

**Self-reported measures versus objective measures of physical activity and sedentary behaviour: Impacts of cardiovascular fitness and physical activity.**

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## DECLARATION

I, **Simone Annabella Tomaz**, hereby declare that the work on which this thesis is based is my original work (except where acknowledgements indicate otherwise), and that neither the whole work nor any part of it has been, is being, or is submitted for another degree in this or any other university.

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## LIST OF ABBREVIATIONS

|                          |   |
|--------------------------|---|
| <b>ACSM</b>              | American College of Sports Medicine               |
| <b>BF%</b>               | Body Fat Percentage                               |
| <b>BMI</b>               | Body Mass Index                                   |
| <b>CRF</b>               | Cardiorespiratory Fitness                         |
| <b>CVD</b>               | Cardiovascular Disease                            |
| <b>GPAQ</b>              | Global Physical Activity Questionnaire            |
| <b>GT3X</b>              | ActiGraph GT3X Accelerometer                      |
| <b>HF</b>                | Higher Fitness                                    |
| <b>HR</b>                | Heart Rate  |
| <b>HRA</b>               | Health Risk Assessment                            |
| <b>HR<sub>max</sub></b>  | Maximum Heart Rate                                |
| <b>IPAQ</b>              | International Physical Activity Questionnaire     |
| <b>LDL</b>               | Low-density Lipoprotein Cholesterol               |
| <b>LF</b>                | Lower Fitness                                     |
| <b>LPL</b>               | Lipoprotein Lipase                                |
| <b>METs</b>              | Metabolic Equivalents                             |
| <b>MPA</b>               | Moderate Intensity Physical Activity              |
| <b>MVPA</b>              | Moderate- to Vigorous-Intensity Physical Activity |
| <b>NCDs</b>              | Non-communicable Diseases                         |
| <b>PA</b>                | Physical Activity                                 |
| <b>SB</b>                | Sedentary Behaviour                               |
| <b>VO<sub>2</sub>max</b> | Maximal Oxygen Consumption                        |
| <b>WHO</b>               | World Health Organisation                         |

## DEFINITIONS OF TERMS

### Cardio-respiratory endurance:

A health-related attribute of physical fitness that pertains to the ability of the circulatory and respiratory systems in the body to supply oxygen during sustained physical activity; additionally, it is another term for cardiovascular fitness <sup>19,21</sup>.

### Delta:

The difference between the objective and subjective (self-report) measurements of physical activity, measured in minutes.

### Exercise:

A subcategory, or a type of *physical activity*; it is planned, structured and serves a purpose, generally to improve or maintain one's *physical fitness* <sup>19</sup>.

### Physical activity:

Is any bodily movement produced by the skeletal muscles that result in energy expenditure <sup>19</sup>.

### Physical fitness:

To be *physically fit* is defined as the ability to perform daily tasks with vigour and alertness without undue fatigue, and with enough energy to perform and enjoy leisure-time pursuits <sup>19</sup>. Furthermore, it is a set of health- and skill-related attributes pertaining to the ability to perform physical activity <sup>21</sup>, including *cardio-respiratory endurance, muscular strength and flexibility*, to name a few <sup>19,21</sup>.

### Physical inactivity:

Being *physically inactive* refers specifically to not meeting current physical activity guidelines, which may be further described as doing less than 30 min of moderate-intensity physical activity on at least 5 days every week, 20 min of vigorous-intensity physical activity on at least 3 days every week, or less than the equivalent combination thereof <sup>21,22</sup>.

Participants in chapter 3 of this manuscript who are *physically inactive* are referred to as being *insufficiently active* in the analyses and discussion.

## Reliability

Reliability, as a property of measurement, is the degree to which an assessment tool produces consistent results. In the context of this manuscript, the reliability of questionnaires and accelerometers are discussed<sup>115</sup>.

## Sedentary behaviours:

Sedentary behaviours are activities that involve sitting, lying down or expending low levels of energy; including watching television, travelling in a motorised vehicle and using a computer. The term *sedentary* is different to that of *physical inactivity* and *sitting behaviour*<sup>23,24,25</sup>. More specifically, sedentary behaviours can be defined as waking behaviours that expend less than or equal to 1.5 METs whilst in a seated or reclined position<sup>26</sup>.

