011: 12), which is only 4.4% higher than the 65.6% low risk in this study. Our findings also included that 18% of participants were considered high risk and 16.4% were at moderate risk. Coopoo, Constantinou and Rothberg (2008: 41) reported a similar median waist-to-hip ratio of office workers which was 0.82. Males were found to have a higher median waist-to-hip ratio of 0.88 (Coopoo, Constantinou and Rothberg, 2008: 41). Seibt, Lützkendorf and Thinschmidt (2005: 310-315) found the median waist-to-hip ratio to be 0.88, which is slightly higher than what was found in this study. The sample in the study consisted of only women, which could have contributed to the differing results as the sample in this study consisted of both women and men.

5.12 Percentage body fat

Our findings were similar to results found by Low, Gramlich and Engram (2007) who conducted a study on self-paced exercise in office workers in America. The median PBF of the sample of 32 office workers was 38.1 (Low, Gramlich and Engram, 2007: 103) which is similar to our findings of 38.3% median PBF. Interestingly, Coopoo, Constantinou and Rothberg (2008: 41) reported a much lower median PBF of 24.15% from office workers in SA. This contradicts our findings of over half (52.5%) of participants classified as having a very high PBF (Figure 4.7). An explanation for this could be that the mean age of the sample was a lot lower than this study at 33.3 years for females, and 30.7 years for males, respectively (Coopoo, Constantinou and Rothberg, 2008: 41). Our findings also included that over half (52.5%) of participants were classified as having a very high PBF (Figure 4.7) and 23% of the sample had a normal PBF (Figure 4.7). A lower median PBF of 30% was found by Pillay *et al*. (2015: 5) in South African workers. The mean age of participants was also lower at 37.4 years of age which was lower than the mean age of 44.1 years of age in this study.

Therefore, a younger sample could account for the lower PBF as it has been shown that body fat mass increases with age (St-Onge and Gallagher, 2010: 152).

5.13 Comparing body mass index, percentage body fat, waist-to-hip ratio and Physical Efficiency Index

Negative correlations were found between PEI and PBF (r = -0.369, p = 0.003). Another negative correlation was present between PEI and BMI (r = -0.308, p = 0.016). PEI (or Physical Fitness Index) requires regular aerobic exercise to rise due to greater oxygen intake (Khodnapur *et al.*, 2012: 137) and therefore aids in loss of BMI and body fat. Regular aerobic exercise has been shown to reduce body fat by decreasing production of enzymes which accumulate body fat, thus decreasing BMI and PBF (Marandi *et al*., 2012: S119). Therefore, individuals with greater PEI values exercise more frequently and burn more body fat and will have lower BMI and PBF values. These findings are supported by previous studies which found that regular aerobic exercise improved body fat composition and other anthropometric measures (Marandi *et al*., 2012: S118-25; Stasiulis, Vizbaraite and Mockus, 2010: 129-34; Suman, 2016: 41-44;).

A strong positive correlation was found between BMI and PBF (r = 0.789, p = <0.001). BMI uses the body mass (kg) and height (m^2) of an individual to determine whether they are overweight or obese (Gallagher *et al.*, 2000: 694). It is commonly assumed that body mass is closely related to body fatness and BMI has been shown to be an adequate measure of general adiposity (Prospective Studies Collaboration, 2009: 1083). Therefore, it is generally expected that BMI and PBF would be closely related and positively correlated. This is supported in previous studies which found BMI and body fat to be strongly correlated (Romero-Corral *et al*., 2008: 959–966; Gallagher *et al.,* 1996: 228-239).

BMI, obesity and waist-to-hip ratio measurements have been found to differ across certain ethnic population groups in South Africa (JEMDSA, 2012:S83). These groups include the African and coloured/Indian population. A higher prevalence of obesity has been found in coloured women at 26.3% and in African women at 31. 8% (JEMDSA, 2012:S83). WHO has reported that the relative PBF at different BMI values differs within populations due to physiological and environmental factors (WHO, Expert Consultation, 2004:160). Furthermore, a weaker relationship between obesity and diabetes has been reported in the Indian population at the same BMI cut-off values used on other ethnic groups (JEMDSA, 2012:S83). Due to this, WHO has suggested the use of lower BMI cut-off ranges when assessing Indian individuals. An Indian individual is considered ‘at risk’ with a BMI of 22-25 kg/m^2, and at ‘higher risk’ at ≥ 26 kg/m^2 (JEMDSA, 2012:S83). The International Diabetes Foundation has advised using a smaller waist circumference to determine risk which is ≥ 80 cm for women and ≥ 90 cm for men (IDF, 2006:11). Durban, Kwa-Zulu Natal, has been reported to have the most substantial Indian population in sub-Saharan Africa (South African History Online, 2019:1). Therefore these alternative cut-off ranges and measurements should have been implemented in this study and this will be a recommendation for future studies in the Kwa-Zulu Natal region.

5.14 Comparing pedometer-measured data with aerobic fitness

Significant relationships were found between PEI and average kilocalories (r = 0.295, p = 0.021) as well as with average distance (r = 0.293, p = 0.022) (Table 4.6). PEI indicates cardiorespiratory endurance (Lee, Roh and Kim, 2016: 642) as a measure of aerobic fitness and requires regular cardiovascular exercise for improvement (Frey, 2018: 1). Therefore, it can be expected that an individual with a higher PEI may expend more kilocalories and cover larger distances as it is required to maintain the PEI level. No other PA studies to our knowledge have attempted to determine if there is an association between PEI and pedometer-measured data.

5.15 Comparing pedometer-measured data with body mass index and percentage body fat

BMI and PBF were both negatively correlated with all pedometer-measured data (Table 4.7 and 4.8). This indicates that with greater activity there is higher energy expenditure and hence loss of body fat. Therefore, this shows that the more active individuals have a lower BMI. This is supported by previous findings that regular PA prevents weight gain (Waller *et al.*, 2008: 353–361) and helps to maintain a low BMI (Mustelin *et al*., 2009: 29–36).

BMI was negatively correlated with all the pedometer measurements and the strongest negative relationship was found to be with average daily steps (*r* = -0.296) (Table 4.7). This was followed by average daily aerobic steps (*r* = -0.244) and average distance covered (*r* = -0.236). It has been shown that overweight and obese individuals are largely physically inactive (Pietiläinen *et al*., 2008: 412), therefore this explains these findings that the higher an individual's BMI, the fewer steps and distance will be covered. Similar results were found by Tudor-Locke *et al*. (2001: 1573), where a negative relationship (*r* = -0.30) between steps per day and BMI was reported in 109 healthy American adults. A stronger negative relationship (*r* = -0.4005) was reported in sedentary office workers in Canada (Chan *et al*., 2003: 1565). This could be attributed to the demographics of the sample consisting of mostly women (86.8%) (Chan *et al*., 2003: 1563), whereas 67.2% of this study's sample were women. A slightly weaker, negative correlation was reported in a Japanese adult population in women (*r* = - 0.217) and men (*r* = - 0.116) (Mitsui *et al.*, 2008: 181). A possible explanation is that obesity is not as prevalent in the Japanese population (OECD, 2017: 3), therefore BMI is generally lower. In South African adults, a similar negative relationship was reported between BMI and average daily steps (*r* = -0.28) (Pillay *et al*., 2014: 17). Interestingly, a stronger negative correlation was found with average daily aerobic steps (*r* = - 0.31) than with average daily steps (Pillay *et al.,* 2014: 17).

PBF was negatively correlated with all pedometer-measured data with the strongest negative correlation being with average aerobic steps (*r* = -0.416) (Table 4.8). This was followed by average aerobic walking time (*r* = -0.409) and average daily steps (*r* = -0.380). These findings support the similar results found by Pillay *et al*. (2014), in a South African working population, where the strongest negative correlation was with average aerobic steps (*r* = –0.45), followed by average daily steps (*r* = –0.38). A weaker negative relationship was found with average aerobic walking time (*r* = –0.37) (Pillay *et al*., 2014: 17). Tudor-Locke *et al*. (2001: 1573) found a similar negative correlation to this study between steps per day and PBF (*r* = - 0.27) in American adults. Literature has shown that higher PA and less sedentary time is related to lower levels of adiposity (Du *et al*., 2013: 6; Pouliou *et al*., 2012: 275–278; Slentz *et al*., 2004: 36). Therefore, the results of this study support this literature. Contradictory results were found in a study conducted on African women in a South African, rural community (Cook, Alberts and Lambert, 2008: 1328). No correlation was found (p = 0.940) between PBF and average steps per day (Cook, Alberts and Lambert, 2008: 1328). This could be attributed to the differing demographic of the sample as it included only women living in a rural community. Very few participants owned motor vehicles, therefore walking was the main mode of transport (Cook, Alberts and Lambert, 2008: 1329).

5.16 Comparisons of physical activity level between groups of participants according to completion of the study

Three groups of participants were established according to level of study participation, namely Group A, Group B and Group C. Group A consisted of participants who only completed the IPAQ questionnaire in the study. Group B consisted of participants who completed the IPAQ questionnaire and pedometer wear. Group C consisted of the participants who completed all three data sets. Group C was found to have the highest percentage of highly active individuals at 44.3% (n = 27) while in Group A, only 11, 1% (n = 3) were considered to be highly physically active (Table 4.9). Group B contained a higher percentage of highly active individuals at 25% (n = 7). Group A consisted of the most inactive individuals, where 40.7% (n = 11) were classified as low activity. There was a significant difference ($p < 0.001$) across the three groups regarding PA level. High activity was more likely to be present in Group C and low activity more likely to be present in Group A.

Therefore, this suggested that the more an individual participated in the study, the more likely they were to be more active. The group of individuals who only completed the questionnaire in this study formed the largest percentage of low activity (40.7%) (Table 4.9). This could possibly be due to participation barriers similar to those found by worksite health programmes. Possible barriers that have been reported are low exercise confidence in individuals who are not regularly active, the attitude that PA is not a priority and lack of motivation to participate (Edmunds, Hurst and Harvey, 2013: 7). Other barriers found included lack of time and interest in participating (Bardus *et al.*, 2014: 17). It has been found that participation in programmes is related to the perception of already being healthy or sufficiently physically active and that worksite programmes tend to attract individuals who are already health-conscious and physically active (Bardus *et al*., 2014: 17). This is further supported by other studies in which individuals who participated in physical activity interventions were more physically active than the general population (Vandelanotte *et al*., 2005: 142; Spittaels *et al*., 2006: 388). Knowledge and insight into these barriers can inform healthcare practitioners and aid them in identifying and addressing these barriers with their patients when offering advice on how to achieve a healthier lifestyle and encourage increased PA in the workplace.

5.17 Summary

Overall, the self-reported data indicated that almost half (49.1%, Table 4.9) of the academic staff were adequately physically active but pedometer-measured data and measurements such as PEI and PBF contradicted this. The daily average of 4824.43 steps found in this study falls into the lower end of the range of between 4000 and 18 000 steps/day typically taken by adults which was determined by Tudor-Locke *et al.* (2011: 14). The average of 83 kilocalories expended daily was significantly lower than previous studies conducted on office workers (Coopoo, Constantinou and Rothberg, 2008: 41; (Matsuura *et al*., 1993: 89). The median PEI for participants was 50 and most participants (62.3%, n = 38) were classified as having a poor PEI. The median PBF was 38.3% with over half of participants classified as having a very high PBF (52.5%, n = 32). According to the IPAQ data, the majority of the academic staff at DUT were found to have sufficient PA levels and were classified as either moderately (49.1%) or highly (31.9%) physically active. However, the pedometer data measurements were all lower than those of previous pedometer-measured studies that were conducted (Miller and Brown, 2004: 220; Sitthipornvorakul, Janwantanakul and van der Beek, 2014: 2, 3; Coopoo, Constantinou and Rothberg, 2008: 41). It was found that as PA increased, so did all the median values of the pedometer measure data. The aerobic fitness of most participants was inadequate with the majority achieving a ‘poor’ PEI score of below 55 in the aerobic fitness assessment. It was found that participants who engaged in all parts of the study were more likely to be highly active than those that only participated in a portion of the study and that the more participants participated, the more active they were likely to be. There is a paucity of information from previous studies on self-reported PA, aerobic fitness and pedometer measured data of academic staff in a university setting. It has been found that academic staff have largely intensive workloads and with technology advances this has led to a unique work environment which is largely sedentary with low activity levels (Pirincci *et al*., 2008: 1261 – 1263). Academic staff therefore perform largely sedentary work similar to office workers (Hush *et al*., 2009: 1533). Hence, they are a reliable indicator of the office-bound adult and therefore a good representation of this population.

Chapter Six:
Conclusion, Limitations and Recommendations

6.1 Introduction

This chapter utilises the results and discussion of this study to form conclusions about the PA patterns and aerobic fitness of academic staff at a University of Technology in South Africa. This chapter includes key findings such as the PA classification of participants, the type of activity engaged in most commonly, self-reported fitness levels, trends found across the participation groups and relationships between pedometer-measured data and aerobic fitness measurements such as BMI, PBF, PEI and waist-to-hip ratio. Strengths of the study are highlighted, such as the comparisons drawn between the PA data. Limitations of the study are mentioned, such as low response rate, limited pedometers and student protests. Recommendations for future studies are included, such as using a larger study population, research assistant recruitment and electronic questionnaire use.

6.2 Key findings

- 49.1% of participants were classified as being moderately active, 31.9% were classified as highly active and 19.0% were classified as low or physically inactive, according to the IPAQ.
- Participants mostly engaged in MPA during the week (1800 MET minutes/week).
- The largest volume of PA was spent performing domestic and gardening/yard activities (1120 MET-minutes/week).
- A significant difference in self-reported fitness levels was found across the PA classifications (p = 0.003), with the most significant differences between the high and low groups (p = 0.01), and moderate and high groups (p = 0.04).
- A trend was found which indicated that as self-reported PA increased, so did all the median values of the pedometer measure data. An overall significant difference between the PA groups in terms of average aerobic steps (p = 0.028) and average aerobic walking time (p = 0.033) was present.

- Most participants (62.3%) were classified as having a poor PEI, followed by 31.1% of participants having a low-average PEI and only 6.6% were found to have a high-average PEI.
- Strong negative correlations were found between PEI and PBF (r = -0.369, p = 0.003). Another negative correlation was present between PEI and BMI (r = -0.308, p = 0.016). A strong positive correlation was found between BMI and PBF (r = 0.789, p = < 0.001).
- BMI was negatively correlated with average daily steps (r = -0.296, p = 0.020), average daily aerobic steps (r = -0.244, p = 0.059) and average distance covered (r = -0.236, p = 0.067).
- Significant relationships were found between PEI and average kilocalories (r = 0.295, p = 0.021) as well as with average distance (r = 0.293, p = 0.022).
- PBF was negatively correlated with average aerobic steps (r = -0.416, p = 0.001), average aerobic walking time (r = -0.409, p = 0.001) and average daily steps (r = -0.380, p = 0.003).
- There was a significant difference (p < 0.001) across the three participation groups regarding PA level, where high activity was more likely to be present in Group C and low activity more likely to be present in Group A.
- A trend was found where total PA MET-minutes/week increased from Groups A to B to C.

6.3 Strengths of the study

The study, in drawing comparisons between different sources of PA data, namely pedometer measurements, self-reported data and aerobic fitness measurements, is to our knowledge the first in SA.

6.4 Limitations

A low response rate led to the initial sample size of 213 participants being reduced to a smaller sample of 61 participants which lead to the study having a lower power regarding results and that the results of the study could not be generalised.

A limited number of pedometers were available to the researcher which resulted in a longer time required for data collection as each pedometer was with each participant for a week at a time.

Student protests during the fourth month of data collection resulted in staff members recruited during that month spending most of the day in their offices. Therefore, the physical activity data from the questionnaires and pedometers may not have reflected their usual daily activity routines during work hours.

Questionnaires were emailed to participants who were then required to scan and email the completed copy back to the researcher. This may have deterred academic staff from participating.

6.5 Recommendations

- A larger population of academic staff members should be included in future studies. This could include all campuses of the DUT and would provide a larger sample size and therefore more accurate data on the PA patterns and aerobic fitness of academic staff. To this end, academic staff from other South African universities should also be included in future studies.
- In future studies, research assistants should be recruited to aid researchers in contacting academic staff in order to decrease the time period of data collection.
- A larger number of pedometers should be available to the researcher in future studies, which would speed up the data collection process.
- Future studies should attempt to conduct data collection during normal term time when the academic staff are engaging in their normal, daily lecturing routine without any disruptions such as student protests.
- Questionnaires could be available electronically in future studies, such as being provided in a link in an email. Staff could easily complete the questionnaire and it would be sent back to the researcher automatically.
- This study did not use the lower BMI cut-off ranges and smaller waist circumference measurement ranges when assessing Indian participants in the sample and therefore this is recommended in future studies to improve

accuracy of data collection specific to the demographic of the Kwa-Zulu Natal region.

6.6 Conclusion

The results of this study revealed that almost half the participants were at least moderately active according to self-reported data. This is higher than previous studies performed nationally and globally among office workers and healthcare workers. Despite this, most participants exhibited poor aerobic fitness when performing the aerobic fitness assessment. Self-reported data indicated that the largest proportion of participants in this study were moderately active which contradicted the objective pedometer data (which was lower than previous studies conducted) and the poor PEI levels found in this study. Therefore this indicates that participants over-reported their PA level which is aligned with the limitations of the IPAQ discussed in 3.14. Due to the small sample size of the study, these results cannot be generalised to the greater population. The study therefore illustrates the need for academic staff members of DUT to improve their aerobic fitness, step count and aerobic walking time on a daily basis. This will benefit the health of academic staff. This was seen in the strong negative correlations found between step counts and aerobic walking time with BMI and PBF as well as between PEI and PBF. By increasing step count and aerobic walking time, staff could potentially maintain a healthy BMI and PBF which could reduce risk of co-morbid pathologies. This would contribute to a healthy lifestyle which should be encouraged. Therefore, it is recommended that employers and management of tertiary institutions consider these findings and use them to implement worksite physical activity programmes in order to improve PA of workers and academic staff. This could ultimately positively impact well-being, and consequent work performance. Chiropractors offer holistic management and lifestyle advice to their patients (CASA, 2020:1), therefore they can encourage patients to be more active and discuss possible solutions and plans to do so with patients. They can organise campaigns in the community encouraging increased PA and offer incentives such as step-count competitions. Healthcare practitioners can offer support and advice to the community through offering blogposts, leaflets and posters educating and encouraging patients and the public to be more active.

