

**THE RELATIONSHIP BETWEEN LEISURE TIME PHYSICAL  
ACTIVITY AND HEALTH-RELATED FITNESS: A SINGLE-  
BLINDED STUDY**

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## GLOSSARY OF TERMS

Physical activity	Movement of the body produced by skeletal muscle contraction, results in a marked increase over resting energy expenditure <sup>38</sup> .
Exercise	A type of physical activity which includes planned, structured, repetitive movement of the body done to develop one or more components of physical fitness <sup>38</sup> .
Physical fitness	A set of characteristics that people have or achieve relating to the ability to perform physical activity <sup>37</sup> .
Health-related fitness	Components of fitness related to health, which can be affected by regular physical activity including cardiorespiratory fitness, motor abilities, musculoskeletal fitness and body composition <sup>39, 123</sup> .
Flexibility	The range of motion available at a joint <sup>38</sup> .
Agility	The ability to change body position in space with speed and accuracy, in response to a stimulus <sup>38, 45</sup> .
Co-ordination	The ability to use the senses (e.g. sight or hearing) with movement of body parts, to perform tasks smoothly and accurately <sup>38</sup> .
Balance	The maintenance of body equilibrium within its base of support while stationary ( <i>static balance</i> ), or while moving from a dynamic to a static state ( <i>dynamic balance</i> ) <sup>38, 151</sup> .
Power	The rate at which work is performed <sup>38</sup> .
Body composition	The relative amounts of muscle, fat, bone and other vital constituents of the body <sup>38</sup> .
Muscle strength	The ability of muscle to exert force <sup>38</sup> .
Leisure time physical activity	Multimodal physical activity including exercise, sport or physically active hobbies done during leisure time <sup>36</sup> .
Activities of daily living	Activities including household living tasks and transportation <sup>4</sup> .

Motor abilities	Task-specific, multi-joint skills reliant on the interaction of neuromuscular, visual, vestibular and somatosensory physiologic systems <sup>41</sup> . Balance, co-ordination and agility are examples of motor abilities which are needed for functional independence <sup>19</sup> . Motor abilities are components of health-related fitness <sup>123</sup> .
Cardiorespiratory fitness	The ability of the circulatory and respiratory systems to supply oxygen to working muscles during physical activity <sup>38</sup> . It is determined by obtaining the maximum oxygen consumption ( $VO_2$ <sub>max</sub> ) <sup>38</sup> . Cardiorespiratory fitness is also referred to as aerobic power, cardiovascular fitness or aerobic fitness.
Endurance exercise	Rhythmic physical activity involving large muscle groups, of at least moderate intensity <sup>19, 38, 39</sup> . Examples include walking, swimming, running and cycling.
Neuromuscular exercise	Modes of physical activity including muscle strengthening, agility, balance or jumping as components <sup>39, 106</sup> . Examples of neuromuscular-type exercise include weight training, dancing, horse riding, yoga and pilates.
Games	Physically active ball or team sports such as volleyball, badminton, squash and tennis <sup>19</sup> .
Muscular fitness	The ability of muscle to exert force continuously with minimal fatigue <sup>38</sup> .
Neuro-motor fitness	Includes motor abilities (such as balance, co-ordination and agility); and muscular fitness such as muscle strength and power <sup>43</sup> .
Motor training	Participation in leisure time physical activity aimed directly at improving motor abilities or neuro-motor fitness such as balance, co-ordination and agility training <sup>19</sup> .
Mature adults	Adults aged between 40 and 60 years <sup>19</sup> .
Older / elderly adults	Adults aged above 60 years <sup>38</sup> .

Descriptive correlational single-blinded study:	This was a descriptive study that examined for consistent relationships between two variables. The assessor (research assistant) was not informed of the group allocation of the participants.
Sarcopaenia	An age-associated reduction in the body's relative skeletal muscle mass <sup>6,157</sup> .
Functional limitation	An impaired ability to perform daily activities such as walking or climbing stairs <sup>6,7</sup> .
Proprioception	Conscious and unconscious awareness of body position, movement and forces acting upon the body <sup>2</sup> .
Principle of specificity	The result of leisure time physical activity or exercise stimulus is specific to the mode and dosage of training <sup>28,121</sup> .
Heart rate reserve	A method used to quantify exercise intensity. Heart rate reserve is expressed as a percentage of the maximum heart rate minus resting heart rate <sup>38</sup> .
The third age	The period in an older person's life between exiting the labour force and the onset of physical dependence <sup>156</sup> .
Health-related quality of life	The value given to life's duration as modified by impairments, function, perceptions and social circumstances influenced by disease, injury, treatment or policy <sup>156</sup> .
Disability-adjusted life years	A disability-adjusted life year represents a year of healthy life lost. In a population, the total disability-adjusted life years represent the divide between the current health situation and an ideal, where no disease or disability exist <sup>182</sup> .
One-repetition maximum	The greatest amount of weight an individual can lift in a single repetition <sup>38</sup> .
Active commuting	The use of physical activity such as walking or cycling for transport <sup>39</sup> .

## LIST OF ABBREVIATIONS

ACSM	American College of Sports Medicine
ADL	Activities of daily living
BMI	Body mass index
CDC	Centres for Disease Control and Prevention
Cm	Centimetres
HIV/AIDS	Human immunodeficiency virus / Acquired immunodeficiency syndrome
HR	Heart rate
HRR	Heart rate reserve
HRQoL	Health-related quality of life
Kg	Kilograms
LTPA	Leisure time physical activity
M	Metres
ml	Millilitres
Min	Minutes
MET	Metabolic equivalent
PAR-Q	Physical activity readiness questionnaire
PNF	Proprioceptive neuromuscular facilitation
RCT	Randomised controlled trial
ROM	Range of motion
S	Seconds
US	United States
VO <sub>2max</sub>	Maximum oxygen consumption
WHO	World Health Organisation

## ABSTRACT

**Background:** Mature adults are at risk of an accelerated age-related reduction in physical function. Declines in aerobic power, functional strength, motor abilities, flexibility and health-related quality of life are thought to be primarily due to reduced physical activity levels with increasing age. Leisure time physical activity (LTPA) has been extensively investigated and is widely advocated for the preservation of function with ageing. However there is a lack of evidence regarding the relationship between LTPA and the individual components of health-related fitness, particularly motor abilities. It is therefore unclear what types of LTPA (endurance, neuromuscular LTPA or games) should be prescribed by health professionals for the development of health-related fitness parameters.

**Aim:** To examine the relationship between LTPA and components of health-related fitness in healthy mature adults.

**Specific Objectives:** (a) To describe the preferred mode(s) and weekly duration of recent LTPA in currently active male and female participants. (b) To describe the preferred mode(s) and years of participation in long term LTPA, in currently active and inactive male and female participants. (c) To determine if there were significant differences in anthropometry and selected health-related fitness components, in currently active and inactive male and female participants. (d) To determine the relationships between recent participation in different types of LTPA (endurance, neuromuscular or games) and total weekly duration of LTPA; and anthropometry and selected components of health-related fitness in currently active male and female participants. (e) To determine the relationships between former participation in different types of LTPA (endurance, neuromuscular or games) and years of LTPA participation; and anthropometry and selected components of health-related fitness in currently active and inactive male and female participants.

**Methods:** This study had a descriptive, correlational design. Healthy adults aged between 40 and 60 who either participated in regular LTPA or no LTPA, were recruited for the study. Participants were excluded if they had any acute or chronic injuries; or used any medication that altered heart rate or physical function. Fifty six healthy mature adults between the ages of 40 and 58 years participated in this study. Twenty nine had participated in at least 30 minutes of LTPA, three times per week in the last three months (active group); and twenty seven had not participated in LTPA in the last three months (inactive group). Data were collected in two sessions. In session one, participants gave written informed consent; completed a physical activity readiness questionnaire (PAR-Q) to screen for safe exercise participation; and completed health-related quality of life and LTPA questionnaires. Body composition measurements were also performed.

In session two, participants completed a battery of physical tests conducted by a blinded assessor, including: cardiorespiratory fitness (2 km walk test); static and dynamic balance (standing on one leg, tandem walking backwards); agility (Illinois agility test); co-ordination (timed bouncing of a ball along a wall from a fixed distance); upper limb function (modified push-up test); lower limb function (vertical jump test); back muscle endurance (static back extension test); and flexibility (sit-and-reach test).

**Results:** Recently active participants had significantly reduced body mass index (BMI) ( $p = 0.04$ ), body fat percentage ( $p = 0.003$ ) and sum of seven skinfold ( $p = 0.004$ ) measurements, compared to inactive participants. In addition, active participants scored significantly better in the tests for cardiorespiratory fitness ( $p = 0.0004$ ) and upper limb function ( $p = 0.01$ ) than inactive participants. Active females had significantly improved cardiorespiratory fitness ( $p = 0.0002$ ) and agility ( $p = 0.0004$ ) compared to inactive females. Of the health-related fitness components, only cardiorespiratory fitness and back muscle endurance were related to recent LTPA participation. Motor abilities such as agility and dynamic balance, upper- and lower limb function were associated with long term rather than recent LTPA, particularly with long term endurance, games and years of long term LTPA participation.

**Discussion and conclusion:** Active participants had significantly improved body composition, cardiorespiratory fitness and upper limb function compared to inactive participants in this study. These results support previous research suggesting that regular participation in LTPA may help to slow the age-associated decline in physical function. However no significant differences were found in motor abilities between recently active and inactive participants, and no significant relationships were found between recent LTPA participation and motor abilities. Based on the findings in this study, long term LTPA and participation in games are advised for the development of motor abilities and functional strength, in healthy mature adults. As this study sample reported mainly endurance LTPA recently and on the long term, future research should aim to explore the independent contributions of different types of LTPA (endurance, neuromuscular or games) on aspects of health-related fitness. Such information may be very useful clinically to improve the accuracy of exercise prescription. There is also a need to further evaluate the relationship between long-term LTPA and health-related fitness in a larger sample of mature adults.



# CHAPTER ONE: INTRODUCTION AND SCOPE OF THE THESIS

## 1.1. INTRODUCTION

The human race is living longer than previous generations, both globally<sup>136</sup> and in South Africa<sup>32, 34</sup>. Compared to the South African child population, which is projected to increase by 10%, the number of older adults in South Africa is expected to rise by 189%, between 1985 and 2025<sup>34</sup>. Advancing age brings about both a reduction in physical abilities<sup>2, 142, 144, 146, 148, 150, 157, 175</sup> and an increased risk of developing chronic diseases of lifestyle<sup>4, 145, 185</sup>. Further, physical activity and health-related fitness (aerobic and muscular function, motor abilities and flexibility) typically deteriorate during adulthood, with a concurrent accumulation of body fat<sup>149</sup>. This decline may result in early falls and other complications as adults age<sup>1, 2, 3</sup>. In most tissues and structures of the body, the age-associated reduction in function already commences in early adulthood<sup>6, 145</sup>. Therefore older people will place a crippling burden on society in terms of healthcare costs in the coming years, if care is not taken to optimise their function<sup>30, 33, 34</sup>. It is necessary that an accelerated ageing process is prevented already in healthy adults, to avoid early institutionalisation and dependence. Mature adults are aged between 40 and 60 years<sup>19</sup>. This population is at risk for the early onset of chronic diseases and functional decline<sup>31, 145, 157, 175</sup>. Considering their expected longer lifespan, it makes sense to target this age group for health promotion interventions.

Leisure time physical activity (LTPA) includes any exercise or physically active hobbies participated in during one's free time<sup>36</sup>. Types of LTPA may include endurance, neuromuscular LTPA or participation in games<sup>19, 39</sup>. Leisure time physical activity has been shown to help prevent and treat chronic disease<sup>4, 30, 31, 185</sup>, reduce unhealthy weight gain<sup>128, 179</sup> and improve aspects of health-related fitness with ageing<sup>7, 39, 47, 54, 55, 115, 123, 181, 147</sup>. Its benefits have been widely studied and confirmed<sup>28, 57</sup>, mostly in terms of developing cardiorespiratory and muscular function<sup>19, 129, 130</sup>. For this reason, the current guidelines on LTPA participation for adults are mainly aimed at improving aerobic and muscular fitness<sup>38</sup>. Although the American College of Sports Medicine recommends the inclusion of balance, agility and co-ordination training into any exercise programme<sup>38</sup>, there is very little evidence on how specific types of LTPA, long term or short term LTPA accounts for motor abilities<sup>19</sup>. Yet motor skills are critical for the safe execution of most functional and sporting tasks<sup>19</sup>. Further, they are needed to preserve independent function and prevent falls in the elderly<sup>1, 3, 19, 29</sup>. The literature in older adults<sup>41, 113, 114, 119, 153</sup> and in athletes<sup>103 - 107</sup> has pointed to the need for specific motor training rather than general exercise or endurance-based activities to enhance balance, agility and co-ordination.

However, at present there is a lack of clear guidelines for the accurate prescription of LTPA in the mature healthy adults. Clinicians require evidence-based information on the required LTPA types and on the time period of LTPA needed to develop motor abilities<sup>19</sup>.

## **1.2. AIM AND OBJECTIVES**

### **1.2.1. Aim**

The aim of this study was to examine the relationship between LTPA and components of health-related fitness in healthy mature adults.

### **1.2.2. Objectives**

- To describe the reported mode(s)<sup>†</sup> and weekly duration of recent LTPA in recently active male and female participants.
- To describe the reported mode(s) and years of participation in long term LTPA, in recently active and inactive male and female participants.
- To determine if there were significant differences in anthropometry and selected health-related fitness components, in recently active and inactive male and female participants.
- To determine the relationships between recent participation in different types of LTPA (endurance, neuromuscular or games) and total weekly duration of LTPA; and anthropometry and selected components of health-related fitness in recently active male and female participants.
- To determine the relationships between long term participation in different types of LTPA (endurance, neuromuscular or games) and years of LTPA participation; and anthropometry and selected components of health-related fitness in recently active and inactive male and female participants.

The selected health-related fitness components that were assessed in this study included: cardiorespiratory fitness, static and dynamic balance, agility, co-ordination, back muscle endurance, upper extremity function, lower extremity function, flexibility and health-related quality of life. These will be described in detail in Section 3.2.5.3 (page 37).

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<sup>†</sup> Please note that the term “mode(s)” refers to specific type(s) of leisure time physical activity.

### **1.3. SIGNIFICANCE OF THE DISSERTATION**

Leisure time physical activity is widely recommended to preserve health and fitness, and to prevent and manage age-related functional decline and chronic disease. However, there is a paucity of literature on adult LTPA participation and how it relates to individual components of health-related fitness. No data could be found on relationship between long- and short term LTPA participation patterns and health-related fitness in South African adults. The results of this study may therefore improve the understanding of the nature of LTPA participation required to develop aspects of health-related fitness with advancing age. In addition, this research may facilitate the development of rehabilitation protocols for deficits in motor and physical function in mature adults.

### **1.4. PLAN OF DEVELOPMENT**

In preparation for the experimental phase of this dissertation, a comprehensive literature review on the relationship between LTPA and health-related fitness in mature adults will be presented in Chapter 2. This will be followed by a description of the single-blinded study designed to investigate the relationships between LTPA and components of health-related fitness (Chapter 3). A summary and conclusion, including recommendations for future research (Chapter 4) will complete this dissertation.

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# CHAPTER TWO: LITERATURE REVIEW: THE RELATIONSHIP BETWEEN LEISURE TIME PHYSICAL ACTIVITY AND HEALTH-RELATED FITNESS IN MATURE ADULTS

## 2.1. INTRODUCTION

Ageing results in a gradual decline of function, postural stability, muscle strength and an increased risk of falls <sup>1, 2, 3</sup>. Moreover, as people age their susceptibility to chronic conditions such as osteoporosis, cardiovascular disease, respiratory disease and diabetes, increases <sup>3, 4</sup>. Peak bone mass is reached in the third decade of life <sup>5</sup>, while loss of skeletal muscle mass commences at age 45 <sup>6</sup>. Inactivity levels are likely to rise in the aging population, together with an accumulation of body fat mass <sup>7</sup>. The body of evidence associating exercise with numerous health benefits is constantly growing <sup>8, 9, 10, 11, 12, 13</sup>. Despite this, the World Health Organisation (WHO) recently issued a warning that *“physical inactivity has become a global health problem, being accountable for two million deaths per year worldwide”* <sup>14</sup>. Recent studies have shown that regular physical activity may help to decrease the risk of chronic disease<sup>15</sup>, reduce the risk of premature mortality and promote an enhanced sense of well-being <sup>16, 17</sup>. In addition, health-related quality of life (HRQoL) scores of healthy adults have been consistently higher, with increased physical activity levels <sup>18</sup>.

Leisure time physical activity (LTPA) consists of multimodal physical activity including exercise, sport or physically active hobbies done during leisure time <sup>36</sup>. Participation in regular LTPA results in favourable effects on health, body weight and the prevention of chronic disease and disability <sup>19</sup>. While endurance exercise has the greatest benefit for reducing cardiovascular disease <sup>20, 21, 22</sup>; motor and muscular exercise may help prevent falls and improve function in the ageing adult <sup>23, 24, 25, 26, 27</sup>. The principle of specificity states that *“physiologic adaptations to exercise are specific to the type of exercise performed”* <sup>28</sup>. However, the influence of LTPA on individual aspects of health-related fitness, especially the motor abilities, is still unclear <sup>19, 29</sup>.

In this review, adults between 40 and 60 years of age will be referred to as “mature adults” This literature review will outline two major challenges that face the modern mature adult population: chronic diseases of lifestyle and age-related functional decline. The review will discuss LTPA in terms of its benefits and applications in mature adults. In addition, this review will explore the current literature regarding the relationship between LTPA and components of health-related fitness in terms of reducing age-related decline, with particular reference to the motor abilities balance, co-ordination and agility.

Data were sourced from sports medicine and science literature utilising searches on Medline, PubMed and Google Scholar. Searches were further refined by setting the limits to healthy adults only. Keywords used in the search included: *“leisure time physical activity”, “health-related fitness”, “motor abilities”, “motor skills”, “musculoskeletal fitness”, “motor fitness”, “flexibility”, “cardiorespiratory fitness”, “balance”, “co-ordination”, “agility”, “age-related decline”, “chronic diseases of lifestyle”, “mature adults”, “muscle strength” and “sarcopaenia”*.

## **2.2. CHRONIC DISEASES OF LIFESTYLE**

Chronic diseases are health problems that develop over a lifetime, and are also referred to as non-communicable diseases,<sup>30, 32</sup> or as chronic diseases of lifestyle<sup>30</sup>. Typically, these illnesses are not self-limiting in nature,<sup>136</sup> with clinical sequelae appearing many years after the underlying pathogenesis of the disease has occurred<sup>30, 32</sup>. Once established, chronic diseases require ongoing management over years or decades<sup>32, 136</sup>. As both life expectancy and quality of life are severely affected by these conditions, the burden they present to society is enormous<sup>30</sup>. Individual chronic diseases are characterised by the similar demands they place on patients, families and on healthcare and socioeconomic systems<sup>32, 136</sup>. Disruptions are caused to not only the physical capabilities of sufferers, but also to their social identities and life trajectories<sup>32</sup>. Examples of chronic disorders may include cardiovascular disease, type-two diabetes, metabolic syndrome, cancer, chronic lung disease, depression, osteoporosis and sarcopaenia<sup>30, 34</sup>. There is overwhelming evidence that lifestyle factors such as regular physical activity, healthy diet and not smoking may prevent, slow progression or even reverse existing disease<sup>30, 31</sup>. The management of chronic disease should focus on prevention<sup>136</sup>.

The impact that chronic diseases have on the world is thought to be due to the increasing life span of the global population and to changing lifestyles<sup>136</sup>. As the burden of chronic disease increases, so do healthcare costs and human suffering<sup>30</sup>. Chronic diseases are often perceived as problems affecting the affluent; however this view is not accurate. Low income countries where resources to make healthy choices are lacking, are often the most affected<sup>31, 34</sup>. Here, chronic diseases of lifestyle are rapidly on the rise due to life expectancy increases, lifestyle changes, decreased physical activity levels, urbanisation and poverty<sup>30, 32</sup>. Furthermore, recent evidence indicates that in these countries deaths from chronic diseases occur at younger ages than in developed nations<sup>31, 185</sup>. This is thought to be due to a shortage of effective treatment strategies and the failure of authorities to prioritise prevention<sup>31, 34</sup>. Chronic disease may worsen or even cause poverty, as the budgets of families are often weighed down heavily by treatment costs<sup>34</sup>.

### **2.2.1. Worldwide epidemiology of chronic disease**

Globally, the burden of chronic disease has been increasing for over 20 years<sup>31, 136, 192</sup>. It is estimated that, worldwide, 60% of all deaths are attributable to some form of chronic disease<sup>192</sup>. Of all the chronic disorders, cardiovascular disease is the single leading cause of deaths worldwide<sup>31</sup>. Although more than 80% of non-communicable disorders occur in adults under 70 years of age, 17 million people aged over 70 years are expected to die in 2015 from some form of chronic disease<sup>31</sup>. In the United States, 60% of adults are classified as either overweight or obese, and both are inextricably linked to the development of these disorders<sup>30</sup>. Chronic conditions such as obesity, hypertension and elevated cholesterol are amongst the top ten risk factors responsible for over one third of deaths worldwide<sup>184</sup>. Recently the chronic disease epidemic has intensified even more, with obesity, diabetes and metabolic syndrome now common even in children and adolescents<sup>30</sup>. Of the rapidly growing global older adult population, more than 85% report having at least one form of chronic disease<sup>4</sup>. Strong et al<sup>31</sup> reported that the years of healthy life lost due to chronic disease were the greatest in mature adults aged 30 to 59 years.

In low-income regions of the world cardiovascular disease, type-two diabetes, cancer, chronic lung disease and depression have now reached endemic proportions<sup>34</sup>. Further, the World Health Organisation (WHO) predicts that in the next ten years, Africa will experience the largest increase in death rates from chronic disease<sup>33</sup>.

### **2.2.2. Epidemiology of chronic disease in South Africa**

Compared to the developed world, there is a lack of reliable epidemiological information regarding non-communicable diseases in South Africa<sup>183, 185</sup>. It is recognised that the burden of disorders needing chronic care has increased disproportionately compared to diseases that need acute care, despite probable underreporting<sup>34, 185</sup>. This is predicted to increase even more in the next few decades if preventative strategies are not put in place<sup>4, 185</sup>. The South African population is growing older, displaying high levels of risk factors for chronic disease: physical inactivity, tobacco use and unhealthy diet<sup>34</sup>. Urban poor communities in South Africa are the most affected by non-communicable diseases, while in rural communities the burden is rapidly increasing<sup>35</sup>. In 2004, WHO estimates placed the extent of the chronic disease epidemic in South Africa at two or three times higher than that in developed countries, as measured by disability-adjusted life years<sup>34</sup>. A disability-adjusted life year represents one year of healthy life lost, while the total disability-adjusted life years in a population represent the divide between current health status and an ideal situation, where no disease or disability exist<sup>182</sup>. Further, according to the WHO: *“disability-adjusted life years for a disease or condition are calculated as the sum of years of life lost due to premature mortality in a population, and years lost due to disability for incident cases of the condition”*<sup>182</sup>.

Chronic conditions contribute the most to the disability-adjusted life years lost in South Africa<sup>34</sup>. A recent study reported that five of the top 20 specific causes of premature mortality in South Africa were chronic diseases<sup>183</sup>. Available data suggests that of the chronic diseases, females in South Africa are mainly affected by stroke while males are most commonly affected by ischaemic heart disease<sup>183</sup>. South African epidemiological studies have placed the prevalence of heart diseases at between 15.3% and 18%, diabetes between 8% and 10.8% and stroke between 6% and 22%<sup>185</sup>. Furthermore, the prevalence of chronic disease risk factors in South Africans has been reported as follows: hypertension 15% to 44%, obesity 4% to 43%, and elevated cholesterol 6% to 20%<sup>185</sup>. Several studies have found that up to one third of South African females were obese<sup>187, 188</sup>. The burden of chronic disease affects mature South African adults in particular: a recent cohort study in our country found that four out of the five most common causes of death in adults aged 50 years or older are non-communicable conditions<sup>186</sup>. Therefore the magnitude of the chronic disease problem in South African mature adults is immense, and it is increasing<sup>183, 185</sup>.

### **2.2.3. Contributing factors to chronic disease**

Most non-communicable (chronic) diseases share common contributing factors, including physical inactivity, advancing age, obesity, tobacco smoking, alcohol abuse and unhealthy eating habits<sup>34</sup>. Understanding these contributing factors to chronic disease is important to ensure that appropriate steps are taken to reduce this major burden to society. Physical inactivity and obesity have been identified as two of the top five factors currently driving our chronic disease epidemic<sup>184</sup>, yet data on these risk factors is extremely sparse<sup>185</sup>. Primary prevention may be the most feasible way to reduce premature mortality ascribed to chronic disease in South Africa, as resources for treatment continue to be lacking<sup>183, 185</sup>. Physical inactivity is modifiable, thus promoting physical activity is potentially one of the main interventions needed in South Africa to mitigate preventable forms of chronic disease<sup>81, 183</sup>. In addition, adults in the mature age group (40 to 60 years) are particularly at risk for premature morbidity and mortality due to chronic diseases<sup>185, 186</sup>. Therefore, this section will focus on physical inactivity and ageing as two major contributing factors to chronic disease.

#### **2.2.3.1. Physical inactivity**

Despite the mounting evidence regarding the benefits of even mild to moderate LTPA on health and wellbeing, physical inactivity remains an important global health concern<sup>17</sup>. Research has shown that in sedentary people, a small increase in the level of physical activity may induce health-enhancing effects, even in the absence of weight loss<sup>128</sup>. Both modern technology and economic incentives serve to discourage physical activity, by reducing the energy expenditure of activities of daily living and by increasing salaries for sedentary work<sup>17</sup>. Physical inactivity and poor diet caused 400 000 deaths in the United States in 2000, ranking second only to tobacco<sup>30</sup>.

Inactivity is expected to become the leading cause of mortality in the next few years in that country, impacting the development of chronic disease not only in the obese, but at any body mass index (BMI)<sup>30</sup>. Survey data from 2005 indicates that fewer than 50% of adults in the United States met the Centers for Disease Control (CDC) / American College of Sports Medicine (ACSM) physical activity recommendations<sup>80</sup>. In that survey, males were slightly more likely to lead active lifestyles than females, while younger people were more physically active than older people<sup>80</sup>. Further, people with a lower level of education were more likely to be sedentary<sup>80</sup>.

Research on the physical activity levels of South African adults is scarce. A South African Demographic and Health Survey conducted in 2003 found that in this country most adults (48% of males and 63% of females) were not achieving health-enhancing levels of LTPA<sup>81</sup>. The same survey found that only a quarter (24%) of South African males and 14% of females participated in sufficient levels of physical activity. These results indicated that South Africa had the third highest prevalence of inactivity of 38 participating developing countries<sup>81</sup>. In keeping with survey data from the United States<sup>80</sup>, the South African Demographic and Health Survey also found inactivity levels to be higher in urban areas than rural, and with lower education levels<sup>81</sup>. Furthermore, this survey identified inactivity as the most common risk factor for non-communicable diseases in our country<sup>81</sup>. Levels of physical activity generally decrease even more as adults advance in age<sup>82</sup>. The promotion of LTPA in the growing older population may therefore be a successful and cost effective intervention to keep South African adults healthy as they get older<sup>183, 185</sup>

### **2.2.3.2. Ageing**

Ageing is a normal physiological process, affecting all major physical organs and functions over time<sup>152</sup>. Ageing results in an increased risk of developing chronic disease<sup>4, 34, 57, 136</sup> and a gradual decline in physical ability<sup>2, 7, 145, 146, 152, 157, 175</sup>. Further, advancing age is frequently related to an increase in body mass and a reduction of muscle strength and overall physical fitness<sup>28</sup>. Health-related fitness components that decline with normal ageing include cardiorespiratory fitness<sup>115, 142-144</sup>, muscle strength<sup>2, 6, 115, 146</sup>, motor abilities<sup>115</sup> and flexibility<sup>115, 145</sup>. A reduction of perceptual, cognitive and fine motor function, together with changes in physical appearance, are also ascribed to advancing age in humans<sup>150, 152</sup>. In lower income countries such as South Africa, the number of older people (who are the most at risk for developing chronic disease), is steadily increasing<sup>34</sup>. The population of people aged over 60 in our country is expected to rise almost threefold by 2025<sup>138</sup>, while the number of mature adults aged between 35 and 64 is also predicted to increase in the coming years<sup>138</sup>. Leeder et al<sup>137</sup> predicted that even without change in the risk factor profile or in the mortality rates from cardiovascular disease, demographic change alone would result in double the number of cardiovascular mortalities by 2040 in developing economies.