## Sitting behaviour:

*Sitting behaviour* refers only to behaviours that are performed seated. The term *sedentary* includes seated behaviour as well as lying down (but not sleeping) and/or reclining.

## Subjective measure:

A subjective measure is a self-report measure.

## Validity

Validity refers to the degree in which a test or measuring device is truly measuring what it is intended to measure. In this manuscript, the validity of self-reported questionnaires and accelerometers for objective measurement of physical activity and sedentary behaviour are addressed<sup>115</sup>.

## **ABSTRACT**

### **Background:**

Physical activity (PA) and sedentary behaviour (SB) can be quantified with both self-report and objective measures, using questionnaires and accelerometers, respectively. There is a paucity of research investigating the possible influence that cardiorespiratory fitness and PA might have on the accuracy of self-reported of PA and SB. This is especially important with the increasing evidence around the risks of SB, independent of PA.

### **Aim:**

The aim of this research study is to describe the difference between self-reported measures of moderate PA, vigorous PA and SB against their objectively measured counterparts. The secondary aim is to identify factors influencing the error in self-report measures; including cardiorespiratory fitness and levels of PA.

### **Methods:**

A convenience sample of participants (n=113) completed the Global Physical Activity Questionnaire (GPAQ), a domain-based SB questionnaire (SBQ), a health risk assessment (HRA), and a sub-maximal 12-minute step test. Age-predicted VO<sub>2</sub>max was used to classify participants as lower fit (LF) and higher fit (HF). In addition, participants were categorised as meeting activity guidelines or being insufficiently active according to objectively measured physical activity. Participants were requested to wear the ActiGraph (GT3X) accelerometers for 7 consecutive days. The Matthews cut points for accelerometry were applied to estimate minutes of moderate and vigorous PA (MVPA) per week. Accelerations of <100 counts per minute, and inclinations (standing, sitting, lying) were used to quantify SB data. SB was subsequently classified as total SB (SED), sitting SB (SIT/SED) and non-sitting SB (no-SIT/SED). The first study included the total sample (n=113), while the second study excluded participants who did not have 7 valid wear days from the GT3X (n=63). Bland Altman plots were used to measure limits of agreement between self-reported PA (GPAQ) and objectively measured MVPA (GT3X), self-reported SB between the GPAQ and SBQ and self-reported SB (GPAQ and SBQ) and objectively measured SB (GT3X).

### **Results:**

The participants' (n=113) mean age was 37.9±12.7 years and more than 60% of the sample were categorised as HF (n=71). Moderate PA was over-reported in 34.5% of all participants. Most of the over-reporters for moderate PA were in the HF group (64.1%). Vigorous PA was over-reported by 72.6% of all participants. Bland-Altman plots showed that there were more over-reporters in the HF group (n=25) than in the LF group. 72.6% of the total sample over-reported vigorous PA. The Bland-

Altman plots indicated that as the duration of reported vigorous PA increased, so did the discrepancy between reported and measured vigorous PA increase. Participants spent almost 70% of total wear time (GT3X) in sedentary (SED) behaviour ( $13.0 \pm 3.3$  hrs/day), of which  $54.0 \pm 10.0\%$  was spent in SIT/SED. The least bias for self-reported and objectively-measured SB was shown when comparing between the SBQ to and SIT/SED. Gender played a significant role in the differences between the insufficiently- and sufficiently active participants; except between %no-SIT/SED, with insufficiently active participants having higher %no-SIT/SED time ( $p=0.009$ , adjusted for gender).

**Conclusion:**

Fitter individuals appear to over-report PA more than lesser fit participants, suggesting that cardiorespiratory fitness could influence the level of agreement between [self-reported](#) and objective measures of PA. There were no significant differences in any of the self-reported measures of sedentary behaviour, between physically active and insufficiently active participants. The results from this novel study highlight the fact that over- and under reporting are influenced by PA and cardiorespiratory fitness. Additionally, using accelerometry in conjunction with inclinometry provides a novel approach in comparing sitting and non-sitting sedentary time.