References

Aandstad, A., Holme, I., Berntsen, S. and Anderssen, S. A. 2011. Validity and reliability of the 20-meter shuttle run test in military personnel. *Military medicine*, 176 (5): 513-518. Available: https://academic.oup.com/milmed/article-pdf/176/5/513/20585198/milmed-d-10-00373.pdf (Accessed 2 April 2019).

Ainsworth, B. E., Haskell, W. L., Whitt, M. C., Irwin, M. L., Swartz, A. M., Strath, S. J., O Brien, W. L., Bassett, D. R., Schmitz, K. H., Emplaincourt, P. O. and Jacobs, D. R. 2000. Compendium of physical activities: an update of activity codes and MET intensities. *Medicine and science in sports and exercise*, 32 (9; Suppl. 1): 498-504. Available: https://partner.ergotron.com/portals/0/literature/compendium-of-physical-activities.pdf (Accessed 18 March 2019).

Alberti, K., Eckel, R. H., Grundy, S. M., Zimmet, P. Z., Cleeman, J. I., Donato, K. A., Fruchart, J. C., James, W. P. T., Loria, C. M. and Smith Jr, S. C. 2009. Harmonizing the metabolic syndrome: a joint interim statement of the international diabetes federation task force on epidemiology and prevention; national heart, lung, and blood institute; American heart association; world heart federation; international atherosclerosis society; and international association for the study of obesity. Circulation, 120 (16): 1640-1645.

Allender, S., Cowburn, G. and Foster, C. 2006. Understanding participation in sport and physical activity among children and adults: a review of qualitative studies. *Health education research*, 21 (6): 826-835. Available: https://pdfs.semanticscholar.org/1a02/99a5a41b092b635ec8413b42825468fd6a69.pdf (Accessed 6 November 2018).

Althubaiti, A. 2016. Information bias in health research: definition, pitfalls, and adjustment methods. *Journal of Multidisciplinary Healthcare*, 9: 211-217. Available: https://pdfs.semanticscholar.org/7a99/c91b1a6439999249bef4cc48284f5afdc042.pdf (Accessed 19 February 2020).

Alves AJ, Viana JL, Cavalcante SL, Oliveira NL, Duarte JA, Mota J, Oliveira J, Ribeiro F.2016. Physical activity in primary and secondary prevention of cardiovascular disease: overview updated. *World Journal of Cardiology*,8:575-83.Available: https://www.researchgate.net/profile/Jose_Oliveira13/publication/309445138_Physical_activity_in_primary_and_secondary_prevention_of_cardiovascular_disease_Overview_updated/links/5813277f08ae90acb23a2771.pdf (Accessed on 24 February 2020).

American College of Sports Medicine. 2018. *ACSM's exercise testing and prescription*.10th ed.Philadelphia, PA: Wolters Kluwer.

American Heart Association. 2016. *About Metabolic Syndrome*. Available: https://www.heart.org/en/health-topics/metabolic-syndrome/about-metabolic-syndrome (Accessed 13 January 2019).

Anderssen, N., Jacobs Jr, D. R., Sidney, S., Bild, D. E., Stemfeld, B., Slattery, M. L. and Hannan, P. 1996. Change and secular trends in physical activity patterns in young adults: a seven-year longitudinal follow-up in the Coronary Artery Risk Development in Young Adults Study (CARDIA). *American journal of epidemiology*, 143 (4): 351-362. Available: https://academic.oup.com/aje/article-pdf/143/4/351/267200/143-4-351.pdf (Accessed 8 October 2018).

Armstrong LE, Brubaker PH, Whaley MH, Otto RM, American College of Sports Medicine. 2005.*ACSM's Guidelines for Exercise Testing and Prescription.* 7th ed. Baltimore (MD): Lippincott Williams & Wilkins:366.

Armstrong, N. and Welsman, J. R. 2007. Aerobic fitness: what are we measuring? *Pediatric Fitness*, Karger Publishers, 50: 5-25. Available: https://www.researchgate.net/profile/Neil_Armstrong/publication/6420832_Aerobic_fitness_what_are_we_measuring/links/0912f510bde97e60aa000000/Aerobic-fitness-what-are-we-measuring.pdf#page=16 (Accessed 4 April 2019).

Australian Bureau of Statistics. 2013. *What is the median?* Available: https://www.abs.gov.au/websitedbs/a3121120.nsf/home/statistical+language+-+measures+of+central+tendency (Accessed 31 July 2019).

Bailey, R. 2005. Evaluating the relationship between physical education, sport and social inclusion. *Educational review*, 57 (1): 71-90. Available: https://www.researchgate.net/profile/Richard_Bailey18/publication/240525769_Evalua ting_the_relationship_between_physical_education_sport_and_social_inclusion/links/5671d7ad08aeb8b21c6dd290.pdf (Accessed 10 April 2019).

Ball, K., Crawford, D. and Owen, N. 2000. Obesity as a barrier to physical activity. *Australian and New Zealand journal of public health*, 24 (3): 331-333. Available: https://onlinelibrary.wiley.com/doi/pdf/10.1111/j.1467-842X.2000.tb01579.x (Accessed 25 November 2018).

Bardus, M., Blake, H., Lloyd, S. and Suzanne Suggs, L. 2014. Reasons for participating and not participating in a e-health workplace physical activity intervention: A qualitative analysis. *International Journal of Workplace Health Management*, 7 (4): 229-246. Available: http://eprints.nottingham.ac.uk/38428/1/MM8_reasons_IJWHM_7%203%202014_revised_v3_mb.pdf (Accessed 7 March 2019).

Barkhuizen, N. and Rothmann, S. 2008. Occupational stress of academic staff in South African higher education institutions. *South African Journal of Psychology,* 38 (2): 321-336. Available: http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.860.4479&rep = rep1&type=pdf (Accessed on 26 May 2019).

Bassett Jr, D. R. and Strath, S. J. 2002. *Use of pedometers to assess physical activity. Physical activity assessments for health-related research*. Champaign, Illinois: Human Kinetics Publishers Inc.

Baum II, C. L. and Ruhm, C. J. 2009. Age, socioeconomic status and obesity growth. *Journal of health economics*, 28 (3): 635-648. Available: https://core.ac.uk/download/pdf/6586824.pdf (Accessed 4 June 2019)

Bauman, A. E., Reis, R. S., Sallis, J. F., Wells, J. C., Loos, R. J., Martin, B. W. and Group, L. P. A. S. W. 2012. Correlates of physical activity: why are some people physically active and others not? *The Lancet*, 380 (9838): 258-271. Available: https://www.sciencedirect.com/science/article/pii/S0140673612607351 (Accessed 17 October 2018).

Bauman, A., Ainsworth, B. E., Sallis, J. F., Hagströmer, M., Craig, C. L., Bull, F. C., Pratt, M., Venugopal, K., Chau, J. and Sjöström, M. 2011. The descriptive epidemiology of sitting: a 20-country comparison using the International Physical Activity Questionnaire (IPAQ). *American journal of preventive medicine*, 41 (2): 228-235. Available: https://www.sciencedirect.com/science/article/pii/S074937971100300X (Accessed 21 September 2018).

Beavis AL, Smith AJ, Fader AN. 2016.Lifestyle changes and the risk of developing endometrial and ovarian cancers: opportunities for prevention and management. *International Journal of Womens Health*, 8:151-67.Available: https://www.researchgate.net/profile/Anna_Smith32/publication/303470914_Lifestyle_changes_and_the_risk_of_developing_endometrial_and_ovarian_cancers_Opportunities_for_prevention_and_management/links/57ba258e08ae14f440bd8eef/Lifestyle-changes-and-the-risk-of-developing-endometrial-and-ovarian-cancers-Opportunities-for-prevention-and-management.pdf (Accessed on 24 February 2020).

Beestone, C.2018. *Bioelectrical Impedance Analysis (BIA).*Available: https://www.scienceforsport.com/bioelectrical-impedance-analysis-bia/ (Accessed on 27 February 2020).

Bhagani, S., Kapil, V. and Lobo, M. D. 2018. Hypertension. *Medicine*, 46 (9): 509-515. Available: https://www.researchgate.net/publication/326637618_Hypertension (Accessed 24 September 2018).

Bi, Y., Wang, T., Xu, M., Xu, Y., Li, M., Lu, J., Zhu, X. and Ning, G. 2012. Advanced research on risk factors of type 2 diabetes. *Diabetes/Metabolism Research and Reviews*, 28: 32-39. Available: https://onlinelibrary.wiley.com/doi/pdf/10.1002/dmrr.2352 (Accessed 13 August 2018).

Biernat, E., Tomaszewski, P. and Milde, K. 2010. Physical activity of office workers. *Biology of Sport*, 27 (4): 289-296. Available: https://www.researchgate.net/profile/Elzbieta_Biernat/publication/49600295_Physical_activity_of_office_workers/links/02bfe5100e2dc343c6000000.pdf (Accessed on 23 November 2018).

Boström, P., Wu, J., Jedrychowski, M. P., Korde, A., Ye, L., Lo, J. C., Rasbach, K. A., Boström, E. A., Choi, J. H. and Long, J. Z. 2012. A PGC1-α-dependent myokine that drives brown-fat-like development of white fat and thermogenesis. *Nature*, 481 (7382): 463. Available:

https://www.researchgate.net/profile/Mark_Jedrychowski/publication/221740266_A_PGC1-dependent_myokine_that_drives_browning_of_white_fat_and_thermogenesis/links/0f3175300f3f4efd52000000.pdf (Accessed 28 September 2018).

Bosy-Westphal, A., Later, W., Hitze, B., Sato, T., Kossel, E., Glüer, C.C., Heller, M. and Müller, M. J. 2008. Accuracy of bioelectrical impedance consumer devices for measurement of body composition in comparison to whole body magnetic resonance imaging and dual X-ray absorptiometry. *Obesity facts*, 1 (6): 319-324. Available: https://www.researchgate.net/profile/Manfred_Mueller3/publication/40870133_Accuracy_of_Bioelectrical_Impedance_Consumer_Devices_for_Measurement_of_Body_Composition_in_Comparison_to_Whole_Body_Magnetic_Resonance_Imaging_and_Dual_X-Ray_Absorptiometry/links/54a13fbe0cf256bf8bae7985.pdf (Accessed 5 March 2019).

Bradshaw D, Norman R, Pieterse D, Levitt NS, South African Comparative Risk Assessment Collaborating Group. Estimating the burden of disease attributable to diabetes in South Africa in 2000. *South African Medical Journal*. 2007; 97:700-706. Available: https://www.ajol.info/index.php/samj/article/viewFile/127307/128345 (Accessed on 19 February 2020).

Brown, S. A. 2005. Measuring perceived benefits and perceived barriers for physical activity. *American journal of health behaviour*, 29 (2): 107-116. Available: https://pdfs.semanticscholar.org/70eb/70a6398baaa6e85b9e6774686b49043a8808.pdf (Accessed 3 November 2018).

Brown, W. J., Miller, Y. D. and Miller, R. 2003. Sitting time and work patterns as indicators of overweight and obesity in Australian adults. *International Journal of Obesity*, 27 (11): 1340-1346. Available: https://pdfs.semanticscholar.org/70eb/70a6398baaa6e85b9e6774686b49043a8808.pdf (Accessed on 25 September 2018).

Buchner, A., Erdfelder, E., Faul, F., Lang, A. 2020. *G*Power: Statistical Power Analyses for Windows and Mac*. Available:

http://www.psychologie.hhu.de/arbeitsgruppen/allgemeine-psychologie-und-arbeitspsychologie/gpower.html (Accessed 20 February 2020).

Buckworth, J. and Dishman, R. 1999. Determinants of physical activity: research to application. *Lifestyle medicine,* January/February: 1016-1027.

Bull, F. C., Armstrong, T. P., Dixon, T., Ham, S., Neiman, A. and Pratt, M. 2004. Physical inactivity. *Comparative quantification of health risks global and regional burden of disease attributable to selected major risk factors*. Geneva: World Health Organization.

Burgess, L. 2017. *Why is the hip-waist ratio important?* Available: https://www.medicalnewstoday.com/articles/319439.php (Accessed 7 April 2019).

Burnstein, B. D., Steele, R. J. and Shrier, I. 2011. Reliability of Fitness Tests Using Methods and Time Periods Common in Sport and Occupational Management. *Journal of Athletic Training*, 46(5): 505-513. Available: http://www.natajournals.org/doi/abs/10.4085/1062-6050-46.5.505 (Accessed 29 April 2016).

Campbell, M. K., Tessaro, I., DeVellis, B., Benedict, S., Kelsey, K., Belton, L. and Sanhueza, A. 2002. Effects of a tailored health promotion program for female blue-collar workers: health works for women. *Preventive medicine*, 34 (3): 313-323. Available:https://www.sciencedirect.com/science/article/pii/S0091743501909880 (Accessed 28 September 2018).

Can, S., Gündüz, N., Arslan, E., Biernat, E., Ersöz, G. and Kilit, B. 2016. Multi-instrument assessment of physical activity in female office workers. *International journal of occupational medicine and environmental health*, 29 (6): 937-945. Available: http://ijomeh.eu/pdf-60993-6360?filename=Multi-instrument.pdf (Accessed 19 November 2018).

Cartee, G. D. and Wojtaszewski, J. F. P. 2007. Role of Akt substrate of 160 kDa in insulin-stimulated and contraction-stimulated glucose transport. *Applied Physiology, Nutrition, and Metabolism*, 32 (3): 557-566. Available: https://www.nrcresearchpress.com/doi/abs/10.1139/h07-026 (Accessed 17 October 2018).

Caspersen, C. 1994. International activity patterns: a methodological perspective. *Advances in exercise adherence* (1994)*:* 73-110.

Caspersen, C. J., Pereira, M. A. and Curran, K. M. 2000. Changes in physical activity patterns in the United States, by sex and cross-sectional age. *Medicine & Science in Sports & Exercise*, 32 (9): 1601-1609. Available: https://pdfs.semanticscholar.org/bed1/9c65d5e453aeb277cfc4aeec9534c6def28c.pdf (Accessed on 22 March 2019).

Caspersen, C. J., Powell, K. E. and Christenson, G. M. 1985. Physical activity, exercise, and physical fitness: definitions and distinctions for health-related research. *Public Health Reports,* 100(2): 126-131. Available: http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1424733/pdf/pubhealthrep00100-0016.pdf (Accessed 29 April 2016).

Cecchini, M., Sassi, F., Lauer, J. A., Lee, Y. Y., Guajardo-Barron, V. and Chisholm, D. 2010. Tackling of unhealthy diets, physical inactivity, and obesity: health effects and cost-effectiveness. *The* Lancet*,* 376 (9754): 1775-1784. Available: https://www.sciencedirect.com/science/article/pii/S0140673610615140 (Accessed 14 September 2018).

Chan, C. B., Spangler, E., Valcour, J. and Tudor-Locke, C. 2003. Cross-sectional relationship of pedometer-determined ambulatory activity to indicators of health. *Obesity Research*, 11 (12): 1563-1570. Available: https://onlinelibrary.wiley.com/doi/full/10.1038/oby.2003.208 (Accessed 5 June 2019).

Chan, J. C., Malik, V., Jia, W., Kadowaki, T., Yajnik, C. S., Yoon, K.-H. and Hu, F. B. 2009. Diabetes in Asia: epidemiology, risk factors, and pathophysiology. *Jama*, 301 (20): 2129-2140. Available: https://pdfs.semanticscholar.org/5bfd/7e45d546191cb153894e8511e0040f6eb97f.pdf (Accessed 8 September 2018).

Charlton-Menys, V. and Durrington, P. 2008. Human cholesterol metabolism and therapeutic molecules. *Experimental physiology*, 93 (1): 27-42. Available: https://physoc.onlinelibrary.wiley.com/doi/pdf/10.1113/expphysiol.2006.035147 (Accessed 29 September 2018).

Chau, J. Y., van der Ploeg, H. P., Merom, D., Chey, T. and Bauman, A. E. 2012. Cross-sectional associations between occupational and leisure-time sitting, physical activity and obesity in working adults. *Preventive medicine*, 54 (3-4): 195-200. Available: https://www.ncbi.nlm.nih.gov/pubmed/22227284 (Accessed 8 June 2019).

Chegg Inc. 2019. *Harvard Step Test*. Available: https://www.chegg.com/homework-help/harvard-step-test-harvard-step-test-developed4-1943-physical-chapter-2.1-problem-1e-solution-9781111808921-exc (Accessed 17 February 2019).

Chia, M., Chen, B. and Suppiah, H. T. 2015. Office sitting made less sedentary: A future-forward approach to reducing physical inactivity at work. *Montenegrin Journal of Sports Science and Medicine*, 4(2): 5-10. Available: http://www.mjssm.me/clanci/MJSSM_Sept_2015_Chia.pdf (Accessed 30 April 2016).

Chiropractic Association of South Africa. 2020. *Conditions and Treatment.* Available: https://chiropractic.co.za/conditions-treatment/ (Accessed 19 February 2020).

Chiu, T. T. W. and Lam, P. K. W. 2007. The Prevalence of and Risk Factors for Neck Pain and Upper Limb Pain among Secondary School Teachers in Hong Kong. *Journal of Occupational Rehabilitation*, 17(1): 19-32. Available: http://dx.doi.org/10.1007/s10926-006-9046-z (Accessed 27 May 2018).

Christie, W. W. 2018. *High-Density Lipoprotein and Cholesterol Metabolism*. Available: http://www.lipidhome.co.uk/lipids/simple/lipoprot/index.htm#hdl (Accessed 6 October 2018).

Church, T. S., Blair, S. N., Cocreham, S., Johannsen, N., Johnson, W., Kramer, K., Mikus, C. R., Myers, V., Nauta, M. and Rodarte, R. Q. 2010. Effects of aerobic and resistance training on hemoglobin A1c levels in patients with type 2 diabetes: a randomized controlled trial. *Jama,* 304 (20): 2253-2262. Available: https://jamanetwork.com/journals/jama/articlepdf/186960/joc05148_2253_2262.pdf (Accessed 18 September 2018).

Cleland, V. J., Schmidt, M. D., Salmon, J., Dwyer, T. and Venn, A. 2011. Correlates of pedometer-measured and self-reported physical activity among young Australian adults. *Journal of science and medicine in sport*, 14 (6): 496-503. Available:

https://www.sciencedirect.com/science/article/pii/S1440244011000818 (Accessed 26 June 2019).

Clemes, S. A., O'Connell, S. E. and Edwardson, C. L. 2014. Office workers' objectively measured sedentary behavior and physical activity during and outside working hours. *Journal of Occupational and Environmental Medicine*, 56 (3): 298-303. Available: https://dspace.lboro.ac.uk/dspace-jspui/bitstream/2134/15587/3/Clemes%20et%20al%20%20Accelerometer%20measured%20SB%20and%20PA%20during%20and%20outside%20working%20hours%20-%20IR.pdf (Accessed 16 June 2019).