## **Summary of the literature: chronic diseases of lifestyle**

The global burden of chronic, non-communicable disorders such as diabetes, cardiovascular and pulmonary disease has been rising for over 20 years- and affects mainly mature and older adults<sup>31</sup>. With the average life expectancy increasing<sup>34, 138</sup>, the human suffering and healthcare costs are enormous<sup>30</sup>. Poorer economies such as South Africa are amongst the worst hit by this epidemic<sup>34</sup>. Physical inactivity, one of the major risk factors of chronic disease and a known problem associated with ageing, may be the most important contributing factor to the burden of chronic diseases of lifestyle in South Africa<sup>83</sup>. The next section will aim to explore the relationship between ageing and health-related fitness components in more detail.

## **2.3. AGEING AND HEALTH-RELATED FITNESS**

The average human lifespan has been increasing steadily since 1840<sup>152</sup>. Between 1970 and 2000, the world population of people aged over 80, doubled<sup>154</sup>. Human ageing is associated with an unavoidable decline in physiological functions of various organs and tissues<sup>152</sup>. While the process of ageing is not uniform either within one person or between different people, certain commonalities exist in terms of the various systems affected<sup>142</sup>. Time-dependent losses in components of health-related fitness with ageing include cardiorespiratory fitness<sup>115, 142 - 144</sup>, muscle strength<sup>2, 6, 115, 146</sup>, flexibility<sup>115, 145</sup>, motor abilities such as balance<sup>113-115, 147</sup>, agility<sup>115, 148</sup>, co-ordination<sup>115</sup>, lean body mass<sup>7, 142, 145, 149</sup> and quality of life<sup>54, 55</sup>. The reduction in motor abilities may eventually lead to disability, cognitive impairment, institutionalisation and mortality<sup>85, 86, 87</sup>. Other changes with advancing age include the reduction of perceptual, cognitive and fine motor skills<sup>150</sup>, organ dysfunction and changes in the physical appearance of individuals<sup>152</sup>. As the aim of this study was to examine the relationship between LTPA and components of health-related fitness, these other age-related changes fall beyond the scope of this review and will not be discussed further.

### **2.3.1. Cardiorespiratory fitness**

Cardiorespiratory fitness (aerobic power) is the maximum amount of oxygen used by the body during exercise, and is expressed in terms of maximal oxygen consumption ( $VO_{2max}$ )<sup>143</sup>. Maximum oxygen consumption is a product of oxygen delivery (cardiac output) and oxygen extraction (artero-venous oxygen difference)<sup>143</sup>. After peaking at 25 years of age, aerobic capacity declines progressively during a person's lifetime<sup>143</sup>. This reduction in cardiorespiratory fitness with increasing age may be further exacerbated by superimposed chronic conditions such as cardiovascular and pulmonary disease, diabetes and arthritis<sup>144</sup>. A loss of aerobic fitness may even lead to early frailty by establishing a cycle of lower activity levels, slower walking speeds and early exhaustion<sup>144</sup>. In the older population, aerobic fitness is related to health status, all-cause mortality, activity levels and functional capacity<sup>142</sup>.

Both cross-sectional and longitudinal studies have found that the age-related decline in aerobic capacity gradually progresses towards the minimum needed for activities of daily living (ADL) <sup>142, 143, 144</sup>. There was a slower rate of reported decline in the cross-sectional studies. This may be due to selection bias, therefore the reported reduction of aerobic fitness of 5% to 10% per decade may be falsely optimistic <sup>143, 144</sup>. Most longitudinal studies of older adults observed an average decline in  $VO_{2max}$  of over 10% in men and women, per decade <sup>142, 143</sup>. Stathokostas et al <sup>142</sup> found that declines in lean body mass and reductions in activity levels contributed to the rate of decline in aerobic capacity. In sedentary individuals, as much as half the age-related decline in aerobic power may be due to a reduction in muscle mass <sup>143</sup>.

### **2.3.2. Muscle strength**

Muscle strength refers to the ability of muscle to exert force <sup>38</sup>. Loss of muscle strength and mass with ageing has been well documented <sup>145, 146, 6, 2, 157</sup>. After reaching a plateau in early adulthood, it appears that the decline in muscle strength may be linear with advancing age <sup>146</sup>. Studies indicate that the rate of decline in muscle strength is approximately 2% per year for men and women after the age of 65 <sup>145</sup>, reaching an estimated total of 20% to 40% <sup>157, 175</sup>. To date, data as to whether age-related loss of muscle strength is due to a loss of muscle fiber size or number has been conflicting; however type two muscle fibers seem to be the most affected by advancing age <sup>175</sup>. Although strength reductions are likely ascribed to a combination of quantitative and qualitative losses in skeletal muscle <sup>146</sup>, current research suggests that reduced muscle mass is the primary reason for an older person's reduced ability to exert muscular force <sup>2, 146, 157</sup>. Moreover, it seems that age-related declines in strength are directly related to losses of skeletal muscle mass <sup>157</sup>. The capacity to exert force is extremely important for activities of daily living (ADL) such as standing up, sitting down and walking <sup>2</sup>. Muscle weakness is associated with a reduced capacity to perform ADL and a higher incidence of falls in the elderly, leading to increased dependence <sup>2, 6</sup>. Further, significant associations have been found between a decline in muscle strength and activity in the elderly and increased depression <sup>145</sup>. Although these age-associated reductions in muscle mass and strength have been well documented, several recent studies have found that a large proportion of sarcopaenia in older persons seems to stem from disease and inactivity (disuse) rather than from ageing alone <sup>3, 88, 157</sup>.

### **2.3.3. Flexibility**

Flexibility is defined as the range of movement around a joint or a group of joints <sup>38</sup>. Joint range of motion is important with ageing for the maintenance of independent function and for participation in activities of leisure <sup>145, 175</sup>. A lack of flexibility may increase the susceptibility to musculoskeletal injury and impair function, particularly from middle age and in sedentary individuals <sup>175, 182</sup>.

Studies have demonstrated that lower limb range of motion declines with walking in the elderly, increasing their susceptibility to falls<sup>175</sup>. It has been shown that flexibility scores track well from adolescence into adulthood, thus joint range of motion may be a component of health-related fitness that is largely influenced by genetic factors<sup>96, 97</sup>. The rate and patterns of age-related decline in terms of flexibility remain to be studied, however compared to young people; older adults perform less well on tests of joint range of motion<sup>115, 175, 180, 182</sup>. This age-related reduction in flexibility is associated with a loss of strength and elasticity of soft tissue matrices, increased fibrous connective tissue, muscle atrophy and diminished capillary blood supply<sup>180</sup>. To date research has shown an average decline in flexibility of 20% to 30% between the ages of 30 and 70 years<sup>175, 182</sup>. Thus age-related loss of flexibility has been well documented, and like cardiorespiratory fitness and muscle strength, much of this decline in flexibility is thought to be due to disuse and may thus be reversible<sup>175, 182</sup>.

#### **2.3.4. Motor abilities (balance, co-ordination and agility)**

Motor abilities are task-specific, multi-joint skills, which are components of health-related fitness<sup>123</sup>. These abilities rely on the interaction of neuromuscular, visual, vestibular and somatosensory physiologic systems<sup>41</sup>. Balance, co-ordination and agility are examples of motor abilities which are needed for functional independence<sup>19</sup>. Balance is the maintenance of body equilibrium within its base of support while stationary (*static balance*), or while moving from a dynamic to a static state (*dynamic balance*)<sup>38, 151</sup>. Co-ordination is the ability to use the senses (e.g. sight or hearing) with the movement of body parts to perform tasks smoothly and accurately<sup>38</sup>. Agility refers to the body's ability to change its position in space with speed and accuracy, in response to a stimulus<sup>38, 45</sup>. With advancing age, the body's ability to remain in equilibrium within its base of support is substantially affected, as is the body's reaction time to external perturbations and its ability to perform functional movements smoothly and accurately<sup>2, 38, 113, 114, 147, 148</sup>. This decline in motor abilities with ageing may be because of a combination of reduced sensory (vision, vestibular and proprioception) and motor (strength, co-ordination, endurance) function and integration, which results in an increased response time when the body's equilibrium is altered<sup>113, 114, 148, 181</sup>. Such slowed protective reflexes may lead to falls - a major cause of disability, morbidity and mortality in the elderly<sup>41, 153</sup>. Moreover, poor balance reactions and repeated falls are common precipitators of admission to nursing homes

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### 2.3.5. Body composition

As the body ages, its relative constituents change<sup>7, 38, 145</sup>. Fat-free body mass declines, while body fat is redistributed and accumulates<sup>142</sup>. This leads to a rise in the body mass index (BMI), waist circumference and waist-to-hip ratio<sup>38, 175</sup>. The redistribution of adipose tissue involves an increase in deposition of abdominal fat, which has adverse effects on metabolic and cardiovascular health and raises the risk of chronic disease<sup>179</sup>. Tager et al<sup>7</sup> demonstrated a causal relationship between obesity and functional impairment in older persons. In addition, obesity and advancing age are major risk factors for various chronic diseases, morbidity and mortality<sup>30, 34, 128</sup>. Recent research has shown that all efforts should be made to minimise the accumulation of fat through adulthood to maintain independent function for as long as possible<sup>7</sup>. This is because both cross-sectional and longitudinal studies have shown associations between the loss of age-related fat-free mass and a decline in cardiorespiratory fitness<sup>143</sup>. A BMI of between 18.5 kg.m<sup>-2</sup> and 25 kg.m<sup>-2</sup> is associated with the lowest mortality risk in adults<sup>38, 128</sup>.

### 2.3.6. Quality of life

Quality of life includes the dynamic interaction between an individual's external life conditions and their internal perceptions of those conditions<sup>154</sup>. Hence quality of life is a highly individualistic measure, with no single factor determining it<sup>154, 155</sup>. Netuveli and Blane (2008)<sup>156</sup> define health-related quality of life (HRQoL) as *"the value given to the duration of life as modified by impairments, functional capacity, perceptions and social opportunities that are influenced by disease, injury, treatment or policy"*. They argue that to optimise HRQoL in the growing older population, the aim should be not only to add survival time, but also to add quality to that time<sup>156</sup>. Although it is commonly assumed that quality of life deteriorates with ageing, this need not be the case<sup>155</sup>. There is good evidence that, at least in the so-called "third age" (the time period from exiting the labour force until the onset of dependency), quality of life may actually increase with advancing age<sup>155, 156</sup>. The absence of chronic diseases and functional limitations are important determinants of quality of life with ageing, along with other factors such as affluence and trusting relationships<sup>155</sup>. Slowing the decline in HRQoL by preventing chronic disease and optimising physical function would ensure that the elderly can spend their old age in good health<sup>154</sup>. This may lead to increased HRQoL despite advancing age<sup>154</sup>.

### **Summary of the literature: ageing and health-related fitness**

Various organs and tissues, as well as health-related fitness components are affected by a gradual reduction in function with ageing<sup>152</sup>. Aerobic fitness<sup>142, 143, 144</sup>, muscle strength<sup>145, 146, 6, 2, 157</sup>, motor abilities<sup>2, 38, 113, 114, 147, 148</sup>, flexibility<sup>115, 175, 180, 182</sup>, body composition<sup>7, 38, 145</sup> and quality of life<sup>154, 155, 156</sup> are involved in this decline. However, it has been established recently that much of this, at least in the early part of ageing (the “third age”), may be due to disuse rather than to ageing *per se*<sup>152</sup>.

Upon review of the literature regarding ageing and health-related fitness, it became apparent that not only ageing, but also disuse and a lack of physical activity were responsible for the decline in health-related fitness components<sup>3, 6, 7, 29, 54, 55, 115, 143, 145, 147, 149, 157, 174, 175</sup>. For this reason, LTPA and its association with health-related fitness will be discussed further in the next section.

### **2.4. LEISURE TIME PHYSICAL ACTIVITY**

Physical activity is defined as “*any bodily movement produced by contraction of skeletal muscle that substantially increases energy expenditure*”<sup>37</sup>. Leisure time physical activity is a more broad concept, referring to any activities that result in an increased energy expenditure (i.e. physical activity), participated in during one’s free time. Leisure time physical activity is based on each individual’s personal interests and needs<sup>37</sup>. It encompasses not only formal exercise training, but also physically active hobbies such as gardening, walking and dancing<sup>37</sup>. Exercise is a subcategory of LTPA which involves planned, structured and repetitive bodily movements, performed to improve or maintain physical fitness<sup>37</sup>. In this review the terms “*exercise*”, “*physical activity*” and “*LTPA*” will be interchanged at times. Leisure time physical activity may include exercise training in various modes and intensities<sup>4, 19</sup>. It is recommended by the Centers for Disease Control and Prevention and by the American College of Sports Medicine to promote and maintain public health<sup>17, 28, 57</sup>. Leisure time physical activity which includes a variety of different forms of exercise training has been shown to enhance the development of motor abilities necessary for optimal function, compared to single modes of exercise<sup>19</sup>. In addition, active LTPA pastimes such as gardening, walking or carpentry may be preferred alternatives to formal exercise training for many mature adults, whilst providing similar health-enhancing benefits<sup>19</sup>.

### **2.4.1. Guidelines for participation in leisure time physical activity: healthy adults**

The components of health-related fitness include cardiorespiratory (aerobic) fitness, muscular strength and endurance, flexibility, motor abilities and body composition<sup>38</sup>. Healthy adults should participate in a variety of modes of LTPA to maximise the development of these various aspects of health-related fitness<sup>19</sup>. Rhythmic, aerobic type exercise modes involving the large muscle groups are recommended to improve cardiorespiratory fitness<sup>38, 84</sup>. Adults should perform activities that promote or maintain muscle strength and endurance to reduce their risk of all-cause mortality even more<sup>38, 84</sup>. Flexibility exercise helps to maintain or improve joint range of motion<sup>57</sup>. In addition exercises that enhance motor abilities should be incorporated into any LTPA programme<sup>38</sup>.

The minimum and maximum amount (dose) of LTPA for the enhancement of health and fitness has not been established<sup>38</sup>. In general, attenuation occurs in the improvement of physical fitness beyond frequencies of three days per week<sup>38</sup>. A plateau in improvement is reached with physical activity on more than five days per week<sup>38</sup>. Moderate intensity activity causes a notable increase in heart rate and is equivalent to brisk walking<sup>17</sup>. Vigorous intensity activity causes rapid breathing and a considerable increase in heart rate, such as jogging<sup>17</sup>. Strengthening activities should consist of multi-joint exercises targeting all major muscle groups<sup>38</sup>. Once established, muscular strength may be maintained using only one training session per week, as long as the training intensity or the resistance lifted remains unaltered<sup>139</sup>. To avoid injury, at least 48 hours of rest should be allowed before repeatedly training the same muscle group<sup>38</sup>. Although the evidence for flexibility training is contradictory<sup>140, 141</sup>, stretching is still recommended for most adults<sup>57, 38</sup>. There are currently no established guidelines for the development of motor abilities such as balance, co-ordination and agility, in terms of the recommended mode, duration and frequency of training. This is due to the lack of studies evaluating the benefits of motor training<sup>38</sup>. For additional improvements in personal fitness, further reduction of chronic disease risk and to reduce or maintain body weight, adults may exceed the minimum amounts of LTPA<sup>17, 38</sup>. A summary of the ACSM guidelines for recommended LTPA participation is provided in Table 2.1.

**Table 2.1** Physical activity for healthy adults: recommendations by the American College of Sports Medicine <sup>38</sup>.

Activity type	Recommended participation guidelines
Aerobic (endurance)	<ul style="list-style-type: none"> <li>• Three to five sessions per week</li> <li>• At least 20 minutes vigorous or 30 minutes moderate intensity per session, or a combination of moderate and vigorous intensity</li> <li>• 150 minutes per week for optimum benefits, may be accumulated in bouts of 10 minutes or more</li> <li>• Less than two or more than five sessions per week may increase risk of musculoskeletal injury</li> </ul>
Neuromuscular (strength)	<ul style="list-style-type: none"> <li>• Two to three training sessions per week</li> <li>• For maintenance of strength, one session per week may be adequate</li> <li>• Use two to four sets of 8-12 repetitions per set</li> <li>• Intensity at 60 – 80% of one repetition maximum</li> </ul>
Flexibility (stretching)	<ul style="list-style-type: none"> <li>• Most effective when muscles are warmed up</li> <li>• Perform at least two to three times per week</li> <li>• 4 or more repetitions per muscle group are recommended</li> <li>• Static stretched should be held for 15-60 seconds each</li> <li>• Dynamic stretching techniques may be prescribed to enhance flexibility further</li> </ul>
Motor training (balance, agility, co-ordination)	<ul style="list-style-type: none"> <li>• Recommended at least two to three times per week</li> <li>• Definitive recommendations cannot be made as few studies have been conducted to demonstrate benefits</li> <li>• Likely that participation in games may enhance motor abilities</li> </ul>

**Summary of the literature: leisure time physical activity**

Leisure time physical activity may include any exercise or physically active hobbies participated in during leisure time <sup>37</sup>. Healthy adults should perform moderate to vigorous LTPA on most or all days of the week, for a total of at least 150 minutes per week <sup>10, 38</sup>. There seems to be a dose-response relationship between LTPA and health benefits with frequencies up to five days per week <sup>17</sup>. Modes of LTPA engaged in should develop various aspects of health-related fitness, including endurance, neuromuscular, motor ability and flexibility training <sup>38, 17</sup>.

**2.5. THE BENEFITS OF LEISURE TIME PHYSICAL ACTIVITY (LTPA) WITH AGEING**

In this section, the benefits of LTPA will be broadly discussed, with particular emphasis on the benefits of LTPA in minimising the age-associated changes in health-related fitness. Endurance-type LTPA leads to functional improvements of the cardiovascular system, increasing aerobic performance <sup>27, 45</sup>. Neuromuscular-type LTPA results in an increase in muscle strength, power and endurance <sup>45, 182</sup>, while flexibility training may help to optimise joint range of movement <sup>28, 178, 180</sup>. Regular LTPA is important for achieving and maintaining a healthy body composition.

This includes optimal levels of total body mass, body fat mass, fat free mass and regional fat distribution<sup>28, 179</sup>. In addition, recent research has demonstrated a consistent association between higher health-related quality of life (HRQoL) scores and increased LTPA in healthy adults<sup>44, 46, 47, 48</sup>. Regular participation in LTPA and a high level of physical fitness result in a reduced risk of chronic disease with ageing<sup>17, 44, 49</sup>.

Leisure time physical activity participation may assist in decreasing the rate of age-related changes in fitness<sup>29, 54</sup>. The influence of LTPA on age-related decline in function and on the enhancement of health and well-being may be underestimated by the available research<sup>117, 118</sup>. This is because most studies to date have not taken long term LTPA participation into account although it has been shown that the effects of LTPA may be maintained for years<sup>117, 118</sup>. Van Heuvelen et al<sup>115</sup> found a reduction in performance of health-related fitness tests (which included cardiorespiratory fitness, balance, flexibility and muscle strength) with increasing age, with larger disparities in fitness between active and less active older participants<sup>115</sup>. This led to the conclusion that LTPA may result in positive effects on health-related fitness, independent of age<sup>115</sup>. Further, there is substantial evidence that LTPA may reduce the risk of falls, injuries due to falls<sup>50</sup> and prevent functional limitations<sup>51, 52, 53</sup> in older adults. Research suggests that LTPA may even help to slow down the rate of age-related functional decline<sup>29, 54, 55</sup>.

Leisure time physical activity plays an important role in the prevention and treatment of chronic diseases including coronary heart disease<sup>56, 57</sup>, hypertension<sup>57, 58</sup>, peripheral vascular disease<sup>59</sup>, type two diabetes<sup>60</sup>, obesity<sup>61</sup>, elevated cholesterol<sup>62</sup>, osteoporosis<sup>63</sup>, osteoarthritis<sup>64</sup>, claudication<sup>65</sup> and chronic obstructive pulmonary disease<sup>57</sup>. Clinical practice guidelines identify a role for LTPA in the treatment of depression and anxiety disorders<sup>66</sup>, dementia<sup>67</sup>, pain<sup>68</sup>, congestive heart failure<sup>69</sup>, syncope<sup>70</sup>, stroke<sup>71</sup>, prophylaxis of venous thromboembolism<sup>72</sup>, back pain<sup>73</sup>, and constipation<sup>74</sup>. LTPA may even assist in delaying cognitive impairment<sup>75</sup> and disability<sup>52, 76</sup> and it may assist in improving sleep<sup>77</sup> in mature and older adults. As adults tend to gain weight with ageing, larger volumes of LTPA in the form of aerobic activity is prescribed to prevent unnecessary increases in body weight<sup>57</sup>. Aside from these extensive health benefits with increasing levels of LTPA, it may also save billions in terms of healthcare costs. In Canada, a recent study estimated that reducing the number of physically inactive people by 10%, would lead to an annual saving of five billion Canadian dollars in costs for medical care, sick leave and loss of revenue<sup>138</sup>. Furthermore, recent evidence has emerged suggesting that the health benefits of exercise may help maintain neuronal plasticity, stimulate the growth and development of brain cells and even protect against ischaemic and neurotoxic damage<sup>78, 79, 80</sup>.



Although some aspects of health-related fitness may be influenced by genetics<sup>93, 94, 95</sup>, research has shown that low levels of fitness in adolescence are not predictive of low adult fitness, thus fitness may be altered with training<sup>4, 96, 97</sup>. Current evidence indicates that most of the physical decline in older adults previously attributed to the effects of ageing may rather be a result of disuse, physical inactivity and sedentary lifestyles<sup>3, 88, 157</sup>. This is apparent if one considers the remarkable improvements in performance of masters' athletes in recent years<sup>88</sup>. Other forms of physical activity that have been shown to influence health-related fitness include occupational physical activity and active commuting<sup>27, 124</sup>.

### **2.5.1. Cardiorespiratory fitness**

The loss of aerobic capacity with ageing has important consequences: independent function is determined largely by cardiorespiratory fitness<sup>144</sup>. The perceived effort and breathlessness of a given task depends on its oxygen cost relative to a person's peak  $VO_2$ <sup>144</sup>. Deconditioned adults tend to avoid strenuous tasks, setting off a vicious cycle of deteriorating aerobic fitness<sup>144</sup>. Leisure time physical activity may slow down the age-related reduction in cardiorespiratory fitness and assist with the prevention and rehabilitation of cardiovascular disease, hypertension, hypercholesterolaemia and stroke<sup>129</sup>. Furthermore, Twisk et al<sup>43</sup> found a healthy cardiovascular disease profile was related to the longitudinal development of physical activity and  $VO_{2max}$ . Research has shown that, while a decline in aerobic function is ultimately inevitable<sup>143</sup>, at least part of this reduction in peak oxygen consumption may be attributed to a decrease in LTPA participation in older adults<sup>144</sup>. Higher habitual levels of aerobic physical activity are associated with increased levels of cardiorespiratory fitness at any age, even the very old<sup>39, 142, 144</sup>. In active individuals,  $VO_{2max}$  declines more slowly, provided that their level of physical activity is maintained<sup>143</sup>. Recent longitudinal studies have shown that regular vigorous LTPA may slow the decline in  $VO_{2max}$  by as much as 50%<sup>143, 158, 159</sup>. Aerobic forms of LTPA at intensities as low as 30% to 40% of heart rate reserve, have demonstrated to increase aerobic fitness in the elderly<sup>143</sup>. Considering the importance of aerobic capacity for ADL, mature adults are advised to engage in regular LTPA throughout their adulthood, to optimise their ability to live independently as they age<sup>144</sup>.

### **2.5.2. Muscle strength**

Resistance training can be employed to maintain sufficient muscle function to last one's lifetime<sup>175</sup>. Health-related fitness components such as upper limb function and back muscle endurance have shown to correlate well with neuromuscular-type LTPA in mature adults<sup>19, 39</sup>. Furthermore, several studies have shown that muscle strength can be maintained and improved through mature adulthood and even in very old age<sup>2, 145, 157, 160, 161</sup>.

The age-associated loss of type two muscle fibers (responsible for high velocity power movements) has shown to be reversible through resistance training<sup>175</sup>. Studies of 10 to 12 weeks in duration with strength training sessions two or three times per week have consistently resulted in significant strength gains and increases in muscle mass, regardless of age<sup>2, 157</sup>. Gains in strength varied between studies as factors such as study population, frequency, intensity and duration of training were different<sup>157</sup>. Nonetheless, muscle cross sectional areas increased between 5% and 40%, although total strength gains were likely the result of a combination of central (neural) and peripheral (muscle mass) changes<sup>157</sup>.

The emphasis with ageing should be on full-range exercises of the large muscle groups to develop and maintain functional capacity<sup>175</sup>. As significant independent associations between the loss of muscle strength and reduction in physical activity have been found in older adults, there is a need to encourage LTPA to maintain strength and function with ageing<sup>6, 145, 157</sup>. Leisure time physical activity which increases muscle strength also facilitates the neural pathways involved in proprioception, central processing and motor skill acquisition, leading to improvements in balance and function<sup>2</sup>. Furthermore, there appears to be an important link between muscular, cardiorespiratory fitness and body composition, where the one may enhance the other. A study of LTPA and health-related fitness by Suni et al<sup>39</sup> confirmed this finding. In their study, muscular exercise associated closely with aerobic fitness in both sexes. Similarly, motor abilities may be enhanced by strength training: exercises utilising the full range of motion of a joint have shown to improve co-ordination and flexibility around that joint<sup>175</sup>. However, the optimal LTPA modality, duration and intensity needed to counteract sarcopaenia with ageing remain to be established<sup>157</sup>.

### **2.5.3. Flexibility**

Flexibility training is the least well researched of all the health-related fitness components in older adults<sup>181</sup>. Flexibility depends on the integrity of bone, muscle and connective tissue, as well as on the ability to produce muscular force<sup>182</sup>. Although stretching does not result in any immediately noticeable effects, it is recommended to counter the age-related loss of joint range of motion as it may improve long term ADL and function<sup>139, 38, 57, 140, 141, 178</sup>. Other postulated benefits of good flexibility include a reduced injury risk and improved sporting performance<sup>177</sup>. Considered an important component of fitness, flexibility training is often neglected as people age<sup>175</sup>. Leisure time physical activity that routinely moves joints through their full range of motion (ROM) has been shown to improve flexibility over time<sup>175, 177, 180, 182</sup>. Physically active individuals in their sixties were as flexible as young people in their twenties, in one study<sup>176</sup>. This demonstrates that joint ROM may be maintained through regular LTPA participation with ageing.

While static stretching does improve available joint range over time <sup>178</sup>, proprioceptive neuromuscular facilitation (PNF) may be a safer and more effective technique to develop flexibility <sup>175, 177</sup>. There is also evidence that LTPA participation need not necessarily include flexibility training to improve ROM: strength training may increase flexibility in both the young and the old when exercises that move joints through their full ROM are employed <sup>175, 182</sup>. Increases in the extensibility of soft tissues are thought to result from neural and viscoelastic tissue adaptations <sup>177</sup>. Such adaptations may occur in response to as little as 15 minutes of flexibility training per day <sup>178</sup>.

Despite the widespread use of stretching and the evidence to substantiate its use, several recent studies on the relationship between LTPA and various health-related fitness outcomes have failed to observe an association between LTPA and flexibility <sup>19, 39, 115</sup>. However, these were not interventional studies therefore participants did not specifically train flexibility but were involved mainly in endurance (aerobic)-type LTPA. Furthermore, flexibility may have a strong genetic influence, as several studies found that flexibility tracked well through adolescence to adulthood regardless of subjects' LTPA previous participation levels or modes <sup>94, 96</sup>. Research is needed on the long term effects of LTPA which includes flexibility training practices <sup>178</sup>. Therefore for range of movement gains, clinical recommendations are that LTPA participation should be specific, i.e. static, dynamic or PNF stretching should be practised regularly over time <sup>180</sup>.