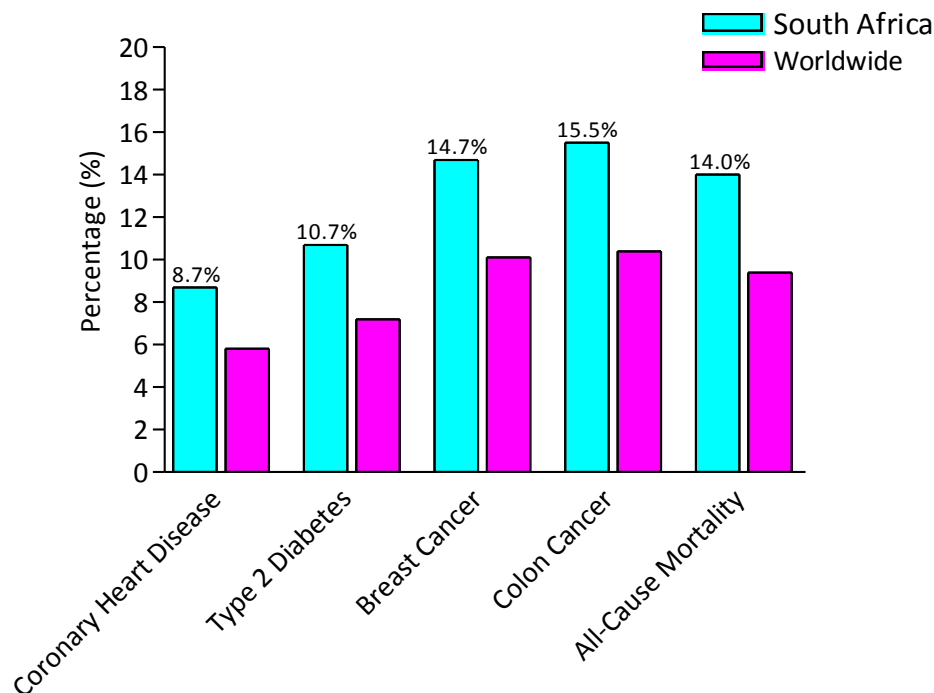
## **CHAPTER 1**

### **LITERATURE REVIEW**

## 1.1 INTRODUCTION

The benefits of physical activity have been well documented, and there is compelling evidence for the effects of physical activity in lowering the risk of all-cause mortality, cardiovascular disease mortality and morbidity, as well as type 2 diabetes, and certain types of cancers<sup>27,28</sup>. According to the WHO, physical inactivity has resulted in an estimated 3.2 million deaths<sup>29</sup>, and has been identified as the fourth leading cause of global mortality related to non-communicable diseases<sup>29</sup>. The primary mechanisms through which cardiovascular disease risk and diabetes is reduced include improved glucose metabolism, reduction in body fat and the lowering of blood pressure<sup>28</sup>. A recent review observed the effect of physical inactivity on the major non-communicable diseases worldwide<sup>30</sup>. The magnitude of the associations of physical inactivity to the non-communicable diseases, comparing South Africans to the worldwide percentages, is shown in Figure 1.