Coakley, J. 2007. *Sports in Society: Issues and Controversies*. New York: McGraw Hill.

Colberg, S. R., Sigal, R. J., Yardley, J. E., Riddell, M. C., Dunstan, D. W., Dempsey, P. C., Horton, E. S., Castorino, K. and Tate, D. F. 2016. Physical activity/exercise and diabetes: a position statement of the American Diabetes Association. *Diabetes Care*, 39 (11): 2065-2079. Available: https://care.diabetesjournals.org/content/diacare/39/11/2065.full.pdf (Accessed 13 October 2018).

Collins English Dictionary. 2018. *Definition of 'cholesterol'*. Available: https://www.collinsdictionary.com/dictionary/english/cholesterol (Accessed 6 November 2018).

Committee of the Japan Diabetes Society on the Diagnostic Criteria of Diabetes Mellitus. 2010. Report of the committee on the classification and diagnostic criteria of diabetes mellitus. *Journal of diabetes investigation*, 1 (5): 212-228. Available: https://scholar.google.co.za/scholar?output=instlink&q=info: hOarDLe8XlEJ: scholar.google.com/&hl=en&as_sdt=0,5&scillfp = 11985327954638879922&oi=lle (Accessed on 20 July 2018).

Conn, V. S., Hafdahl, A. R., Cooper, P. S., Brown, L. M. and Lusk, S. L. 2009. Meta-analysis of workplace physical activity interventions. *American journal of preventive medicine*, 37 (4): 330-339. Available: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2758638/ (Accessed 25 September 2018).

Cook, I., Alberts, M. and Lambert, E. 2008. Relationship between adiposity and pedometer-assessed ambulatory activity in adult, rural African women. *International Journal of Obesity*, 32 (8): 1327. Available: https://www.nature.com/articles/ijo200826 (Accessed 7 October 2018).

Coopoo, Y., Constantinou, D. and Rothberg, A. D. 2008. Energy expenditure in office workers with identified health risks. *South African Journal of Sports Medicine*, 20 (2): 40-43. Available: https://www.ajol.info/index.php/sasma/article/view/31928 (Accessed 27 July 2018).

Corder, K., Brage, S. and Ekelund, U. 2007. Accelerometers and pedometers: methodology and clinical application. *Current Opinion in Clinical Nutrition & Metabolic Care*, 10 (5): 597-603. Available: https://pdfs.dev-journals2013.lww.com/co-clinicalnutrition/2007/09000/Accelerometers_and_pedometers__methodology_and.00006.pdf (Accessed on 13 July 2019).

Dalal, S., Beunza, J. J., Volmink, J., Adebamowo, C., Bajunirwe, F., Njelekela, M., Mozaffarian, D., Fawzi, W., Willett, W. and Adami, H. O. 2011. Non-communicable diseases in sub-Saharan Africa: what we know now*. International journal of epidemiology*, 40 (4): 885-901. Available: https://www.researchgate.net/profile/Clement_Adebamowo/publication/51084001_Non-communicable_diseases_in_sub-Saharan_Africa_What_we_know_now/links/09e4150ece18e2d3de000000.pdf (Accessed 27 August 2018).

De Bourdeaudhuij, I. and Sallis, J. 2002. Relative contributions on psychosocial variables to the explanation of physical activity in three population-based adult samples. *Preventive Medicine*, 34: 279-288. Available: https://www.sciencedirect.com/science/article/pii/S009174350190979X (Accessed 7 November 2018).

Department of Health, South Africa. 2016. *Strategy for prevention and control of obesity in South Africa*. Available: http://www.health.gov.za/index.php/2014-03-17-09-09-38/policies-and-guidelines/category/327-2017po?download=1832: strategy-for-the-prevention-and-control-of-obesity-in-south-africa (Accessed 12 September 2019).

Department of Health .1991.Dietary Reference Values for Food, Energy and Nutrients for the United Kingdom. HMSO: London.Department of Health Health Survey for England 1998. The Stationery Office: London. Available: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/743790/Dietary_Reference_Values_-_A_Guide__1991_.pdf (Accessed on 21 February 2020).

Department of Health, United Kingdom. 2004. *At Least Five a Week. Evidence on the Impact of Physical Activity and Its Relationship to Health*. London: Department of Health. Available: https://www.staffs.ac.uk/images/First%20steps%20SHE%20CMO%2520Report%2520Summary_tcm68-26370.pdf (Accessed 2 June 2019).

Ding, D., Sallis, J. F., Kerr, J., Lee, S. and Rosenberg, D. E. 2011. Neighborhood environment and physical activity among youth: a review. *American journal of preventive medicine*, 41 (4): 442-455. Available: http://willsull.net/la570/ewExternalFiles/neighbouhood%20environment%20and%20physical%20activity%20among%20youth.pdf (Accessed 16 August 2018).

Dipietro, L., Caspersen, C. J., Ostfeld, A. M. and Nadel, E. R. 1993. A survey for assessing physical activity among older adults. *Medicine & Science in Sports & Exercise,* 25(5): 628-42. Available: https://www.ncbi.nlm.nih.gov/pubmed/8492692 (Accessed 7 September 2018).

Doll-Tepper, G. and Scoretz, D., 2001. *World Summit on Physical Education–Proceedings*. Schorndorf: Hofmann

Donnelly, J. E., Hillman, C. H., Castelli, D., Etnier, J. L., Lee, S., Tomporowski, P., Lambourne, K. and Szabo-Reed, A. N. 2016. Physical activity, fitness, cognitive function, and academic achievement in children: a systematic review. *Medicine and science in sports and exercise*, 48 (6): 1197. Available: http://labs.kch.illinois.edu/Research/Labs/neurocognitive-kinesiology/files/Articles/Physical_Activity,_Fitness,_Cognitive_Function,.27.pdf (Accessed 14 August 2018).

Du, H., Bennett, D., Li, L., Whitlock, G., Guo, Y., Collins, R., Chen, J., Bian, Z., Hong, L.-S. and Feng, S. 2013. Physical activity and sedentary leisure time and their associations with BMI, waist circumference, and percentage body fat in 0.5 million adults: The China Kadoorie Biobank study. *The American journal of clinical nutrition*, 97(3): 487-496. Available: https://www.researchgate.net/profile/Huaidong_Du/publication/235385230_Physical_activity_and_sedentary_leisure_time_and_their_associations_with_BMI_waist_circumference_and_percentage_body_fat_in_05_million_adults_The_China_Kadoorie_Biobank_study1-3/links/0c96052bdad06eb500000000/Physical-activity-and-sedentary-leisure-time-and-their-associations-with-BMI-waist-circumference-and-percentage-body-fat-in-05-million-adults-The-China-Kadoorie-Biobank-study1-3.pdf (Accessed 4 June 2019).

Dugdill, L., Brettle, A., Hulme, C., McCluskey, S. and Long, A. 2008. Workplace physical activity interventions: a systematic review. *International Journal of Workplace Health Management*, 1 (1): 20-40. Available: http://eprints.hud.ac.uk/6052/1/McCluskeyWorkplace.pdf (Accessed 17 November 2019).

Dunn, A. L., Trivedi, M. H. and O'Neal, H. A. 2001. Physical activity dose-response effects on outcomes of depression and anxiety. *Database of Abstracts of Reviews of Effects (DARE): Quality-assessed Reviews*, 33(Suppl. 6): S587-S597. Available: https://www.ncbi.nlm.nih.gov/books/NBK68727/ (Accessed 7 November 2019).

Dupuis, J., Langenberg, C., Prokopenko, I., Saxena, R., Soranzo, N., Jackson, A. U., Wheeler, E., Glazer, N. L., Bouatia-Naji, N. and Gloyn, A. L. 2010. New genetic loci implicated in fasting glucose homeostasis and their impact on type 2 diabetes risk. *Nature genetic*, 42 (2): 105. Available: https://www.ncbi.nlm.nih.gov/pubmed/20081858 (Accessed 15 November 2018).

Durrington, P. 2003. Dyslipidaemia. *The Lancet* (online), 362 (9385): 717-731. Available: https://www.ncbi.nlm.nih.gov/pubmed/12957096 (Accessed 6 September 2018).

Edmunds, S., Hurst, L. and Harvey, K. 2013. Physical activity barriers in the workplace: an exploration of factors contributing to non-participation in a UK workplace physical activity intervention. *International Journal of Workplace Health Management*, 6 (3): 227-240. Available:

https://westminsterresearch.westminster.ac.uk/download/be2c9a37896fea124ca742f90ed3b8a42fe186057da837c4bc00e302102f86b8/103983/Edmunds_et_al_2012_final_author.pdf (Accessed 27 July 2018).

Eisenmann, J. C., Laurson, K. R. and Welk, G. J. 2011. Aerobic fitness percentiles for US adolescents. *American journal of preventive medicine*, 41 (4): S106-S110. Available: https://www.cooperinstitute.org/vault/2440/web/files/790.pdf (Accessed 5 March 2019).

Erick, P. N. and Smith, D. R. 2011. A systematic review of musculoskeletal disorders among school teachers. *BMC musculoskeletal disorders*, 12 (1): 260. Available:https://bmcmusculoskeletdisord.biomedcentral.com/articles/10.1186/1471-2474-12-260 (Accessed 27 July 2018).

Esterhuizen, T. (tonya.esterhuizen7@gmail.com), 17 April 2019. Statistical methodology. Emailed to V Roelofse (valeskaroelofse@gmail.com). (Accessed 17 April 2019).

Faghri, P. D., Omokaro, C., Parker, C., Nichols, E., Gustavesen, S. and Blozie, E. 2008. E-technology and pedometer walking program to increase physical activity at work. *The journal of primary prevention*, 29 (1): 73-91. Available: https://www.researchgate.net/profile/Dr_Pouran_Faghri/publication/5637262_E-technology_and_Pedometer_Walking_Program_to_Increase_Physical_Activity_at_Work/links/0deec51565adb6a931000000/E-technology-and-Pedometer-Walking-Program-to-Increase-Physical-Activity-at-Work.pdf (Accessed 6 May 2019).

Ferreira, E. and Strydom, E. 2016. Managing work-related musculoskeletal disorders in the virtual office. *Journal of Contemporary Management*, 13 (1): 117-143. Available: https://www.ingentaconnect.com/content/sabinet/jcman/2016/00000013/00000001/art00005 (Accessed 27 August 2018).

Fox, K. R. 2003. The effects of exercise on self-perceptions and self-esteem. In: Physical activity and psychological well-being. *Routledge,* 100-119. Available: https://www.taylorfrancis.com/books/e/9780203468326/chapters/10.4324/9780203468326-16 (Accessed 28 November 2018).

Franklin, B. A., Swain, D. P. and Shephard, R. J. 2003. New Insights in the Prescription of Exercise for Coronary Patients. *The Journal of Cardiovascular Nursing*, 18 (2): 116-123. Available: https://journals.lww.com/jcnjournal/Fulltext/2003/04000/New_Insights_in_the_Prescription_of_Exercise_for.7.aspx (Accessed 5 April 2019).

Friedenreich, C. M. and Orenstein, M. R. 2002. Physical activity and cancer prevention: etiologic evidence and biological mechanisms. *The Journal of nutrition* , 132 (11): 3456S-3464S. Available: https://academic.oup.com/jn/article-abstract/132/11/3456S/4687180 (Accessed 26 August 2018).

Gallagher, D., Heymsfield, S. B., Heo, M., Jebb, S. A., Murgatroyd, P. R. and Sakamoto, Y. 2000. Healthy percentage body fat ranges: an approach for developing guidelines based on body mass index. *The American journal of clinical nutrition*, 72 (3): 694-701. Available: https://www.sportmedizin-hamburg.com/images/pdfs/Kalopermetrie_Gallagher2000.pdf (Accessed 17 July 2019).

Garber CE, Blissmer B, Deschenes MR, *et al*. American College of Sports Medicine position stand. The quantity and quality of exercise for developing and maintaining cardiorespiratory, musculoskeletal, and neuromotor fitness in apparently healthy adults:guidance for prescribing exercise. *Medicine and science in sports and exercise*. 2011;43(7):1334–59.

Gartenmann, C., Kirchberger, I., Herzig, M., Baumgartner, I., Saner, H., Mahler, F. and Meyer, K. 2002. Effects of exercise training program on functional capacity and quality of life in patients with peripheral arterial occlusive. *Vasa,* 31: 29-34. Available: https://www.researchgate.net/profile/Inge_Kirchberger/publication/11414708_Effects_of_exercise_training_program_on_functional_capacity_and_quality_of_life_in_patients_with_peripheral_arterial_occlusive_disease_Evaluation_of_a_pilot_project/links/0c960516cebce9566a000000.pdf (Accessed 5 July 2018).

Gayen, A., Bandopadhyay, S. and Mitra, S. 2013. Estimation of VO2 Max by different exercise testing methods. *International Journal of Health*, Physical Education & Computer Science in Sports, 12 (1): 101-104.

Gerrard, P. 2012. Accuracy of self-reported physical activity as an indicator of cardiovascular fitness depends on education level. *Archives of physical medicine and rehabilitation*, 93 (10): 1872-1874. Available: https://www.ncbi.nlm.nih.gov/pubmed/22525669 (Accessed on 23 June 2019).

Gilson, N. D., Puig-Ribera, A., McKenna, J., Brown, W. J., Burton, N. W. and Cooke, C. B. 2009. Do walking strategies to increase physical activity reduce reported sitting in workplaces: a randomized control trial. *International Journal of Behavioural Nutrition and Physical Activity*, 6 (1): 43. Available: https://core.ac.uk/download/pdf/29019049.pdf (Accessed 7 March 2019).

Gowans, S., DeHueck, A., Voss, S., Silaj, A., Abbey, S. and Reynolds, W. 2001. Effect of a randomized, controlled trial of exercise on mood and physical function in individuals with fibromyalgia. Arthritis Care & Research: *Official Journal of the American College of Rheumatology*, 45 (6): 519-529. Available: https://pdfs.semanticscholar.org/c009/f3f463058662dd5a0efbd587f0ba2007f4f5.pdf (Accessed on 5 August 2018).

Guthold, R., Ono, T., Strong, K. L., Chatterji, S. and Morabia, A. 2008. Worldwide variability in physical inactivity: a 51-country survey. *American journal of preventive medicine*, 34 (6): 486-494. Available: https://www.ajpmonline.org/article/S0749-3797(08)00257-2/fulltext (Accessed on 16 ay 2017).

Hager, R. L., Hardy, A., Aldana, S. G. and George, J. D. 2002. Evaluation of an Internet, stage-based physical activity intervention. *American Journal of Health Education*, 33 (6): 329-337. Available: https://eric.ed.gov/?id=EJ665491 (Accessed 23 October 2018).

Hagstromer, M., Oja, P. and Sjostrom, M. 2006. The International Physical Activity Questionnaire (IPAQ): a study of concurrent and construct validity. *Public Health Nutrition*, 9(6): 755-62. Available: http://dx.doi.org/10.1079/PHN2005898

Hallal, P. C., Andersen, L. B., Bull, F. C., Guthold, R., Haskell, W., Ekelund, U. and Group, L. P. A. S. W. 2012. Global physical activity levels: surveillance progress, pitfalls, and prospects. *The Lancet*, 380 (9838): 247-257. Available: https://nih.brage.unit.no/nihxmlui/bitstream/handle/11250/170988/Andersen%20LB%20Lancet%202012%20Global%20physical%20activity%20levels.pdf?sequence=1 (Accessed 4 February 2018).

Hamasaki, H.2016. Daily physical activity and type 2 diabetes: a review. *World Journal of Diabetes,* 7:243-51.Available: https://www.researchgate.net/profile/Hidetaka_Hamasaki/publication/304026280_Daily_physical_activity_and_type_2_diabetes_A_review/links/576e67ac08ae842225a87ea0/Daily-physical-activity-and-type-2-diabetes-A-review.pdf (Accessed on 24 February 2020).

Han, G., Lee, Y., Ko, W. and Cho, B. 2012. Effect of exercise therapy on elasticity of the blood vessels. *Journal of Physical Therapy Science*, 24 (5): 401-403. Available: https://www.jstage.jst.go.jp/article/jpts/24/5/24_401/_pdf (Accessed 19 June 2018).

Hansen, Å. M., Blangsted, A. K., Hansen, E. A., Søgaard, K. and Sjøgaard, G. 2010. Physical activity, job demand–control, perceived stress–energy, and salivary cortisol in white-collar workers. *International archives of occupational and environmental health*, 83 (2): 143-153. Available: https://www.researchgate.net/profile/Karen_Sogaard/publication/227335053_Physical_activity_job_demand-control_perceived_stress-energy_and_salivary_Cortisol_in_white-collar_workers/links/0fcfd50916ab7c3fd2000000/Physical-activity-job-demand-control-perceived-stress-energy-and-salivary-Cortisol-in-white-collar-workers.pdf (Accessed on 3 August 2018).

Harcombe, H., McBride, D, Derrett, S and Gray, A. 2009. Prevalence and impact of musculoskeletal disorders in New Zealand nurses, postal workers and office workers. *Australian and New Zealand Journal of Public Health*, 33(5): 438-439. Available: http://onlinelibrary.wiley.com/doi/10.1111/j.1753-6405.2009.00425.x/full (Accessed November 2017).

Hardman, A. and Buttriss, J. 2005. *Physical activity: where are we now?* Oxford: Blackwell Science.

Hart, T. L., Swartz, A. M., Cashin, S. E. and Strath, S. J. 2011. How many days of monitoring predict physical activity and sedentary behaviour in older adults?

International Journal of Behavioral Nutrition and Physical Activity, 8(1): 62-69. Available: http://dx.doi.org/10.1186/1479-5868-8-62 (Accessed 23 September 2018).

Haskell, W. L., Blair, S. N. and Hill, J. O. 2009. Physical activity: health outcomes and importance for public health policy. *Preventive medicine*, 49 (4): 280-282. Available:https://activelivingresearch.org/sites/default/files/2_PM2009_Haskell_0.pdf (Accessed 26 March 2019).

Hasson, R., Haller, J., Pober, D., Staudenmayer, J. and Freedson, P. 2009. Validity of the Omron HJ-112 pedometer during treadmill walking. *Medicine and Science in Sports and Exercise*, 41(4): 805-809. Available: https://www.researchgate.net/profile/Rebecca_Hasson/publication/24191993_Validity_of_the_Omron_HJ-112_Pedometer_during_Treadmill_Walking/links/0046351bb551c5c6bd000000/Validity-of-the-Omron-HJ-112-Pedometer-during-Treadmill-Walking.pdf (Accessed 6 April 2017).