#### **2.5.4. Motor abilities (balance, co-ordination and agility)**

Research on motor abilities such as balance, co-ordination and agility is scarce <sup>19, 43</sup>. Balance was the most widely studied component of the motor abilities. Although motor abilities may track better (i.e. are maintained for longer) than cardiorespiratory fitness from childhood to adulthood even without participation in LTPA <sup>43, 97, 102</sup>, motor training has been shown to be beneficial by various authors in young, mature and older adult populations <sup>19, 39, 41, 113, 114</sup>. Various trials have found specific motor training to be more effective in improving balance than general physical activity or education and more effective in preventing falls in the older adult population <sup>41, 113, 114</sup>. Also in older adults, participation in forms of LTPA that develop balance and co-ordination were associated with improved scores in these motor abilities, compared to forms of LTPA which did not include specific motor training <sup>119</sup>. In stroke survivors, there was also good evidence that training motor abilities specifically rather than generalised exercise, resulted in specific improvements in motor abilities <sup>111, 112</sup>. Similarly, various studies found that strength, speed and power were poor predictors of agility and co-ordination in young sportsmen, and concluded that specific agility and co-ordination training were needed to develop these motor skills <sup>103, 104, 105</sup>.

The inclusion of specific balance, agility and co-ordination exercises into the warm-up routine of sportspeople has resulted in consistently higher motor performance scores compared with peers who utilised standard warm-up modalities<sup>106, 107, 108, 109, 110</sup>. Despite this, there is also some evidence that strength- and flexibility training may result in improved balance and co-ordination outcomes<sup>181</sup>.

Very few studies to date have examined the long term effects of motor training. One study in older people that measured motor ability outcomes three months after an intervention, found no lasting difference between groups<sup>114</sup>. Leisure time physical activity which involves motor ability training may thus need on-going input, much like other components of health-related fitness such as cardiorespiratory fitness, muscle strength and flexibility<sup>19</sup>. Buchman et al<sup>29</sup> studied the age-related decline in motor function of healthy older adults in units per year over eight years. This study found that the average elderly participant, who was physically active, had a 35% slower rate of decline in motor function than the average inactive participant<sup>29</sup>. The association of physical activity with motor function persisted even after controlling for confounding variables such as body composition, disability status and vascular disease<sup>29</sup>. Improvements were not related to muscle strength, but only to motor performance<sup>29</sup>. This is one of few available studies examining motor abilities specifically as they relate to LTPA<sup>19, 29</sup>.

In mature adults, a recent study found that long term and regular LTPA resulted in improved motor performance scores in mature adults<sup>19</sup>. Participation in a variety of games strongly correlated with motor abilities in males, while in females the duration of long term participation in LTPA was the best predictor of motor abilities. This sheds new light on the association between LTPA and health-related fitness, as no other studies were found that explored long term LTPA patterns in this age group. More research is needed to determine the consistency of this finding. Furthermore, the volume of reported recent LTPA correlated statistically significantly with balance and agility, while static balance correlated with cardiorespiratory and muscle fitness in males and in females, and not with neuromuscular training as a previous study had found<sup>39</sup>. In addition, participants who focused on endurance training alone had reduced scores in motor ability tests compared to those who participated in neuromuscular training<sup>19</sup>. This indicates that specific exercise may be critical to enhance motor function in healthy middle aged adults. On the other hand, it is not possible to tell from this study the direction of causality. Improved motor ability scores may have been due to the participation in games, long term LTPA or neuromuscular training; or participants who already had improved motor abilities, chose to participate in games, long term physical activity and neuromuscular training<sup>19</sup>.

### 2.5.5. Body composition

Leisure time physical activity is one of the most important factors affecting body composition from childhood to old age<sup>175</sup>. By countering the major health challenge of sedentary lifestyles, LTPA helps to prevent obesity and thus enhances health and well-being in the adult population<sup>44, 46</sup>. Masters athletes had lower waist circumferences and lower waist-to-hip ratios than age and BMI-matched controls<sup>179</sup>. Thus, evidence that supports the benefits of LTPA to slow the age-related changes in body composition is overwhelming<sup>6, 7, 38, 128, 129, 145, 149</sup>. Even low intensity LTPA was associated with reduced waist girth in one study<sup>179</sup>. Although there was not sufficient evidence to determine a dose-response relationship, when diet is controlled there may be a linear relationship between weight lost and the amount of LTPA participated in<sup>128, 129</sup>. In addition, both cross-sectional and longitudinal studies have demonstrated an association between age-related changes in body composition and the decline in aerobic fitness with increasing age<sup>7, 143, 142</sup>. This may be because much of the age-associated reduction in aerobic power is due to a decrease in muscle mass<sup>143</sup>. In a large study examining the relationship between LTPA and health-related fitness, Suni et al<sup>39</sup> found that strength-trained participants had lower BMI's compared to inactive participants or those participating in other forms of LTPA.

The mechanism of improvement in body composition through participation in LTPA is most likely the result of a reduction of fat mass relative to lean mass<sup>7, 149</sup>. A cohort study of 1655 elderly participants found that this improvement in the ratio of lean mass to fat mass mediated by increased LTPA participation was directly related to fewer functional limitations<sup>149</sup>. Although the association between LTPA and change in BMI has been inconsistent in prospective studies, mature adults who regularly participated in LTPA have shown to gain less weight than their sedentary counterparts<sup>128</sup>. This finding may be because BMI fails to distinguish between muscle and fat<sup>128</sup>. Together with duration, the literature indicates that there seems to be an intensity threshold of LTPA participation needed for the maintenance and reduction of body weight, and the improvement of fat-free mass<sup>7, 128</sup>. Most research to date has focused on LTPA participation for the improvement of cardiovascular health rather than for reducing body weight<sup>128</sup>. However it seems that higher dosages of LTPA may be required for weight regulation effects compared to cardiovascular benefits<sup>128</sup>. In addition, long term participation in LTPA may be necessary for the maintenance of a healthy body composition and fat-free mass. Physical activity, physical fitness, lipoproteins and blood pressure were highly related to body fatness in a recent longitudinal study conducted over 14 years<sup>43</sup>.

### **2.5.6. Health-related quality of life**

Concerning the relationship between Leisure time physical activity and health-related quality of life (HRQoL), most research to date has focused on populations with chronic conditions with few studies in the general population<sup>44, 47</sup>. Most of these have been cross-sectional, but they suggest that LTPA is favourably associated with HRQoL<sup>47, 48, 55</sup>. A systematic review has reported consistent associations of higher HRQoL with increased LTPA among healthy adults<sup>46</sup>. In institutionalised older adults, a study recently measured decline in HRQoL together with decline in motor function, after either administering two different LTPA programs or no intervention, for six months. Measurements were taken at three, six and twelve months<sup>54</sup>. Results were promising: Both these adapted exercise programs resulted in a slowing down of age-related functional decline<sup>54</sup>. While the control group experienced a reduction in activities of daily living and reduced scores in the Neuropsychiatric Inventory Score over the twelve month period, these outcomes were either unchanged or improved in both intervention groups<sup>54</sup>.

Similar results were found in healthy mature and older adults in another study, which investigated age-related functional decline in perceived health over a ten year period. Multivariate analyses revealed, among males, that no weekly LTPA and no monthly sport activity were associated with a decline in perceived health<sup>55</sup>. Among females, the risk of decline in perceived health was increased with LTPA of less than once per week<sup>55</sup>. The authors concluded that moderate to high levels of LTPA may have a protective effect against the risk of decline in perceived health in middle-aged and elderly adults<sup>55</sup>. Another large study of healthy adults<sup>47</sup> found that higher levels of LTPA were associated with higher HRQoL scores in both males and females<sup>47</sup>. Even in very young males, similar associations were recently established<sup>44</sup>. Although the available literature points to a positive relationship between LTPA and health-related quality of life, the situation in South African adults is not known. Further research to explore this relationship is needed. A summary of the literature examining the relationship between LTPA and the age-associated reduction in health-related fitness is provided in Table 2.2.

**Table 2.2** Summary of studies examining the relationship between LTPA and age-associated decline in health-related fitness components, in older people.

Study	Sample	Inclusion criteria	Outcome measures	Results
Buchman et al <sup>29</sup>	850 older persons.	Healthy older adults who expressed interest in the study. Aged 60 years or older.	Nine strength measures. Nine motor performance measures. Measurements taken up to eight years.	Higher rate of LTPA associated with slower rate of motor decline ( $p < 0.001$ ). Level of evidence: 3.
Van Heuvelen et al <sup>115</sup>	Community-based sample of 624 people.	Healthy older adults living in the North of Netherlands. Aged 57 years or older.	Seven fitness, strength & flexibility tests.	LTPA associated with most fitness components. Larger differences between active and inactive with increasing age. Level of evidence: 3.
Tager et al <sup>7</sup>	1655 adults.	Aged 55 years or older. Participants were already part of a larger longitudinal study.	Lean : fat mass ratio Self-reported functional limitation. Surveyed three times over six years.	Increased body fat related to reduced functional performance. Increased LTPA related to better function, improved lean: fat mass ratio. Level of evidence: 3.
Haight et al <sup>149</sup>	1655 older adults.	Residing in Sonoma, California. Aged above 55 years.	Functional limitation based on self-report questionnaires over six years. Body composition.	Higher levels of LTPA reduced risk of future functional limitation. Increased LTPA related to increased lean: fat mass ratio. Level of evidence: 3.
Dechamps et al <sup>54</sup>	160 institutionalised persons.	Aged 65 years or older. Able to understand instructions and change body positions.	HRQOL changes based on ADL, Neuropsychiatric Inventory Scores. Measured over 12 months.	Adapted exercise programs slowed decline in HRQoL significantly, compared to control ( $p < 0.001$ ). Level of evidence: 1b.
Malmberg et al <sup>55</sup>	2353 adults aged 19-63 years.	Good perceived health.	Perceived health by self-administered questionnaire.	Moderate to high weekly LTPA protected against decline in health. Level of evidence: 3.

## **Summary of the literature: the benefits of leisure time physical activity with ageing**

Collectively, the literature demonstrates a positive association between the volume of LTPA participated in and a reduction in age-related functional decline. Research concerning the relationship between LTPA and age-related decline has been conducted in older adults, although physiologically, ageing already commences in early adulthood<sup>5, 6</sup>. Amongst many other health benefits, regular LTPA participation helps to prevent<sup>17, 44, 49</sup> and treat<sup>56-65</sup> various forms of chronic disease, slow the age-related decline in function<sup>29, 54, 55</sup> and improve quality of life<sup>44, 46, 47, 48</sup>. Endurance and neuromuscular LTPA result in specific improvements in cardiorespiratory fitness and muscle strength, respectively<sup>19</sup>. However the modes and dosages of LTPA needed to improve motor abilities and flexibility with ageing are less clear<sup>19</sup>. This may be due to the lack of standardised testing procedures and outcome measures for aspects of motor fitness, and the paucity of good quality research. Various methods are used in the literature to determine levels of LTPA, HRQoL and age-related reduction in function<sup>4, 19, 29, 39, 47, 55, 128, 130, 149</sup>. This makes it difficult to compare study results to each other.

## **2.6. INSTRUMENTATION**

### **2.6.1. Measurement of leisure time physical activity**

Leisure time physical activity assessments may have limited accuracy and reliability, as they usually rely on the subjective recall of participants' memory<sup>43, 19, 100, 101</sup>. In addition, the variation in reporting amongst individuals may be large<sup>101</sup>. LTPA was most often assessed through self-administered questionnaires or personal interviews developed by the researchers of the respective studies<sup>29, 39, 55, 115</sup>. Most studies to date have focused on measuring the volume and frequency of recent participation in LTPA, to determine its associations with parameters such as perceived health<sup>127, 55</sup>, quality of life<sup>27, 44, 47, 128</sup>, motor decline<sup>7, 29, 149</sup>, chronic disease<sup>4</sup>, BMI<sup>128</sup> or cardiorespiratory health<sup>129, 130</sup>. Only two studies have examined the relationship between different types of LTPA and components of health-related fitness<sup>19, 39</sup>, while only one has examined long term LTPA participation patterns over more than one year, in mature adults<sup>19</sup>. Ropponen et al<sup>101</sup> found the repeatability of long term exercise reporting to be high for commonly reported exercise modes in terms of exercise years and mean hours of participation per week. However, they also found poor reliability for reported exercise intensity when they studied the repeatability of lifetime (long term) exercise in a Finnish sample of middle-aged twins<sup>101</sup>. For the purpose of relating LTPA types to health-related fitness outcomes, detailed and specific LTPA assessment was required in this study.



Both long term and short term LTPA needed to be assessed by including questions on the mode(s), frequency, intensity and duration <sup>39, 115</sup>. In addition, LTPA assessment was to include questions on LTPA during adulthood from 18 years of age until one year prior to the interview (long term LTPA), active transportation, occupational and other household physical activity <sup>39, 19</sup>. For this reason, standardised questionnaires such as the Modified Activity Questionnaire or the Minnesota LTPA questionnaire were not suitable for use in this study. Rather, the LTPA questionnaire developed for this study was closely based on questions used in previous literature on the relationship between LTPA and health-related fitness by Rinne et al <sup>19</sup> and Suni et al <sup>39</sup>. A summary of the LTPA assessment methods used in previous research is provided in Table 2.3.

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**Table 2.3** Summary of LTPA assessment methods in the literature.

Study	Population	Method of LTPA assessment	Period over which LTPA was assessed
Lemaitre et al <sup>130</sup>	Cardiac patients aged 25-74 years.	In-person interviews. Modified Minnesota LTPA questionnaire: Modes, duration, intensity.	One year.
Ashe et al <sup>4</sup>	Adults aged 65 years or older.	Telephonic: questions regarding modes, duration, frequency.	Three months.
Buchman et al <sup>29</sup>	Older adults.	In-person interviews. Weekly duration of LTPA summed & expressed as hours per week.	Two weeks.
Haight et al <sup>149</sup>	Adults aged 55 years or older.	Interviews: average weekly LTPA frequency and intensity.	One year.
Malmberg et al <sup>55</sup>	Mature and elderly adults.	Self-assessment of intensity, frequency and duration of LTPA.	One year.
Rinne et al <sup>19</sup>	Mature adults.	Recent and former (long term) LTPA: modes, duration & frequency. Modes categorised (endurance, neuromuscular or games). Physical loading level at work assessed categorically.	Three months (recent), 18 years old until one year previously (former).
Suni et al <sup>39</sup>	Mature adults.	Self-administered questionnaires. Frequency, intensity & duration per week. Active transportation (commuting) in distance per day, other physical activity (duration per week).	Recent (exact period not specified).
Droyvold et al <sup>128</sup>	Adult males.	Self-administered questionnaire: low, moderate or high LTPA.	Recent (exact period not specified).
Vuillemin et al <sup>47</sup>	Adults.	Self-administered Modified Activity Questionnaire (MAQ): modes, frequency & duration.	One year.

### **2.6.2. Measurement of health-related quality of life**

The literature reports variable levels of reliability of self-reported health status questionnaires<sup>90, 91, 92</sup>. Most studies so far have measured HRQoL in older populations therefore HRQoL testing instruments were mainly designed for these age groups<sup>47</sup>. Measurement instruments for HRQoL varied considerably across the various studies. One study utilised a single item standard question relating to perceived health<sup>55</sup>, while others used more comprehensive assessments of HRQoL<sup>44, 47, 54, 154, 155</sup>. In healthy adults, a comprehensive standardised HRQoL assessment such as the SF-36 questionnaire has been found reliable and valid. The SF-36 contains 36 items divided further into eight dimensions of health using multi-item scales, each scored from 0-100<sup>44, 47</sup>. The short four-item questionnaire, CDC Healthy Days Core Questions has been developed to provide a quick surveillance of the health-related quality of life (HRQoL) of participants. It has been shown to be a reliable and valid measure of HRQoL in several studies<sup>164, 165, 166</sup>. This instrument was selected for its simplicity and ease of use in this study, and because it had demonstrated reliability and validity in healthy adults. Health-related quality of life assessment formed part of several questionnaires and tests performed at session one, therefore due to time constraints a more comprehensive HRQoL questionnaire was not used in this study.

### **2.6.3. Measurement of health-related fitness**

Health-related fitness is multifactorial and therefore cannot be determined using a single measure<sup>39</sup>. It comprises aerobic capacity, muscle strength, flexibility, motor ability and body composition<sup>19, 39</sup>. Standard laboratory methods are available to measure certain components such as cardiorespiratory fitness and muscle strength<sup>39</sup>. However to evaluate health-related fitness components of the general population, field measures that are reliable, safe, economical and easy to administer, are preferred<sup>39, 123</sup>. Although physical test batteries including tests for performance and motor skills have become popular in recent years to assess these different components accurately and efficiently, most of these have been designed for testing school-age children or older adults<sup>123</sup>. Further, most of these test batteries have not included aspects of motor fitness such as co-ordination<sup>131</sup>. Suni et al<sup>40</sup> developed a test battery designed to assess the health-related fitness of healthy middle-aged adults. Many of the tests used in the current study were based on these tests, which were found reliable and valid for mature adults<sup>40, 122</sup>.

### 2.6.3.1. Body Composition

#### a) Body mass index (BMI)

In adults, BMI is used to assess weight relative to height by dividing body weight (in kilograms) by height (in meters squared) <sup>38</sup>. Usually, obesity-related health problems increase with a BMI greater than 25 kg.m<sup>-2</sup>. Generally, a BMI of 25 kg.m<sup>-2</sup> to 29 kg.m<sup>-2</sup> is considered overweight, while a BMI greater than 30 kg.m<sup>-2</sup> is considered obese <sup>38</sup>. An increased risk of hypertension, hypercholesterolaemia, coronary heart disease and premature mortality are associated with a BMI greater than 30 kg.m<sup>-2</sup>. Conversely a BMI of less than 18.5 kg.m<sup>-2</sup> is associated with a greater risk of cardiovascular disease <sup>38</sup>.

#### b) Percentage body fat

Measuring percentage body fat by taking skinfold measures, has demonstrated high test-retest reproducibility <sup>43</sup>. There is no consensus for the exact percentage of body fat optimal for health; however currently a range of 10-22% for men and 20-32% for women is recommended <sup>38</sup>. Skinfold measurement has been shown to correlate well with the criterion standard of body composition hydrodensitometry; provided that appropriate techniques and equations are used <sup>38</sup>. Predicting body fat percentage may be as accurate as ± 3.5%, with the use of appropriate techniques and equations <sup>38</sup>. Body fat percentage was determined in this study by converting the sum of seven skinfolds to body density using the following equation for males <sup>38,135</sup>:

$$1.112 - 0.00043499(\text{sum of seven skinfolds}) + 0.00000055(\text{sum of seven skinfolds})^2 - 0.00028826(\text{age});$$

In addition, for females <sup>38,135</sup>:

$$1.097 - 0.00046971(\text{sum of seven skinfolds}) + 0.00000056(\text{sum of seven skinfolds})^2 - 0.00012828(\text{age})$$

The equation used to determine body fat percentage is as follows <sup>38</sup>:

$$457/\text{body density} - 414.2$$

#### c) Sum of seven skinfolds

For South Africans, there are no population-specific equations to determine body fat percentage. For this reason it was decided to use the sum of seven skinfolds as an additional instrument to determine body composition in this study. The seven skinfolds (measured in millimetres) were also used to calculate body fat percentage described above.

### 2.6.3.2. Cardiorespiratory fitness

Walking is a socially acceptable, safe, simple and economical mode for establishing the cardiorespiratory fitness of healthy adults<sup>122</sup>. Furthermore, walking speed has shown to relate well to the cardiorespiratory fitness of healthy adults<sup>19, 39, 122, 132</sup>. When comparing three walking distances, Oja et al<sup>122</sup> found the 2 km test the most accurate in predicting  $VO_{2max}$  in healthy adults. In addition, this test was found reliable and the most preferable field-based test for cardiorespiratory endurance<sup>122</sup>. Cross-validation studies of this test have confirmed its validity and relative accuracy in estimating the  $VO_{2max}$  of healthy adults<sup>39, 122, 123</sup>, therefore it was selected for use in this study. Maximal oxygen consumption in  $ml.kg^{-1}.min^{-1}$  was determined in this study by using the following equation for males<sup>191</sup>:

$$1840 - 4.65(time) - 0.22(HR) - 0.26(age) - 1.05(BMI)$$

In addition, for females<sup>191</sup>:

$$116.2 - 2.98(time) - 0.11(HR) - 0.14(age) - 0.39(BMI)$$

Other field tests for cardiorespiratory fitness such as the six minute walk test and the shuttle test have been used and validated mainly in populations other than healthy adults<sup>189</sup>. Further, these tests have failed to demonstrate good correlations with peak oxygen uptake in most studies thus far<sup>189</sup>. Two previous studies investigating the relationship between LTPA and health-related fitness have successfully used the 2 km walk test to determine cardiorespiratory fitness<sup>19, 39</sup>. A further benefit of using the 2 km walk test is therefore that comparison between these previous studies and the present study is possible.

### 2.6.3.3. Static balance

Standing on one leg tests have been found valid in relation to back function in middle-aged adults and falls in the elderly<sup>40</sup>. Suni et al<sup>40</sup> found standing on one leg with eyes open a reliable measure for field fitness testing of healthy adults. Its health-related validity in females was subsequently established by two further studies<sup>123, 39</sup>. Both studies concluded that males may need a more challenging test of balance. Testing static balance with the eyes closed may thus be a suitable, more challenging alternative. However, the reliability of this test has not been established, as researchers found it difficult to determine the exact moment the test began<sup>40</sup>. Both previous studies investigating the relationship between LTPA and health-related fitness in healthy adults have employed the standing on one leg (eyes open) test for static balance. Another field test for static balance that had demonstrated reliability was the test of balancing on one leg on a narrow bar<sup>131</sup>.

However this test may have increased the probability of injury to participants in case of a fall off the narrow bar. Therefore it was decided to use both standing on one leg tests (eyes open and eyes closed) as static balance outcome measures in this study.

#### **2.6.3.4. Dynamic balance**

Despite the importance of good dynamic balance for optimum motor function, there are few available tests in the literature<sup>131</sup>. Tandem walking backwards on a narrow 6 metre line was found to be a feasible and reliable field test for dynamic balance in healthy adults<sup>131</sup>, therefore it was selected for this study. It was used to determine dynamic balance in a previous study investigating the relationship between LTPA and health-related fitness<sup>19</sup>. In most other studies to date, static balance was assessed but not dynamic balance<sup>39, 123</sup>.

#### **2.6.3.5. Agility**

Numerous tests are available for this essential motor skill, with considerable variance in terms of the extent to which cognitive decision making and multidirectional movement is required<sup>45</sup>. For the purpose of testing middle aged active and inactive adults, the chosen agility test needed to be appropriate for this age group and for individuals with varying levels of fitness. The Illinois Agility Test has been found reliable and valid in terms of velocity and acceleration by Draper and Lancaster<sup>172</sup>. It involves both quick decision making and multidirectional movement, whilst being easy and economical to administer<sup>45</sup>. Other feasible options considered for testing agility in this study were the 505 agility test<sup>172</sup> and running a 10 m course in a figure of eight<sup>19</sup>. However, when one considers that the modern understanding of agility combines cognitive and reactive abilities with explosive acceleration<sup>45</sup>, both these tests would have failed to accurately measure agility. These tests require speed and direction changes with minimal opportunity for cognitive processing or reactive ability, and were therefore deemed unsuitable for this study.

#### **2.6.3.6. Co-ordination**

There was a scarcity of literature on co-ordination testing in healthy adults. Few health-related fitness test batteries developed thus far have included tests for this motor ability. A field test considered for use in this study was a timed vertical ball throw and catch<sup>19</sup>. However this test had not demonstrated reliability and validity, and it would have been difficult to standardise the testing procedure. A further option was a rhythm co-ordination test, which had demonstrated limited reliability in one study<sup>131</sup>. For the present study, a simple test described by Rinne et al<sup>131</sup> was selected as it had demonstrated higher intra- and inter-rater reliability than the rhythm co-ordination test<sup>131</sup>. For this test, a ball was bounced above a fixed line against a wall from a distance of two metres. This was repeated 20 times, as fast as possible<sup>19, 131</sup>.

### **2.6.3.7. Back muscle endurance**

Trunk muscle endurance is the most widely accepted indicator of fitness with regards to back health and function<sup>40</sup>. The static back extension test, designed to assess the endurance capacity of the trunk extensors, was found to be a valid measure of back health in several studies, although its reliability has not been confirmed<sup>39, 40, 133</sup>. It was chosen as an indicator for functional back muscle strength in this study as it was easy to administer, and as no other reliable field tests for back muscle endurance were found.

### **2.6.3.8. Upper limb function**

To measure the muscular endurance capacity of the upper body and the ability to stabilise the trunk, a modified push-up test was selected for use in this study<sup>131</sup>. This test included modifications to the traditional push-up test to improve standardisation of testing<sup>40</sup>. It was safe and easy to administer, and required no specialised equipment<sup>39</sup>. The modified push-up test also has acceptable inter- and intra-rater reliability<sup>39</sup>, and is highly related to several health-related fitness outcomes<sup>123</sup>. Further, it was found to be strongly related to perceived health, back function, cardiorespiratory fitness<sup>123</sup> and participation in muscular exercise in both sexes<sup>39</sup>. No other field tests for measuring upper body function were considered suitable for use in this study.

### **2.6.3.9. Lower limb function**

Lower limb function was assessed by the vertical jump test, which is also known as the jump-and-reach test<sup>123</sup>. Excellent reliability was found for this field assessment of lower limb function<sup>40</sup>. One study found the vertical jump test did not relate to health-related fitness outcomes, and therefore its health-related validity has not been established<sup>40</sup>. An alternative measure of lower limb function may have been the one leg squat with increasing weights<sup>123</sup>. This test would have required the use of a weight belt system of up to 140% of a participant's body weight, which may potentially have increased the risk of injury. Similar to the vertical jump test, this test had established reliability but not validity. There is a lack of valid field tests for the lower limb function of active and inactive middle aged adults.

### **2.6.3.10. Flexibility**

Evidence of the associations of flexibility to health-related fitness outcomes is conflicting<sup>39, 40</sup>. Further, it is difficult to determine overall flexibility using just one test. As it has been found a valid measure of back and hamstring flexibility in adults<sup>134</sup>, the sit-and-reach test was selected as the flexibility measure in this study. The reliability of this test has been shown to be good if conditions of testing are standardised as much as possible<sup>134</sup>. Trunk side bending is a test for flexibility which could have been used<sup>19, 39</sup>. However this test focuses on the flexibility of the trunk only, whereas the sit-and-reach test incorporates both trunk and leg flexibility.

Another alternative was trunk forward bending in standing, using modified fingertip to floor measurement<sup>19, 131</sup>. However, the sit-and-reach test has been used widely and has been more extensively investigated for its validity and reliability.

## **2.7. SUMMARY OF THE LITERATURE: THE RELATIONSHIP BETWEEN LEISURE TIME PHYSICAL ACTIVITY AND HEALTH-RELATED FITNESS IN MATURE ADULTS**

Chronic diseases of lifestyle are the leading cause of premature deaths worldwide<sup>30, 31</sup>. The WHO placed the burden of chronic diseases in South Africa at two or three times higher than that in developed countries<sup>34</sup>, with middle-aged (mature) adults being the most severely affected. It is estimated that more than 80% of chronic diseases occur in this age group<sup>31</sup>. Primary prevention, which encourages an increase in physical activity, may be the most successful and most feasible way to reduce the burden of chronic disease in our country<sup>82, 183</sup>. This is because physical inactivity and ageing are two of the most important risk factors for chronic disease in South African mature adults<sup>34, 82, 83</sup>.

The concept health-related fitness includes the following aspects of physical fitness that are important for health: cardiorespiratory fitness, muscle function, motor abilities (balance, coordination and agility) and flexibility<sup>39</sup>. The maintenance of health-related fitness is mandatory to help prevent chronic diseases of lifestyle, prevent falls and to keep independent function with ageing<sup>19</sup>. Components of health-related fitness have shown to decline as people age<sup>142, 181</sup>, although much of this decline may be related to disuse rather than ageing<sup>115</sup>. Leisure time physical activity includes any exercise or physically active hobbies participated in during free time. The extensive benefits of LTPA with ageing include the prevention and treatment of chronic diseases<sup>30, 31</sup>, the development of aspects of health-related fitness<sup>29, 54, 55, 115, 147, 174</sup>, and the maintenance of a healthy body composition<sup>7, 149</sup>. Moreover, these benefits have shown to result in fewer falls<sup>3, 41, 113, 114</sup>, the preservation of independent function<sup>157</sup> and improved quality of life<sup>47, 54, 55</sup> in older adults. Compared to cardiorespiratory fitness and muscle strength, evidence of the nature of LTPA required to develop other components of health-related fitness is extremely scarce<sup>19, 131</sup>. In addition, the long term relationship between LTPA and health-related fitness is still largely unknown<sup>19</sup>.

The South African population is ageing<sup>34</sup> and is also burdened by the high prevalence of chronic diseases of lifestyle<sup>34, 183, 185</sup>, obesity and inactivity<sup>34, 183, 185</sup>. Despite this, there is a lack of evidence regarding the nature of the short- and long term LTPA patterns of South African mature adults, and the association between LTPA and body composition and health-related fitness.



Therefore the following study was undertaken to determine the recent and former participation levels of LTPA in a sample of mature male and female South African adults; to compare active and inactive participants in terms of selected health-related fitness components; and to determine the associations between various forms of reported recent and long term LTPA, with health-related fitness outcomes.

# CHAPTER THREE: THE RELATIONSHIP BETWEEN LEISURE TIME PHYSICAL ACTIVITY AND HEALTH-RELATED FITNESS: A SINGLE-BLINDED STUDY

## 3.1. INTRODUCTION

Leisure time physical activity is widely recommended for enhancing health and wellbeing<sup>16, 17</sup>, and for the prevention and treatment of chronic diseases of lifestyle<sup>15</sup>. In addition, LTPA is thought to help control age-associated body weight gain and bone loss in the growing older population, and to assist in improving motor function<sup>23-27</sup>. As adults age, the need to enhance motor abilities in terms of balance, co-ordination and agility becomes critical for the preservation of function in later years<sup>19, 29, 43, 115</sup>.

Certain types of LTPA are prescribed for the promotion of certain health-related outcomes, for example vigorous endurance exercise may help to reduce cardiovascular disease<sup>10, 21, 22</sup>, while musculoskeletal exercise is used to prevent muscle weakness<sup>23-27</sup>. Although LTPA has shown to enhance health-related fitness parameters such as cardiorespiratory fitness, muscle power and flexibility, the effect of specific types of exercise on the individual health-related fitness components is not clear<sup>19</sup>. In particular, there is a lack of evidence regarding the relationship between LTPA and motor abilities such as agility, balance and co-ordination<sup>22</sup>.

Most studies examining the effect of LTPA on health-related fitness have involved age groups other than mature adults<sup>19, 43, 96, 97, 125</sup>. In these populations, low levels of LTPA have been associated with poor health and impaired components of health-related fitness<sup>57, 115</sup>. A previous study found that most adults in this country are not achieving health-enhancing levels of LTPA<sup>173</sup>. There is a lack of information on the LTPA of mature adults in South Africa, and LTPA is critical for the maintenance of function with ageing. Accordingly, the purpose of this study was to examine the relationship between LTPA and components of health-related fitness in healthy mature adults. The study objectives are outlined in section 1.2.2, page 2.

## **3.2. METHODS**

### **3.2.1. Study design and recruitment**

This was a descriptive, correlational single-blinded study. Fifty-six healthy male and female volunteers aged between 40 and 60 were recruited for this study through advertisements placed in the local Oudtshoorn newspaper, on notice boards at shopping centres and local libraries (*Appendix 1*) and by word of mouth. Twenty-nine participants (15 males and 14 females) who took part in regular LTPA were assigned to the active group<sup>38, 39</sup>. Twenty-seven participants were recruited for the inactive group (13 males and 14 females), which consisted of participants who did not take part in regular LTPA<sup>38</sup>. Active and inactive groups were matched for other confounding variables such as occupational physical activity levels and weekly duration of active commuting (*Appendix 2*).

### **3.2.2. Sample size calculation**

Data from a previous study investigating LTPA<sup>19</sup> were used to ensure that the sample size would provide sufficient statistical power. Static back muscle endurance was selected to determine the required sample size, as this was one of the main outcome measures for this study, and was expected to have the greatest degree of standard deviation of all the parameters that were measured in this study. Required sample size for static back muscle endurance was calculated using a smallest meaningful difference of 100 s and a standard deviation of 100 s. With statistical significance accepted as  $p < 0.05$ , groups of 17, 22 and 27 participants would provide 80%, 90% and 95% statistical power for static back muscle endurance respectively. Fifty-six participants were recruited for this study to ensure sufficient statistical power in the event that some participants were unable to complete the study.

### **3.2.3. Inclusion criteria**

Healthy adults aged 40 to 60 years were included in the study. Participants were included in the active group if they participated in a minimum of 30 minutes of LTPA, at least three times per week<sup>38</sup>. Participants were included in the inactive group if they participated in LTPA less than three times per week, for less than 30 minutes per session; or if they participated in less than 90 minutes of total LTPA per week<sup>38, 39</sup>.

### **3.2.4. Exclusion criteria**

Elite athletes who participated in competitive sport at national or international level were excluded to minimise potential bias of results due to high levels of physical activity. Participants that could not safely participate in physical activity, as determined by the Physical Activity Readiness Questionnaire (PAR-Q) (*Appendix 3*), were also excluded from the study.

Participants were also excluded if they were taking medication known to affect balance, coordination or agility (for example, anti-epileptics); or heart rate (for example beta-blockers, certain calcium channel blockers and anti-arrhythmics). Participants that reported any musculoskeletal pathology or injury in the eight weeks prior to testing were excluded, to avoid potential risk of re-injury due to the physical nature of some tests. Participants with relevant medical or surgical history that may have resulted in impaired physical testing were also excluded from the study.

### **3.2.5. Instrumentation**

#### **3.2.5.1. Questionnaires**

##### **3.2.5.1.1. Physical Activity Readiness Questionnaire (PAR-Q) <sup>38, 167</sup>:**

The PAR-Q (*Appendix 3*) is a self-guided screening tool that was used to determine that it was medically safe for volunteers to participate in the study. Any volunteers that were excluded during the screening process were referred to their doctor for further management. The validity and reliability of the PAR-Q has previously been established <sup>162, 163</sup>.

##### **3.2.5.1.2. CDC Healthy Days Core Questions (CDC HRQOL – 4) <sup>165, 166</sup>:**

This short four-item questionnaire (*Appendix 4*) was used to determine the health-related quality of life (HRQoL) of participants. The CDC HRQOL-4 has been shown to be a reliable and valid measure of HRQoL in several studies <sup>164, 165, 166</sup>.

##### **3.2.5.1.3. LTPA questionnaire <sup>16, 19, 39</sup>:**

The questionnaire was designed to determine the short term (recent) and long term (former) LTPA patterns of participants in terms of modes, frequency, duration and intensity, and was based on LTPA or physical activity questionnaires used in similar studies <sup>19, 39</sup>. The questionnaire (*Appendix 2*) comprised four sections: personal details including education, recent, long term and other LTPA such as commuting and occupational physical activity, which was included for the purpose of matching the active and inactive groups as closely as possible. Reported modes of recent and long term LTPA were categorised into endurance, neuromuscular LTPA or games. For recent LTPA, hours per week for each category were added together. For long term LTPA, the years of participation in each category were added together.

##### **3.2.5.1.3 a) Validity of the LTPA questionnaire**

The LTPA questionnaire was reviewed by a panel of three experts in health-related fitness to ensure content and construct validity. The panel was contacted requesting their assistance in validating the questionnaire. The expert panel had the opportunity to comment on every question based on its relevance and importance, and whether the question was clear and easy to understand.

In addition, members of the panel had the opportunity to suggest any questions that may be added to the questionnaire to enhance the quality of the study (*Appendix 5*). All three experts returned the questionnaires. Feedback given was mainly related to the clarity of questions, correction of language use and the explanation of health-related fitness terminology in layman's terms. Appropriate changes were subsequently made to the questionnaire together with the re-wording of certain questions.

### **3.2.5.2. Anthropometry**

Stature (m) was measured with a single flexible yet inelastic measuring tape<sup>38</sup>. Body mass (kg) was measured using a calibrated scale<sup>38</sup>. Body mass and stature were recorded with participants lightly clothed and without shoes. Body mass index (BMI) ( $\text{kg}\cdot\text{m}^{-2}$ ) was calculated, as this is a valid and reliable measure to predict body fat percentage and risk of disease and mortality<sup>38,168</sup>. Body fat was expressed as the sum of seven skinfolds (chest, triceps, subscapular, supra-iliac, mid-axillary, thigh and abdomen)<sup>135</sup>. Body fat was also expressed as a percentage of body mass according to the equation described in Section 2.6.3.1 b) (page 28).

### **3.2.5.3. Physical test battery**

#### **3.2.5.3.1. Maximum oxygen consumption: 2 km walk test**

Following a five minute warm-up walk, participants walked 2 km on a flat 400 m tartan athletics track<sup>122</sup>. Walking time was measured using a stopwatch. Heart rate was recorded (Suunto Memory belt, SS013444000, Vantaa, Finland) at five-second intervals throughout the 2 km walk<sup>122</sup>. Participants were instructed to walk "as fast as possible" and were given standardised verbal encouragement during the test. Maximal oxygen consumption was calculated based on time to complete the test, heart rate at the end of the test, BMI, age and sex<sup>122</sup>. The formula for this calculation is described in Section 2.6.3.2 (page XX). The 2 km walk test has been shown to be reliable and valid for accurately predicting  $\text{VO}_{2\text{max}}$  in both active and inactive adults<sup>40,122,170</sup>.

#### **3.2.5.3.2. Static balance: eyes open and eyes closed**

To measure static balance, participants were required to stand as still as possible on one leg, with the other foot at the knee level on the inner side of the supporting leg, rotating the thigh outwards. Hands were relaxed at the sides. The time on one foot (seconds) was measured with a stopwatch for a maximum of one minute<sup>40,131</sup>. Three trials were allowed, unless the participant reached the time limit of one minute in the first trial. Suni et al<sup>40</sup> found that this test was a reliable measure of static balance. However as this test was not challenging enough for the males in a previous study<sup>39</sup>, it was decided to measure static balance with eyes closed as well. For this test, participants stood in the same position as for the static balance test (eyes open) described above.

Participants then closed their eyes, and the time was taken from this moment until any corrective touches occurred with the free foot or participants opened their eyes. The maximum time for this test was 40 s<sup>40</sup>.

#### **3.2.5.3.3. Dynamic balance**

Tandem walking backwards on a narrow 6 m line was used to determine dynamic balance. Participants were required to walk backwards for 6 m, placing their feet behind each other with the heel and toes touching, as fast as possible without touching their feet next to the line (time taken in seconds). The best of three attempts was recorded<sup>131</sup>. Rinne et al<sup>131</sup> found this test to be a reliable measure of motor skills in non-sporting adults.

#### **3.2.5.3.4. Agility: Illinois Agility Test**

Agility was assessed using the Illinois Agility Test (*Appendix 6*). Eight cones demarcated the obstacle course. A hand-held stop watch was used to record time taken to perform the Illinois Agility Test. Participants ran around cones in a criss-cross manner to assess agility. Participants were instructed to complete the course “as fast as possible”. The test was performed three times with a one-minute rest interval on completion of each test. The best time was recorded. This test has been found to be a reliable and valid measure of agility<sup>172</sup>.

#### **3.2.5.3.5. Co-ordination**

Co-ordination was assessed using a ball test. Participants were required to bounce a ball from a distance of two metres against a wall with a line two metres high as fast as possible. The time, in seconds, needed for 20 bounces above the line was recorded with a hand-held stop watch<sup>131</sup>. Rinne et al<sup>131</sup> found this test to be a reliable measure of motor skills in adults.

#### **3.2.5.3.6. Back muscle endurance**

For the measurement of back muscle endurance, participants were positioned in prone lying on a low bench, with their hands crossed behind their neck. The edge of the bench was positioned in line with the anterior superior iliac spines of participants’ pelvises, so that the upper body of participants was off the bench. The researcher held the participants’ ankles to prevent leg movement during the test. Participants then raised their upper body to the horizontal level (in line with the bench) and held the position for as long as possible for a maximum of four minutes<sup>133</sup>. Participants performed a single repetition and this time was recorded. This test has been found to be a valid measure of back muscle endurance<sup>39,40</sup>.

#### **3.2.5.3.7. Upper limb function: modified push-up test**

Upper limb function was assessed using a modified push-up test. From a prone lying position with hands clasped behind their neck, participants were required to perform a straight leg push-up, extending their elbows completely in the “up” position. One hand then touched the supporting hand, before returning to the prone lying position. The number of push-up cycles completed in 40 seconds was recorded. Participants were allowed to practice one push-up cycle before starting the test<sup>40</sup>. This test has been found to be a valid measure of upper limb function<sup>39,40</sup>.

#### **3.2.5.3.8. Lower limb function: vertical jump test**

Before the test, participants covered their middle finger with lightly coloured chalk powder. Participants stood side-on to a dark coloured wall with their feet flat on the floor and their arm closest to the wall reaching as high up as possible with their middle finger, to measure standing reach height. Participants were instructed to squat down with the fingertips touching the floor in a standardised starting position. They were instructed to jump as high as possible from the squat position with their dominant arm reaching above their head and reaching for the highest marker possible on the wall. Vertical jump height was recorded as the highest point reached on the wall with their middle finger. The participants received standard verbal encouragement during the test to ensure maximal performance. The test was repeated three times with a one-minute break between each attempt, and the maximum jump height was recorded. Vertical jump height was calculated as the difference between the standing height and the maximum jump height achieved. This test is a valid and reliable measure of lower limb function<sup>40</sup>.

#### **3.2.5.3.9. Flexibility: sit-and-reach test**

This test was first described by Wells and Dillon<sup>134</sup>. Participants were required to sit on the floor with their knees in extension, and with their ankles in neutral with the soles of both feet against a wall. Participants were instructed to reach forwards as far as they could with their fingertips towards their toes. Both hands were to reach forward equally and no jerky movements were allowed. The distance was measured between the tip of the middle finger and the first toe in centimetres (cm). The participant was allowed to practice and the best of three reaches was recorded. If the participants’ fingertips touched or reached past their big toes, the score was recorded as 0 cm. This test has been shown to be a valid measure of back and hamstring flexibility

<sup>134</sup>.

#### **3.2.5.4. Feasibility of the testing procedure**

A pilot study was conducted to determine the feasibility of the testing procedure. Five healthy adults, who met the inclusion criteria for the main study, took part in the feasibility study. Small practical changes were made to the testing procedure following this pilot study, including the standardisation of the order of completion of the different questionnaires, the standardisation of all verbal explanations given to participants, and the use of colour-coded marking on participants, stop-watches and heart rate monitors during the physical test battery to eliminate possible confusion of data. In addition, the pilot study assisted in clarifying the roles of the researcher and research assistant during the measurement of different tests. No changes were made to the LTPA questionnaire following the pilot study. The results of the pilot study were not included for data analysis.

#### **3.2.6. Procedure**

After the LTPA questionnaire was validated and the pilot study completed, an advertisement was placed in the local newspaper in Oudtshoorn (*Appendix 1*) for the recruitment of participants. The first session for each participant was held at a physiotherapy practice in Oudtshoorn, Western Cape, South Africa. Session two was conducted at a municipal sports complex in Oudtshoorn (*Appendix 7*). Volunteers were invited to present to the testing venue for session one individually, and to session two three to five days later, in groups of three to five. To maintain blinding, the researcher was responsible for the recruitment and screening of participants, the completion of questionnaires, anthropometric assessments and group allocation. A research assistant performed the physical tests in the second testing session, and was blinded to the group allocations. Participants were instructed not to reveal their group allocation to the research assistant. The research assistant was a qualified physiotherapist with 12 years of postgraduate clinical experience. The research assistant was trained by the researcher to correctly assess each of the physical tests.

##### **3.2.6.1. Session one**

After reading the participant information sheet (*Appendix 8*), participants were required to sign an informed consent form (*Appendix 9*). The modified PAR-Q questionnaire was completed to screen for safe participation in physical activity (*Appendix 3*). The LTPA Questionnaire (*Appendix 2*) was completed. Finally, participants completed the standard four-item set of Healthy Days core questions from the Centers for Disease Control and Prevention (CDC HRQOL-4) (*Appendix 4*) to assess health-related quality of life<sup>36</sup>. The questionnaires were completed with the researcher to ensure that participants had assistance as needed when completing the questionnaires. Anthropometric measurements (stature, body mass, and skinfold thicknesses) were performed and entered into a data sheet (*Appendix 10*). Participants were then familiarised with the physical tests.



### **3.2.6.2. Session two**

Session two was performed three to five days after session one, and consisted of a battery of physical tests to determine the health-related fitness. Participants warmed up by walking once around the athletics track. Physical testing was conducted in the following order: the 2 km walk test, static balance, dynamic balance, the Illinois Agility Test, co-ordination, back muscle endurance, the modified push-up test, the vertical jump test, and the sit-and-reach test<sup>38</sup>. Participants had the opportunity to rest between tests, for as long as they needed up to a maximum of five minutes. One-minute rests periods were allowed between repetitions of each test.

### **3.2.7. Statistical analyses**

Data were entered in a Microsoft Excel spreadsheet. Statistical analyses were performed using STATISTICA software (StatSoft, Inc. 2013). STATISTICA (Data analysis software system version 11: [www.statsoft.com](http://www.statsoft.com)). Normality was assessed using a Shapiro-Wilkes test. Differences between groups were assessed using an independent t-test or the Mann-Whitney U test for parametric and non-parametric outcome measures respectively. For descriptive purposes, chi-squared measures of association were used where data were nominal. Pearson's correlational analyses were also performed to assess the relationships between different types of LTPA and motor abilities (static or dynamic balance, co-ordination, agility) or other components of health-related fitness (cardiorespiratory fitness, back muscle endurance, upper limb function, lower limb function, flexibility); or anthropometric measures (body fat percentage, BMI, sum of seven skinfolds). Statistical significance was accepted as  $p < 0.05$ .

### **3.2.8. Ethical considerations**

The study was conducted according to the principles of the Declaration of Helsinki (Seoul version, 2008). The proposal was submitted and approved by the Faculty of Health Sciences Human Research Ethics Committee of the University of Cape Town (HREC REF: 329/2012) (*Appendix 11*). Participants were given an information sheet (*Appendix 8*) and were also informed orally about the purpose of the project, the testing procedures and about the possible risks that were involved. The participant information sheet and informed consent form were forward- and back-translated into Afrikaans, which allowed participants to give consent in their preferred language. Participants had the right to withdraw from the study at any stage without reason or prejudice. Participants were required to give written informed consent (*Appendix 9*) to take part in the study. All data were kept confidential and anonymous. In addition, permission was obtained to conduct the study from the respective testing venues in Oudtshoorn.

### **3.2.8.1. Risks to participants**

There were no risks involved for participants in terms of completing the written consent form and questionnaires. Measurement of body mass, stature and skinfolds were not associated with any potential risks to participants. The risks related to the measurement of cardiorespiratory fitness (2 km walk test) and agility (Illinois Agility Test), were minimised by the completion of a modified PAR-Q screening form prior to testing (*Appendix 3*). Also, participants were excluded from the study if they had any medical condition or physical injury, illness or disability. Risks to participants were further minimised by performing a standardised warm-up before participation in the 2 km walk test. Every test was thoroughly explained and demonstrated by the researcher before starting the test. Familiarisation with tests and practice rounds were allowed before measurements were taken by the research assistant. In addition, the research assistant carefully controlled all testing procedures. Tests such as the jump and reach and modified push-up require near maximal contractions of muscle groups. The risks associated with these tests are similar to the risks associated with unaccustomed exercise, such as painful or stiff quadriceps or pectoral muscles.

### **3.2.8.2. Benefits to participants**

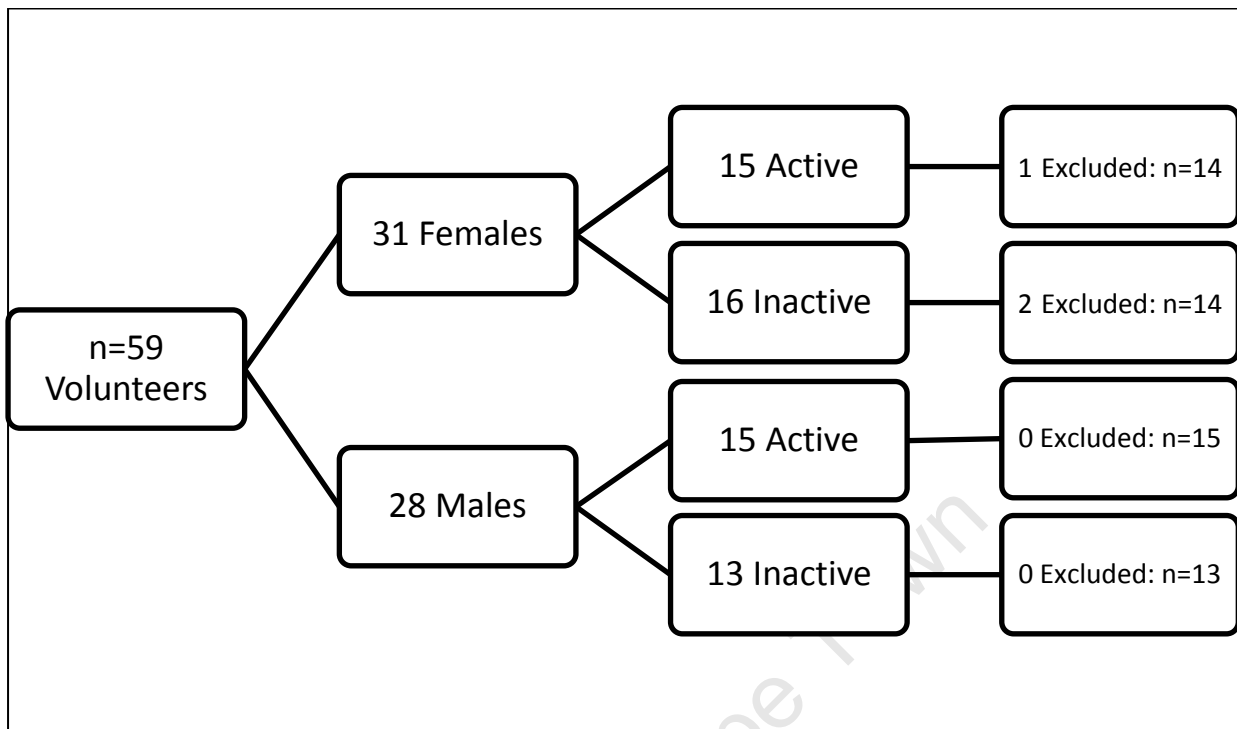
All participants were provided with a summary of their test scores after the completion of data collection. In addition, participants were provided with information leaflets regarding the importance of regular LTPA, and the latest recommendations regarding exercise for adults, according to the American College of Sports Medicine (ACSM) Guidelines for Exercise Testing and Prescription (*Appendix 12*)<sup>38</sup>. If participants required additional input or advice regarding training interventions, they were referred to a physiotherapist or biokineticist. Participants who were excluded from the study due to their PAR-Q (*Appendix 3*) responses were referred to their doctor for further management.

## **3.3. RESULTS**

### **3.3.1. Participants**

Fifty nine healthy mature adults were recruited for this study. Thirty one were females, of which fifteen were active and sixteen inactive. Twenty eight were males, of which fifteen were active and thirteen inactive. Three female volunteers (one active and two inactive) were excluded from the study due to their responses to the PAR-Q (*Appendix 3*). All three volunteers were taking medication for chronic conditions, and were therefore not eligible to participate in the study.

Therefore, the study sample was comprised of fifty six participants: twenty eight males and twenty eight females. There were fourteen inactive females and thirteen inactive males; and fourteen active females and fifteen active males. The study sample is summarised in Figure 3.1.



**Figure 3.1:** Summary of the study sample.

### 3.3.2. Descriptive characteristics

Descriptive characteristics of participants are shown in Table 3.1. There were no significant differences in age between males and females or between active and inactive groups. There was no significant interaction between sex and physical activity for stature; however there was a significant main effect of sex ( $F_{(1, 52)} = 64.8$ ;  $p = 0.000001$ ). Males were significantly taller than females ( $p = 0.001$ ). There was no significant interaction between sex and physical activity for body mass; however there were significant main effects of sex ( $F_{(1, 52)} = 30.9$ ;  $p = 0.000001$ ) and physical activity ( $F_{(1, 52)} = 7.4$ ;  $p = 0.009$ ) respectively. Body mass was significantly increased in males compared to females ( $p = 0.001$ ). Body mass was significantly reduced in active participants compared to inactive participants ( $p = 0.02$ ).

**Table 3.1** Descriptive characteristics of active males (n=15), inactive males (n=13), active females (n=14) and inactive females (n=14). Data are expressed as mean  $\pm$  standard deviation (SD).

Variable	Active males (n=15)	Inactive males (n=13)	Active females (n=14)	Inactive females (n=14)
Age (years)	48.6 $\pm$ 6.7	47.4 $\pm$ 7	44.9 $\pm$ 3.8	48.5 $\pm$ 3.7
Stature (cm) <sup><math>\alpha</math></sup>	177 $\pm$ 0.1	182 $\pm$ 0.1	165 $\pm$ 0.1	164 $\pm$ 0.1
Mass (kg) <sup><math>\alpha\phi</math></sup>	87.9 $\pm$ 10.4	99.6 $\pm$ 12.8	69.6 $\pm$ 14.7	77.6 $\pm$ 15.8

Significant differences:

$\alpha$  main effect of sex for stature ( $p = 0.001$ )

$\alpha$  main effect of sex for body mass ( $p = 0.001$ )

$\phi$  main effect of physical activity for body mass ( $p = 0.02$ )

### 3.3.2.1. Anthropometry

Anthropometric characteristics of participants are shown in Table 3.2. There was no significant interaction between sex and physical activity for BMI; however there was a significant main effect of physical activity ( $F_{(1, 52)} = 5.11$ ;  $p = 0.03$ ). BMI was significantly reduced in active compared to inactive participants ( $p = 0.04$ ). There was no significant interaction between sex and physical activity for body fat percentage; however there were significant main effects of sex ( $F_{(1, 52)} = 31.36$ ;  $p = 0.000001$ ) and physical activity ( $F_{(1, 52)} = 8.95$ ;  $p = 0.04$ ) respectively. Body fat percentage was significantly reduced in males compared to females ( $p = 0.0001$ ), and in active participants compared to inactive participants ( $p = 0.003$ ). There was no significant interaction between gender and physical activity for the sum of seven skinfolds; however there was a significant main effect of physical activity ( $F_{(1, 52)} = 9.0$ ;  $p = 0.004$ ). The sum of seven skinfolds was significantly reduced in active participants compared to inactive participants ( $p = 0.004$ ).

**Table 3.2** Anthropometric characteristics of active males (n=15), inactive males (n=13), active females (n=14) and inactive females (n=14). Data are expressed as mean  $\pm$  standard deviation (SD).

Variable	Active males (n=15)	Inactive males (n=13)	Active females (n=14)	Inactive females (n=14)
BMI (kg.m <sup>-2</sup> ) <sup><math>\phi</math></sup>	28.1 $\pm$ 2.9	30.2 $\pm$ 3.7	25.5 $\pm$ 5.3	28.9 $\pm$ 5.6
Body fat (%) <sup><math>\alpha\phi</math></sup>	24.9 $\pm$ 5.6	28.9 $\pm$ 5.1	32.9 $\pm$ 7.2	38.3 $\pm$ 5.0
Sum of skinfolds (mm) <sup><math>\phi</math></sup>	170.5 $\pm$ 49.6	210.9 $\pm$ 53.1	189.8 $\pm$ 69.0	243.9 $\pm$ 62.6

Significant differences:

$\phi$  main effect of physical activity for BMI ( $p = 0.04$ )

$\alpha$  main effect of sex for body fat percentage ( $p = 0.0001$ )

$\phi$  main effect of physical activity for body fat percentage ( $p = 0.003$ )

$\phi$  main effect of physical activity for sum of seven skinfolds ( $p = 0.004$ )

### 3.3.2.2. Health-related quality of life (HRQoL)

Health related quality of life (HRQoL) scores for currently active and inactive male and female participants are shown in Table 3.3. There were no significant differences in HRQoL scores between male and female participants, or between currently active and inactive participants.