Healy, G. N., Dunstan, D. W., Salmon, J., Cerin, E., Shaw, J. E., Zimmet, P. Z. and Owen, N. 2007. Objectively measured light-intensity physical activity is independently associated with 2-h plasma glucose. *Diabetes care*, 30 (6): 1384-1389. Available: https://care.diabetesjournals.org/content/diacare/30/6/1384.full.pdf (Accessed 26 July 2018).

Healy, G. N., Wijndaele, K., Dunstan, D. W., Shaw, J. E., Salmon, J., Zimmet, P. Z. and Owen, N. 2008. Objectively measured sedentary time, physical activity, and metabolic risk: the Australian Diabetes, Obesity and Lifestyle Study (AusDiab). *Diabetes care*, 31 (2): 369-371. Available: https://care.diabetesjournals.org/content/diacare/31/2/369.full.pdf (Accessed 18 November 2018)

Heart UK. 2018. *Heart UK FH GIT Toolkit: 4.0 Diagnosis of Familial Hypercholesterolaemia*. Available: https://www.nice.org.uk/sharedlearning/heart-uk-fh-toolkit (Accessed on 13 July 2018).

Hess, I., Borg, J. and Rissel, C. 2011. Workplace nutrition and physical activity promotion at Liverpool Hospital. *Health Promotion Journal of Australia*, 22 (1): 44-50. Available:

https://www.researchgate.net/profile/Chris_Rissel/publication/51456362_Workplace_nutrition_and_physical_activity_promotion_at_Liverpool_Hospital/links/0fcfd514130ff2ea40000000.pdf (Accessed 16 April 2019).

Hildebrandt, V., Bongers, P., Dul, J., Van Dijk, F. and Kemper, H. 2000. The relationship between leisure time, physical activities and musculoskeletal symptoms and disability in worker populations. *International archives of occupational and environmental health*, 73 (8): 507-518. Available: http://webarchiv.ethz.ch/premus2004/Vorlesungen/Beweg/Literatur_05-06/relationship%20between%20leisure%20time%20physical%20activities%20ans%20mu.pdf (Accessed 14 June 2017).

Hillman, C. H., Pontifex, M. B., Castelli, D. M., Khan, N. A., Raine, L. B., Scudder, M. R., Drollette, E. S., Moore, R. D., Wu, C.-T. and Kamijo, K. 2014. Effects of the FITKids randomized controlled trial on executive control and brain function. *Pediatrics: peds,* 134(4): 2013-3219. Available: https://pediatrics.aappublications.org/content/pediatrics/134/4/e1063.full.pdf (Accessed on 24 July 2018).

Hinkley, T., Teychenne, M., Downing, K. L., Ball, K., Salmon, J. and Hesketh, K. D. 2014. Early childhood physical activity, sedentary behaviors and psychosocial well-being: a systematic review. *Preventive medicine*, 62: 182-192. Available: http://dro.deakin.edu.au/eserv/DU: 30062343/hinkley-earlychildhood-post-2014.pdf (Accessed 23 August 2018).

Hiremath, S., Patil, P. and Goudar, S. Assessment Of Anthropometry And Physical Fitness Index Among Indian Wrestlers By Harvard Step Test. *IOSR Journal of Sports and Physical Education,*3(5):2. Available: https://s3.amazonaws.com/academia.edu.documents/56761631/A05030104.pdf?response-content-disposition=inline%3B%20filename%3DAssesmentOf_Anthropometry_And_PhysicalFi.pdf&X-Amz-Algorithm=AWS4-HMAC-SHA256&X-Amz-Credential=AKIAIWOWYYGZ2Y53UL3A%2F20200227%2Fus-east-1%2Fs3%2Faws4_request&X-Amz-Date=20200227T153038Z&X-Amz-Expires=3600&X-Amz-SignedHeaders=host&X-Amz-

Signature=07e12fb13fff9453d3d07a14777a1435f414832c1bed6ece85c69d8632a3999c (Accessed on 27 February 2020).

Holbrook, E., Barreira, T. and Kang, M. 2009. Validity and reliability of Omron pedometers for prescribed and self-paced walking. *Medicine and Science in Sports and Exercise*, 41(3): 669-673. Available: http://mtweb.mtsu.edu/mkang/Validity%20and%20reliability%20of%20Omron%20pedometers%20for%20prescribed%20and%20self-paced%20walking.pdf (Accessed 22 May 2016).

Holick, M. F., Chen, T. C., Lu, Z. and Sauter, E. 2007. Vitamin D and Skin Physiology: A D-Lightful Story. *Journal of Bone and Mineral Research*, 22 (S2): V28-V33. Available: https://scholar.google.co.za/scholar?output=instlink&q=info: WuKB7ERTIAwJ: scholar.google.com/&hl=en&as_sdt=0,5&scillfp = 7248987008119116014&oi=lle (Accessed 2 July 2018).

Howley, E. T. 2001. Type of activity: resistance, aerobic and leisure versus occupational physical activity. *Medicine & Science in Sports & Exercise*, 33 (6): S364-S369. Available: https://pdfs.semanticscholar.org/30f6/65fba79722890d4240a4dba60bda20ba6848.pdf (Accessed 15 January 2018).

Hughes, S. L., Seymour, R. B., Campbell, R. T., Shaw, J. W., Fabiyi, C. and Sokas, R. 2011. Comparison of two health-promotion programs for older workers. American *Journal of Public Health*, 101 (5): 883-890. Available: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3076396/ (Accessed on 15 June 2019).

Hush, J. M., Michaleff, Z., Maher, C. G. and Refshauge, K. 2009. Individual, physical and psychological risk factors for neck pain in Australian office workers: a 1-year longitudinal study. *European spine journal*, 18 (10): 1532-1540. Available: http://www.academia.edu/download/41675167/Individual_physical_and_psychological_ri20160128-8147-1f879zf.pdf (Accessed 8 August 2018).

Institute of Medicine (US) and Committee on Social Security Cardiovascular Disability Criteria. 2010. *Cardiovascular Disability: Updating the Social Security Listings*. Washington, DC: The National Academies Press.

International Agency for Research on Cancer. 2002. *Weight Control and Physical Activity*. Lyon, France: IARC Press. Available: https://www.cabdirect.org/cabdirect/abstract/20033086172 (Accessed 12 August 2019).

International Diabetes Federation. 2018. *South Africa*. Available: https://idf.org/our-network/regions-members/africa/members/25-south-africa.html (Accessed 3 August 2018).

IPAQ research committee. 2002. *International Physical Activity Questionnaire (October 2002): Long Last 7 days self-administered format*. Available: https://sites.google.com/site/theipaq/questionairre_links (Accessed 21 March 2017).

IPAQ research committee. 2005. *Guidelines for Data Processing and Analysis of the International Physical Activity Questionnaire (IPAQ): Short and Long Forms*. Available: http://www.ipaq.ki.se/scoring.pdf (Accessed February 2017).

Jacobson, B. H. and Aldana, S. G. 2001. Relationship between frequency of aerobic activity and illness-related absenteeism in a large employee sample. *Journal of occupational and Environmental medicine*, 43 (12): 1019-1025. Available: https://journals.lww.com/joem/fulltext/2001/12000/relationship_between_frequency_of_aerobic_activity.4.aspx (Accessed 2 October 2018).

Jenkins, S., Cecins, N., Camarri, B., Williams, C., Thompson, P. and Eastwood, P. 2009. Regression equations to predict 6-minute walk distance in middle-aged and elderly adults. *Physiotherapy theory and practice*, 25 (7): 516-522. Available: https://www.researchgate.net/profile/Philip_Thompson/publication/38112718_Regression_equations_to_predict_6-minute_walk_distance_in_middle-aged_and_elderly_adults/links/0046352f56058a056e000000.pdf (Accessed 13 May 2019).

Jinzhou, Y., Fu, Y., Zhang, R., Li, X. and Shan, G. 2008. The reliability and sensitivity of indices related to cardiovascular fitness evaluation. *Kinesiology: International journal of fundamental and applied kinesiology*, 40 (2): 139-146. Available: https://hrcak.srce.hr/file/48810 (Accessed 20 June 2019).

Jonsdottir, I. H., Börjesson, M. and Ahlborg, G. 2011. Healthcare workers' participation in a healthy-lifestyle-promotion project in western Sweden. *BioMed Central Public Health,* 11(1): 448. Available: http://dx.doi.org/10.1186/1471-2458-11-448 (Accessed 30 April 2016).

Joseph, J. J. and Golden, S. H. 2017. Cortisol dysregulation: the bidirectional link between stress, depression, and type 2 diabetes mellitus. *Annals of the New York Academy of Sciences*, 1391 (1): 20-34. Available: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5334212/ (Accessed 4 April 2019).

Joubert, J., Norman, R., Lambert, E. V., Groenewald, P., Schneider, M., Bull, F., Bradshaw, D. and Collaboration, S. A. C. R. A. 2007. Estimating the burden of disease attributable to physical inactivity in South Africa in 2000. *South African Medical Journal*, 97 (8): 725-731. Available: https://www.ajol.info/index.php/samj/article/download/13903/59682 (Accessed 18 February 2017).

Joyner, M. J. and Green, D. J. 2009. Exercise protects the cardiovascular system: effects beyond traditional risk factors. *The Journal of physiology*, 587 (23): 5551-5558. Available: https://scholar.google.co.za/scholar?output=instlink&q=info: 6ilE6ThNSW8J: scholar.google.com/&hl=en&as_sdt=0,5&scillfp = 4099882530484698904&oi=lle (Accessed 3 October 2018).

Kassi, E., Pervanidou, P., Kaltsas, G. and Chrousos, G. 2011. Metabolic syndrome: definitions and controversies. *BMC medicine* , 9 (1): 48. Available: https://bmcmedicine.biomedcentral.com/articles/10.1186/1741-7015-9-48 (Accessed 10 August 2018).

Katzmarzyk, P. T., Denstel, K. D., Beals, K., Bolling, C., Wright, C., Crouter, S. E., McKenzie, T. L., Pate, R. R., Saelens, B. E. and Staiano, A. E. 2016. Results from the United States of America's 2016 report card on physical activity for children and youth. *Journal of physical activity and health*, 13 (s2): S307-S313. Available: https://www.researchgate.net/profile/Amanda_Staiano/publication/310471959_Results_From_the_United_States_of_America's_2016_Report_Card_on_Physical_Activity_for_Children_and_Youth/links/5834a72b08ae102f07395f09/Results-From-the-United-

States-of-Americas-2016-Report-Card-on-Physical-Activity-for-Children-and-Youth.pdf (Accessed 14 September 2018).

Khodnapur, J. P., Dhanakshirur, G. B., Bagali, S., Mullur, L. M. and Aithala, M. 2012. Status of Physical Fitness Index (PFI%) and anthropometric parameters in residential school children compared to nonresidential school children. *JKIMSU*, 1: 137-141. Available: https://core.ac.uk/download/pdf/27052963.pdf (Accessed 8 July 2019).

Kimm S.Y., G. N. W., Mcmahon P., Voorhees C.C., Striegel-Moore R.H., Daniels S.R. 2006. Self-Perceived barriers to activity participation among sedentary adolescent girls. *Medicine Science & Sports Exercise*, 38(3): 534-540. Available: https://insights.ovid.com/crossref?an=00005768-200603000-00019 (Accessed 18 May 2018).

Kimm, S. Y., Glynn, N. W., Kriska, A. M., Barton, B. A., Kronsberg, S. S., Daniels, S. R., Crawford, P. B., Sabry, Z. I. and Liu, K. 2002. Decline in physical activity in black girls and white girls during adolescence. *New England Journal of Medicine*, 347 (10): 709-715. Available: https://www.researchgate.net/profile/Nancy_Glynn/publication/11175094_Decline_in_Physical_Activity_in_Black_Girls_and_White_Girls_during_Adolescence/links/58e8e2d50f7e9b978f8119d7/Decline-in-Physical-Activity-in-Black-Girls-and-White-Girls-during-Adolescence.pdf (Accessed 28 July 2018).

King AC, Taylor CB, Haskell WL, 1989. Influence of regular aerobic exercise on psychological health: a randomized, controlled trial of healthy, middle-aged adults. *Health Psychology*,8 (3): 305-24.Accessed on 24 February 2020.

Kirkham AA, Davis MK. 2015. Exercise prevention of cardiovascular disease in breast cancer survivors. *Journal of Oncology*, 2015:917606.Available: https://www.amykirkham.ca/wp-content/uploads/2015/05/Kirkham-2015-Exercise-Prevention-of-Cardiovascular-Disease-in-Breast-Cancer-Survivors1.pdf (Accessed on 24 February 2020).

Klok, M., Jakobsdottir, S. and Drent, M. 2007. The role of leptin and ghrelin in the regulation of food intake and body weight in humans: a review. *Obesity reviews*, 8 (1): 21-34. Available: https://onlinelibrary.wiley.com/doi/full/10.1111/j.1467-789X.2006.00270.x (Accessed 7 October 2018).

Kohrt, W. M., Bloomfield, S. A., Little, K. D., Nelson, M. E. and Yingling, V. R. 2004. Physical activity and bone health. *Medicine & Science in Sports & Exercise*, 36 (11): 1985-1996. Available: https://pdfs.semanticscholar.org/6b78/789d51b30e7a2165b03f14859d6ce15c0f42.pdf (Accessed on 16 September 2018).

Kruger, H. S., Venter, C. S. and Vorster, H. H. 2003. Physical inactivity as a risk factor for cardiovascular disease in communities undergoing rural to urban transition: the THUSA study: cardiovascular topics. *Cardiovascular Journal of South Africa*, 14 (1): 16-23. Available: https://www.researchgate.net/profile/Herculina_Kruger/publication/10868811_Physical_inactivity_as_a_risk_factor_for_cardiovascular_disease_in_communities_undergoing_rural_to_urban_transition_the_THUSA_Study/links/56ab09ac08aeadd1bdcafedd/Physical-inactivity-as-a-risk-factor-for-cardiovascular-disease-in-communities-undergoing-rural-to-urban-transition-the-THUSA-Study.pdf (Accessed on 7 June 2019).

Kruger, H. S., Venter, C. S., Vorster, H. H. and Margetts, B. M. 2002. Physical inactivity is the major determinant of obesity in black women in the North West Province, South Africa: the THUSA study. *Nutrition*, 18 (5): 422-427. Available: http://www.academia.edu/download/46808509/Physical_Inactivity_Is_the_Major_Determi20160626-21485-10g0x75.pdf (Accessed on 28 ay 2018).

Kunene, S. H. and Taukobong, N. P. 2015. Level of physical activity of health professionals in a district hospital in KwaZulu-Natal, South Africa. *South African Journal of Physiotherapy*, 71(1): 234. Available: http://dx.doi.org/10.4102/sajp.v71i1.234 (Accessed 22 May 2016).

Lahti, J., Laaksonen, M., Lahelma, E. and Rahkonen, O. 2010. The impact of physical activity on physical health functioning–a prospective study among middle-aged employees. *Preventive medicine*, 50 (5-6): 246-250. Available: http://www.academia.edu/download/41795178/The_impact_of_physical_activity_on_physi20160130-22482-1t3xszq.pdf (Accessed on 25 April 2018).

Lambert, E., Bohlmann, I. and Kolbe-Alexander, T. 2001. Be active-physical activity for health in South Africa. *South African Journal of Clinical Nutrition*, 14 (3 Suppl):

S12-S16. Available: https://www.popline.org/node/264970 (Accessed on 11 March 2018).

Landkammer, Y. T., Wicker, A., Bernecker, R. and Herfert, J. 2014. Physical activity and bone health: FIMS Position Statement 2014. *International SportMed Journal*, 15 (2): 113-122. Available: https://www.ingentaconnect.com/content/sabinet/ismj/2014/00000015/00000002/art00001 (Accessed on 13 July 2018).

Lee, H. T., Roh, H. L. and Kim, Y. S. 2016. Cardiorespiratory endurance evaluation using heart rate analysis during ski simulator exercise and the Harvard step test in elementary school students. *Journal of physical therapy science*, 28 (2): 641-645. Available: https://www.jstage.jst.go.jp/article/jpts/28/2/28_jpts-2015-861/_pdf (Accessed on 12 February 2019).

Leicht, A. S., Sealey, R. M. and Devine, S. 2013. Relationship between employment category and gender on quality of life, physical activity and their barriers and motivators, for full-time university staff. *International Journal of Workplace Health Management*, 6 (3): 160-173. Available: https://www.ingentaconnect.com/content/mcb/ijwhm/2013/00000006/00000003/art00001 (Accessed on 23 November 2018).

Li, J. and Siegrist, J. 2012. Physical activity and risk of cardiovascular disease--a meta-analysis of prospective cohort studies. *International journal of environmental research and public health*, 9 (2): 391-407. Available: https://www.mdpi.com/1660-4601/9/2/391/pdf (Accessed on 8 July 2018).

Lilly, L. S. 2012. *Pathophysiology of heart disease: a collaborative project of medical students and faculty*. Baltimore, USA: Lippincott Williams & Wilkins.

Low, D., Gramlich, M. and Engram, B. W. 2007. Self-paced exercise program for office workers: impact on productivity and health outcomes. *Aaohn Journal*, 55 (3): 99-105. Available: https://journals.sagepub.com/doi/pdf/10.1177/216507990705500302 (Accessed 6 September 2018).

Low W.Y, Lee Y.K and Samy A.L.2015. Non-communicable diseases in the Asia-Pacific region: prevalence, risk factors and community-based prevention. *International*

Journal of Occupational Medicine and Environmental Health, 28:20-6.Available: https://www.researchgate.net/profile/Alexander_Samy/publication/269765986_Non-communicable_diseases_in_the_Asia-Pacific_region_Prevalence_risk_factors_and_community-based_prevention/links/54ffcff50cf2672e2248b6b6.pdf (Accessed on 24 February 2020).

Macera, C. A., Hootman, J. M. and Sniezek, J. E. 2003. Major public health benefits of physical activity. *Arthritis Care & Research*, 49 (1): 122-128. Available: https://scholar.google.co.za/scholar?output=instlink&q=info: smzbgM0dDfgJ: scholar.google.com/&hl=en&as_sdt=0,5&scillfp = 1618492027149071505&oi=lle (Accessed on 7 September 2018).

Maddison, R., Jiang, Y., Vander Hoorn, S., Exeter, D., Mhurchu, C. N. and Dorey, E. 2010. Describing patterns of physical activity in adolescents using global positioning systems and accelerometry. *Pediatric exercise science*, 22 (3): 392-407. Available: https://pdfs.semanticscholar.org/03e0/84f6886ccb70c27523c7e72ef4fa2dbdc812.pdf (Accessed on 16 November 2018).