**Table 3.3** Health-related quality of life (HRQoL) scores of active males (n=15), inactive males (n=13), active females (n=14) and inactive females (n=14). Data are expressed as mean  $\pm$  standard deviation (SD). Note: Lower scores indicate improved HRQoL.

Variable	Active males (n=15)	Inactive males (n=13)	Active females (n=14)	Inactive females (n=14)
HRQoL (points)	3.8 $\pm$ 3.7	2.9 $\pm$ 2.3	4.3 $\pm$ 3.6	5.6 $\pm$ 8.5

### 3.3.2.3. Education and occupational characteristics

Working hours per week of participants are shown in Table 3.4. There was a significant interaction between sex and physical activity. There were significant main effects of sex ( $F_{(1, 52)} = 27.83$ ;  $p = 0.000001$ ) and physical activity ( $F_{(1, 52)} = 9.06$ ;  $p = 0.004$ ) respectively. Working hours were significantly higher in males compared to females ( $p = 0.0001$ ), and in inactive participants compared to active participants ( $p = 0.008$ ). Working hours were also significantly higher in active males compared to active females ( $p = 0.0002$ ), and in inactive males compared to active females ( $p = 0.0002$ ). In addition, working hours were significantly higher in inactive females compared to active females ( $p = 0.0006$ ).

**Table 3.4** Working hours per week of active males (n=15), inactive males (n=13), active females (n=14) and inactive females (n=14). Data are expressed as mean  $\pm$  standard deviation (SD).

Variable	Active males <sup>#</sup> (n=15)	Inactive males <sup>γ</sup> (n=13)	Active females <sup>**</sup> (n=14)	Inactive females (n=14)
Work (h. wk <sup>-1</sup> ) <sup>αφ</sup>	44.9 $\pm$ 10.8	44.8 $\pm$ 11	13.2 $\pm$ 15.6	36.2 $\pm$ 18.3

Significant differences:

α main effect of sex ( $p = 0.0001$ )

φ main effect of physical activity ( $p = 0.008$ )

# active males compared to active females ( $p = 0.0002$ )

γ inactive males compared to active females ( $p = 0.0002$ )

\*\* inactive females compared to active females ( $p = 0.0006$ )

Education levels, physical loading levels and active commuting habits of participants are shown in Table 3.5. Of the fifty six participants, forty five (80%) had completed tertiary education. Male participants had significantly higher education levels compared to female participants ( $\chi^2 = 8.5$ ;  $p = 0.01$ ); however there were no significant differences in education levels between active and inactive participants. Thirty two participants (57%) reported that their work required only light physical loading. Males had significantly lower physical loading levels at work compared to females ( $\chi^2 = 14.2$ ;  $p = 0.002$ ). Active participants had significantly lower physical loading levels at work than inactive participants ( $\chi^2 = 9.6$ ;  $p = 0.02$ ). Active females had significantly lower levels of physical loading at work than inactive females ( $\chi^2 = 11.6$ ;  $p = 0.009$ ). There were no statistically significant differences in physical loading levels at work between active and inactive males. Forty four participants (79%) reported no active commuting in an average week. There were no significant differences in active commuting between male and female participants, or in active and inactive participants.

**Table 3.5** Education and occupational characteristics of active males (n=15), inactive males (n=13), active females (n=14) and inactive females (n=14).

Variable	Active males (n=15)	Inactive males (n=13)	Active females** (n=14)	Inactive females (n=14)
<b>Education:</b> <sup>α</sup> <b>Primary school</b> <b>Secondary school</b> <b>Tertiary</b>	Primary school (n = 1) Secondary school (n = 1) Tertiary (n = 13)	Tertiary (n = 13)	Secondary school (n = 5) Tertiary (n = 9)	Secondary school (n = 4) Tertiary (n = 10)
<b>Physical loading level at work:</b> <sup>α φ</sup> <b>Light</b> <b>Medium</b> <b>Heavy</b> <b>Unemployed</b>	Light (n = 12) Medium (n = 3)	Light (n = 9) Medium (n = 4)	Light (n = 7)  Unemployed (n = 7)	Light (n = 4) Medium (n = 6) High (n = 2) Unemployed (n = 2)
<b>Active Commuting:</b> <b>Yes</b> <b>No</b>	Yes (n = 3) No (n = 12)	Yes (n = 3) No (n = 10)	Yes (n = 3) No (n = 11)	Yes (n = 3) No (n = 11)

Significant differences:

α education levels: males vs. females

α physical loading levels at work: males vs. females

φ physical loading levels at work: active vs. inactive participants

\*\* physical loading levels at work: inactive females vs. active females

### 3.3.3. Leisure time physical activity participation patterns

Recent participation refers to LTPA during the three months preceding the study. Long term participation refers to LTPA from age 18 until one year prior to the study. Recently active participants had engaged in regular LTPA for the previous three months, while inactive participants had not. Participants who had engaged in regular long term LTPA may have been recently either active or inactive.

#### 3.3.3.1. Recent leisure time physical activity

##### 3.3.3.1.1. Modes of recent leisure time physical activity

Active males participated in seven different modes of recent LTPA. The three most common modes of recent LTPA for males were cycling (n = 9), running (n = 8) and weight training (n = 4). Active females participated in eight different modes of recent LTPA. The three most common modes of recent LTPA for females were walking (n = 9), running (n = 6) and weight training (n = 3). There were no significant differences in the number of recent modes of LTPA between males and females. (Table 3.6)

**Table 3.6** Number of recent LTPA participation modes of active males (n=15) and active females (n=14). Data are expressed as mean  $\pm$  standard deviation (SD).

Variable	Active males (n=15)	Active females (n=14)
Recent number of LTPA modes	1.9 $\pm$ 0.9	1.9 $\pm$ 1.0

##### 3.3.3.1.2. Recent LTPA characteristics of active participants

The total LTPA, endurance, neuromuscular LTPA and games of participants is shown in Table 3.7. There were no significant differences in the total recent LTPA, endurance LTPA, neuromuscular LTPA or games per week between active males and active females. Active participants reported significantly more hours per week of endurance LTPA compared to neuromuscular LTPA ( $p = 0.01$ ) and games ( $p = 0.00001$ ).

**Table 3.7** Total recent LTPA, endurance, neuromuscular LTPA and games (h.wk<sup>-1</sup>) of active males (n=15) and active females (n=14). Data are expressed as mean  $\pm$  standard deviation (SD).

Variable	Active males (n=15)	Active females (n=14)
Total recent LTPA (h.wk <sup>-1</sup> )	6.5 $\pm$ 3.3	5.1 $\pm$ 2.8
Recent endurance LTPA (h.wk <sup>-1</sup> )	5.3 $\pm$ 2.6	3.9 $\pm$ 2.4
Recent neuromuscular LTPA (h. wk <sup>-1</sup> )	1.0 $\pm$ 1.9	1.0 $\pm$ 1.2
Recent games (h.wk <sup>-1</sup> )	0.1 $\pm$ 1.5	0.3 $\pm$ 1.2

### 3.3.3.2. Long term leisure time physical activity

#### 3.3.3.2.1. Modes of long term leisure time physical activity

Males participated in a total of sixteen long term LTPA modes. The three most common long term LTPA modes for males were cycling (n = 15), running (n = 14) and rugby (n = 11). Females participated in a total of thirteen long term LTPA modes. The three most common long term LTPA modes for females were walking (n = 9), running (n = 7) and cycling (n = 7). The number of long term modes of LTPA for participants are shown in Table 3.8. There was no significant interaction between sex and physical activity; however there were significant main effects of sex ( $F_{(1, 52)} = 5.39$ ;  $p = 0.02$ ) and physical activity ( $F_{(1, 52)} = 14.00$ ;  $p=0.0005$ ) respectively. Males participated in significantly more long term modes of LTPA compared to females ( $p = 0.02$ ). Recently active participants participated in significantly more modes of long term LTPA compared to inactive participants ( $p = 0.0005$ ). In addition, recently active females participated in significantly more long term modes of LTPA compared to inactive females ( $p = 0.0002$ ). There were no significant differences in long term LTPA modes between active and inactive males.

**Table 3.8** Number of long Term LTPA modes of active males (n=15), inactive males (n=13), active females (n=14) and inactive females (n=14). Data are expressed as mean  $\pm$  standard deviation (SD).

Variable	Active males (n=15)	Inactive males (n=13)	Active females** (n=14)	Inactive females (n=14)
Long term LTPA modes <sup><math>\alpha</math> <math>\phi</math></sup>	3.2 $\pm$ 1.4	2.2 $\pm$ 2.1	2.8 $\pm$ 1.9	0.5 $\pm$ 1.2

Significant differences:

$\alpha$  main effect of sex ( $p = 0.02$ )

$\phi$  main effect of physical activity ( $p = 0.0005$ )

\*\* active females vs. inactive females ( $p = 0.0002$ )

#### 3.3.3.2.2. Years of participation in long term leisure time physical activity (LTPA)

Total years of participation in long term LTPA for participants are shown in Table 3.9. There was no significant interaction between sex and physical activity; however there were significant main effects of sex ( $F_{(1, 52)} = 8.42$ ;  $p = 0.005$ ) and physical activity ( $F_{(1, 52)} = 16.60$ ;  $p=0.0002$ ) respectively. Males participated in significantly more years of long term LTPA compared to females ( $p = 0.004$ ). Recently active participants participated in significantly more years of long term LTPA compared to inactive participants ( $p = 0.0002$ ). In addition, currently active females participated in significantly more years of long term LTPA compared to inactive females ( $p = 0.02$ ). There were no significant differences in years of long term LTPA participation between active and inactive males.



There was no significant interaction between sex and physical activity for years of participation in endurance LTPA; however there was a significant main effect of physical activity ( $F_{(1, 52)} = 16.4$ ;  $p = 0.0002$ ). Active participants participated in significantly more years of long term endurance LTPA compared to inactive participants ( $p = 0.0003$ ). In addition, active males participated in significantly more years of endurance LTPA than inactive males ( $p = 0.01$ ) and inactive females ( $p = 0.0008$ ) respectively. There were no significant differences in long term endurance LTPA between active females and inactive females or inactive males.

There was no significant interaction between sex and physical activity for years of participation in neuromuscular LTPA; however there was a significant main effect of physical activity ( $F_{(1, 52)} = 5.2$ ;  $p = 0.03$ ). Active participants participated in significantly more years of long term neuromuscular LTPA compared to inactive participants ( $p = 0.03$ ). There were no significant differences in long term neuromuscular LTPA between males and females. There was no significant interaction between sex and physical activity for long term games participation; however there was a significant main effect of sex ( $F_{(1, 52)} = 6.8$ ;  $p = 0.01$ ). Males participated in significantly more years of games compared to females ( $p = 0.01$ ). There were no significant differences in long term games participation between males and females.

Participants who reported long term LTPA, participated in significantly more years of long term endurance LTPA compared to long term neuromuscular LTPA ( $p = 0.00001$ ) and long term games ( $p = 0.003$ ).

**Table 3.9** Total long term participation, endurance, neuromuscular LTPA and games (years) of active males (n=15), inactive males (n=13), active females (n=14) and inactive females (n=14). Data are expressed as mean  $\pm$  standard deviation (SD).

Variable	Active males* (n=15)	Inactive males (n=13)	Active females** (n=14)	Inactive females $^{\Psi}$ (n=14)
Total long term LTPA $^{\alpha\phi}$ (years)	25.4 $\pm$ 10.1	13.8 $\pm$ 14.6	17.3 $\pm$ 10.7	4.5 $\pm$ 6.5
Long term endurance LTPA $^{\phi}$ (years)	21.3 $\pm$ 11.2	7.9 $\pm$ 11.8	14.3 $\pm$ 10.6	4.5 $\pm$ 9.0
Long term neuromuscular LTPA $^{\phi}$ (years)	2.7 $\pm$ 5.1	1.0 $\pm$ 2.1	3.7 $\pm$ 6.8	0 $\pm$ 0
Long term games LTPA $^{\alpha}$ (years)	9.1 $\pm$ 11.5	9.0 $\pm$ 12.5	3.2 $\pm$ 7.6	1.5 $\pm$ 1.7

Significant differences:

$\alpha$  main effect of sex: years of long term LTPA (p = 0.004)

$\phi$  main effect of physical activity: years of long term LTPA (p = 0.0002)

\*\* active females vs. inactive females: years of long term LTPA (p = 0.02)

$\phi$  main effect of physical activity: years of long term endurance LTPA (p = 0.0003)

\* active males vs. inactive males: years of long term endurance LTPA (p = 0.01)

$\Psi$  active males vs. inactive females: years of long term endurance LTPA (p = 0.0008)

$\phi$  main effect of physical activity: years of long term neuromuscular LTPA (p = 0.03)

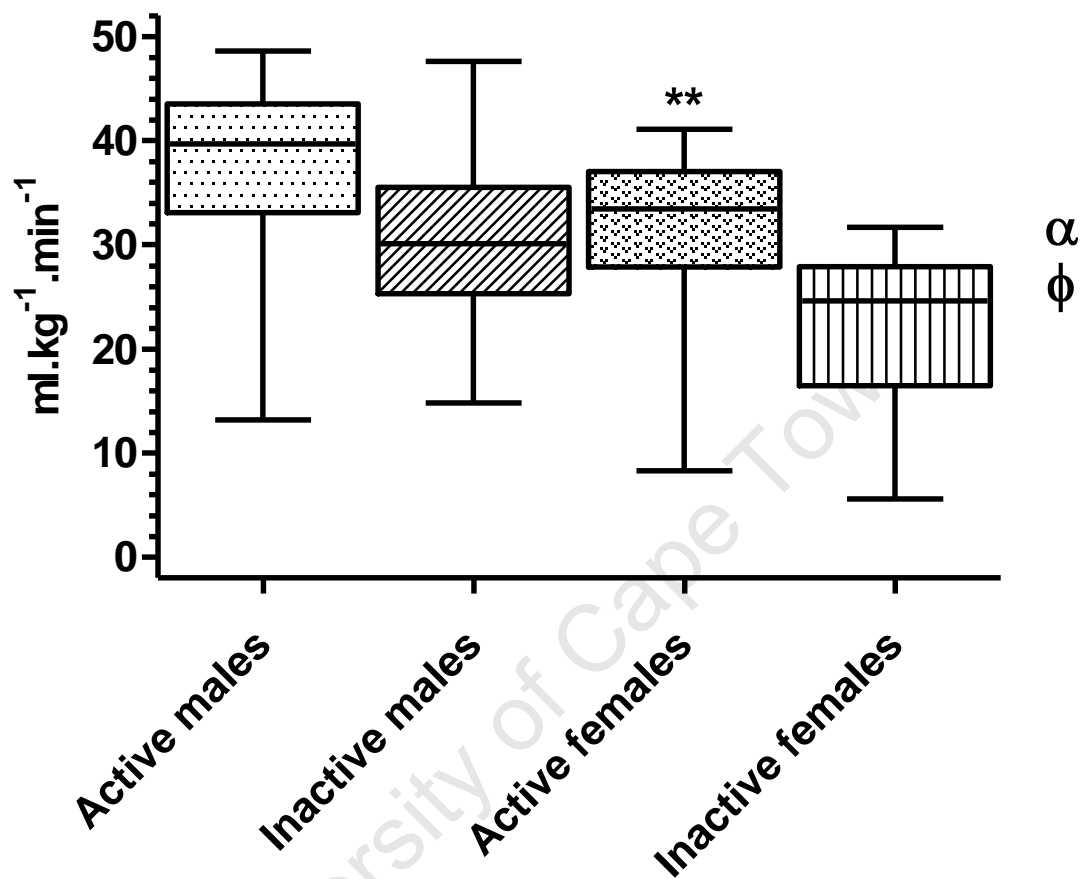
$\alpha$  main effect of sex: years of games participation (p = 0.01)

### 3.3.4. Health-related fitness components

#### 3.3.4.1. Maximum oxygen consumption

Maximum oxygen consumption ( $VO_{2max}$ ) of participants is shown in Figure 3.2. There was no significant interaction between sex and physical activity; however there were significant main effects of sex ( $F_{(1, 52)} = 9.59$ ; p = 0.03) and physical activity ( $F_{(1, 52)} = 14.43$ ; p=0.004) respectively. Maximum oxygen consumption was significantly increased in males compared to females (p = 0.002). Maximum oxygen consumption was significantly increased in active compared to inactive participants (p = 0.0004). In addition,  $VO_{2max}$  was significantly increased in active females compared to inactive females (p = 0.0002).

## Maximum oxygen consumption



**Figure 3.2:** Maximum oxygen consumption (ml.kg<sup>-1</sup>.min<sup>-1</sup>) of participants in the active male (n = 15), inactive male (n = 13), active female (n = 14) and inactive female (n = 14) groups. Data are expressed as median ± 5<sup>th</sup> and 95<sup>th</sup> percentile. Note: higher scores indicate improved VO<sub>2 max</sub>.

Significant differences:

α main effect of sex (p = 0.03)

φ main effect of physical activity (p = 0.0004)

\*\* active females vs. inactive females (p = 0.0002)

### 3.3.4.2. Static balance

Static balance (eyes open) and static balance (eyes closed) of participants are shown in Table 3.10. There were no significant differences in static balance (eyes open) or static balance (eyes closed) between male and female participants, or between currently active and inactive participants.

**Table 3.10** Static balance (eyes open) (s) and static balance (eyes closed) (s) of active males (n=15), inactive males (n=13), active females (n=14) and inactive females (n=14). Data are expressed as mean  $\pm$  standard deviation (SD). Note: higher scores indicate improved static balance.

Variable	Active males (n=15)	Inactive males (n=13)	Active females (n=14)	Inactive females (n=14)
Balance: eyes open (s)	55 $\pm$ 13.6	57.4 $\pm$ 7.2	57.4 $\pm$ 7.2	50.7 $\pm$ 17.4
Balance: eyes closed (s)	12.4 $\pm$ 11.6	12.8 $\pm$ 10.2	9 $\pm$ 6.2	7.3 $\pm$ 3.6

### 3.3.4.3. Dynamic balance

Dynamic balance scores of participants are shown in Table 3.11. There was no significant interaction between sex and physical activity; however there was a significant main effect of sex ( $F_{(1, 52)} = 16.22$ ;  $p = 0.0002$ ). Dynamic balance was significantly improved in males compared to females ( $p = 0.0003$ ). Active males had significantly improved dynamic balance scores compared to active ( $p = 0.04$ ) and inactive ( $p = 0.01$ ) females; and inactive males had significantly improved scores compared to inactive females ( $p = 0.03$ ).

**Table 3.11** Dynamic balance (s) of active males (n=15), inactive males (n=13), active females (n=14) and inactive females (n=14). Data are expressed as mean  $\pm$  standard deviation (SD). Note: lower scores indicate improved dynamic balance.

Variable	Active males <sup>#</sup> (n=15)	Inactive males <sup>⊖</sup> (n=13)	Active females (n=14)	Inactive females <sup>ψ</sup> (n=14)
Dynamic balance (s) <sup>α</sup>	15 $\pm$ 5.3	16.2 $\pm$ 4	25.7 $\pm$ 11.7	28.1 $\pm$ 16.2

Significant differences:

α main effect of sex ( $p = 0.0002$ )

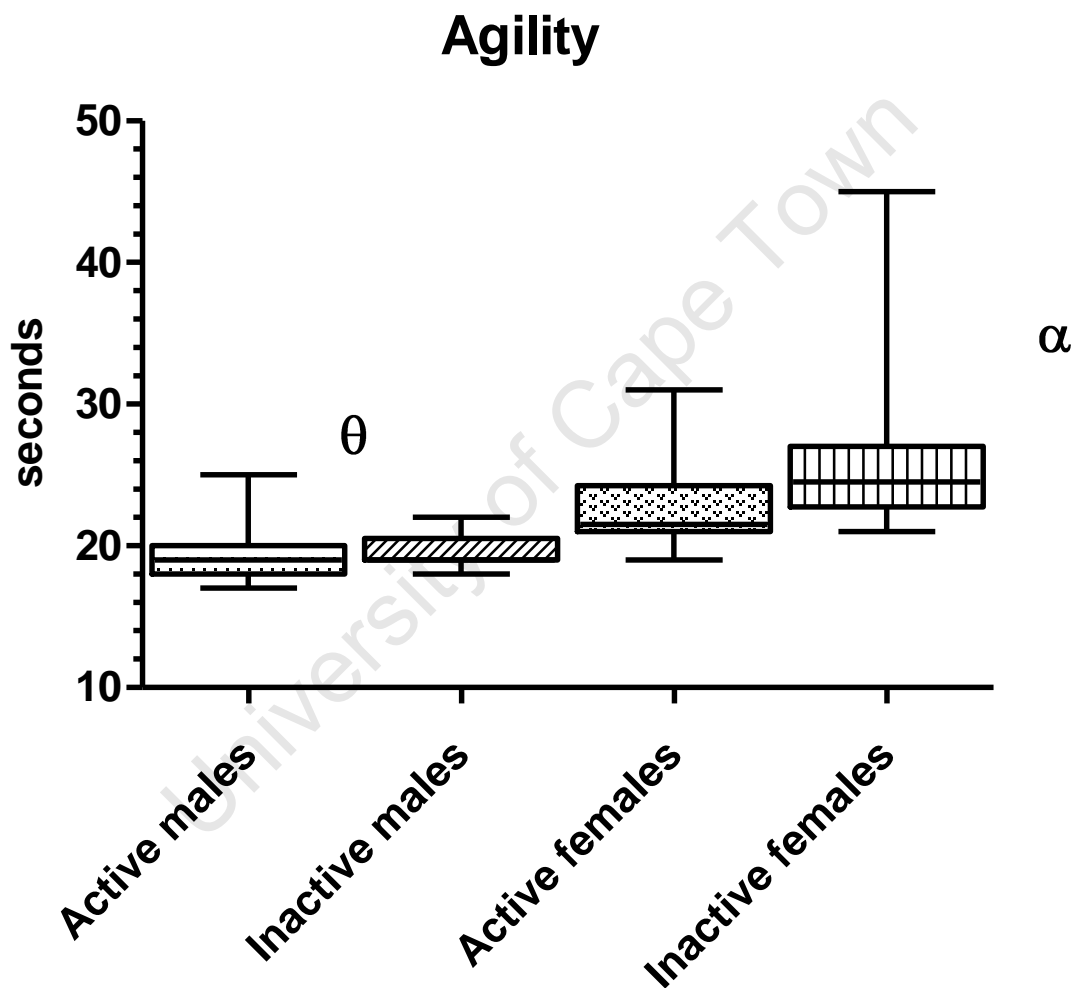
# active males vs. active females ( $p = 0.04$ )

ψ active males vs. inactive females

⊖ inactive males vs. inactive females

### 3.3.4.4. Agility

Agility scores of participants are shown in Figure 3.3. There was no significant interaction between sex and physical activity; however there was a significant main effect of sex ( $F_{(1, 52)} = 22.91$ ;  $p = 0.0001$ ). Agility scores were significantly lower in males compared to females ( $p = 0.0001$ ), indicating improved agility performance. Active females had significantly improved agility performance compared to inactive females ( $p = 0.0004$ ).



**Figure 3.3:** Agility scores (s) of participants in the active male ( $n = 15$ ), inactive male ( $n = 13$ ), active female ( $n = 14$ ) and inactive female ( $n = 14$ ) groups. Data are expressed as median  $\pm$  5<sup>th</sup> and 95<sup>th</sup> percentile. Note: lower scores indicate improved agility performance.

Significant differences:

$\alpha$  main effect of sex ( $p = 0.0001$ )

$\theta$  active females vs. inactive females ( $p = 0.0004$ )

### 3.3.4.5. Co-ordination

Co-ordination scores of participants are shown in Table 3.12. There was no significant interaction between sex and physical activity; however there was a significant main effect of sex ( $F_{(1, 52)} = 30.44$ ;  $p = 0.000001$ ). Co-ordination was significantly improved in males compared to females ( $p = 0.0001$ ).

**Table 3.12** Co-ordination scores (sec) of active males ( $n=15$ ), inactive males ( $n=13$ ), active females ( $n=14$ ) and inactive females ( $n=14$ ). Data are expressed as mean  $\pm$  standard deviation (SD). Note: lower scores indicate improved co-ordination performance.

Variable	Active males (n=15)	Inactive males (n=13)	Active females (n=14)	Inactive females (n=14)
Co-ordination (s) $^{\alpha}$	18.4 $\pm$ 3.8	17.4 $\pm$ 1.5	22.9 $\pm$ 2.7	22.9 $\pm$ 4.5

Significant differences:

$\alpha$  main effect of sex ( $p = 0.0001$ )

### 3.3.4.6. Upper limb function

Upper limb function scores of participants are shown in Table 3.13. There was no significant interaction between sex and physical activity; however there were significant main effects of sex ( $F_{(1, 52)} = 22.94$ ;  $p = 0.00001$ ) and physical activity ( $F_{(1, 52)} = 5.92$ ;  $p=0.18$ ) respectively. Upper limb function scores were significantly improved in males compared to females ( $p = 0.0001$ ), and in active compared to inactive participants ( $p = 0.01$ ).

**Table 3.13** Upper limb function (reps) of active males ( $n=15$ ), inactive males ( $n=13$ ), active females ( $n=14$ ) and inactive females ( $n=14$ ). Data are expressed as mean  $\pm$  standard deviation (SD). Note: higher scores indicate improved upper limb function.

Variable	Active males (n=15)	Inactive males (n=13)	Active females (n=14)	Inactive females (n=14)
Upper limb function (reps) $^{\alpha\phi}$	15.1 $\pm$ 3.1	13.4 $\pm$ 2.2	11.4 $\pm$ 2.4	9.1 $\pm$ 4.3

Significant differences:

$\alpha$  main effect of sex ( $p = 0.0001$ )

$\phi$  main effect of physical activity ( $p = 0.01$ )

### 3.3.4.7. Lower limb function

Lower limb function scores of participants are shown in Table 3.14. There was a significant interaction between sex and physical activity ( $F_{(1, 52)} = 6.06$ ;  $p = 0.17$ ). There was a significant main effect of sex ( $F_{(1, 52)} = 51.50$ ;  $p = 0.000001$ ). Lower limb function scores were significantly improved in males compared to females ( $p = 0.0001$ ). Active males had significantly improved scores compared to active females ( $p = 0.008$ ) and inactive females ( $p = 0.0002$ ) respectively. Inactive males had significantly improved scores compared to active females ( $p = 0.001$ ).

**Table 3.14** Lower limb function (cm) of active males ( $n=15$ ), inactive males ( $n=13$ ), active females ( $n=14$ ) and inactive females ( $n=14$ ). Data are expressed as mean  $\pm$  standard deviation (SD). Note: higher scores indicate improved lower limb function.

Variable	Active males $\Psi$ ( $n=15$ )	Inactive males ( $n=13$ )	Active females $\#$ ( $n=14$ )	Inactive females ( $n=14$ )
Lower limb function (cm) $\alpha$	38.2 $\pm$ 9.4 ** $\phi$	40.5 $\pm$ 4.4 *	29.5 $\pm$ 6.7	22.7 $\pm$ 5.7

Significant differences:

$\alpha$  main effect of sex ( $p = 0.0001$ )

$\#$  active males vs. active females ( $p = 0.008$ )

$\Psi$  active males vs. inactive females ( $p = 0.001$ )

### 3.3.4.8. Back muscle endurance

Back muscle endurance scores of participants are shown in Table 3.15. There were no significant differences in back muscle endurance between males and females, or between recently active and inactive participants.

**Table 3.15** Back muscle endurance (s) of active males ( $n=15$ ), inactive males ( $n=13$ ), active females ( $n=14$ ) and inactive females ( $n=14$ ). Data are expressed as mean  $\pm$  standard deviation (SD). Note: higher scores indicate improved back muscle endurance performance.

Variable	Active males ( $n=15$ )	Inactive males ( $n=13$ )	Active females ( $n=14$ )	Inactive females ( $n=14$ )
Back endurance (s)	106.5 $\pm$ 32.3	92.5 $\pm$ 29.7	140.4 $\pm$ 72.3	105.4 $\pm$ 40.9

### 3.3.4.9. Flexibility

Flexibility scores of participants are shown in Table 3.16. There were no significant differences in flexibility scores between males and females, or between recently active and inactive participants.