Mäder, U., Martin, B. W., Schutz, Y. and Marti, B. 2006. Validity of four short physical activity questionnaires in middle-aged persons*. Medicine and Science in Sports and Exercise*, 38(7): 1255-1266. Available: http://dx.doi.org/10.1249/01.mss.0000227310.18902.28 (Accessed on 19 May 2017).

Malik, S. H., Blake, H. and Suggs, L. S. 2014. A systematic review of workplace health promotion interventions for increasing physical activity. *British journal of health psychology*, 19 (1): 149-180. Available: http://eprints.nottingham.ac.uk/38444/1/BJHP%20-%20Malik%20et%20al%20Final.pdf (Accessed on 22 August 2018).

Mancia, G., Fagard, R., Narkiewicz, K., Redon, J., Zanchetti, A., Böhm, M., Christiaens, T., Cifkova, R., De Backer, G. and Dominiczak, A. 2013. 2013 ESH/ESC guidelines for the management of arterial hypertension: The Task Force for the Management of Arterial Hypertension of the European Society of Hypertension (ESH) and of the European Society of Cardiology (ESC). *Blood pressure*, 22 (4): 193-278.

Available: https://www.ncbi.nlm.nih.gov/pubmed/23817082 (Accessed on 27 June 2018).

Manson, J. E., Greenland, P., LaCroix, A. Z., Stefanick, M. L., Mouton, C. P., Oberman, A., Perri, M. G., Sheps, D. S., Pettinger, M. B. and Siscovick, D. S. 2002. Walking compared with vigorous exercise for the prevention of cardiovascular events in women. *New England Journal of Medicine*, 347 (10): 716-725. Available: http://sphweb.bumc.bu.edu/otlt/MPH-Modules/Weymouth/Manson-WALKING%20COMPARED%20WITH%20VIGOROUS%20EXERCISE.pdf (Accessed on 3 November 2018).

Marandi, S. M., Abadi, N. G. B., Esfarjani, F., Mojtahedi, H. and Ghasemi, G. Effects of Intensity of Aerobics on Body Composition and Blood Lipid Profile in Obese/Overweight Females. *International journal of preventive medicine*, no. Suppl 1(1): S118. Available: https://pdfs.semanticscholar.org/7e77/20f5fd4dbab4271d070527fb4e68320062b3.pdf (Accessed on 26 June 2019).

Martins, C., Morgan, L. and Truby, H. 2008. A review of the effects of exercise on appetite regulation: an obesity perspective. *International journal of obesity*, 32 (9): 1337. Available: http://www.academia.edu/download/45933003/A_review_of_the_effects_of_exercise_on_a20160524-25867-ewdynz.pdf (Accessed on 29 September 2018).

Matsuura, Y., Makoro, S., Tsubouchi, S., Hasegawa, S. and SHIMIZU, N. 1993. A Study on Assessment of Physical Activity in Workers. *Bulletin of the University of Osaka Prefecture. Ser. B, Agriculture and life sciences*, 45: 85-91. Available: http://repository.osakafu-u.ac.jp/dspace/handle/10466/2759 (Accessed on 8 March 2019).

Mayes, P. A. and Botham, K. M. 2003. *Cholesterol synthesis, transport, and excretion*. Harper’s Illustrated Biochemistry, 26th ed, New York: McGraw Hill Companies.

McCarthy, H., Cole, T., Fry, T., Jebb, S. and Prentice, A. 2006. Body fat reference curves for children. *International journal of obesity*, 30 (4): 598. Available: http://library.nuft.edu.ua/ebook/file/0803232a.pdf (Accessed on 7 April 2019).

Mchiza, Z. J., Parker, W.A., Makoae, M., Sewpaul, R., Kupamupindi, T. and Labadarios, D. 2015. Body image and weight control in South Africans 15 years or older: SANHANES-1. *BMC public health*, 15 (1): 992. Available: http://www.hsrc.ac.za/en/research-outputs/ktree-doc/15747 (Accessed 14 September 2018).

Medical Research Council. 2002. *The 1st South-African nation youth risk behaviour survey*. Available: https://www.gov.za/sites/default/files/gcis_document/201409/complete4.pdf (Accessed 7 March 2019).

Merriam-Webster Dictionary. 2019. *Prevalence.* Available: https://www.merriam-webster.com/dictionary/prevalence (Accessed 25 August 2019).

Mikkelsson, L., Kaprio, J., Kautiainen, H., Kujala, U. M. and Nupponen, H. 2005. Associations between self-estimated and measured physical fitness among 40-year-old men and women. *Scandinavian journal of medicine & science in sports*, 15 (5): 329-335. Available: https://onlinelibrary.wiley.com/doi/abs/10.1111/j.1600-0838.2004.00429.x (Accessed on 19 June 2019).

Miles, L. 2007. Physical activity and health. *Nutrition bulletin*, 32 (4): 314-363. Available: https://onlinelibrary.wiley.com/doi/pdf/10.1111/j.1467-3010.2007.00668.x (Accessed on 2 November 2018).

Mitsui, T., Shimaoka, K., Tsuzuku, S., Kajioka, T. and Sakakibara, H. 2008. Pedometer-determined physical activity and indicators of health in Japanese adults. *Journal of physiological anthropology*, 27 (4): 179-184. Available: https://www.jstage.jst.go.jp/article/jpa2/27/4/27_4_179/_pdf (Accessed on 8 May 2018).

Mustelin, L., Silventoinen, K., Pietiläinen, K., Rissanen, A. and Kaprio, J. 2009. Physical activity reduces the influence of genetic effects on BMI and waist circumference: a study in young adult twins. *International journal of obesity*, 33 (1): 29. Available: https://www.researchgate.net/profile/Kirsi_Pietilaeinen/publication/23560940_Physical_activity_reduces_the_influence_of_genetic_effects_on_BMI_and_waist_circumferenc e_a_study_in_young_adult_twins/links/0fcfd5108d6dd07bd2000000.pdf (Accessed on 10 July 2019).

National Centre of Social Research. 2017. *Health Survey for England 2016 Children's health.* Available: https://digital.nhs.uk/data-and-information/publications/statistical/health-survey-for-england/health-survey-for-england-2016 (Accessed on 12 October 2018).

National Department of Health, South African Medical Research Council and ICF. 2017. *South Africa Demographic and Health Survey 2016: Key Indicators*. Available: https://www.statssa.gov.za/publications/Report%2003-00-09/Report%2003-00-092016.pdf (Accessed 12 September 2018).

National Health Service of England. 2019. *Physical activity guidelines for adults aged 19 to 64.* Available: https://www.nhs.uk/live-well/exercise/ (Accessed 19 Febrauary 2020).

Ndahimana, D. and Kim, E.-K. 2017. Measurement methods for physical activity and energy expenditure: a review. *Clinical nutrition research*, 6 (2): 68-80. Available: https://pdfs.semanticscholar.org/c729/43a7754b9cda8f0792ce46b6bbefe793c6f9.pdf (Accessed on 4 June 2019).

Nelson, M. E., Rejeski, W. J., Blair, S. N., Duncan, P. W., Judge, J. O., King, A. C., Macera, C. A. and Castaneda-Sceppa, C. 2007. Physical activity and public health in older adults: recommendation from the American College of Sports Medicine and the American Heart Association. *Circulation*, 116 (9): 1094. Available: https://scholarcommons.sc.edu/cgi/viewcontent.cgi?article=1361&context=sph_epidemiology_biostatistics_facpub (Accessed on 6 April 2019).

Neuhaus, M., Healy, G. N., Dunstan, D. W., Owen, N., & Eakin, E. G. (2014). Workplace sitting and height-adjustable workstations: a randomized controlled trial. *American Journal of Preventive Medicine*, 46(1): 30-40.Available: https://espace.library.uq.edu.au/data/UQ_320388/UQ320388_postprint.pdf?dsi_version=e62d81853186b26632eef4877ccab0d3&Expires=1582283922&Key-Pair-Id=APKAJKNBJ4MJBJNC6NLQ&Signature=cxRYyG4ca~QW0PsNDJ-dR-JnFho876itQpE4m2d~XpuFpJHRKMDig8djCRnmyWhLdEVa3azAR4eZvf1EgL9vqc0ioGuGYWWw9b11ZnnjWOm3fjupcr2EEoD-JSoZ-

eiOnx1UW8PtQ~TXdK11hCsgU476IhmhcICwfoyy8zHuwEEzhEZSYHxvr0KnuLKb5h89B7x7--8ojSYAzKtNctNzQ3KCbxwgh5zWCOWcRBFvFkG~7k~9J-5Dk6edHi9B9Bh7MI9bT5v-e5VTLubepchTen1oSC5LCorkHLrvbOPh0tqoQEN5NrY2u98bDjxQYqYHr0JYGvZV-UhDhV2Jyd8Anw__ (Accessed on 21 February 2020).

OECD. 2017. *Obesity Update 2017.* Available: www.oecd.org/health/health-data.htm (Accessed 5 June 2019).

Omondi, D. O., Othuon, L. O. A. and Mbagaya, G. M. 2007. Physical activity patterns, dietary intake and health status among University of Nairobi lecturers in Kenya. *South African Journal for Research in Sport, Physical Education and Recreation*, 29 (2): 87-98. Available: https://journals.co.za/content/sport/29/2/EJC108855 (Accessed on 4 May 2018).

OMRON Healthcare. 2007. *OMRON Instruction Manual: Pocket Pedometer Model HJ-720 ITC.* Japan: OMRON Healthcare.

OMRON Healthcare. 2017. *Body Composition Monitor: Instruction Manual.* Japan: OMRON Healthcare.

Ortega, F., Ruiz, J., Castillo, M. and Sjöström, M. 2008. Physical fitness in childhood and adolescence: a powerful marker of health. *International journal of obesity*, 32 (1): 1. Available: https://digitalcommons.providence.edu/cgi/viewcontent.cgi?article=2422&context=inti (Accessed on 16 July 2018).

Paluska, S. A. and Schwenk, T. L. 2000. Physical activity and mental health. *Sports medicine,* 29 (3): 167-180. Available: https://link.springer.com/article/10.2165/00007256-200029030-00003 (Accessed on 12 June 2018).

Panel on Dietary Reference Values, Great Britain; Department of Health, Great Britain. 1991. *Dietary Reference Values for Food Energy and Nutrients for the United Kingdom: Report of the Panel on Dietary Reference Values of the Committee on Medical Aspects of Food Policy*. Great Britain: Her Majesty's Stationery Office.

Parks, S., Housemann, R. A. and Brownson, R. C. 2003. Differential correlates of physical activity in urban and rural adults of various socioeconomic backgrounds in the United States. *Journal of Epidemiology & Community Health*, 57 (1): 29-35. Available: https://jech.bmj.com/content/jech/57/1/29.full.pdf (Accessed on 19 October 2018).

Pate, R. R., O'Neill, J. R. and Lobelo, F. 2008. The evolving definition of "sedentary". *Exercise and sport sciences reviews*, 36 (4): 173-178. Available: https://pdfs.semanticscholar.org/eaa6/43e22b7bc16da6d82654ecf91afb637b4bc1.pdf (Accessed on 8 March 2019).

Pedersen, B. K. and Saltin, B. 2006. Evidence for prescribing exercise as therapy in chronic disease. *Scandinavian Journal of Medicine, Science and Sports*, 16 (1), 3-63. Available: http://www.cardiology.org/recentpapers/Pedersen_ExerciseAsMedicine_ScandJMSS.pdf (Accessed on 16 September 2018).

Penedo, F. J. and Dahn, J. R. 2005. Exercise and well-being: a review of mental and physical health benefits associated with physical activity. *Current opinion in psychiatry*, 18 (2): 189-193. Available: https://journals.lww.com/co-psychiatry/fulltext/2005/03000/exercise_and_well_being__a_review_of_mental_and.13.aspx (Accessed on 19 September 2018).

Penry, J. T., Wilcox, A. R. and Yun, J. 2011. Validity and reliability analysis of Cooper's 12-minute run and the multistage shuttle run in healthy adults. *The Journal of Strength & Conditioning Research*, 25 (3): 597-605. Available: https://ir.library.oregonstate.edu/downloads/gt54kq44j (Accessed on 17 April 2019).

Pietiläinen, K. H., Kaprio, J., Borg, P., Plasqui, G., Yki-Järvinen, H., Kujala, U. M., Rose, R. J., Westerterp, K. R. and Rissanen, A. 2008. Physical inactivity and obesity: a vicious circle. *Obesity*, 16 (2): 409-414. Available: https://scholar.google.co.za/scholar?output=instlink&q=info: PXeMxa8BXokJ: scholar.google.com/&hl=en&as_sdt=0,5&scillfp = 472869238671048625&oi=lle (Accessed on 13 March 2019).

Pillay, J. D., Kolbe-Alexander, T. L., Proper, K. I., Van Mechelen, W. and Lambert, E. V. 2014. Steps that count! A feasibility study of a pedometer-based, health promotion intervention in an employed, South African population. *South African Journal of Sports*

Medicine, 26 (1): 15-19. Available: https://www.ajol.info/index.php/sasma/article/viewFile/102692/92959 (Accessed on 16 June 2017).

Pillay, J. D., van der Ploeg, H. P., Kolbe-Alexander, T. L., Proper, K. I., van Stralen, M., Tomaz, S. A., van Mechelen, W. and Lambert, E. V. 2015. The association between daily steps and health, and the mediating role of body composition: a pedometer-based, cross-sectional study in an employed South African population. *BioMed Central Public Health*, 15(1): 174. Available: http://dx.doi.org/10.1186/s12889-015-1381-6 (Accessed 22 May 2016).

Pirincci, E., Rahman, S., Durmuş, A. and Erdem, R. 2008. Factors affecting health-promoting behaviours in academic staff. *Public health*, 122 (11): 1261-1263. Available: https://europepmc.org/abstract/med/18849056 (Accessed on 15 July 2018).

Poole, D. C., Wilkerson, D. P. and Jones, A. M. 2008. Validity of criteria for establishing maximal O2 uptake during ramp exercise tests. *European Journal of Applied Physiology*, 102: 403-410. Available: https://www.researchgate.net/profile/David_Poole4/publication/5876906_Validity_of_criteria_for_establishing_maximal_O2_uptake_during_ramp_exercise_test/links/53dab10c0cf2631430cb1006/Validity-of-criteria-for-establishing-maximal-O2-uptake-during-ramp-exercise-test.pdf (Accessed on 8 May 2019).

Pouliou, T., Ki, M., Law, C., Li, L. and Power, C. 2012. Physical activity and sedentary behaviour at different life stages and adult blood pressure in the 1958 British cohort. *Journal of hypertension*, 30 (2): 275-283. Available: https://journals.lww.com/jhypertension/Fulltext/2012/02000/Physical_activity_and_sedentary_behaviour_at.7.aspx (Accessed on 18 July 2018).

Proper, K. I., Koning, M., van der Beek, A. J., Hildebrandt, V. H., Bosscher, R. J. and van Mechelen, W. 2003. The effectiveness of worksite physical activity programs on physical activity, physical fitness, and health. *Clinical Journal of Sport and Medicine*, 13 (2), pp.106-17. Available: https://pdfs.semanticscholar.org/dafc/1c3b969c711352ea3d7c2eed26c42e976970.pdf

Prospective Studies Collaboration. 2009. Body-mass index and cause-specific mortality in 900 000 adults: collaborative analyses of 57 prospective studies. *The*

Lancet, 373 (9669): 1083-1096. Available: https://www.sciencedirect.com/science/article/pii/S0140673609603184 (Accessed 2 June 2019).

Puig-Ribera, A., Martínez-Lemos, I., Giné-Garriga, M., González-Suárez, Á. M., Bort-Roig, J., Fortuño, J., Muñoz-Ortiz, L., McKenna, J. and Gilson, N. D. 2015. Self-reported sitting time and physical activity: interactive associations with mental well-being and productivity in office employees. *BMC public health*, 15 (1): 72-72. Available: https://bmcpublichealth.biomedcentral.com/articles/10.1186/s12889-015-1447-5 (Accessed on 25 July 2019).

Puoane, T., Fourie, J., Shapiro, M., Rosling, L., Tshaka, N. and Oelefse, A. 2005. \'Big is beautiful\'-an exploration with urban black community health workers in a South African township. *South African Journal of Clinical Nutrition*, 18 (1): 6-15. Available: https://www.ajol.info/index.php/sajcn/article/viewFile/34726/91761 (Accessed on 27 September 2018).

Puoane T, Steyn K, Bradshaw D, *et al*. Obesity in South Africa: the South African demographic and health survey. *Obesity Research*. 2002;10:1038-1048. Available: https://onlinelibrary.wiley.com/doi/pdf/10.1038/oby.2002.141 (Accessed 19 February 2020).

Rafferty, A. P., Reeves, M. J., McGee, H. B. and Pivarnik, J. M. 2002. Physical activity patterns among walkers and compliance with public health recommendations. *Medicine and science in sports and exercise*, 34 (8): 1255-1261. Available: https://europepmc.org/abstract/med/12165679 (Accessed on 27 November 2018).

Reiner, M., Niermann, C., Jekauc, D. and Woll, A. 2013. Long-term health benefits of physical activity–a systematic review of longitudinal studies. *BMC public health*, 13 (1): 813. Available: http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.838.3245&rep = rep1&type=pdf (Accessed on 12 August 2018).

Riddoch, C. J., Andersen, L. B., Wedderkopp, N., Harro, M., Klasson-Heggebø, L., Sardinha, L. B., Cooper, A. R. and Ekelund, U. 2004. Physical activity levels and patterns of 9-and 15-yr-old European children. *Medicine & Science in Sports & Exercise*, 36 (1): 86-92. Available:

http://www.academia.edu/download/44034984/Physical_Activity_Levels_and_Patterns_of20160323-808-1mv6nym.pdf (Accessed on 24 September 2018 .)

Robert K. Murray, D. K. G., Peter A. Mayes, Victor W. Rodwell, 2003. *Harper's Illustrated Biochemistry, Twenty-Sixth Edition*. 26 ed. United States of America: The McGraw-Hill Companies.

Rolls, B. J. 2003. The supersizing of America: portion size and the obesity epidemic. Nutrition Today, 38 (2): 42-53. Available: https://journals.lww.com/nutritiontodayonline/Fulltext/2003/03000/The_Supersizing_of_America__Portion_Size_and_the.4.aspx (Accessed on 15 February 2019).