**Table 3.16** Flexibility (sit-and-reach) scores (cm) of active males (n=15), inactive males (n=13), active females (n=14) and inactive females (n=14). Data are expressed as mean  $\pm$  standard deviation (SD). Note: lower scores indicate improved flexibility performance.

Variable	Active males (n=15)	Inactive males (n=13)	Active females (n=14)	Inactive females (n=14)
Flexibility (cm)	3 $\pm$ 5.1	4.4 $\pm$ 6.7	1 $\pm$ 2.4	1.5 $\pm$ 3.8

### 3.3.5. Correlational analyses

Selected correlational analyses were performed to determine the relationships between recent and long term LTPA participation; and anthropometry and health-related fitness components. Correlational analyses were performed for the total group only, as the sample size was not large enough to warrant separate correlations for male and female participants.

#### 3.3.5.1.1. Recent leisure time physical activity and anthropometry

Significant correlations found between recent LTPA and anthropometry are summarised in Table 3.17. There were significant negative relationships between recent participation in endurance LTPA and anthropometric characteristics, including the sum of seven skinfolds ( $r = -0.43$ ,  $p = 0.001$ ) and body fat percentage ( $r = -0.45$ ,  $p = 0.001$ ). Significant negative correlations were found between recent neuromuscular LTPA and body mass index (BMI) ( $r = 0.29$ ,  $p = 0.03$ ). There were no significant relationships between recent participation in games and anthropometry. Significant negative correlations were found between total weekly LTPA and anthropometric characteristics, including BMI ( $r = 0.32$ ,  $p = 0.02$ ), body fat percentage ( $r = 0.45$ ,  $p = 0.001$ ) and the sum of seven skinfolds ( $r = 0.46$ ,  $p = 0.0001$ ).



**Table 3.17** Correlations between recent LTPA and anthropometric characteristics in the total group. Significant relationships are indicated in bold.

	Recent endurance LTPA	Recent neuromuscular LTPA	Recent games	Total recent LTPA per week
<b>BMI</b>	$r = -0.24, p = 0.07$	<b><math>r = -0.29, p = 0.03</math></b>	$r = -0.17, p = 0.22$	<b><math>r = -0.32, p = 0.02</math></b>
<b>Body fat %</b>	<b><math>r = -0.45, p = 0.001</math></b>	$r = -0.18, p = 0.17$	$r = -0.14, p = 0.30$	<b><math>r = -0.45, p = 0.001</math></b>
<b>Sum of seven skinfolds</b>	<b><math>r = -0.43, p = 0.001</math></b>	$r = -0.23, p = 0.09$	$r = -0.18, p = 0.18$	<b><math>r = -0.46, p = 0.0001</math></b>

Note: A negative correlation indicates that as recent LTPA participation increased, BMI, body fat percentage or sum of seven skinfolds decreased.

### 3.3.5.1.2. Recent leisure time physical activity and health-related fitness

Significant correlations between recent participation in LTPA and components of health-related fitness are summarised in Table 3.18. There were significant correlations between recent participation in endurance LTPA and  $VO_{2max}$  ( $r = 0.39; p = 0.003$ ). There were significant correlations between recent participation in neuromuscular LTPA and  $VO_{2max}$  ( $r = 0.29, p = 0.03$ ). There were significant relationships between recent participation in games and back muscle endurance ( $r = 0.35, p = 0.009$ ). There were significant correlations between the total LTPA per week and  $VO_{2max}$  ( $r = 0.44, p = 0.01$ ). No significant relationships were found between recent LTPA and static or dynamic balance, agility, co-ordination, upper limb function, lower limb function, flexibility or HRQoL.

**Table 3.18** Correlations between recent LTPA and health-related fitness components in the total group. Significant relationships are indicated in bold.

	Recent endurance LTPA	Recent neuromuscular LTPA	Recent games	Total recent LTPA per week
<b>VO<sub>2max</sub></b>	<b>r = 0.39, p = 0.003</b>	<b>r = 0.29, p = 0.03</b>	r = 0.14, p = 0.30	<b>r = 0.44, p = 0.01</b>
<b>Balance (eyes open)</b>	r = -0.03, p = 0.85	r = 0.17, p = 0.22	r = 0.07, p = 0.62	r = 0.09, p = 0.52
<b>Balance (eyes closed)</b>	r = -0.14, p = 0.92	r = -0.05, p = 0.71	r = 0.05, p = 0.70	r = -0.02, p = 0.89
<b>Dynamic balance</b>	r = -0.14, p = 0.92	r = -0.15, p = 0.28	r = -0.08, p = 0.57	r = -0.11, p = 0.41
<b>Agility</b>	r = -0.18, p = 0.18	r = -0.13, p = 0.34	r = -0.08, p = 0.57	r = -0.21, p = 0.13
<b>Co-ordination</b>	r = 0.06, p = 0.69	r = -0.01, p = 0.95	r = -0.01, p = 0.97	r = 0.04, p = 0.77
<b>Upper limb function</b>	r = 0.23, p = 0.09	r = 0.22, p = 0.11	r = -0.04, p = 0.75	r = 0.25, p = 0.06
<b>Lower limb function</b>	r = 0.19, p = 0.16	r = 0.01, p = 0.93	r = -0.01, p = 0.97	r = 0.16, p = 0.25
<b>Back muscle endurance</b>	r = 0.02, p = 0.90	r = 0.15, p = 0.27	<b>r = 0.35, p = 0.009</b>	r = 0.12, p = 0.37
<b>Flexibility</b>	r = -0.02, p = 0.88	r = -0.04, p = 0.77	r = -0.09, p = 0.53	r = -0.04, p = 0.74
<b>HRQoL</b>	r = -0.06, p = 0.67	r = 0.13, p = 0.33	r = 0.06, p = 0.65	r = 0.01, p = 0.96

Note: a positive correlation with VO<sub>2max</sub>, balance (eyes open), balance (eyes closed), upper limb function, lower limb function or back muscle endurance indicates that as recent LTPA increased, performance improved. A negative correlation with dynamic balance, agility, co-ordination, flexibility or HRQoL indicates that as recent LTPA increased, performance improved.

### 3.3.5.2.1. Long term leisure time physical activity and anthropometry

Significant correlations between long term LTPA and anthropometry are summarised in Table 3.19. There were significant negative correlations between long term endurance LTPA and anthropometric characteristics, including BMI ( $r = 0.3, p = 0.02$ ), body fat percentage ( $r = 0.51, p = 0.0001$ ), and the sum of seven skinfolds ( $r = 0.55, p = 0.0001$ ). There were no significant relationships between long term neuromuscular LTPA or games participation, and anthropometry. There were significant negative correlations between years of long term LTPA participation and body fat percentage ( $r = -0.49, p = 0.0001$ ) and the sum of seven skinfolds ( $r = -0.47, p = 0.0001$ ).

**Table 3.19** Correlations between long term LTPA and anthropometry in the total group. Significant relationships are indicated in bold.

	Long term endurance LTPA	Long term neuromuscular LTPA	Long term games	Years of long term LTPA
<b>BMI</b>	<b>r = -0.30, p = 0.02</b>	r = -0.06, p = 0.67	r = 0.06, p = 0.67	r = -0.18, p = 0.18
<b>Body fat %</b>	<b>r = -0.51, p = 0.0001</b>	r = -0.09, p = 0.49	r = -0.23, p = 0.09	<b>r = -0.49, p = 0.0001</b>
<b>Sum of seven skinfolds</b>	<b>r = -0.55, p = 0.0001</b>	r = -0.10, p = 0.46	r = -0.11, p = 0.43	<b>r = -0.47, p = 0.0001</b>

Note: A negative correlation indicates that as long term LTPA participation increased, BMI, body fat percentage or sum of seven skinfolds decreased.

### 3.3.5.2.2. Long term leisure time physical activity and health-related fitness

Significant correlations found between long term LTPA and components of health-related fitness are summarised in Table 3.20. There was a significant correlation between long term endurance LTPA and  $VO_{2max}$  ( $r = 0.49, p = 0.0001$ ). There were significant negative relationships between long term endurance LTPA and agility ( $r = -0.27, p = 0.04$ ) and dynamic balance ( $r = -0.29, p = 0.03$ ) respectively. There were significant correlations between long term endurance LTPA and back muscle endurance ( $r = 0.32, p = 0.02$ ) and upper limb function ( $r = 0.3, p = 0.03$ ) respectively. No significant relationships were found between long term endurance LTPA and static balance, co-ordination, upper limb function, lower limb function, flexibility or HRQoL.

There were no significant correlations between long term neuromuscular LTPA participation and any of the selected health-related fitness components.

There was a significant negative correlation between long term participation in games and agility scores ( $r = -0.27, p = 0.04$ ). There was a significant relationship between long term games participation and lower limb function ( $r = 0.28, p = 0.04$ ). There were no significant relationships between long term games participation and  $VO_{2max}$ , static or dynamic balance, agility, co-ordination, upper limb function, flexibility or HRQoL.

There were significant correlations between years of long term LTPA and  $VO_{2max}$  ( $r = 0.46$ ,  $p = 0.0001$ ), lower limb function ( $r = 0.27$ ,  $p = 0.04$ ) and upper limb function ( $r = 0.34$ ,  $p = 0.01$ ), respectively. There were significant negative correlations between years of long term LTPA and agility scores ( $r = -0.34$ ,  $p = 0.01$ ) and dynamic balance scores ( $r = -0.35$ ,  $p = 0.009$ ), respectively. No significant relationships were found between years of long term LTPA and static balance, co-ordination, back muscle endurance, flexibility or HRQoL.

**Table 3.20** Correlations between long term LTPA and health-related fitness components in the total group. Significant relationships are indicated in bold.

	Long term endurance LTPA	Long term neuromuscular LTPA	Long term games	Years of long term LTPA
$VO_{2max}$	<b><math>r = 0.49</math>, <math>p = 0.0001</math></b>	$r = 0.15$ , $p = 0.26$	$r = 0.10$ , $p = 0.48$	<b><math>r = 0.46</math>, <math>p = 0.0001</math></b>
Balance (eyes open)	$r = 0.24$ , $p = 0.08$	$r = 0.15$ , $p = 0.26$	$r = -0.20$ , $p = 0.14$	$r = 0.13$ , $p = 0.33$
Balance (eyes closed)	$r = 0.09$ , $p = 0.49$	$r = -0.07$ , $p = 0.58$	$r = -0.08$ , $p = 0.56$	$r = 0.01$ , $p = 0.96$
Dynamic balance	<b><math>r = -0.29</math>, <math>p = 0.03</math></b>	$r = -0.13$ , $p = 0.35$	$r = -0.25$ , $p = 0.07$	<b><math>r = -0.35</math>, <math>p = 0.009</math></b>
Agility	<b><math>r = -0.27</math>, <math>p = 0.004</math></b>	$r = -0.14$ , $p = 0.29$	<b><math>r = -0.27</math>, <math>p = 0.04</math></b>	<b><math>r = -0.34</math>, <math>p = 0.01</math></b>
Co-ordination	$r = 0.03$ , $p = 0.83$	$r = 0.04$ , $p = 0.76$	$r = -0.25$ , $p = 0.06$	$r = -0.07$ , $p = 0.60$
Upper limb function	<b><math>r = 0.30</math>, <math>p = 0.03</math></b>	$r = 0.20$ , $p = 0.14$	$r = 0.17$ , $p = 0.20$	<b><math>r = 0.34</math>, <math>p = 0.01</math></b>
Lower limb function	$r = 0.12$ , $p = 0.36$	$r = 0.12$ , $p = 0.39$	<b><math>r = 0.28</math>, <math>p = 0.04</math></b>	<b><math>r = 0.27</math>, <math>p = 0.04</math></b>
Back muscle endurance	<b><math>r = 0.32</math>, <math>p = 0.02</math></b>	$r = -0.19$ , $p = 0.51$	$r = -0.15$ , $p = 0.28$	$r = 0.20$ , $p = 0.14$
Flexibility	$r = -0.04$ , $p = 0.77$	$r = -0.13$ , $p = 0.34$	$r = -0.07$ , $p = 0.63$	$r = -0.07$ , $p = 0.59$
HRQoL	$r = 0.17$ , $p = 0.21$	$r = 0.05$ , $p = 0.69$	$r = -0.09$ , $p = 0.50$	$r = 0.09$ , $p = 0.52$

Note: A positive correlation with  $VO_{2max}$ , balance (eyes open), balance (eyes closed), upper limb function, lower limb function or back muscle endurance indicates that as long term LTPA increased, performance improved. A negative correlation with dynamic balance, agility, co-ordination, flexibility or HRQoL indicates that as long term LTPA increased, performance improved.

### 3.3.6. Summary of results

Active participants had significantly improved anthropometric characteristics compared to inactive participants. Most of the employed participants reported only light physical loading levels at work, and most participants reported no regular active commuting. Ninety per cent of the active participants reported participating in moderate LTPA. Both recent and long term LTPA consisted of mainly endurance for both sexes. Males reported significantly more long term LTPA modes and years of LTPA participation compared to females. Recently active participants reported significantly more long term modes and years of LTPA participation compared to inactive participants. Active participants had significantly improved  $VO_{2max}$  and upper limb function compared to inactive participants. Further, the  $VO_{2max}$  of active females was significantly improved compared to inactive females. There were no statistically significant differences between groups or between sexes in terms of static balance, back muscle endurance, flexibility or HRQoL, however males had significantly improved dynamic balance, agility, co-ordination, lower limb function and upper limb function compared to females.

There were numerous significant negative correlations between both recent and long term LTPA and anthropometric characteristics. There were significant relationships between recent endurance, recent neuromuscular LTPA and total hours of LTPA per week, and  $VO_{2max}$ . There was a significant correlation between recent participation in games and back muscle endurance. There were significant correlations between long term endurance LTPA and years of LTPA participation, and  $VO_{2max}$ . There were significant negative relationships between long term endurance, long term games and years of long term LTPA, and agility scores. There were also significant negative correlations between long term endurance and years of LTPA participation, and dynamic balance scores. There was a significant relationship between long term endurance LTPA and back muscle endurance. There were significant relationships between long term endurance and years of long term LTPA, and upper limb function. Finally, there were significant correlations between long term games participation and years of LTPA participation, and lower limb function.

### **3.4 DISCUSSION**

The use of LTPA to improve fitness and health has been extensively investigated and discussed. Studies have shown that LTPA may be used to enhance and maintain components of health-related fitness such as balance<sup>41, 113, 114</sup>, co-ordination<sup>106</sup>, agility<sup>106-110</sup>, functional strength<sup>45, 174</sup>, flexibility<sup>28, 178, 180</sup> and cardiorespiratory fitness<sup>45, 174</sup>. Current literature points to the need for specific LTPA (endurance, neuromuscular or games) to improve individual aspects of health-related fitness<sup>19, 39, 123</sup>. A variety of LTPA modes may therefore be necessary to obtain concurrent development of different components of health-related fitness<sup>19, 39, 106-110</sup>. Most of the available studies have focused on other populations such as older adults<sup>4, 41, 113, 114, 181</sup>, young adults<sup>44, 47, 125, 151</sup>, children<sup>43, 96, 97, 98</sup> or athletes<sup>103, 104, 106, 107</sup>, and very few have evaluated motor abilities such as balance, agility and co-ordination<sup>19, 39</sup>. Further, it has been shown that motor abilities may be attained for longer than other health-related fitness components, and therefore may be related to long term rather than recent LTPA<sup>43, 97, 102</sup>. Only one study in mature adults has included long term LTPA patterns in their analysis<sup>19</sup>. To date and to the knowledge of this author, no study has investigated the relationship between LTPA and health-related fitness components including motor abilities, in mature South African adults. In this study, recently active participants were significantly leaner, had improved cardiorespiratory fitness and upper limb function compared to recently inactive participants. Long term LTPA participation was associated with cardiorespiratory fitness, motor abilities and functional strength outcomes. This section will aim to discuss the main findings of this study in context with previous literature, and to review its limitations. It will conclude with recommendations for future research.

#### **3.4.1 Participants**

##### **3.4.1.1. Sample size**

Recent studies investigating the relationship between LTPA and single or multiple components of health-related fitness had sample sizes ranging between 27 and 21 685 participants<sup>19, 39, 44, 47, 103, 106, 107, 119, 128, 147, 181</sup>. Only two of these studies investigated this relationship using a comprehensive health-related fitness test battery in mature adults<sup>19, 39</sup>, making it difficult to decide whether the results of other studies may be applicable to the population of interest. Further, there is considerable variation in the assessment of LTPA used in these studies (Table 2.3 page 26), which limits the potential for accurate and objective comparison between studies. It is also recognised that, although the sample size was sufficient to ensure statistical power (Section 3.2.8, page 41), a larger sample size would have allowed for an improved representation of the relationship between LTPA and health-related fitness in healthy mature adults.

### **3.4.1.2. Descriptive characteristics**

There were no significant differences between groups in terms of age, stature, education levels, other physical activity involvement or active commuting, between active and inactive male or active and inactive female groups. There was a similar representation of sex and health status in both groups. This is in keeping with the descriptive characteristics of participants in previous similar studies<sup>19, 39</sup>. However, working hours reported were significantly longer, and perceived physical loading levels at work significantly higher in inactive females compared to active females in this study. In the study by Rinne et al<sup>19</sup>, inactive males reported more physically heavy work compared to the active males. Neither of the two previous studies examining the relationship between LTPA and health-related fitness in mature adults, assessed the working hours of their participants<sup>19, 39</sup>. Both of these previous studies were conducted using larger sample sizes of mature adults in Finland, therefore socio-economic and geographical factors were different than in the present study. This study was conducted in a rural setting in South Africa. To the knowledge of the authors, this was the first time that the relationship between LTPA and health-related fitness was studied in a rural setting.

### **3.4.1.3. Leisure time physical activity participation patterns**

Active males and females reported a high number of hours of LTPA per week (Table 3.7, page 47). This weekly duration is higher than the minimum LTPA per week required to achieve health enhancement<sup>38</sup>, but in agreement with the latest recommended weekly duration for optimising health benefits and promoting weight loss<sup>17, 38</sup>. However, most of the active participants in this study reported moderate intensity LTPA. Current recommendations suggest interspersing moderate with vigorous LTPA to derive even greater benefits in terms of reducing morbidity and mortality and preventing weight gain<sup>17, 38</sup>. As in previous studies by Rinne et al<sup>19</sup> and Suni et al<sup>39</sup>, this study sample also participated mainly in endurance-type LTPA in the short- and long term, while current recommendations suggest that adults should perform muscular LTPA for a minimum of two days per week<sup>17, 38</sup>.

Walking was the most commonly reported LTPA mode in both previous studies<sup>19, 39</sup>. In this study, running and cycling were the most frequently reported modes by the total group both recently and on the long term. As in the previous research<sup>19, 39</sup>, there was a similar profile of recent LTPA participation between the active males and females in this study. Active females in this study participated in significantly more long term modes and years of long term LTPA than inactive females. The only other study which examined long term LTPA as it relates to health-related fitness<sup>19</sup>, found a similar profile of active and inactive females in terms of long term participation in LTPA. However, in that study the number of long term modes participated in were not assessed.

In addition, the authors of that study (Rinne et al <sup>19</sup>) categorised years of long term LTPA participation as “less than three years” or “three years or more”. This makes it difficult to compare long term LTPA between the two studies, as in this study years of long term LTPA was assigned a numerical value. Active participants in this sample participated in significantly more years of long term endurance and neuromuscular LTPA than inactive participants, while males participated in significantly more years of games than females. These findings were similar to those of Rinne et al <sup>19</sup>. Although, Rinne et al <sup>19</sup> observed that more females participated in long term neuromuscular LTPA than males; this was not found in the present study.

#### **3.4.1.4. Anthropometry**

This study assessed body composition in terms of BMI, body fat percentage and the sum of seven skinfolds. Previous studies have used BMI scores only in the assessment of body composition <sup>19, 39</sup>. However in light of BMI failing to distinguish between muscle and fat <sup>128</sup>, and as precise population-specific equations for body fat percentage measurement were not available, it was decided to utilise all three anthropometric determinants. Although there were no significant differences between active and inactive males or females, the anthropometric characteristics were all significantly improved in active compared to inactive participants. Similarly, Suni et al <sup>39</sup> reported significant BMI differences between active and inactive participants in a sample of 498 mature adults. Research has shown that an inverse association exists between LTPA and BMI <sup>39, 128, 129</sup>. Leisure time physical activity is vital for the maintenance of fat free mass<sup>43</sup> and may slow the decline in body composition with advancing age <sup>6, 7, 38, 128, 129, 145, 149</sup>.

There were significant negative correlations between anthropometric measures and participation in recent endurance LTPA, recent neuromuscular LTPA, the amount of weekly LTPA, long term endurance and years of long term LTPA. Although LTPA is the most variable part of energy expenditure in humans, there is a paucity of literature regarding LTPA for the maintenance of healthy body composition at a population level <sup>128</sup>. However the research points to an association between the amount of long term LTPA and anthropometric measures such as BMI <sup>128</sup>. There have been few studies thus far examining the relationship between long term LTPA patterns and body composition, therefore these results warrant further exploration. A BMI of between 18 kg. m<sup>-2</sup> and 25 kg. m<sup>-2</sup> is considered “within healthy limits” <sup>38</sup>. The mean BMI of active participants in this study was 26.8 kg. m<sup>-2</sup> ± 4.4. The mean BMI of inactive participants was 29.5 kg. m<sup>-2</sup> ± 4.7. Therefore the mean BMI of both groups may be categorised as “overweight” (25 kg. m<sup>-2</sup> – 30 kg. m<sup>-2</sup>). These results are of concern, considering the high number of hours of weekly LTPA of active participants. It is possible that the LTPA intensity of the active participants was not high enough, or that other lifestyle factors prevented the maintenance of a BMI within healthy limits.



Healthy body composition has been associated with more vigorous LTPA in several studies <sup>7, 128, 179</sup>. Of the 29 active participants in this study, 26 reported participating in LTPA of moderate intensity, while only three reported participating in regular vigorous LTPA.

### **3.4.2. Health-related fitness components**

#### **3.4.2.1. Maximum oxygen consumption**

This study showed significantly improved aerobic capacity in active participants, compared to inactive participants. Significant associations were also found between cardiorespiratory fitness and recent endurance, neuromuscular LTPA and total recent weekly LTPA. These findings are in agreement with previous studies, which found associations between aerobic power and total weekly LTPA and neuromuscular LTPA <sup>19, 39</sup>. Increased levels of LTPA have consistently shown to increase aerobic capacity regardless of age <sup>39, 142, 144</sup>. Neuromuscular training increases muscle mass, which enhances aerobic power by increasing the number of capillaries per muscle fibre and therefore improves the ability of skeletal muscle to extract oxygen <sup>143</sup>. Both recent and long term LTPA participation was also associated with improved aerobic capacity. These results warrant further exploration, as there is a lack of evidence regarding the relationship between long term LTPA and cardiorespiratory fitness.

In contrast to two recent studies <sup>19, 39</sup> and to the active females in this study, active males did not have significantly improved cardiorespiratory fitness compared to inactive males. These findings may be related to the mode of testing maximum oxygen consumption in this study. Walking was not a frequently reported mode of LTPA either recently or on the long term by the males. A cycle ergometer test may therefore have been more appropriate to determine cardiorespiratory fitness, as cycling was a far more frequently reported exercise mode in males. Years of long term LTPA participation did not differ significantly between active and inactive males in this study. This may partially explain the lack of significant differences in  $VO_{2max}$  between active and inactive males in this study.

#### **3.4.2.2. Static and dynamic balance**

In this study, there were no significant differences between active and inactive males or females in terms of static or dynamic balance. No significant correlations were found between recent or long term LTPA and static balance. There were also no significant correlations between any of the recent LTPA participation patterns and dynamic balance. However, there were significant relationships between long term endurance, years of LTPA participation and dynamic balance. Similarly, a previous study in mature adults found that long term LTPA was associated with improved static and dynamic balance <sup>19</sup>.

Longitudinal studies of Twisk et al<sup>43</sup> and others<sup>97, 102</sup> found that motor abilities such as balance may be attained for longer than other components of fitness, and therefore more related to long term activity patterns. More research is therefore needed regarding the relationship between long term LTPA and motor abilities such as balance.

To date, most of the available research in various populations other than mature adults has indicated that specific balance training results in improved balance outcomes compared to general LTPA<sup>41, 103-105, 111-114, 119</sup>. In addition, recent studies have shown that improving strength and flexibility may improve balance as well<sup>2, 181</sup>. Suni et al<sup>39</sup> confirmed this when they found significant associations between balance and neuromuscular LTPA, so similar results were expected in this study. However such associations were not found. This may be related to the reduced number of participants who reported recent and long term participation in neuromuscular LTPA, compared to endurance (Section 3.3.3.1.2, page 47 and Section 3.3.3.2.2, page 49). Few studies so far have examined the long term effects of LTPA on motor abilities such as balance, and further investigation is required.

#### **3.4.2.3. Agility**

Active females scored significantly better on the Illinois Agility Test than inactive females however this was not the case in the males. As mentioned previously, the active and inactive males had more similar amounts of long term LTPA compared to the active and inactive females, which may explain why there was no significant difference in terms of agility between the male groups. Agility demonstrated significant negative correlations (i.e. improved scores) in this study with the number of years of long term LTPA, and with long term games participation. Similarly, Rinne et al<sup>19</sup> found significant relationships between the amount of long term LTPA per week and agility. Agility seems to be another motor ability which may be developed over years of long term LTPA, in particular through participation in games. Games are a highly diversified form of LTPA, and this may be the reason for their relationship with motor abilities<sup>19</sup>. Further research is required regarding the relationship between long term LTPA, participation in games and agility.

#### **3.4.2.4. Co-ordination**

No significant differences were found in terms of co-ordination between active and inactive males and females. In addition, no associations were found between recent or long term LTPA and co-ordination in this study. Rinne et al<sup>19</sup> found significant associations between long term games participation and improved co-ordination, only in males. However the relatively small sample size of this study precluded the performance of sex-specific correlational analyses. Research has shown that co-ordination may be improved with neuromuscular- and flexibility training<sup>181</sup>.

The relative lack of participation in neuromuscular LTPA and games compared to endurance LTPA in this sample may have prevented similar findings in this study. Long term LTPA patterns as they relate to co-ordination need to be explored in future studies. Furthermore, there is a need to develop a reliable and valid field test for co-ordination in the mature adult population.

#### **3.4.2.5. Upper limb function**

There was significantly improved upper limb function in active participants compared to inactive participants, and males performed significantly better in the upper limb function test than females. There were significant relationships between upper limb function and long term endurance and years of LTPA participation. Similarly, Suni et al <sup>39</sup> found that aerobic fitness and physical activity dosage was associated with upper limb function. This relationship between muscular and cardiorespiratory fitness has been confirmed in the literature <sup>143</sup>. Gains in strength, power and limb function through neuromuscular training have been extensively demonstrated <sup>2, 145, 157, 160, 161</sup>. Previous studies investigating the relationship between LTPA and health-related fitness have demonstrated significant associations between upper limb function and neuromuscular LTPA. Such an association was not observed in this study, perhaps due to the small amount of neuromuscular LTPA participation in this study sample.

#### **3.4.2.6. Lower limb function**

Although the males in this study performed significantly better in the test for lower limb function than the females, there were no significant differences between active and inactive males or females in terms of lower limb function. There were significant correlations between improved lower limb function performance and long term games participation and total years of LTPA. Similarly, Rinne et al <sup>19</sup> found associations between improved lower limb function and participation in games and long term LTPA. In contrast, Suni et al <sup>39</sup> did not find lower limb function to be related to LTPA despite their method of testing (the jump-and-reach test) being very similar to the test used in this study (vertical jump test). Long term participation in games may help to develop the explosive power needed to perform well in the vertical jump test <sup>19</sup>. Furthermore, games seem to assist in the development of motor performance, perhaps due to the large variety of physical skills they require <sup>19</sup>. Further investigation is needed regarding the relationship between lower limb function, long term LTPA and games participation in mature adults.

#### **3.4.2.7. Back muscle endurance**

There were significant relationships between back muscle endurance and recent participation in games and long term endurance. This is in agreement with previous research, which has demonstrated stronger associations between back muscle endurance and overall LTPA volume than with neuromuscular LTPA <sup>19, 39</sup>. Back muscle endurance is an important aspect of health-related fitness in mature adults as poor back muscle endurance has been associated with reduced mobility, disability, back dysfunction and pain <sup>123</sup>. Suni et al <sup>123</sup> found improved performance in the static back extension test to be related to good perceived back function, with “seldom problems in the back while stooping” and “seldom back pain” in a sample of 498 healthy mature adults. In addition, a prospective finding in a study by Biering-Sorensen <sup>133</sup> suggested that good isometric back muscle endurance may prevent first-time occurrence of back pain. The results of this study therefore highlight that long term LTPA and participation in games may, over time, prevent back pain and immobility by helping to preserve back function. These findings may be clinically useful for exercise prescription, as low back pain is an important health concern in mature adults <sup>123</sup>.

#### **3.4.2.8. Flexibility**

There were no significant differences in flexibility between active or inactive males or females in this study, and there were no significant relationships between flexibility and LTPA participation patterns. Other studies that have investigated the association between LTPA and flexibility have also failed to find significant relationships <sup>19, 39, 97, 115, 123</sup>. It is possible that the LTPA of mature adults typically may not include enough flexibility exercises, therefore this aspect of health-related fitness may not get sufficient training attention <sup>39</sup>. Studies have shown that joint range of motion may improve with specific flexibility training <sup>174, 175, 177, 180</sup>. Even strength training may improve flexibility if joints are moved through their available range <sup>174</sup>. Alternatively, flexibility may be more related to genetic factors than other components of health-related fitness, as joint range of motion in school-age children was predictive of adult flexibility in several longitudinal studies, regardless of LTPA patterns <sup>94, 95, 96, 97</sup>. The sit-and-reach test was one of very few health-related fitness tests in adolescents, which may be predictive of adult fitness <sup>94, 96</sup>. This finding was confirmed by Beunen et al <sup>95</sup>, who found that flexibility was the most strongly maintained health-related fitness component from age 13 to 30 in adolescent boys.

#### **3.4.2.9. Health-related quality of life (HRQoL)**

Previous studies using various different HRQoL questionnaires, have found significant positive relationships between the weekly amount of LTPA and HRQoL<sup>47, 48, 55</sup>. However previous studies on the relationship between different LTPA participation patterns and health-related fitness, have not evaluated HRQoL. There were no significant differences in HRQoL between active and inactive males or females in this study, and no relationships were found between LTPA and HRQoL. It is possible that the CDC-4 Healthy Days Core Questions did not provide an accurate reflection of HRQoL of participants in this study, as it was intended for surveillance only. A more comprehensive HRQoL questionnaire such as the SF-36 may therefore have been more appropriate. Further research is therefore needed, particularly to clarify the relationship between different LTPA patterns (as opposed to LTPA dosage), and HRQoL.

#### **3.4.3. Limitations of study**

The main limitation of this study was that it was not possible to determine the direction of causality between LTPA participation and anthropometry or health-related fitness, due to its cross-sectional design. Therefore it is possible that the LTPA of individuals may depend on their physical fitness, and not the other way around. In addition, the intra-individual changes in LTPA and health-related fitness were not studied over time. Had this been studied, it may have assisted to determine the sensitivity of the health-related fitness test battery to changes in physical fitness. These limitations were under-recognised and not dealt with in previous literature on the relationship between LTPA and health-related fitness. To address this limitation, prospective, longitudinal population-based studies are urgently required.

A potential limitation of this study is that recently active participants reported significantly more hours per week of endurance compared to neuromuscular LTPA and games (Section 3.3.3.1.2, page 47). In addition, participants reported significantly more years of long term endurance compared to neuromuscular LTPA and games (Section 3.3.3.2.2, page 49). This made it less likely to find significant correlations between participation in these forms of LTPA and health-related fitness components. Moreover, those that did participate in neuromuscular LTPA and games also participated in endurance LTPA, which means that the effect of certain types of LTPA (endurance, neuromuscular or games) could not be separated. In addition, some of the LTPA modes classified as neuromuscular may also enhance aerobic fitness. Therefore it is recommended that future studies attempt to recruit similar numbers of participants who exclusively participate in endurance, neuromuscular LTPA or games both on the short- and long term to allow a more accurate reflection of the relationship between different types of LTPA and health-related fitness outcomes.

A suitably detailed standardised LTPA questionnaire including questions on long term LTPA was not found, therefore the researcher developed a LTPA questionnaire based on questions used previously by Suni et al <sup>39</sup> and Rinne et al <sup>19</sup> in similar studies. Unfortunately, LTPA questionnaires rely on the memory of participants <sup>19, 43, 100, 101</sup> however this remains the only feasible way to assess long term LTPA patterns <sup>101</sup>. To increase the precision of assessment of the intensity of recent LTPA in this study, activity monitors collecting data over several days could have been used in addition to the LTPA questionnaire. There is a need for the development of a standardised, reliable and valid LTPA questionnaire which includes detailed questions on long term LTPA participation for mature adults. This would allow for more accurate conclusions to be drawn and assist in drawing comparisons between different studies. This needs to be addressed in future research.

A further limitation of this study was that volunteers were required to participate in 30 minutes of LTPA three times per week to be allocated to the active group. This dosage of weekly LTPA has been described as the minimum effective for enhancing health <sup>38</sup>. Previous studies evaluating the relationship between LTPA and health-related fitness have used similar criteria for minimum weekly LTPA for including participants into active groups <sup>19, 39</sup>. However, it is possible that a larger dosage of weekly LTPA may be needed for enhancing health-related fitness parameters such as motor abilities. The low recent LTPA requirement in this study may partially explain why significant between-group differences were not found for many of the health-related fitness components. It is therefore recommended that in future studies active participants should take part in at least 150 minutes of LTPA per week, as per the latest recommendations for optimal health and fitness benefits <sup>10, 38</sup>. The relationship between recent LTPA and health-related fitness may then be reassessed.

In this study, great care was taken to select reliable, valid and feasible field tests of components of health-related fitness, for this age group. The health-related fitness tests were closely based on a test battery developed by Suni et al <sup>39</sup>, which had been systematically evaluated for its reliability <sup>40, 131</sup>, safety and feasibility <sup>190</sup> and health-related validity <sup>123</sup>. However, it is acknowledged that the lack of research in the context of LTPA for health means that there are still limitations in the assessment of health-related fitness. Further, prospective studies are required to assess the predictive health-related validity and the sensitivity to changes in physical fitness, of this test battery.

As participants volunteered their involvement in the study and were aware of its purpose and of the health-related fitness test battery they would be required to complete, this study may have attracted participants who had an interest in their health-related fitness and were confident in their physical capabilities, regardless of their recent LTPA participation status.

Inactive participants in this study may therefore have had improved health-related fitness compared to persons who turned down participation in this study due to their lack of perceived fitness. Previous studies encountered similar challenges in terms of selection bias of their participants, and this limitation was recognised by several studies<sup>39, 123</sup>. The participants of previous studies were invited to participate after indicating a special interest in their health<sup>19, 39, 123</sup>. This makes the results of the current and previous studies difficult to generalise and apply to the general population. However, this selection bias may have resulted in an underestimation of the strength of the associations between LTPA and health-related fitness, rather than an overestimation.

As in previous similar research<sup>19, 39</sup>, the majority (80%) of participants in this study had obtained tertiary education. It has been shown that lower education levels are associated with higher levels of inactivity<sup>80</sup>. Therefore a broader representation of the general population will need to be investigated in future studies to confirm the generalisability of the findings in the current study.

Finally, a sample size calculation was performed to ensure that the sample size was large enough to provide statistical power. However as mentioned before, a larger population would have provided a better representation of the relationship between LTPA and health-related fitness. Previous studies investigating the relationship between LTPA and a comprehensive battery of health-related fitness had sample sizes of 148<sup>19</sup> and 498<sup>39</sup> participants respectively, while studies exploring the relationship between LTPA and only one or a few health-related fitness outcomes had sample sizes ranging between 27 and 21 685 participants<sup>44, 47, 103, 106, 107, 119, 128, 147, 174, 181</sup>. The large variation in sample sizes between these studies may be ascribed to the fact that certain aspects of health-related fitness were easily assessed by postal surveys, while others required field tests or extensive testing equipment.

#### **3.4.4. Recommendations for future research**

Considering the importance of motor abilities for maintaining independent function with ageing, these aspects of health-related fitness need to be studied among large populations of mature adults. Prospective, longitudinal population-based studies are recommended. In addition, there is a great need to study the independent contributions of different types of LTPA (endurance, neuromuscular or games) to components of health-related fitness. This would be useful clinically when giving individual advice in terms of LTPA and health outcomes. More extensive research is required to further evaluate and develop existing measurement tools, and to assess the predictive health-related validity of tests of health-related fitness in healthy mature adults. Future studies should recruit a more varied group of mature adults in terms of education levels and socio-economic status, allowing for a better representation of the South African context.

## CHAPTER FOUR: SUMMARY AND CONCLUSION

When adults age, there is a gradual decline in the components of health-related fitness including aerobic power<sup>143</sup>, functional strength<sup>1-3, 145, 146, 157, 175</sup>, flexibility<sup>115, 174, 175, 180</sup> and the motor abilities balance, co-ordination and agility<sup>2, 38, 113, 114, 147, 148</sup>. Lifestyle factors and physical inactivity place mature adults at risk for an accelerated reduction in these physical abilities<sup>152</sup>. Regular LTPA has shown to not only improve and maintain aspects of health-related fitness and therefore independent function<sup>19, 39</sup>, but also to help prevent and treat modern diseases of lifestyle<sup>15-17, 19</sup> and to improve quality of life<sup>18, 44, 47</sup>. However, it is unclear how different types of LTPA influence in particular the motor abilities<sup>19</sup>, making it difficult clinically to prescribe the correct type and dosage of physical activity for their development. For example, it is not known if endurance LTPA alone is sufficient to improve and maintain aspects of health-related fitness such as balance, agility and co-ordination, or if specific neuromuscular LTPA is required. It has been established that motor abilities may help to preserve function<sup>51-53</sup> and prevent falls<sup>50</sup> as adults age, therefore further investigation of this question is of critical importance in this age group. There is also a lack of evidence regarding the importance of long term LTPA in the development and maintenance of health-related fitness<sup>19</sup>. Therefore the overall aim of this study was to examine the relationship between LTPA and components of health-related fitness in healthy mature adults. Based on the evidence provided in this thesis, the study objectives as described in Section 1.2.2 (page 1) may be answered as follows:

*To describe the reported mode(s) and weekly duration of recent LTPA, in recently active male and female participants.*

In this study, the most frequently reported recent LTPA mode was running. Only one other study examined specific LTPA modes in mature adults. Participants in that study reported mainly walking<sup>19</sup>. Most of the hours per week of recent LTPA in this study consisted of endurance activity. Recently active participants reported significantly fewer hours per week of neuromuscular LTPA, and even fewer hours per week of participation in games. This is congruent with two previous studies, where participants also reported mainly endurance LTPA<sup>19, 39</sup>. Unfortunately, previous studies did not report the recent LTPA duration per week of their participants<sup>19, 39</sup>, therefore this data cannot be compared to other current research. In addition, most recently active participants reported their LTPA intensity as “moderate”, while only three participants reported regular “vigorous” LTPA. Suni et al<sup>39</sup> also reported mainly “brisk” (moderate) activity, compared to “vigorous”, while Rinne et al<sup>19</sup> placed “moderate” and “vigorous” LTPA into a single category in their study.



It is recommended that mature adults participate in a variety of different LTPA modes including neuromuscular LTPA and games, and that they alternate moderate with vigorous LTPA to optimise their health benefits<sup>19</sup>.

*To describe the reported mode(s) and years of participation in long term LTPA, in recently active and inactive male and female participants.*

In this study, the most popular modes of LTPA in the participants who reported long term LTPA were cycling, running and rugby. The males participated in mainly cycling and running, while the females reported mainly walking, running and cycling. Recently active participants reported significantly more years of LTPA participation than inactive participants, and males reported significantly more years of long term LTPA than females. Most years of long term LTPA were spent participating in endurance, followed by games and neuromuscular LTPA. Recently active participants participated in significantly more years of endurance and neuromuscular LTPA than inactive participants, while males participated in significantly more years of games than females. Thus clinicians should recommend long term LTPA which incorporates a large variety of activities including neuromuscular LTPA and games, to healthy adults. Variation and the addition of games into regular LTPA programmes from a young age may help ensure that adults develop motor abilities and functional strength.

*To determine if there were significant differences in anthropometry measurements and selected health-related fitness components in recently active and inactive male and female participants.*

Active participants had significantly lower body mass index (BMI), body fat percentage and sum of seven skinfold measurements compared to inactive participants in this study. Active participants had significantly improved cardiorespiratory fitness compared to inactive participants, and the cardiorespiratory fitness of active females was significantly better than in inactive females. There were no statistically significant differences between groups or between genders in terms of static balance scores, back muscle endurance or flexibility, however males scored significantly better in the dynamic balance test, the Illinois Agility Test, the co-ordination test, lower limb function and upper limb function than females. Active females scored significantly better in the Illinois Agility Test than inactive females. Active participants scored significantly better on the test for upper limb function than inactive participants. These favourable differences in body composition, aerobic power, agility and upper limb function reflect the benefits of LTPA in the maintenance of health and function in mature adults. However, between-group differences in most motor abilities were not found. Motor fitness may therefore not depend on recent LTPA, but rather on long term participation in LTPA.

*To determine the relationships between recent participation in different types of LTPA (endurance, neuromuscular or games) and the total weekly duration of LTPA, with anthropometry and selected components of health-related fitness in recently active male and female participants.*

In this study, significant negative correlations were found between recent participation in endurance LTPA and the sum of seven skinfolds and body fat percentage. In addition, there were significant correlations between recent participation in endurance LTPA and aerobic power. Significant negative correlations were found between recent neuromuscular LTPA and BMI scores and aerobic power. Recent participation in games demonstrated significant correlations with back muscle endurance. There were significant negative correlations between total recent LTPA per week and BMI, body fat percentage, the sum of seven skinfolds and aerobic power. Therefore, recent participation in endurance and neuromuscular LTPA were related to improved body composition and aerobic power, while recent participation in games may facilitate back muscle endurance.

*To determine the relationships between long term participation in different types of LTPA (endurance, neuromuscular or games) and total years of LTPA participation, with anthropometry and selected components of health-related fitness in recently active and inactive male and female participants.*

In this study there were significant negative correlations between long term endurance LTPA and all the anthropometric characteristics. Long term participation in endurance correlated significantly with aerobic capacity. There were significant negative correlations between long term endurance LTPA and agility scores and dynamic balance. Long term endurance LTPA correlated significantly with back muscle endurance and upper limb function. Long term neuromuscular LTPA failed to demonstrate significant correlations with anthropometric measurements or components of health-related fitness. Long term participation in games demonstrated significant negative correlations with agility scores, and significant positive correlations with lower limb function. There were significant negative correlations between years of long term LTPA participation and body fat percentage and the sum of seven skinfolds. Years of long term LTPA participation demonstrated the following significant correlations with health-related fitness components: positive with aerobic capacity, negative with agility and dynamic balance, positive with lower limb function and upper limb function. Therefore aspects of health-related fitness such as motor abilities and functional strength (upper limb function, lower limb function and back muscle endurance) were mainly related to years of long term LTPA and long term games participation.

Based on the findings of this study, it is recommended that the relationship between both recent and long term neuromuscular LTPA and games be further evaluated in larger samples of healthy mature adults. Future studies should take care to recruit participants who are involved in types of LTPA other than endurance. This would help to further evaluate their associations with health-related fitness. Suggested modifications to this study design include a larger sample size, a higher required amount of recent weekly LTPA for participants to be assigned to the active group and a more comprehensive evaluation of health-related quality of life. A further recommendation for future research includes the development of a standardised LTPA questionnaire for the evaluation of both recent and long term LTPA patterns. The findings of this study highlight the importance of regular LTPA for mature adults in terms of maintaining a healthy body composition, cardiorespiratory fitness, functional strength and agility. Moreover, the benefits of long term LTPA and participation in games were confirmed for the improvement of motor abilities such as balance and agility in this age group. Based on the findings of this study, clinicians should encourage mature adults to participate in a variety of LTPA modes including neuromuscular LTPA and games. To prevent an accelerated decline in motor function with ageing, clinical recommendations should place particular emphasis on the importance of long term (i.e. lifetime) LTPA participation.

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UCT/MRC Research Unit for Exercise Science and Sports Medicine

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## ACTIVE OR INACTIVE HEALTHY ADULTS AGED 40-60 INVITED TO PARTICIPATE IN UCT RESEARCH

Be a part of this study investigating the effects of leisure time physical activity on health-related fitness.

### Study outline

The University of Cape Town is investigating the influence of leisure time physical activity on the health-related fitness of healthy adults.

The study requires participation in two sessions of one hour each. At the first session participants will complete questionnaires regarding former and recent leisure time physical activity and health-related quality of life. Body composition will be determined by measuring the stature, body mass and body fat % of each participant. At session 2, cardiorespiratory fitness, balance, agility, strength and flexibility will be tested using physical tests.

### Those interested in participating should ..

- be a healthy adult aged between 40 and 60
- be either active or inactive in their leisure time
- be free of any injury or disability
- live in or near Oudtshoorn

### Benefits of participating in the study include

- Individual anthropometric measurements (Height, weight, BMI, body fat %)
- Test scores: cardiorespiratory fitness, balance, agility, strength and flexibility
- An information sheet including the latest exercise recommendations for your age group

**If you are interested in taking part in the study and would like additional information, please contact:**

Anita Beutel Cell: 0715394920

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Appendix 2

## LTPA QUESTIONNAIRE

### SECTION A: PERSONAL DETAILS

Name: \_\_\_\_\_ Age: \_\_\_\_\_

Occupation: \_\_\_\_\_

Highest level of education (please tick appropriate option and specify highest grade / tertiary qualification achieved).

Primary school	<input type="checkbox"/>	_____
High School	<input type="checkbox"/>	_____
Tertiary qualification	<input type="checkbox"/>	_____

Please note: Leisure time physical activity may include any exercise, sport or physically active hobbies which you participate in during your leisure time.

### SECTION B: RECENT LEISURE TIME PHYSICAL ACTIVITY

1. Have you taken part in any leisure time physical activity lasting 30 minutes or more, in the past THREE MONTHS?

Yes                      No

If you answered No to Question 1, please go to Section C (LONG TERM LEISURE TIME PHYSICAL ACTIVITY).

2. Which of these categories describes how often you participate in physical activity during your leisure time? (Consider the past three months and take into account all leisure time physical activity that lasted at least 30 minutes at a time.

- a) Twice per week or less
- b) Three times per week
- c) At least four times per week

3. On average, how long is your session of leisure time physical activity in minutes?

\_\_\_\_\_ minutes.

**4. How intense is your average exercise session?**

- a) Light and relaxed
- b) Moderate – some sweating and shortness of breath
- c) Brisk, vigorous

**Please specify all types of leisure time physical activity you have been involved in regularly in the past 3 months (maximum 5 activities).**

(Examples: running, walking, cycling, horse riding, rugby, soccer, cricket, netball, hockey, dancing, martial arts, yoga, pilates, bowling, tennis, aerobics, swimming, weight training, basketball, golf, badminton, hiking, fishing etc.)

**Activity 1:** \_\_\_\_\_

Average hours per week: \_\_\_\_

**Activity 2:** \_\_\_\_\_

Average hours per week: \_\_\_\_

**Activity 3:** \_\_\_\_\_

Average hours per week: \_\_\_\_

**Activity 4:** \_\_\_\_\_

Average hours per week: \_\_\_\_

**Activity 5:** \_\_\_\_\_

Average hours per week: \_\_\_\_



**SECTION C: LONG TERM LEISURE TIME PHYSICAL ACTIVITY**

**1. Have you exercised regularly during your adulthood (from age 18 until 1 year ago)?**

Yes                  No

**If you answered No to question 1, please go to SECTION D (OTHER CURRENT PHYSICAL ACTIVITY).**

**2. For how many years in total have you engaged in regular physical activity (at least 30 minutes at a time, three times per week)? Take into account all regular leisure time exercise which has lasted for 6 months or more. \_\_\_\_**

**Think back carefully and take into account all regular leisure time physical activity which lasted for 6 months or more. Please list the activity type(s) you were most involved in on a regular basis, for the longest period of time from age 18 to 1 year ago (maximum 5 activities). Then please specify for each activity for how many years you participated, the average amount of months per year, and hours per week.**

(Examples of activities: walking, cycling, swimming, running, aerobics, rowing, weight training, horse riding, dancing, martial arts, boxing, yoga, pilates, rugby, cricket, hockey, netball, tennis, bowling, basketball, jukskei, badminton, table tennis, golf, hiking, fishing)

**Activity 1:** \_\_\_\_\_

Amount of years: \_\_\_\_

Average months per year: \_\_\_\_

Average hours per week: \_\_\_\_

**Activity 2:** \_\_\_\_\_

Amount of years: \_\_\_\_

Average months per year: \_\_\_\_

Average hours per week: \_\_\_\_

**Activity 3:** \_\_\_\_\_

Amount of years: \_\_\_\_

Average months per year: \_\_\_\_

Average hours per week: \_\_\_\_

**Activity 4:** \_\_\_\_\_

Amount of years: \_\_\_\_

Average months per year: \_\_\_\_

Average hours per week: \_\_\_\_

**Activity 5:** \_\_\_\_\_

Amount of years: \_\_\_\_

Average months per year: \_\_\_\_

Average hours per week: \_\_\_\_

**SECTION D: RECENT OTHER PHYSICAL ACTIVITY**

**1. I would classify the physical loading level at my work to be: (please circle)**

Light / Medium / Heavy / Not employed.

**2. How many hours per week, on average, do you spend at work? \_\_\_\_\_**

**3. Please estimate the percentage of time at work you spend**

a) standing \_\_\_\_%

b) sitting \_\_\_\_%

c) walking \_\_\_\_%

**4. In an average week, do you walk, cycle or run as a means of transport (commuting)? Yes / No**

**IF you answered yes to question 4 above, please specify by answering a), b) and c) below:**

a) Walking\_\_\_\_ Running\_\_\_\_ Cycling\_\_\_\_ Other \_\_\_\_\_

b) How many hours do you spend on average, per week to walk / cycle / run / \_\_\_\_\_ to get around (commute)? \_\_\_\_\_

**5. How many hours do you spend on average per week, while not at work,**

a) doing heavy housework such as sweeping, mopping and vacuuming \_\_\_\_\_

b) mowing the lawn and doing carpentry \_\_\_\_\_

c) shovelling / digging / carrying heavy loads \_\_\_\_\_

**Thank you very much for taking the time to complete this questionnaire, which will add to the body of knowledge regarding the leisure time physical activity of South African adults.**

University of Cape Town

### Appendix 3

## Modified Physical Activity Readiness Questionnaire

Name:

E-mail:

Date of birth:

Age:

Home phone nr:

Cell nr:

Please list any medication you are currently taking: \_\_\_\_\_

---

Regular physical activity is safe and healthy for most people. The following questions are designed to ascertain whether you should check with your doctor before you become more physically active.

Please answer questions honestly by ticking the relevant box:

- |            |           |  |
|------------|-----------|--|
| <b>Yes</b> | <b>No</b> | 1. Has a doctor ever said that you have a heart problem and that you should only do physical activity recommended by a doctor? |
| <b>Yes</b> | <b>No</b> | 2. Do you have chest pain when you are physically active?  |
| <b>Yes</b> | <b>No</b> | 3. Have you had any chest pain in the past month, when you were not exercising?  |
| <b>Yes</b> | <b>No</b> | 4. Do you ever lose consciousness, or lose your balance because you feel dizzy?  |
| <b>Yes</b> | <b>No</b> | 5. Do you have a bone or joint problem which could be worsened by a change in your physical activity?                          |
| <b>Yes</b> | <b>No</b> | 6. Are you currently using medication for your blood pressure or heart condition?  |
| <b>Yes</b> | <b>No</b> | 7. Are you pregnant?   |
| <b>Yes</b> | <b>No</b> | 8. Do you know of any other reason you should not exercise or increase your level of physical activity?                        |

If you answered yes to any of the above questions, talk to your doctor before becoming more physically active. Tell your doctor about this questionnaire and to which question/s you answered yes.

If you answered no to all questions you can be reasonably sure that you can safely increase your activity level gradually. Should your health change so that you answer yes to any of the above questions, seek medical advice.

**Participant Signature**

**Date**

Appendix 4

Name:

**Health-related Quality of Life: Healthy Days Core Module**

(CDC HRQOL-4)

**1. Would you say that in general your health is:**

**(Please read)**

- a. Excellent 1
- b. Very good 2
- c. Good 3
- d. Fair 4
- e. Poor 5

**Do not read these responses**

- Don't know / not sure 7
- Refused 9

**2. Now thinking about your physical health, which includes physical illness and injury, for how many days during the past 30 days was your physical health not good?**

- a. Number of days —
- b. None 88
- Don't know / Not sure 77
- Refused 99

**3. Now thinking about your mental health, which includes stress, depression and problems with emotions, for how many days during the past 30 days was your mental health not good?**

- a. Number of days —
- b. None 88 (Skip next question if both Q2 & Q3 'None'.)
- c. Don't know / Not sure 77
- d. Refused 99

**4. In the past 30 days, for about how many days did poor physical or mental health keep you from doing your usual activities, such as self-care, work or recreation?**

- a. Number of days —
- b. None 88
- c. Don't know / not sure 77
- d. Refused 99

## Appendix 5



UNIVERSITY OF CAPE TOWN  
IYUNIVESITHI YASEKAPA • UNIVERSITEIT VAN KAAPSTAD

Dear Validator,

20 August 2012

### Request for Assistance: Validation of Leisure Time Physical Activity (LTPA) Questionnaire

I am an MPhil Sports Physiotherapy student at the University of Cape Town, and am writing to you to request your voluntary assistance in the validation of a leisure time physical activity questionnaire. As a 'validator', you will not be considered as a study participant and all information will be treated with utmost confidentiality.

As you know, leisure time physical activity (LTPA) is widely recommended to improve health and wellbeing, and for the prevention of disabilities later in life.

I will be conducting a study to investigate the relationship between leisure time physical activity and the health-related fitness of South African adults between ages 40 and 60, and to compare the health-related fitness between active and inactive healthy adults. This study has been approved by the Human Research Ethics Committee, Faculty of Health Sciences, University of Cape Town.

For my study I have developed a questionnaire designed to determine the current and long term LTPA patterns of participants in terms of mode, frequency, duration and intensity. For the purpose of matching the active and inactive groups as closely as possible for confounding variables, additional questions relating to commuting, occupational and other physical activity (physical activity outside of leisure time)<sup>1, 2</sup> are included. This questionnaire is closely based on questions used by Rinne et al (2010) examining LTPA and motor abilities in mature adults, and on a study by Suni et al (1999) which examined physical activity patterns as they relate to physical fitness parameters in adults. The questionnaire will be completed by each study participant together with the researcher on an individual basis. The researcher will thus have the opportunity to explain a question to the participant should any misinterpretation occur. Upon completion of this questionnaire, a battery of physical tests will be conducted to determine the correlation between reported LTPA patterns and physical components of health-related fitness.

Please could you assist me in reviewing this questionnaire to ensure that the questions are clear and easy to understand, and that they adequately assess the current and long term participation patterns in LTPA?

I have attached the questionnaire with an allocated comments section for each question. Your feedback will be greatly appreciated.

If possible, please return any feedback before Friday 31 August 2012. Please contact me should you have any further questions or should you be unable to assist with the validation process.

My contact details are as follows:

071 539 4920

[beutelphysio@gmail.com](mailto:beutelphysio@gmail.com)

Thank you for your time and for supporting research in the field of sports physiotherapy and health-related fitness.

Kind regards,

Anita Beutel

Research Supervisors: Dr T Burgess [theresa.burgess@uct.ac.za](mailto:theresa.burgess@uct.ac.za)

Ms H Talberg [heather.talberg@uct.ac.za](mailto:heather.talberg@uct.ac.za)

University of Cape Town

## Validator's LTPA Questionnaire

- Please indicate in the provided boxes below questions, your consensus as to the clarity and importance of the question.
- You may add a comment or suggestion below any question, should you wish to do so.
- Section A requires the personal details of the participant, such as name, age and occupation. This section has been removed from the validator's questionnaire. Your questionnaire will start from Section B.
- For convenience, references are supplied after each question. A reference list for the questionnaire is attached at the end.