Romero-Corral, A., Somers, V. K., Sierra-Johnson, J., Thomas, R. J., Bailey, K. R., Collazo-Clavell, M. L., Allison, T. G., Korinek, J., Batsis, J. A. and Lopez-Jimenez, F. 2008. Accuracy of Body Mass Index to Diagnose Obesity in the US Adult Population. *International Journal of Obesity*, 32 (6): 959-966. Available: https://www.researchgate.net/profile/Fatima_Sert-Kuniyoshi/publication/5569489_Accuracy_of_Body_Mass_Index_to_Diagnose_Obesity_In_the_US_Adult_Population/links/0deec526f194d4f9e7000000/Accuracy-of-Body-Mass-Index-to-Diagnose-Obesity-In-the-US-Adult-Population.pdf (Accessed on 24 May 2019).

Rosenberg, D. E., Bull, F. C., Marshall, A. L., Sallis, J. F. and Bauman, A. E. 2008. Assessment of sedentary behavior with the International Physical Activity Questionnaire. *Journal of Physical Activity and Health*, 5 (s1): S30-S44. Available: https://api.research-repository.uwa.edu.au/files/1579264/10928_PID10928.pdf (Accessed on 17 March 2019).

Rowe, D. A., Kemble, C. D., Robinson, T. S. and Mahar, M. T. 2007. Daily walking in older adults: day-to-day variability and criterion-referenced validity of total daily step counts. *Journal of Physical Activity and Health*, 4 (4): 435-447. Available: https://journals.humankinetics.com/view/journals/jpah/4/4/article-p435.xml (Accessed on 23 August 2018).

Rye, K. A. and Barter, P. J. 2014. Cardioprotective functions of HDLs. *Journal of lipid research*, 55 (2): 168-179. Available: http://www.jlr.org/content/55/2/168.full.pdf (Accessed on 4 September 2018).

Sahu, A. 2003. Leptin signaling in the hypothalamus: emphasis on energy homeostasis and leptin resistance. *Frontiers in neuroendocrinology*, 24 (4): 225-253. Available: https://socallaserspa.com/wp-content/uploads/2018/09/leptin.pdf (Accessed on 16 July 2018).

Sallis, J. F., Prochaska, J. J. and Taylor, W. C. 2000. A review of correlates of physical activity of children and adolescents. *Medicine and science in sports and exercise*, 32 (5): 963-975. Available: http://www.academia.edu/download/27071238/afs_sallis_et_al_2000.pdf (Accessed on 18 May 2019).

Sallis J.F., Owen N., Fotheringham M.J.2000. Behavioral epidemiology: a systematic framework to classify phases of research on health promotion and disease prevention. *Annals of Behavioural Medicin,e* 22: 294–98.Available: https://search.proquest.com/docview/875675187?accountid=10612&pq-origsite=summon (Accessed on 24 February 2020).

Saris, W., Blair, S., Van Baak, M., Eaton, S., Davies, P., Di Pietro, L., Fogelholm, M., Rissanen, A., Schoeller, D. and Swinburn, B. 2003. How much physical activity is enough to prevent unhealthy weight gain? Outcome of the IASO 1st Stock Conference and consensus statement. *Obesity reviews*, 4 (2): 101-114. Available: https://pdfs.semanticscholar.org/0181/49b41b02235fe40c93e82dc1d4574d2c8b32.pdf (Accessed on 7 March 2019).

Sato, R. 2015. Functions of Cholesterol Metabolites. Journal of Nutritional Science and Vitaminology, 61 (Suppl.): S151-S153. Available: https://www.ncbi.nlm.nih.gov/pubmed/26598835 (Accessed on 26 August 2018).

Schellenberg, E. S., Dryden, D. M., Vandermeer, B., Ha, C. and Korownyk, C. 2013. Lifestyle interventions for patients with and at risk for type 2 diabetes: a systematic review and meta-analysis. *Annals of internal medicine*, 159 (8): 543-551. Available: http://annals.org/data/journals/aim/927894/0000605-201310150-00007.pdf (Accessed on 27 March 2019).

Schneider, P. L., Crouter, S. E., Lukajic, O. and Bassett, J. D. 2003. Accuracy and reliability of 10 pedometers for measuring steps over a 400-m walk. *Medicine and* *science in sports and exercise*, 35 (10): 1779-1784. Available: https://europepmc.org/abstract/med/14523320 (Accessed on 11 April 2018).

Schoenborn, C. A., Adams, P. F., Barnes, P. M., Vickerie, J. L. and Schiller, J. S. 2004. Health behaviors of adults; United States, 1999-2001. *Vital and health statistics. Series 10, Data from the National Health Survey*, 219 (2004): 1-79. Available: https://europepmc.org/abstract/med/15791896 (Accessed on 17 July 2018).

Scholes, S. and Neave, A. 2013. *Health Survey for England 2016: Physical activity in adults*. Available: http://healthsurvey.hscic.gov.uk/media/63730/HSE16-Adult-phy-act.pdf (Accessed on 18 September 2018).

Schrauwen, P. 2007. Physical activity and diabetes: current considerations. *Applied physiology, nutrition, and metabolism= Physiologie appliquee, nutrition et metabolisme*, 32 (3): 535. Available: https://www.ncbi.nlm.nih.gov/pubmed/17510693(Accessed on 19 October 2018).

Schwartz, M. W. 2001. Brain pathways controlling food intake and body weight. *Experimental Biology and Medicine*, 226 (11): 978-981. Available: https://journals.sagepub.com/doi/abs/10.1177/153537020122601103 (Accessed on 27 May 2019).

Seibt, R., Lützkendorf, L. and Thinschmidt, M. 2005. Risk factors and resources of work ability in teachers and office workers. In: Proceedings of International Congress Series. Elsevier (1280): 310-315. Available: https://www.sciencedirect.com/science/article/pii/S0531513105000774 (Accessed on 17 November 2018).

Sengupta, P., Chaudhuri, P. and Bhattacharya, K. 2013. Screening obesity by direct and derived anthropometric indices with evaluation of physical efficiency among female college students of Kolkata. *Annuals of medical and health sciences research*, 3 (4): 517-522. Available: https://www.ajol.info/index.php/amhsr/article/download/99618/88900 (Accessed on 15 June 2019).

Sexton, H., Søgaard, A. and Olstad, R. 2001. How are mood and exercise related? Results from the Finnmark study. *Social psychiatry and psychiatric epidemiology*, 36

(7): 348-353. Available: https://link.springer.com/article/10.1007/s001270170040 (Accessed on 4 August 2018).

Shisana, O., Labadarios, D., Rehle, T., Simbayi, L., Zuma, K., Dhansay, A., Reddy, P., Parker, W., Hoosain, E. and Naidoo, P. 2014. *The South African National Health and Nutrition Examination Survey, 2012: SANHANES-1: the health and nutritional status of the nation*. Available: http://repository.hsrc.ac.za/handle/20.500.11910/2864 (Accessed on 19 March 2019).

Singh, A. and Purohit, B. 2012. Physical activity, sedentary lifestyle, and obesity among Indian dental professionals. *Journal of Physical Activity and Health*, 9 (4): 563-570. Available: https://pdfs.semanticscholar.org/6c53/bf99e30ea6a757399fd97d6fe4722ed6f7e8.pdf (Accessed on 23 October 2018).

Sitthipornvorakul, E., Janwantanakul, P. and van der Beek, A. J. 2014. Correlation between pedometer and the Global Physical Activity Questionnaire on physical activity measurement in office workers. *BMC Research Notes*, 7(1): 280. Available: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4023491/ (Accessed on 12 June 20119).

Skaal, L. and Pengpid, S. 2011. Obesity and health problems among South African healthcare workers: do healthcare workers take care of themselves? *South African Family Practice*, 53 (6): 563-567. Available: https://www.tandfonline.com/doi/pdf/10.1080/20786204.2011.10874153 (Accessed on 13 September 2018).

Skaal, L. and Pengpid, S. 2012. The predictive validity and effects of using the transtheoretical model to increase the physical activity of healthcare workers in a public hospital in South Africa. *Translational behavioral medicine*, 2 (4): 384-391. Available: http://www.academia.edu/download/39389751/The_predictive_validity_and_effects_of_u20151023-15382-3m847t.pdf (Accessed on 8 April 2018).

Slentz, C. A., Duscha, B. D., Johnson, J. L., Ketchum, K., Aiken, L. B., Samsa, G. P., Houmard, J. A., Bales, C. W. and Kraus, W. E. 2004. Effects of the amount of exercise on body weight, body composition, and measures of central obesity: STRRIDE—a randomized controlled study. *Archives of internal medicine*, 164 (1): 31-39. Available: https://jamanetwork.com/journals/jamainternalmedicine/articlepdf/216495/ioi30059.pdf (Accessed on 14 May 2019).

Smith, J. C. 2013. Effects of emotional exposure on state anxiety after acute exercise. *Medicine and science in sports and exercise*, 45 (2): 372-378. Available: https://pdfs.semanticscholar.org/bcb8/57a005e6dc38b66e3f55fb7a9d5401d3a6f5.pdf (Accessed on 14 October 2018).

Smith, L., Gardner, B., Fisher, A. and Hamer, M. 2015. Patterns and correlates of physical activity behaviour over 10 years in older adults: prospective analyses from the English Longitudinal Study of Ageing. *BMJ open*, 5 (4): e007423. Available: http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.956.1589&rep = rep1&type=pdf (Accessed on 12 March).

Soo, K., Wan Abdul Manan, W. and Wan Suriati, W. 2015. The Bahasa Melayu version of the Global Physical Activity Questionnaire: reliability and validity study in Malaysia. *Asia Pacific Journal of Public Health*, 27 (2): NP184-NP193. Available: https://journals.sagepub.com/doi/abs/10.1177/1010539511433462 (Accessed on 17 July 2018).

Soran, H., Adam, S., Mohammad, J. B., Ho, J. H., Schofield, J. D., Siahmansur, T., Liu, Y., Syed, A. A., Dhage, S. S. and Stefanutti, C. 2018. Hypercholesterolaemia – practical information for non-specialists. *Archives of medical science*, 14 (1): 1. Available: https://www.researchgate.net/profile/Maciej_Banach/publication/321951825_Guidelines_Hypercholesterolaemia_-_practical_information_for_non-specialists/links/5a3ae6bda6fdcc7ffe63f0a1/Guidelines-Hypercholesterolaemia-practical-information-for-non-specialists.pdf (Accessed on 17 June 2018).

South African History Online, 2019. *Indian South Africans.* Available: https://www.sahistory.org.za/article/indian-south-africans (Accessed 21 February 2020).

Spittaels, H., De Bourdeaudhuij, I., Brug, J. and Vandelanotte, C. 2006. Effectiveness of an online computer-tailored physical activity intervention in a real-life setting. *Health* *education research*, 22 (3): 385-396. Available: https://academic.oup.com/her/article-abstract/22/3/385/597066 (Accessed on 9 March).

Stamler, J., Daviglus, M. L., Garside, D. B., Dyer, A. R., Greenland, P. and Neaton, J. D. 2000. Relationship of Baseline Serum Cholesterol Levels in 3 Large Cohorts of Younger Men to Long-term Coronary, Cardiovascular, and All-Cause Mortality and to Longevity. *JAMA*, 284: 311-318. Available: https://jamanetwork.com/journals/jama/articlepdf/192897/joc00012.pdf (Accessed on 9 October).

Stasiulis A, M. A., Vizbaraite D, Mockus P. 2010. Aerobic exercise-induced changes in body composition and blood lipids in young women. *Medicina* 46: 129-134. Available: https://www.mdpi.com/1010-660X/46/2/129/pdf (Accessed 31 July 2019).

Statistics Solutions. 2013. *ANOVA (Analysis of Variance).* Available: https://www.statisticssolutions.com/manova-analysis-anova/ (Accessed 20 February 2020).

Steyn, K., Fourie, J. and Temple, N. 2006. Chronic diseases of lifestyle in South Africa: 1995–2005. *Cape Town: South African Medical Research Council,* 33-47.

Steyn, K., Levitt, N. S., Hoffman, M., Marais, A., Fourie, J. M., Lambert, E. V., Gaziano, T. A., Kepe, L. and Lombard, C. J. 2004. The global cardiovascular diseases risk pattern in a peri-urban working-class community in South Africa. The Mamre study. *Ethnicity & Disease*, 14 (2): 233-242. Available: https://www.researchgate.net/profile/David_Marais/publication/8573949_The_global_cardiovascular_diseases_risk_pattern_in_a_peri-urban_working-class_community_in_South_Africa_The_Mamre_Study/links/0fcfd507ef3bf43dbb000000.pdf (Accessed on 6 September 2018).

St-Onge, M.P. and Gallagher, D. 2010. Body composition changes with aging: the cause or the result of alterations in metabolic rate and macronutrient oxidation? *Nutrition*, 26 (2): 152-155. Available: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2880224/ (Accessed on 17 November 2019).

Strath, S. J., Kaminsky, L. A., Ainsworth, B. E., Ekelund, U., Freedson, P. S., Gary, R. A., Richardson, C. R., Smith, D. T. and Swartz, A. M. 2013. Guide to the assessment of physical activity: clinical and research applications: a scientific statement from the American Heart Association. *Circulation*, 128 (20): 2259-2279. Available: https://pdfs.semanticscholar.org/c3d9/f2331e9780aefc91240f892eaf90fe31d8c5.pdf (Accessed on 8 April 2019).

Stumvoll, M., Goldstein, B. J. and van Haeften, T. W. 2005. Type 2 diabetes: principles of pathogenesis and therapy. *The Lancet*, 365 (9467): 1333-1346. Available: https://dspace.library.uu.nl/bitstream/handle/1874/10604/Haeften_Pathogenesis+of+type+2+diabetes.pdf?sequence=2 (Accessed on 22 September 2018).

Suman, C. Aerobic Exercise Programme and Reduction in Body Weight and Body Mass Index (BMI). *Galore International Journal of Health Sciences and Research,* 1(1): 41-44. Available: http://www.gijhsr.com/GIJHSR_Vol.1_Issue.1_Dec2016/7.pdf (Accessed on 19 March 2019).

Sun, F., Norman, I. J. and While, A. E. 2013. Physical activity in older people: a systematic review. *BMC public health*, 13 (1): 449. Available: https://www.researchgate.net/profile/Alison_While/publication/236642019_Physical_activity_in_older_people_A_systematic_review/links/0deec5223617874d14000000.pdf (Accessed on 12 August 2018).

Swain, D. P. 2005. Moderate or vigorous intensity exercise: which is better for improving aerobic fitness? *Preventive cardiology*, 8 (1): 55-58. Available: https://scholar.google.co.za/scholar?output=instlink&q=info: JfbjZJZ_5DIJ: scholar.google.com/&hl=en&as_sdt=0,5&scillfp = 1767821058620073728 7&oi=lle (Accessed on 15 July 2018).

Swinburn, B. A., Sacks, G., Hall, K. D., McPherson, K., Finegood, D. T., Moodie, M. L. and Gortmaker, S. L. 2011. The global obesity pandemic: shaped by global drivers and local environments. *The Lancet*, 378 (9793): 804-814. Available: https://cdn.auckland.ac.nz/assets/fmhs/School%20of%20Population%20Health/documents/global-obesity-pandemic-lancet-2011-swinburn-et-al.pdf (Accessed on 18 May 2019).

Taylor, R. S., Brown, A., Ebrahim, S., Jolliffe, J., Noorani, H., Rees, K., Skidmore, B., Stone, J. A., Thompson, D. R. and Oldridge, N. 2004. Exercise-based rehabilitation for patients with coronary heart disease: systematic review and meta-analysis of randomized controlled trials. *The American journal of medicine*, 116 (10): 682-692. Available: http://www.academia.edu/download/3742432/Taylor_et_al__2004.pdf (Accessed on 7 September 2018).

Telama, R. 2009. Tracking of physical activity from childhood to adulthood: A review. *Obesity facts* 3(2): 187–195. Available: https://www.ncbi.nlm.nih.gov/pubmed/20054224?dopt=Abstract (Accessed on 6 March 2019).

Telama, R. and Yang, X. 2000. Decline of physical activity from youth to young adulthood in Finland. *Medicine and science in sports and exercise*, 32 (9): 1617-1622. Available: https://www.researchgate.net/profile/Xiaolin_Yang/publication/12328113_Decline_of_Physical_Activity_from_Youth_to_Young_Adulthood_in_Finland/links/59db22b70f7e9b12b36fb800/Decline-of-Physical-Activity-from-Youth-to-Young-Adulthood-in-Finland.pdf (Accessed on 27 August 2018).

The National Heart, Lung and Blood Institute. 2018. *Atherosclerosis*. Available: https://www.nhlbi.nih.gov/health-topics/atherosclerosis (Accessed on 6 July 2018).

The NHS Information Centre. 2008. *Health Survey for England 2008: Physical activity and fitness: Summary of key findings.* Available: https://digital.nhs.uk/data-and-information/publications/statistical/health-survey-for-england/health-survey-for-england-2008-physical-activity-and-fitness (Accessed 26 October 2018).

Thompson, P. D. and Rader, D. J. 2001. Does Exercise Increase HDL Cholesterol in Those Who Need It the Most? *Arteriosclerosis, thrombosis, and vascular biology*, 21(7): 1097-1098. Available: http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.504.7116&rep = rep1&type=pdf (Accessed on 25 July 2018).

Tigbe, W. W., Lean, M. E. and Granat, M. H. 2011. A physically active occupation does not result in compensatory inactivity during out-of-work hours. *Preventive medicine,* 53 (1-2): 48-52. Available:

https://www.sciencedirect.com/science/article/pii/S009174351100171X (Accessed on 7 March 2019).

Tremblay, M. S., Gray, C. E., Akinroye, K., Harrington, D. M., Katzmarzyk, P. T., Lambert, E. V., Liukkonen, J., Maddison, R., Ocansey, R. T. and Onywera, V. O. 2014. Physical activity of children: a global matrix of grades comparing 15 countries. *Journal of physical activity and health*, 11 (s1): S113-S125. Available: http://ugspace.ug.edu.gh/bitstream/handle/123456789/27111/Physical%20Activity%20of%20Children%20A%20Global%20Matrix%20of%20Grades%20Comparing%2015%20Countries.pdf?sequence=1&isAllowed=y (Accessed on 8 October 2018).

Tudor-Locke, C. E. and Myers, A. M. 2001. Challenges and opportunities for measuring physical activity in sedentary adults. *Sports medicine*, 31 (2): 91-100. Available: https://www.ncbi.nlm.nih.gov/pubmed/11227981 (Accessed on 17 April 2019).

Tudor-Locke, C., Craig, C.L., Brown, W.J., Clemes, S.A., De Cocker, K., Giles-Corti, B., Hatano, Y., Inoue, S., Matsudo, S.M., Mutrie, N. and Oppert, J.M., 2011. How many steps/day are enough? For adults. *International Journal of Behavioral Nutrition and Physical Activity*, *8*(1), p.79.Available:https://www.scienceopen.com/document_file/ffc65594-b1a2-4436-b856-f829400e8be9/PubMedCentral/ffc65594-b1a2-4436-b856-f829400e8be9.pdf (Accessed on 15 October 2018).