Please note: Leisure time physical activity may include any exercise, sport or physically active hobbies which you participate in during your leisure time.

### SECTION B: RECENT LEISURE TIME PHYSICAL ACTIVITY

1. **Have you taken part in any leisure time physical activity lasting 30 minutes or more, in the past THREE MONTHS <sup>1</sup>?**

Yes                      No

**If you answered No to Question 1, please go to Section C (LONG TERM LEISURE TIME PHYSICAL ACTIVITY).**

Is the question important?                      Yes    No

Is the question clear?                              Yes    No

Comments:

2. **Which of these categories describes how often you participate in physical activity during your leisure time? (Consider the past three months and take into account all leisure time physical activity that lasted at least 30 minutes at a time.) <sup>1,2</sup>**

- a) Twice per week or less
- b) Three times per week
- c) At least four times per week

Is the question important?                      Yes    No

Is the question clear?                              Yes    No



Comments:

**3. On average, how long is your session of leisure time physical activity in minutes? <sup>1,2</sup>**

\_\_\_ minutes.

Is the question important?      Yes                                      No

Is the question clear?            Yes                                      No

Comments:

**4. How intense is your average exercise session? <sup>1,2</sup>**

- a) Light and relaxed
- b) Moderate – some perspiration and shortness of breath
- c) Brisk, vigorous

Is the question important?      Yes                                      No

Is the question clear?            Yes                                      No

Comments:

**Please specify all types of leisure time physical activity you have been involved in regularly in the last 3 months (maximum 5 activities) <sup>1</sup>.**

(Examples: running, walking, cycling, horse riding, rugby, soccer, cricket, netball, hockey, dancing, martial arts, yoga, pilates, bowling, tennis, aerobics, swimming, weight training, basketball, golf, badminton, hiking, fishing etc.)

**Activity 1:** \_\_\_\_\_

Average hours per week: \_\_\_\_

**Activity 2:** \_\_\_\_\_

Average hours per week: \_\_\_\_

**Activity 3:** \_\_\_\_\_

Average hours per week: \_

**Activity 4:** \_\_\_\_\_

Average hours per week: \_\_\_\_

**Activity 5:** \_\_\_\_\_

Average hours per week: \_\_\_\_

Is the question important?      Yes                                      No

Is the question clear?              Yes                                      No

Comments:

**SECTION C: LONG TERM LEISURE TIME PHYSICAL ACTIVITY**

**1. Have you exercised regularly during your adulthood (from age 18 until 1 year ago)?<sup>1</sup>**

Yes                                      No

**If you answered No to question 1, please go to SECTION D (OTHER CURRENT PHYSICAL ACTIVITY).**

Is the question important?      Yes                                      No

Is the question clear?              Yes                                      No

Comments:

**2. For how many years in total have you engaged in regular physical activity (at least 30 minutes at a time, three times per week)? Take into account all regular leisure time exercise which has lasted for 6 months or more<sup>1</sup>. \_\_\_\_**

Is the question important?      Yes                                      No

Is the question clear?              Yes                                      No

Comments:

**Think back carefully and take into account all regular leisure time physical activity which lasted for 6 months or more. Please list the activity type(s) you were most involved in on a regular basis, for the longest period of time from age 18 to 1 year ago (maximum 5 activities). Then please specify for each activity for how many years you participated, the average amount of months per year, and hours per week<sup>1</sup>.**

(Examples of activities: walking, cycling, swimming, running, aerobics, rowing, weight training, horse riding, dancing, martial arts, boxing, yoga, pilates, rugby, cricket, hockey, netball, tennis, bowling, basketball, jukskei, badminton, table tennis, golf, hiking, fishing)

**Activity 1:** \_\_\_\_\_

Amount of years: \_\_\_\_

Average months per year: \_\_\_\_

Average hours per week: \_\_\_\_

**Activity 2:** \_\_\_\_\_

Amount of years: \_\_\_\_

Average months per year: \_\_\_\_

Average hours per week: \_\_\_\_

**Activity 3:** \_\_\_\_\_

Amount of years: \_\_\_\_

Average months per year: \_\_\_\_

Average hours per week: \_\_\_\_

**Activity 4:** \_\_\_\_\_

Amount of years: \_\_\_\_

Average months per year: \_\_\_\_

Average hours per week: \_\_\_\_

**Activity 5: \_\_\_\_\_**

Amount of years: \_\_\_\_

Average months per year: \_Average hours per week: \_\_\_\_

Is the question important?      Yes                                      No

Is the question clear?              Yes                                      No

Comments:

**SECTION D: RECENT OTHER PHYSICAL ACTIVITY**

**1. I would classify the physical loading level at my work to be: (please circle) <sup>3,4</sup>**

Light / Medium / Heavy / Not employed.

Is the question important?      Yes                                      No

Is the question clear?              Yes                                      No

Comments:

**2. How many hours per week, on average, do you spend at work <sup>4</sup>? \_\_\_\_\_**

Is the question important?      Yes                                      No

Is the question clear?              Yes                                      No

Comments:

**3. Please estimate the percentage of time at work you spend <sup>3</sup>**

a) standing \_\_\_\_%

b) sitting \_\_\_\_%

c) walking \_\_\_\_%

Is the question important?      Yes                                      No

Is the question clear?              Yes                                      No

Comments:

**4. In an average week, do you walk, cycle or run as a means of transport (commuting) <sup>2</sup>? Yes / No**

Is the question important? Yes No

Is the question clear? Yes No

Comments:

**IF you answered yes to question 4 above, please specify by answering a), b) and c) below:**

**a) Walking\_\_\_\_ Running\_\_\_\_ Cycling\_\_\_\_ Other \_\_\_\_\_**

Is the question important? Yes No

Is the question clear? Yes No

Comments:

**b) How many hours do you spend on average, per week to walk / cycle / run / \_\_\_\_\_ to  
get around (commute) <sup>2</sup>? \_\_\_\_\_**

Is the question important? Yes No

Is the question clear? Yes No

Comments:

**5. How many hours do you spend on average per week, while not at work, <sup>2</sup>**

a) doing heavy housework such as sweeping, mopping and vacuuming \_\_\_\_\_

b) mowing the lawn and doing carpentry \_\_\_\_\_

c) shovelling / digging / carrying heavy loads \_\_\_\_\_

Is the question important? Yes No

Is the question clear? Yes No

Comments:

**Thank you very much for taking the time to complete this questionnaire, which will add to the  
body of knowledge regarding the leisure time physical activity of South African adults.**

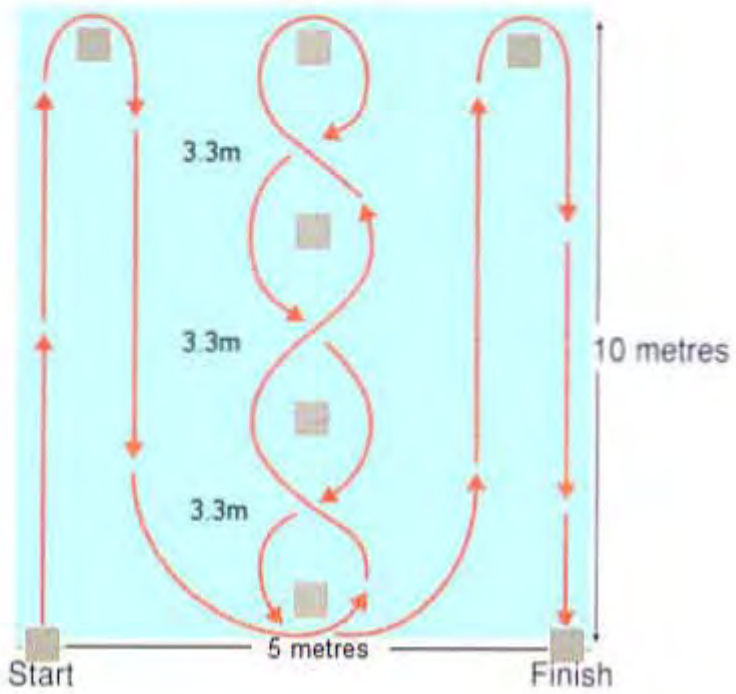
## References:

1. Rinne M, Pasanen M, Miilunpalo S, Malkia E. Is Generic Physical Activity Associated with Motor Abilities? *Med Sci Sports Exerc* 2010; 42(9):1760-8.
2. Suni JH, Oja P, Miilunpalo SI, Pasanen ME, Vuori IM, Bos K. Health-Related Fitness Test Battery for Middle-Aged Adults: Associations with Physical Activity Patterns. *Int J Sports Med* 1999; 20:183-91.
3. Ainsworth B, Haskell MC, White, et al. Compendium of Physical activities: an Update of Activity Codes and MET-Intensities. *Med Sci Sports Exerc.* 2000; 32:S498-S504.
4. Leino-Arjas P, Solovieva S, Kirjonen J, et al. Leisure Time Physical Activity and Strenuousness of Work as Predictors of Physical Functioning: a 28 Year Follow-Up of a Cohort of Industrial Employees. *Occup Environ Med* 2004; 61:1032-8.

University of Cape Town

Appendix 6

**ILLINOIS AGILITY TEST**



**UCT/MRC Research Unit for Exercise Science and Sports  
Medicine**



**Department of Human Biology  
Division of Physiotherapy, Department of Health & Rehabilitation Sciences  
Faculty of Health Sciences  
University of Cape Town, South Africa**

28 October 2012

To Oudtshoorn Municipality: De Jagers Sports Complex

**RE: REQUEST FOR USE OF FACILITIES FOR UCT RESEARCH STUDY**

Dear Sir,

I am a Masters student at the University of Cape Town, and I will be conducting a study investigating the motor abilities and physical fitness of local adults aged between 40 and 60. For this purpose I would like to request the use of De Jagers sports centre and the adjacent tartan track during hours that would be most convenient for you.

My study will include the physical testing of 56 healthy adults. Tests will be conducted in groups of three to five participants, who will be supervised by myself and my research assistant (Ms Carien Loubser) at all times. Each testing session will take about one hour. We will require the use of a medium-sized room where balance, agility, muscle power and flexibility can be tested. Participants will then be requested to walk five laps around the athletics track after which their heart rate will be recorded.

We therefore request the use of your facilities over a period of three months between November 2012 and January 2013. I will provide all the equipment that will be needed for the testing sessions, and the room will be left neat and tidy after use. Testing will not involve excessive noise.

This study will provide important information regarding the effects of leisure time physical activity on the motor abilities of adults living in Oudtshoorn. Further, it will assist in determining the amount, type and frequency of leisure time physical activity that should be prescribed for mature adults.

Thank you in advance for your kind assistance.

Kind Regards,

Anita Beutel  
B.Sc (Physiotherapy)



## Appendix 8



**Department of Health and Rehabilitation  
Sciences**

**Faculty of Health Sciences**

Divisions of Communications Sciences and  
Disorders, Nursing and Midwifery,  
Occupational Therapy, Physiotherapy

### Participant information sheet

Dear Participant

I am a Masters student at the University of Cape Town, Division of Physiotherapy and am conducting a study to investigate the relationship between leisure time physical activity and the health-related fitness of adults between ages 40 and 60, and to compare the health-related fitness between active and inactive healthy adults. This study has been approved by the Human Research Ethics Committee, Faculty of Health Sciences, University of Cape Town.

Leisure time physical activity is widely recommended to improve health and wellbeing, and for the prevention of disabilities later in life. At the moment it is unclear which modes of exercise should be prescribed by health professionals to improve health-related fitness components such as balance and co-ordination. By participating in this study you will not only learn about your own fitness levels but also help our understanding of the effects of leisure time physical activity on South African adults.

Participation in this study will involve two sessions of one hour each. Session 1 will take place at the physiotherapy practice at 145B St John's Street, Oudtshoorn and session 2 will be at De Jager's Sports Complex in Voortrekker Road, Oudtshoorn. All data will be held in the strictest of confidence, and in any ensuing publication, all participants will remain anonymous.

You will be asked to read this letter carefully then sign the informed consent section below. Next, please read and complete the Modified Physical Activity Readiness Questionnaire (PAR-Q), the LTPA Questionnaire and the Health-related Quality of Life questions. These are needed to make sure that it is safe for you to participate in this study, to ascertain your physical activity history and your health-related quality of life. (The questions will be read out and explained to you by the principal investigator).

Next, your height, weight and the sum of 7 skinfolds (front upper arm, back upper arm, upper back, waist, abdomen, thigh and calf) will be measured to determine your body composition. You will then be familiarised with the set of physical tests which will be done at session 2.

The physical tests performed at session 2 will be as follows:

Cardiorespiratory fitness: This test requires walking five laps around a 400 m athletics track, as fast as you comfortably can. Your heart rate will be measured using a heart rate monitor. Warm up by walking at leisurely pace for five minutes before the test.

Balance in standing: Standing on one leg for a maximum of one minute per leg with your eyes open. The amount of seconds you manage to stand on each leg will be recorded, and you are allowed three attempts on each leg.

Dynamic balance: Walk backwards along a straight line of 6 metres with the toe of your shoe touching the heel of your other shoe, as fast as possible without stepping off the line. You are allowed three attempts and the fastest time will be recorded as the test score.

Agility: Running a course marked out with cones as fast as possible. The course will be 10 m by 5 m, with cones set up in the middle around which you will run in a criss-cross fashion, without knocking over any of the cones. You may run the course three times, and your best time will be your test score.

Co-ordination: You will stand 2 m away from a wall, and there will be a line 2 m high on the wall. Throw and catch a ball against the wall above the line as fast as possible. Your time taken for 20 bounces will be the test score. The best time of three rounds will be taken as your test score.

Back muscle endurance: Lying face down with your lower body on a low bench, you are asked to raise your upper body up into a horizontal position, and to hold it as long as you can for a maximum of 4 minutes. This test will be done only once. The time you are able to hold this position will be your test score.

Upper body power: Lying face down, the cycle starts as you lie clasping your hands behind your back. Then, perform a straight leg push-up. Now touch one hand with your supporting hand then lie back down. Do as many of these push-up cycles as you can in 40 seconds. The test score is the amount of fully completed push-up cycles in one minute and you may have three attempts.

Leg muscle power: For this test you will be standing side-on next to a wall. Extend your arm upwards along the wall and the researcher will make a mark at the highest point along the wall you are able to reach, with white chalk. Your fingertips closest to the wall will then be dipped in yellow chalk powder. Next, bend your knees and jump up and reach as high up along the wall with your fingertips as you can. Touch the wall at your highest point so that your fingertips make a yellow mark on the wall. The researcher will then measure the distance between the white and the yellow mark on the wall. This will be your test score. You are allowed three attempts and the best one will count as the test score.

**Flexibility:** Sitting on the floor with your knees straight and your feet against a box, you reach as far forwards towards your toes as you can. You are allowed to practice twice before the distance between your middle fingertips and toes will be measured.

**Potential risks to participants:**

There are no potential risks associated with completing the questionnaires, or with the measurement of height, mass or skinfolds. The fitness test will involve walking for 2 km, and the agility test will involve completing a course set out with cones. Participants suffering from cardiovascular, circulatory disorders or musculoskeletal injuries will be excluded from the study, to minimise the risks associated with these tests. An adequate warm-up will precede the fitness test, and the physical tests will be explained and demonstrated in full. Two practice rounds will be allowed before most tests to ensure familiarisation with the procedure so as to prevent any injuries. Muscle strength tests will require maximal contractions of muscle groups, so the risks involved in these tests are similar to moderate gym training. Balance and co-ordination testing will involve risks associated with light physical activity.

**Anticipated benefits to participants:**

All participants will be provided with their test scores after the completion of the study. This may be of value to you if you are interested in the level of your fitness by providing information relating to the different components of your fitness. Possible areas of weakness may be identified so that they can be addressed through training. An information leaflet about the benefits of regular exercise, as well as the latest recommendations regarding mode, dosage and frequency of recommended exercise for your age group will be provided for all participants. Should you require any further input or advice regarding training interventions, you will be referred to a biokineticist. No remuneration is available for taking part in this study.

Should you have any questions or concerns regarding this study, please feel free to contact me or any one of the supervisors.

Researcher: Anita Beutel 071 539 4920 [beutelphysio@gmail.com](mailto:beutelphysio@gmail.com)

Supervisor: Dr Theresa Burgess 021 4066171 [theresa.burgess@uct.ac.za](mailto:theresa.burgess@uct.ac.za)

Co-supervisor: Heather Talberg 083 462 8187 [heather.talberg@uct.ac.za](mailto:heather.talberg@uct.ac.za)

Chairperson, Human Research Ethics Committee, University of Cape Town:

Professor Marc Blockman 021 4066492 [marc.blockman@uct.ac.za](mailto:marc.blockman@uct.ac.za)

**No-fault insurance:**

The University of Cape Town offers a no-fault insurance that covers all participants of this study for any trial-related injuries. This insurance will provide compensation according to the Association of the British Pharmaceutical Industry (ABPI) guidelines of 1991. These guidelines recommend that you be compensated without the need of proving that UCT is at fault. An injury is considered trial-related if it is caused by trial activities. You are requested to immediately notify the study investigators in case of any such injuries occurring.

UCT reserves the right not to compensate you if the injury occurred because you did not follow the instructions provided. Your right in law to claim compensation for injury where you prove negligence is not affected.

Thank you for supporting research in the field of health-related fitness.

Kind Regards,

Anita Beutel

BSc Physiotherapy

University of Cape Town

## Appendix 9

### **Informed consent form**

#### **The relationship between leisure time physical activity and motor abilities in mature adults: a single-blinded study.**

Participation in this study is voluntary. Please sign this informed consent form and complete the three attached questionnaires. All questionnaires will be kept confidential and locked away. All data studied will remain anonymous.

#### **Potential risks to participants**

There are no potential risks associated with completing questionnaires, or with the measurement of body height, mass or skinfolds. The cardiorespiratory fitness test involves walking for 2 km, and the agility test will involve running a course marked out with cones. Participants suffering from cardiovascular, circulatory disorders or musculoskeletal injuries will be excluded from the study, in order to minimise the risks associated with these tests. In addition, an adequate warm-up will precede these tests. The muscle strength tests will require maximal contractions of muscle groups. The risks involved in these tests are similar to moderate gym training. Two practice rounds will be allowed before testing in order to ensure familiarisation with the procedure so as to prevent any injury from occurring, and a 10 minute warm-up before the cardiorespiratory fitness test is mandatory. Balance and co-ordination testing will involve risks associated with light physical activity.

#### **Anticipated benefits to participants**

All participants will be provided with their test scores once data collection has been completed. This may be of great value to participants interested in their level of fitness, flexibility and strength. Possible areas of weakness may be identified so that they can be addressed through training. An information leaflet about the benefits of regular exercise, as well as the latest recommendations regarding mode, dosage and frequency of recommended physical activity for this age group will be made available to all participants in the study, free of charge. Participants requiring further input or advice will be referred to a biokineticist. No remuneration is available for participants in this study.

#### **No-fault insurance**

The University of Cape Town offers a no-fault insurance that covers all participants of this study for any trial-related injuries. This insurance will provide compensation according to the Association of the British Pharmaceutical Industry (ABPI) guidelines of 1991. These guidelines recommend that you be compensated without the need of proving that UCT is at fault. An injury is considered trial-related if it is caused by trial activities. You are requested to immediately notify the study investigators in case of any such injuries occurring. UCT reserves the right not to compensate you if the injury occurred because you did not follow the instructions provided. Your right in law to claim compensation for injury where you prove negligence is not affected.

**Questions or concerns:**

For any questions regarding this study, please contact:

Researcher: Anita Beutel                    071 539 4920    [beutelphysio@gmail.com](mailto:beutelphysio@gmail.com)

Supervisor: Dr Theresa Burgess    021 406 6171    [theresa.burgess@uct.ac.za](mailto:theresa.burgess@uct.ac.za)

Co-supervisor: Heather Talberg        083 462 8187    [heather.talberg@uct.ac.za](mailto:heather.talberg@uct.ac.za)

Chairperson, Human Research Ethics Committee, University of Cape Town:

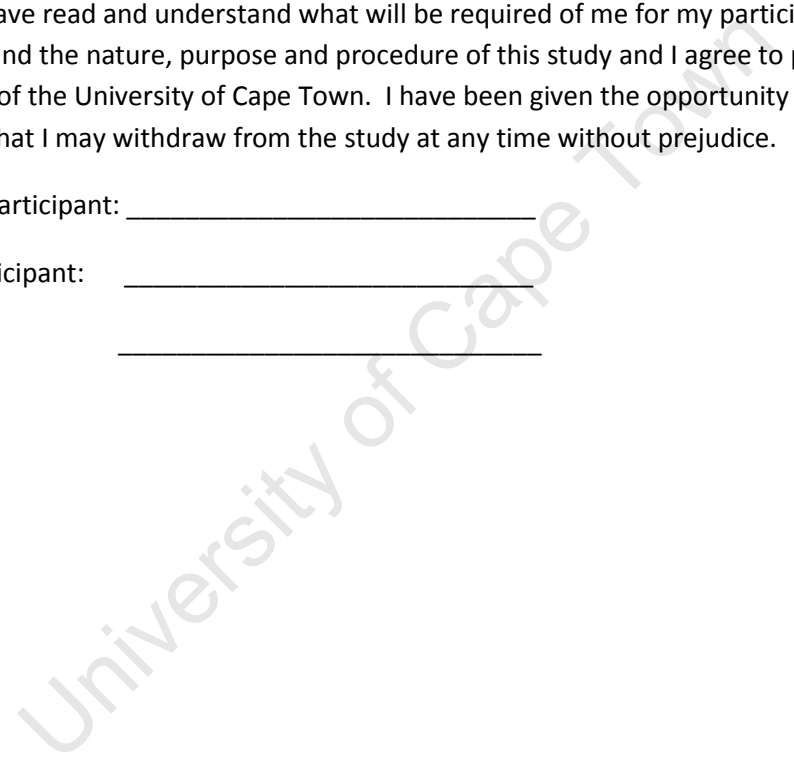
Professor Marc Blockman                021 4066492    [marc.blockman@uct.ac.za](mailto:marc.blockman@uct.ac.za)

I confirm that I have read and understand what will be required of me for my participation in this study. I understand the nature, purpose and procedure of this study and I agree to participate in this research project of the University of Cape Town. I have been given the opportunity to ask questions and I am aware that I may withdraw from the study at any time without prejudice.

Full Name(s) of participant: \_\_\_\_\_

Signature of participant: \_\_\_\_\_

Date: \_\_\_\_\_



## Appendix 10

# DATA SHEET

### Personal information

Name:

Age:

Sex:

Active / Inactive:

Category: Long term:

Category: Recent

HRQoL:

### Anthropometry

Height:

Weight:

BMI:

Skinfolds: Abdominal:

Triceps:

Pectoral:

Mid-axillary:

Subscapular:

Supra-iliac:

Thigh:

Test battery:

	Time:	HR:	Colour:
1. 2km walk			
2. Balance: eyes open	s	s	s
3. Balance: eyes closed	s	s	s
4. Dynamic balance	s	s	s
5. Agility	s	s	s
6. Co-ordination	s	s	s
7. Back endurance	s	s	s
8. Arm power	reps	reps	reps
9. Leg power	cm	cm	cm
10. Flexibility	cm	cm	cm

University of Cape Town



UNIVERSITY OF CAPE TOWN



Faculty of Health Sciences  
Faculty of Health Sciences Research Ethics Committee  
Room E52-24 Groote Schuur Hospital Old Main Building  
Observatory 7925  
Telephone [021] 406 6338 • Facsimile [021] 406 6411  
e-mail: sumayah.ariel@uct.ac.za

23 July 2012

HREC REF: 329/2012

Mrs A Beutel  
c/o Dr I Durgess  
Health & Rehab Sciences  
Physiotherapy  
DMB

Dear Mrs Beutel

**PROJECT TITLE: THE RELATIONSHIP BETWEEN LEISURE TIME PHYSICAL ACTIVITY AND HEALTH-RELATED FITNESS IN MATURE ADULTS- A SINGLE BLINDED STUDY**

Thank you for submitting your study to the Faculty of Health Sciences Human Research Ethics committee for review.

It is a pleasure to inform you that the Ethics Committee has formally approved the above-mentioned study.

Approval is granted for one year till the 28 July 2013.

Please submit a progress form, using the standardised Annual Report Form (HHS016), if the study continues beyond the approval period. Please submit a Standard Closure form (HHS010) if the study is completed within the approval period.

Please note that the ongoing ethical conduct of the study remains the responsibility of the principal investigator.

Please quote the REC REF in all your correspondence.

Yours sincerely,

Sumayah Ariel

Chairperson

Research Ethics Committee

Faculty of Health Sciences

Observatory 7925

Telephone: 021 406 6338

Facsimile: 021 406 6411

E-mail: sumayah.ariel@uct.ac.za

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FHS016: Annual Progress Report / Renewal

HREC office use only (FWA00001637; IRB00001938)			
This serves as notification of annual approval, including any documentation described below.			
<input checked="" type="checkbox"/> Approved	Annual progress report	Approved until/next renewal date	28/07/2014
<input type="checkbox"/> Not approved	See attached comments		
Signature Chairperson of the HREC			Date Signed 15/7/2013
Comments to PI from the HREC			

Principal Investigator to complete the following:

1. Protocol information

Date form submitted	15.07.2013					
HREC REF Number	329/2012	Current Ethics Approval was granted until	28 July 2013			
Protocol title	THE RELATIONSHIP BETWEEN LEISURE TIME PHYSICAL ACTIVITY AND HEALTH-RELATED FITNESS IN MATURE ADULTS: A SINGLE-BLINDED STUDY					
Protocol number (if applicable)	-					
Are there any sub-studies linked to this study?	<input type="checkbox"/> Yes <input checked="" type="checkbox"/> No					
If yes, could you please provide the HREC Ref's for all sub-studies? Note: All sub-studies must be submitted for each sub-study.	<table border="1"> <tr> <td>Approved by HREC Committee</td> </tr> <tr> <td>2013-07-15</td> </tr> <tr> <td>HEALTH SCIENCES FACULTY UNIVERSITY OF CAPE TOWN</td> </tr> </table>			Approved by HREC Committee	2013-07-15	HEALTH SCIENCES FACULTY UNIVERSITY OF CAPE TOWN
Approved by HREC Committee						
2013-07-15						
HEALTH SCIENCES FACULTY UNIVERSITY OF CAPE TOWN						
Principal Investigator	ANITA BEUTEL					
Department / Office Internal Mail Address	c/o Dr T. Burgess Health & Rehabilitation Sciences Physiotherapy Old main Building					
1.1 Does this protocol receive US Federal funding?	<input type="checkbox"/> Yes	<input checked="" type="checkbox"/> No				
1.2 Does this study require full committee approval?	<input type="checkbox"/> Yes	<input checked="" type="checkbox"/> No				

## Appendix 12

### EXERCISE RECOMMENDATIONS FOR HEALTHY ADULTS

WEEKLY FREQUENCY: choose one option below	TYPE OF EXERCISE
At least 5 days per week	Moderate intensity exercise: noticeably increased heart rate and breathing
At least 3 days per week	High intensity (brisk) exercise: substantial increase in heart rate and breathing
3-5 days per week	Combine high and moderate intensity exercise

AND:

2-3 days per week	Muscular strength and endurance exercise, balance and agility.
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Components of an exercise training session:

- Warm-up: 5-10 minutes of low intensity exercise
- Conditioning: 20 to 60 minutes of exercise, as in tables above
- Cool-down: 5-10 minutes of low intensity exercise
- Stretching: 10 minutes. These may be done after warming up or after cooling down.

Tips:

- Start slowly, build up gradually.
- Progress duration of exercise by 5-10 minutes every 1 to 2 weeks in the first 4-6 weeks after starting an exercise program.
- Choose a type of physical activity that you enjoy.
- Exercise with a friend.
- Establish a regular schedule for exercise
- Consider getting an individualised exercise program by a qualified health or fitness professional.

See your doctor if at any time you feel faint, dizzy or have pain in your chest during exercise.

Feel free to contact me should you have any questions regarding the above information.

Anita Beutel

0715394920

beutelphysio@gmail.com

Adapted from: ACSM's Guidelines for Exercise Testing and Prescription, Eighth Edition (2010).

University of Cape Town