Tudor-Locke, C., Henderson, K. A., Wilcox, S., Cooper, R. S., Durstine, J. L. and Ainsworth, B. E. 2003. In their own voices: definitions and interpretations of physical activity. *Women's Health Issues*, 13 (5): 194-199. Available: https://www.sciencedirect.com/science/article/pii/S1049386703000380 (Accessed on 3 May 2018).

Tudor-Locke, C., Williams, J. E., Reis, J. P. and Pluto, D. 2002. Utility of pedometers for assessing physical activity. *Sports medicine*, 32 (12): 795-808. Available: https://pdfs.semanticscholar.org/0982/4b5e5efc34c4ccea4f8b18c7b5da8a9d5eae.pdf (Accessed on 23 February 2019).

Tudor-Locke, C., Williams, J. E., Reis, J. P. and Pluto, D. 2004. Utility of pedometers for assessing physical activity. *Sports Medicine*, 34 (5): 281-291. Available:

https://link.springer.com/article/10.2165/00007256-200232120-00004 (Accessed on 26 May 2018).

US Department of Health and Human Services. 1996. *Physical Activity and Health. A report of the Surgeon General*. Atlanta, Georgia: Centers for Disease Control and Prevention, US Department of Health and Human Services.

U.S. Department of Health and Human Services.2008.*2008 Physical Activity Guidelines for Americans.* Available: https://health.gov/sites/default/files/2019-09/paguide.pdf (Accessed on 19 February 2020).

Uth, N., Sørensen, H., Overgaard, K. and Pedersen, P. K. 2004. Estimation of V̇O 2max from the ratio between HR max and HR rest – the Heart Rate Ratio Method. *European journal of applied physiology*, 91 (1): 111-115. Available: https://www.ncbi.nlm.nih.gov/pubmed/14624296 (Accessed on 5 April 2019).

Van der Niet, A. G., Smith, J., Scherder, E. J., Oosterlaan, J., Hartman, E. and Visscher, C. 2015. Associations between daily physical activity and executive functioning in primary school-aged children. *Journal of Science and Medicine in Sport*, 18 (6): 673-677. Available: http://www.npenn.org/cms/lib/PA09000087/Centricity/Domain/1230/sedentary%20cognition%20youngchildren.pdf (Accessed on 12 August 2018).

Van Mechelen, W. and Kemper, H. 1995. Habitual physical activity in longitudinal perspective. *The Amsterdam growth study: a longitudinal analysis of health, fitness, and lifestyle*, 6: 135-158.

Van Mechelen, W., Twisk, J. W., Post, G. B., Snel, J. and Kemper, H. C. 2000. Physical activity of young people: the Amsterdam Longitudinal Growth and Health Study. *Medicine & Science in Sports & Exercise*, 32(9): 1610-6. Available: https://www.ncbi.nlm.nih.gov/pubmed/10994913 (Accessed on 26 March 2019).

Van Wier, M. F., Ariëns, G. A., Dekkers, J. C., Hendriksen, I. J., Smid, T. and Van Mechelen, W. 2009. Phone and e-mail counselling are effective for weight management in an overweight working population: a randomized controlled trial. *BMC public health*, 9 (1): 6. Available: https://core.ac.uk/download/pdf/15459089.pdf (Accessed on 6 May 2019).

Vandelanotte, C., De Bourdeaudhuij, I., Sallis, J. F., Spittaels, H. and Brug, J. 2005. Efficacy of sequential or simultaneous interactive computer-tailored interventions for increasing physical activity and decreasing fat intake. *Annuals of Behavioral Medicine*, 29 (2): 138-146. Available: http://www.academia.edu/download/37397148/2005_-_Vandelanotte_-_effectiveness_simultane_and_sequential_computer_tailored_PA_and_fat_intake_intervention.pdf (Accessed on 17 August 2018).

Von Thiele Schwarz, U., Lindfors, P. and Lundberg, U. 2008. Health-related effects of worksite interventions involving physical exercise and reduced workhours. *Scandinavian Journal of Work, Environment and Health*, 34 (3): 179-188. Available: http://www.academia.edu/download/37397148/2005_-_Vandelanotte_-_effectiveness_simultane_and_sequential_computer_tailored_PA_and_fat_intake_intervention.pdf (Accessed on 14 October 2018).

Walker, B.R., Colledge, N.R., Ralston, S.H. and Penman, I. D. eds. 2014. *Davidson's principles & practice of medicine.* 22nd ed. London: Elsevier.

Waller, K., Kaprio, J. and Kujala, U. 2008. Associations between long-term physical activity, waist circumference and weight gain: a 30-year longitudinal twin study. *International journal of obesity*, 32 (2): 353. Available: https://jyx.jyu.fi/bitstream/handle/123456789/49197/associations%20between%20longterm%20physical%20activitywallerijo.pdf?sequence=1 (Accessed on 6 June 2019).

Walter, C. M. and Du Randt, R. 2011. Socio-cultural barriers to physical activity among black isiXhosa speaking professional women in the Nelson Mandela Metropolitan Municipality. *South African Journal for Research in Sport, Physical Education and Recreation*, 33 (2): 143-55. Available: http://search.ebscohost.com/login.aspx?direct=true&profile=ehost&scope=site&authtype=crawler&jrnl=03799069&asa=Y&AN=67011177&h=YNWI85wLFzYQQcVEJqUhtD6sR%2Fy%2Fd9uuF9IP4lxOcphnCdaCEn9Sec1B6qZGwcJVvDP64ixfuRQQ0OcgEcHseg%3D%3D&crl=c (Accessed on 25 August 2018).

Warburton, D. E., Nicol, C. W. and Bredin, S. S. 2006. Health benefits of physical activity: the evidence. *Canadian Medical Association Journal*, 174 (6): 801-809.

Available: https://pdfs.semanticscholar.org/0f21/55889dceb74cc58941ec406f6fe30f376f0d.pdf (Accessed on 13 June 2018).

Wedro, B 2019. *Triglyceride Test (Lowering Your Triglycerides).* Available: https://www.medicinenet.com/triglyceride_test/article.htm (Accessed on 27 February 2020).

White, C. R., Giordano, S. and Anantharamaiah, G. M. 2016. High-density lipoprotein, mitochondrial dysfunction and cell survival mechanisms. *Chemistry and Physics of Lipids*, 199: 161-169. Available: https://europepmc.org/articles/pmc4972637 (Accessed on 16 April 2019).

Wood, R. 2008. *Astrand Cycle Fitness Test*. Available: https://www.topendsports.com/testing/tests/astrand.htm (Accessed 16 January 2019).

Wood, R. 2008. *Cardiovascular / Aerobic Endurance Fitness Tests*. Available: https://www.topendsports.com/testing/aerobic.htm (Accessed 2 May 2019).

World Health Organisation, Expert Consultation, 2004. Appropriate body-mass index for Asian populations and its implications for policy and intervention strategies. *Lancet*, 363 (9403):157. Available: https://www.ncbi.nlm.nih.gov/pubmed/14726171. (Accessed 20 February 2020).

World Health Organisation. 2010. *Global recommendations on physical activity for health Geneva*: Available: https://www.who.int/dietphysicalactivity/factsheet_recommendations/en/ (Accessed 12 September 2019).

World Health Organisation. 2015. *Top 10 causes of death*. Available: http://www.who.int/gho/countries/zaf.pdf (Accessed 28 November 2018).

World Health Organisation. 2018. *Obesity*. Available: https://www.who.int/topics/obesity/en/ (Accessed 14 December 2018).

World Health Organisation. 2018. *What is Moderate-intensity and Vigorous-intensity Physical Activity?* Available: https://www.who.int/dietphysicalactivity/physical_activity_intensity/en/ (Accessed 25 July 2018).

World Health Organisation. 2019. *Body mass index - BMI*. Available: http://www.euro.who.int/en/health-topics/disease-prevention/nutrition/a-healthy-lifestyle/body-mass-index-bmi (Accessed 3 March 2019).

World Health Organization. 2002-2003. *Preliminary results of the World Health Survey, 2002-2003; International Physical Activity Data, South African results*. Geneva: World Health Organisation.

World Health Organization. 2011. *Waist circumference and waist-hip ratio: report of a WHO expert consultation, Geneva, 8-11 December 2008*. Available: https://apps.who.int/iris/bitstream/handle/10665/44583/9789241501491_eng.pdf;jses (Accessed on 19 June 2019).

World Health Organization. 2016. *Raised total cholesterol (≥5.0 mmol/L) data by country*. Available: http://apps.who.int/gho/data/node.main.A884?lang=en (Accessed 16 December 2018).

Wright, S. M. and Aronne, L. J. 2012. Causes of obesity. *Abdominal Radiology*, 37 (5): 730-732. Available: https://link.springer.com/article/10.1007/s00261-012-9862-x (Accessed on 19 August 2018).

Xu, F., Town, M., Balluz, L. S., Bartoli, W. P., Murphy, W., Chowdhury, P. P., Garvin, W. S., Pierannunzi, C., Zhong, Y. and Salandy, S. W. 2013. Surveillance for certain health behaviors among states and selected local areas—United States, 2010. *Morbidity and Mortality Weekly Report: Surveillance Summaries*, 62 (1): 1-247. Available: https://www.jstor.org/stable/pdf/24806068.pdf (Accessed on 12 November 2018).

Yamauchi, T., Kamon, J., Waki, H., Terauchi, Y., Kubota, N., Hara, K., Mori, Y., Ide, T., Murakami, K. and Tsuboyama-Kasaoka, N. 2001. The fat-derived hormone adiponectin reverses insulin resistance associated with both lipoatrophy and obesity. *Nature medicine*, 7 (8): 941. Available: https://www.nature.com/articles/nm0801_941 (Accessed on 20 June 2018).

Appendices

Appendix A: Letter of Information and consent

DUT DURBAN UNIVERSITY OF TECHNOLOGY

FACULTY OF HEALTH SCIENCES

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APPENDIX A

LETTER OF INFORMATION

Dear Participant,
Welcome to my study and thank you for your interest.

Title of the Research Study: Physical activity patterns and aerobic fitness of academic staff at a University of Technology in South Africa

Principal Investigator/s/researcher: Prof. JD Pillay (PhD (Exercise Science and Sports Medicine) (UCT); M. Public Health (UKZN); B. Med. Sc. (Hon)(UDW))

Co-Investigator/s/supervisor/s: Prof. F Haffejee (PhD)

Research Student: Valeska Roelofse

Name of Institution: Durban University of Technology (DUT)

Brief Introduction and Purpose of the Study:
This study will involve 61 staff members at DUT. The purpose of which is to determine how physically active participants are through a questionnaire, pedometer readings and a fitness test.

Outline of the Procedures: In order to participate in this study, you must be a full-time employee at DUT for a duration of at least one year and be willing to wear a pedometer during waking hours for a week. You will not be able to participate if you partake in cycling or swimming or are unable to perform a fitness test due to health problems for example injury or heart disease. You will be required to complete a physical activity questionnaire. You will be asked questions regarding activity levels at work, while travelling and during leisure time . This questionnaire will be anonymous and confidential and after completion you will be required to send it to the researcher. The questionnaire should not take more than a few minutes to complete and if you have any questions please contact the researcher to address any queries. A pedometer will be given to you after completion of the questionnaire. You are required to wear it daily for one week and to follow your daily routine. The pedometer may only be removed when sleeping, showering or bathing. After a week you will then meet the researcher in the rehabilitation room at the DUT chiropractic clinic to return the pedometer and perform a step fitness test. This test will involve you being timed for five minutes while stepping onto and off a step. You will then be asked to sit down and be as still as possible. Your heart rate will be measured. Body Mass Index will be calculated using your height and weight with the formula of kg/m2. Body fat percentage and waist measurements will also be taken. This will not take more than an hour.

Risks or Discomforts to the Participant: You may feel transient muscle stiffness resulting in discomfort after the fitness step assessment is performed.

Benefits: The results of this study will benefit you as you will receive pedometer data such as the distance you walk every day and steps taken per day. The fitness test will give you an indication of your aerobic fitness levels. You will also receive information such as your Body Mass Index, body fat percentage and waist measurements. The questionnaire results will reveal whether you meet the

WHO (World Health Organization) physical activity guidelines in your every-day life. This information gives you insight into your fitness and health and can help you make appropriate changes in exercise routines to improve activity levels. Results of the study will be made available in the form of a dissertation at the Durban University of Technology library. The results give DUT insight into the activity of employees which can aid in steps being taken to educate employees on the importance of exercise and interventions can be done to improve this.

Reason/s why the Participant May Be Withdrawn from the Study: If you are non-compliant with pedometer wear, if you cannot perform the fitness test, if you cycle or swim while wearing the pedometer. You are free to withdraw from the study at any stage. There will be no adverse consequences for you should you choose to withdraw from the study.

Remuneration: Participation in this study will be entirely voluntary and without remuneration. You are free to leave the research at any time.

Costs of the Study: There is no cost to you or your family for you participating in this research.

Confidentiality: All research data will be submitted to chiropractic program for storage and disposal after 5 years will be shredded. Questionnaires will be kept in a locked cupboard at home and kept safe.

Research-related Injury: Research-related injuries should not occur.

Persons to Contact in the Event of Any Problems or Queries:

Please contact the research student, Valeska Roelofse (061 280 5447), my supervisor, Prof. JD Pillay (031 373 2398), my co-supervisor, Prof. F Haffejee (031 373 2395), the Institutional Research Ethics Administrator on 031 373 2375 or the Acting Director: Research and Postgraduate Support, Professor C E Napier on 031 373 2577 or at carinn@dut.ac.za.

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CONSENT

Statement of Agreement to Participate in the Research Study:

- I hereby confirm that I have been informed by the researcher, Valeska Roelofse , about the nature, conduct, benefits and risks of this study - Research Ethics Clearance

Number:__________

- I have also received , read and understood the above written information (Participant Letter of Information) regarding the study.

- I am aware that the results of the study, including personal details regarding my sex, age, date of birth, initials and diagnosis will be anonymously processed into a study report.

- In view of the requirements of research, I agree that the data collected during this study can be processed in a computerised system by the researcher.

- I may, at any stage, without prejudice, withdraw my consent and participation in the study.

- I have had sufficient opportunity to ask questions and (of my own free will) declare myself prepared to participate in the study.

- I understand that significant new findings developed during the course of this research which may relate to my participation will be made available to me.

______________________ ____________ ____________ __________________________

Full Name of Participant Date Time Signature / Right Thumbprint

I, Valeska Roelofse, herewith confirm that the above participant has been fully informed about the nature, conduct and risks of the above study.

______________________ ____________ ____________________

Full Name of Researcher Date Signature

______________________ ____________ ____________________

Full Name of Witness (If applicable) Date Signature

______________________ ____________ ____________________

Full Name of Legal Guardian (If applicable) Date Signature

Appendix B: Confidentiality Agreement

DUT DURBAN UNIVERSITY OF TECHNOLOGY

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APPENDIX B

CONFIDENTIALITY STATEMENT-IMPORTANT NOTICE:

THIS IS TO BE FILLED IN AND READ BY EVERY MEMBER TAKING PART IN THE RESEARCH STUDY,BEFORE THE STUDY COMMENCES.
DECLARATION:

1. All information in the research documents and any information discussed during the study will be kept private and confidential. This is especially binding to any information that may identify any of the participants in the research process.

2. The returned questionnaire, pedometer and fitness test data will be coded and kept anonymous in the research process.

3. None of the information shall be communicated to any other individual or organization outside the specific focus group as to the decision of the focus group.

4. The information from this research study will be made public in terms of journal publication, which will in no way identify any participants of this research.

Once this has been agreed upon and read, please fill in the suitable information below and sign to acknowledge agreement.

Research participant:______________________________Signature:________________________

Witness name:____________________________Signature:________________________

Researcher's
Name:________________________________Signature:________________________

Supervisor's
Name:________________________________Signature:________________________

Appendix C: Questionnaire

Personal details:

Date:____________________

Name and surname:_______________________________

Department: ____________________________________

Faculty:____

Gender:_____________________________

Age:____________

Exercise and sports details:

1) Please specify the sports that you are involved in:
   ____
   ____
   ____
   ____

2) Please specify any other forms of exercise done during leisure time eg. gym, jogging, yoga :
   ____
   ____
   ____
   ____

3) Please rate your level of fitness out of ten: 1 2 3 4 5 6 7 8 9 10

4) Please list any recreational activities eg. dancing, shopping. Please exclude activities which you have already mentioned:
   ____
   ____
   ____
   ____

   Physical activity readiness:

5) Are you physically fit enough to participate in a fitness assessment? This will be a step test where you will be required to step up and down a step as quickly as you can for five minutes or for as long as possible. Your heart rate will be measured after activity has stopped.

   Please circle: Yes / No

6) Please specify any health problems that would prevent you from being able to perform the fitness assessment eg. injuries or heart conditions:
____
____
____
____

Please give your signature in agreement that all information given here is to your knowledge true and correct:

Signature______________________ Date___________________

INTERNATIONAL PHYSICAL ACTIVITY QUESTIONNAIRE

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

Think about all the **vigorous** and **moderate** activities that you did in the **last 7 days**. **Vigorous** physical activities refer to activities that take hard physical effort and make you breathe much harder than normal. **Moderate** activities refer to activities that take moderate physical effort and make you breathe somewhat harder than normal.

PART 1: JOB-RELATED PHYSICAL ACTIVITY

The first section is about your work. This includes paid jobs, farming, volunteer work, course work, and any other unpaid work that you did outside your home. Do not include unpaid work you might do around your home, like housework, yard work, general maintenance, and caring for your family. These are asked in Part 3.

1. Do you currently have a job or do any unpaid work outside your home?

☐ Yes

☐ No → ***Skip to PART 2: TRANSPORTATION***

The next questions are about all the physical activity you did in the **last 7 days** as part of your paid or unpaid work. This does not include traveling to and from work.

2. During the **last 7 days**, on how many days did you do **vigorous** physical activities like heavy lifting, digging, heavy construction, or climbing up stairs **as part of your work**? Think about only those physical activities that you did for at least 10 minutes at a time.

_____ **days per week**

☐ No vigorous job-related physical activity → ***Skip to question 4***

3. How much time did you usually spend on one of those days doing **vigorous** physical activities as part of your work?

_____ **hours per day**
_____ **minutes per day**

4. Again, think about only those physical activities that you did for at least 10 minutes at a time. During the **last 7 days**, on how many days did you do **moderate** physical activities like carrying light loads **as part of your work**? Please do not include walking.

_____ **days per week**

☐ No moderate job-related physical activity → ***Skip to question 6***

LONG LAST 7 DAYS SELF-ADMINISTERED version of the IPAQ. Revised October 2002.

5. How much time did you usually spend on one of those days doing **moderate** physical activities as part of your work?

_____ **hours per day**
_____ **minutes per day**

6. During the **last 7 days**, on how many days did you **walk** for at least 10 minutes at a time **as part of your work**? Please do not count any walking you did to travel to or from work.

_____ **days per week**

☐ No job-related walking → ***Skip to PART 2: TRANSPORTATION***

7. How much time did you usually spend on one of those days **walking** as part of your work?

_____ **hours per day**
_____ **minutes per day**

PART 2: TRANSPORTATION PHYSICAL ACTIVITY

These questions are about how you traveled from place to place, including to places like work, stores, movies, and so on.

8. During the **last 7 days**, on how many days did you **travel in a motor vehicle** like a train, bus, car, or tram?

_____ **days per week**

☐ No traveling in a motor vehicle → ***Skip to question 10***

9. How much time did you usually spend on one of those days **traveling** in a train, bus, car, tram, or other kind of motor vehicle?

_____ **hours per day**
_____ **minutes per day**

Now think only about the **bicycling** and **walking** you might have done to travel to and from work, to do errands, or to go from place to place.

10. During the **last 7 days**, on how many days did you **bicycle** for at least 10 minutes at a time to go **from place to place**?

_____ **days per week**

☐ No bicycling from place to place → ***Skip to question 12***

11. How much time did you usually spend on one of those days to **bicycle** from place to place?

_____ **hours per day**
_____ **minutes per day**

12. During the **last 7 days**, on how many days did you **walk** for at least 10 minutes at a time to go **from place to place**?

_____ **days per week**

☐ No walking from place to place → ***Skip to PART 3: HOUSEWORK, HOUSE MAINTENANCE, AND CARING FOR FAMILY***

13. How much time did you usually spend on one of those days **walking** from place to place?

_____ **hours per day**
_____ **minutes per day**

PART 3: HOUSEWORK, HOUSE MAINTENANCE, AND CARING FOR FAMILY

This section is about some of the physical activities you might have done in the **last 7 days** in and around your home, like housework, gardening, yard work, general maintenance work, and caring for your family.

14. Think about only those physical activities that you did for at least 10 minutes at a time. During the **last 7 days**, on how many days did you do **vigorous** physical activities like heavy lifting, chopping wood, shoveling snow, or digging **in the garden or yard**?

_____ **days per week**

☐ No vigorous activity in garden or yard → ***Skip to question 16***

15. How much time did you usually spend on one of those days doing **vigorous** physical activities in the garden or yard?

_____ **hours per day**
_____ **minutes per day**

16. Again, think about only those physical activities that you did for at least 10 minutes at a time. During the **last 7 days**, on how many days did you do **moderate** activities like carrying light loads, sweeping, washing windows, and raking **in the garden or yard**?

_____ **days per week**

☐ No moderate activity in garden or yard → ***Skip to question 18***

17. How much time did you usually spend on one of those days doing **moderate** physical activities in the garden or yard?

_____ **hours per day**
_____ **minutes per day**

18. Once again, think about only those physical activities that you did for at least 10 minutes at a time. During the **last 7 days**, on how many days did you do **moderate** activities like carrying light loads, washing windows, scrubbing floors and sweeping **inside your home**?

_____ **days per week**

☐ No moderate activity inside home → ***Skip to PART 4: RECREATION, SPORT AND LEISURE-TIME PHYSICAL ACTIVITY***

19. How much time did you usually spend on one of those days doing **moderate** physical activities inside your home?

_____ **hours per day**
_____ **minutes per day**

PART 4: RECREATION, SPORT, AND LEISURE-TIME PHYSICAL ACTIVITY

This section is about all the physical activities that you did in the **last 7 days** solely for recreation, sport, exercise or leisure. Please do not include any activities you have already mentioned.

20. Not counting any walking you have already mentioned, during the **last 7 days**, on how many days did you **walk** for at least 10 minutes at a time **in your leisure time**?

_____ **days per week**

☐ No walking in leisure time → ***Skip to question 22***

21. How much time did you usually spend on one of those days **walking** in your leisure time?

_____ **hours per day**
_____ **minutes per day**

22. Think about only those physical activities that you did for at least 10 minutes at a time. During the **last 7 days**, on how many days did you do **vigorous** physical activities like aerobics, running, fast bicycling, or fast swimming **in your leisure time**?

_____ **days per week**

☐ No vigorous activity in leisure time → ***Skip to question 24***

23. How much time did you usually spend on one of those days doing **vigorous** physical activities in your leisure time?

_____ **hours per day**
_____ **minutes per day**

24. Again, think about only those physical activities that you did for at least 10 minutes at a time. During the **last 7 days**, on how many days did you do **moderate** physical activities like bicycling at a regular pace, swimming at a regular pace, and doubles tennis **in your leisure time**?

_____ **days per week**

☐ No moderate activity in leisure time → ***Skip to PART 5: TIME SPENT SITTING***

25. How much time did you usually spend on one of those days doing **moderate** physical activities in your leisure time?

_____ **hours per day**
_____ **minutes per day**

PART 5: TIME SPENT SITTING

The last questions are about the time you spend sitting while at work, at home, while doing course work and during leisure time. This may include time spent sitting at a desk, visiting friends, reading or sitting or lying down to watch television. Do not include any time spent sitting in a motor vehicle that you have already told me about.

26. During the **last 7 days**, how much time did you usually spend **sitting** on a **weekday**?

_____ **hours per day**
_____ **minutes per day**

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

_____ **hours per day**
_____ **minutes per day**

This is the end of the questionnaire, thank you for participating.

LONG LAST 7 DAYS SELF-ADMINISTERED version of the IPAQ. Revised October 2002.

Appendix D: Letter requesting gatekeeper permission and response

Letter requesting gatekeeper permission and response: Acting Director: Research and Postgraduate Support: Professor Napier

3 Overdale Road, Berea
Durban
4001
valeskaroeloise@gmail.com
061 280 5447

June 2018

Faculty of Health Sciences
P.O. Box 1334
Durban
4000

Dear Acting Director: Research and Postgraduate Support: Professor Napier,

I am a chiropractic masters' student doing my research on physical activity patterns and fitness levels of staff at the Durban University of Technology and thus am writing to ask permission for access to the staff at the university for the duration of my study.

Title of Research Study:
Physical activity patterns and aerobic fitness of academic staff at a University of Technology in South Africa

Brief Introduction and Purpose of the Study:
Physical activity has become a health issue globally and internationally and has become a concern for government and health-care providers. Physical inactivity has been found to be high in six studies done in South Africa and has been linked to co-morbid pathologies such as cardiovascular disease, diabetes mellitus as well as disability and death. Physical activity has been shown to be caused largely by office occupations which involve sitting for most of the day, leading to development of work-related musculoskeletal disorders (WRMSD), poor sleep quality impacting work productivity and can then lead to increased sick leave. Therefore the purpose of this study is to determine the physical activity patterns and fitness levels of academic staff at the university through a questionnaire, pedometer readings and a fitness test.

Outline of the Procedures:
61 staff members will be recruited by the researcher who will email staff members and the study will be explained and participation will be asked for. Those staff that are willing to participate in the study will receive a Letter of Information and Informed consent, confidentiality statement and the questionnaire to complete. All information will be strictly anonymous and confidential. Participation in this study will be entirely voluntary and the participants will be free to withdraw at any time. The participants will be required to wear a pedometer daily for a week and instructed to follow their daily routine. After completion of one week the participants will meet the researcher at the rehabilitation room in the DUT chiropractic clinic to return the pedometer and do the Harvard step test which requires the patient to climb onto and off a step continuously for five minutes after which their heart rates will be measured. Body Mass Index will be calculated using the participant's height and weight with the formula of kg/m^2. Body fat percentage and waist measurements will also be taken. This will not take more than an hour.

Risks or Discomforts to the Participant:
Patients may feel transient muscle stiffness resulting in discomfort after the fitness step assessment is performed.

Confidentiality:
All research data and information received in the study is strictly confidential and anonymous and will be submitted to chiropractic program for storage and disposal after 5 years will be shredded. Questionnaires will be kept in a locked cupboard at home and kept safe.

Please see my research proposal attached for further information regarding my study.

Persons to contact with problems or queries:
Should you have any questions please contact my supervisor, Prof. JD Pillay (031 373 2398),co-supervisor, Prof. Haffejee (031 345 678) or myself (061 280 5447).

In order to move forward with this study, would you be so kind as to respond to this letter in writing indicating whether you would approve of this study and give permission for access to the academic and administrative staff at the Durban University of Technology.

Regards,

Signature__ [redacted] _ Date: 15/06/18

Valeska Roelofse

Signature [redacted] ____ Date: 15/02/2018

Prof JD Pillay (Supervisor)

[redacted]

Signature________________ Date:_14 June 2018___

Prof F Haffejee (co-supervisor)

Directorate for Research and Postgraduate Support
Durban University of Technology
Tromso Annexe, Steve Biko Campus
P.O. Box 1334, Durban 4000
Tel.: 031-3732576/7
Fax: 031-3732946

24th July 2018

Ms Valeska Roelofse
c/o Department of Chiropractic and Somatology
Faculty of Health Sciences
Durban University of Technology

Dear Ms Roelofse

PERMISSION TO CONDUCT RESEARCH AT THE DUT

Your email correspondence in respect of the above refers. I am pleased to inform you that the Institutional Research and Innovation Committee (IRIC) has granted full permission for you to conduct your research "Physical activity patterns and aerobic fitness of academic staff at a University of Technology in South Africa" at the Durban University of Technology.

The DUT may impose any other condition it deems appropriate in the circumstances having regard to nature and extent of access to and use of information requested.

We would be grateful if a summary of your key research findings can be submitted to the IRIC on completion of your studies.

Kindest regards.
Yours sincerely

[redacted]

PROF CARIN NAPIER
DIRECTOR (ACTING): RESEARCH AND POSTGRADUATE SUPPORT DIRECORATE

Appendix E: Letter requesting gatekeeper permission from DUT Chiropractic Clinic Director

MEMORANDUM

To	:	Prof Adam Chair : IREC
From	:	Prof A Ross Deputy Dean : Faculty of Health Sciences Dr Charmaine Korporaal Clinic Director : Chiropractic Day Clinic : Chiropractic and Somatology
Date	:	19.03.2018
Re	:	Request for permission to use the Chiropractic Day Clinic for research purposes

Permission is hereby granted to :

Ms Valeska Roelofse (Student Number: 21323599)

Research title : " Physical activity patterns and aerobic fitness of academic staff at a University of Technology in South Africa".

Ms Roelofse, is requested to submit a copy of her FRC / IREC approved proposal along with proof of her MTech:Chiropractic registration to the Clinic Administrators before she starts with her research in order that any special procedures with regards to her research can be implemented prior to the commencement of her seeing patients.

Thank you for your time.

Kind regards

[redacted]

Prof AHA Ross
Deputy Dean
Faculty of Health Sciences

[redacted]

Dr Charmaine Korporaal
Clinic Director : Chiropractic Day Clinic :
Chiropractic and Somatology

Cc: Mrs Linda Twiggs : Chiropractic Day Clinic
Dr L O'Connor : Research co-ordinator and supervisor
Dr J Pillay and Dr F Haffejee : Research supervisor(s)

Appendix F: Advertisement

- Would you like a **free fitness assessment and wear a pedometer to know how many steps you take?**

- Are you a **full-time academic staff member at DUT on Ritson, ML Sultan or Steve Biko campuses?**

(Marwah 2013: 1)

Haase 2016: 1)

Research is being carried out at the Durban University of Technology Chiropractic Day Clinic

For more information contact Valeska at

[redacted]

Appendix G: Data collection sheet: aerobic fitness assessment

Date: _________________

Name and surname of participant: ___________________

Time of stepping**:** ______________minutes

Table One: Heart rate and seconds

Seconds	Heart rate
0-30 s	
30s-60s	
60s-90s	
90s-120s	
120s-150s	
150-180s	
180s-210s	
210s-240s	
240s-270s	
270s-300s	
300s	

Table Two: Body Mass Index (kg/m^2)

Height (metres)	
Weight (kilograms)	
Body Mass Index (kg/m^2)	

Waist Circumference (cm): ___________

Hip Circumference (cm): _____________

Body fat percentage (%): _____________

Appendix H: IREC approval letter

DUT
DURBAN
UNIVERSITY OF
TECHNOLOGY

Institutional Research Ethics Committee
Research and Postgraduate Support Directorate
2nd Floor, Berwyn Court
Gate 1, Steve Biko Campus
Durban University of Technology

P O Box 1334, Durban, South Africa, 4001

Tel: 031 373 2375
Email: lavishad@dut.ac.za
http://www.dut.ac.za/research/institutional_research_ethics

www.dut.ac.za

31 July 2018

IREC Reference Number: **REC 37/18**

Ms V Roelofse
9 Edmonds Place
Glenwood
Durban
4001

Dear Ms Roelofse

Physical activity patterns and aerobic fitness of academic staff at a University of Technology in South Africa

The Institutional Research Ethics Committee acknowledges receipt of your gatekeeper permission letter.

Please note that FULL APPROVAL is granted to your research proposal. You may proceed with data collection.

Any adverse events [serious or minor] which occur in connection with this study and/or which may alter its ethical consideration must be reported to the IREC according to the IREC Standard Operating Procedures (SOP's).

Please note that any deviations from the approved proposal require the approval of the IREC as outlined in the IREC SOP's.

Yours Sincerely,

[redacted]

Professor J K Adam
Chairperson: IREC

DUT DURBAN UNIVERSITY OF TECHNOLOGY
2018 -07- 31
INSTITUTIONAL RESEARCH ETHICS COMMITTEE
P O BOX 1334 DURBAN 4000 SOUTH AFRICA

Appendix I: Biostatistics letter

Biostatistics Unit

Division of Epidemiology and Biostatistics

Faculty of Medicine and Health Sciences

Stellenbosch University

17 March 2019

To whom it may concern

Re: Reduction in sample size for Valeska Roelofse's study

As the consultant biostatistician for this study, I have been asked to comment on the validity of a sample size reduction from the originally approved total of 213. The student is requesting a reduction in sample size due to time difficulties with recruitment of participants for pedometer measurements. She has already been collecting data for five months and has achieved just over 60 participants.

Her protocol states an *a priori* sample size calculation: "The sample size required for completion of the questionnaire and pedometer study is 213 staff members. A power analysis for a chi-squared test was conducted in G-POWER to determine a sufficient sample size. An alpha of 0.05, power of 0.80, a medium effect size (w = 0.4) and 4 degrees of freedom was used". *A priori* sample size estimation is extremely difficult, as one has to predict the results of the experiment beforehand. These predictions are actually assumptions which need to be made, and factors such as variability within the participant groups need to be taken into account. This is usually not possible to do accurately without conducting simulation models and experiments.

In the case of this student's research, at present she has collected data on just over 60 participants. I was able to examine the data and conduct an interim analysis and power calculation with the actual data collected. The data is already showing trends of clinically important differences in the mean from one group to the next, but due to a large amount of variability within groups (high standard deviations), the differences do not reach statistical significance with the current sample size. I calculated effect sizes for all five of the outcomes by comparison of the means and standard deviations between the three groups. These effect sizes are small to moderate in size, much lower than was previously assumed in the sample size calculation in the protocol. The revised sample size calculations in G*POWER are shown below for each outcome based on the actual effect sizes observed:

Average steps:

F tests – ANOVA: Fixed effects, omnibus, one-way

Analysis:	A priori: Compute required sample size		
Input:	Effect size f	=	0.24
	α err prob	=	0.05
	Power (1–β err prob)	=	0.8
	Number of groups	=	3
Output:	Noncentrality parameter λ	=	9.8496000
	Critical F	=	3.0497921
	Numerator df	=	2
	Denominator df	=	168
	Total sample size	=	171
	Actual power	=	0.8017516

Average aerobic steps

F tests – ANOVA: Fixed effects, omnibus, one-way

Analysis:	A priori: Compute required sample size		
Input:	Effect size f	=	0.303
	α err prob	=	0.05
	Power (1−β err prob)	=	0.8
	Number of groups	=	3
Output:	Noncentrality parameter λ	=	9.9153720
	Critical F	=	3.0828520
	Numerator df	=	2
	Denominator df	=	105
	Total sample size	=	108
	Actual power	=	0.8000178

Average walking time

F tests – ANOVA: Fixed effects, omnibus, one-way

Analysis:	A priori: Compute required sample size		
Input:	Effect size f	=	0.248
	α err prob	=	0.05
	Power (1−β err prob)	=	0.8
	Number of groups	=	3
Output:	Noncentrality parameter λ	=	9.9636480
	Critical F	=	3.0528908
	Numerator df	=	2
	Denominator df	=	159
	Total sample size	=	162
	Actual power	=	0.8061328

Average calories

F tests – ANOVA: Fixed effects, omnibus, one-way

Analysis:	A priori: Compute required sample size		
Input:	Effect size f	=	0.31
	α err prob	=	0.05
	Power (1−β err prob)	=	0.8
	Number of groups	=	3
Output:	Noncentrality parameter λ	=	10.0905000
	Critical F	=	3.0854650
	Numerator df	=	2
	Denominator df	=	102
	Total sample size	=	105
	Actual power	=	0.8069765

Average distance

F tests – ANOVA: Fixed effects, omnibus, one-way

Analysis:	A priori: Compute required sample size		
Input:	Effect size f	=	0.19
	α err prob	=	0.05
	Power (1−β err prob)	=	0.8
	Number of groups	=	3
Output:	Noncentrality parameter λ	=	9.7470000
	Critical F	=	3.0295971
	Numerator df	=	2
	Denominator df	=	267
	Total sample size	=	270
	Actual power	=	0.8001460

The highlighted numbers are the total sample size required for each outcome. As can be seen, the minimum sample size required is 105. The student has taken 5 months to collect the current sample size, presumably it would take another 4 months to collect a further 45 participants. And this would only ensure statistical significance in one or maybe two of the five outcomes. In the interests of completion of the study I would recommend to discontinue participant enrolment and data collection for pedometer data and that the student uses what time she has remaining to collect fitness assessment data to equal the numbers of pedometer and IPAQ participants she currently has. It will have to be noted that no statistical significance will be found for the main objectives, however the student could discuss the trend observed and comment on the limitations of time and cost to collect the required sample size. Recommendations for further research could be presented which would assist future students who are wanting to design a similar study.

Yours sincerely

[redacted]

Tonya Esterhuizen

Biostatistician/Senior Lecturer