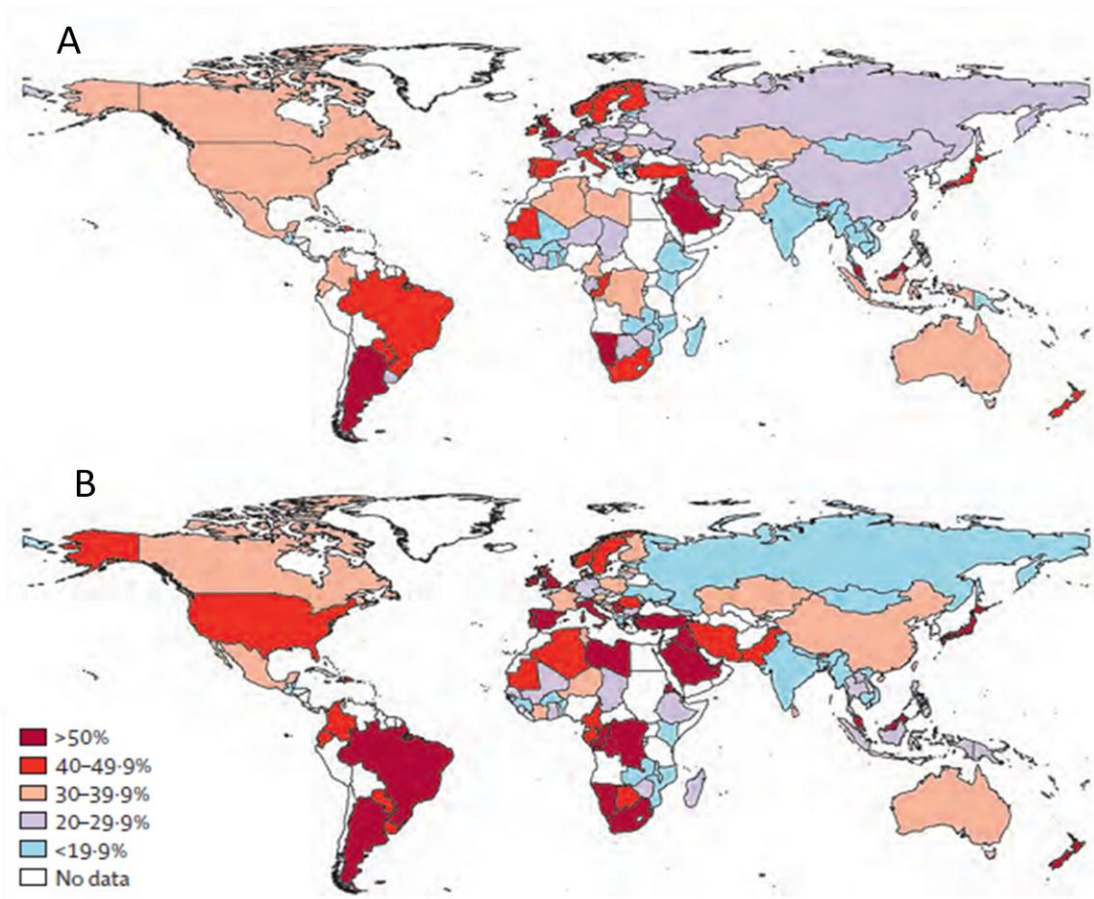
**Figure 1.1:** Estimates of disease and all-cause mortality attributed to physical inactivity in South Africa; from Lee et al., Effect of physical inactivity on major non-communicable diseases worldwide: an analysis of burden of disease and life expectancy. 2012.<sup>30</sup>



The global prevalence of self-reported physical activity suggests that 31.1% (95%CI 30.9-31.2) of adults are currently not meeting physical activity guidelines<sup>22</sup>. Nearly half of all South African men (40-49.9%) and 50% of South African women are insufficiently physically active based on self-

reported data (GPAQ) (Figure 1.2)<sup>22</sup>. Furthermore, the prevalence of physical inactivity was found to increase with age, was more common among woman and was found to be more common in countries representing higher income, versus lower income countries<sup>22</sup>.

**Figure 1.2:** Physical inactivity in adults worldwide in men (A: top figure) and women (B: bottom figure); from Hallal et al., Global physical activity levels: surveillance progress, pitfalls, and prospects. 2012.<sup>22</sup>



Sedentary behaviour, which is sometimes incorrectly used interchangeably with physical inactivity, is a developing area of interest pertaining to health. Recent evidence has shown that sedentary behaviour is a risk for metabolic disease, the metabolic syndrome and all-cause mortality. This risk has been shown to be independent of total time spent in moderate to vigorous intensity physical activity<sup>15,31,32</sup>. There is a paucity of data on the proportion of time South African adults spend sitting. Australians spend approximately 38.8 hours per week in sedentary behaviour<sup>33</sup>. Several countries have released sedentary behaviour guidelines for members of the population to follow in addition to physical activity guidelines. Australian sedentary behaviour guidelines advise

adults to sit less by making an effort to break up prolonged periods of sitting<sup>116</sup>. In the United Kingdom, the Sedentary Behaviour and Obesity Expert Working Group summarised several strategies to reduce sedentary behaviour<sup>117</sup>. These included the general reduction in sedentary behaviour throughout the day, the replacement of sedentary travel with active travel, breaking up extended sitting hours with active breaks at 30-minute intervals and reducing screen viewing time as a family<sup>117</sup>.

A timeline summary of some of the research related to sedentary behaviour published in the last ten years is illustrated in Figure 1.3.

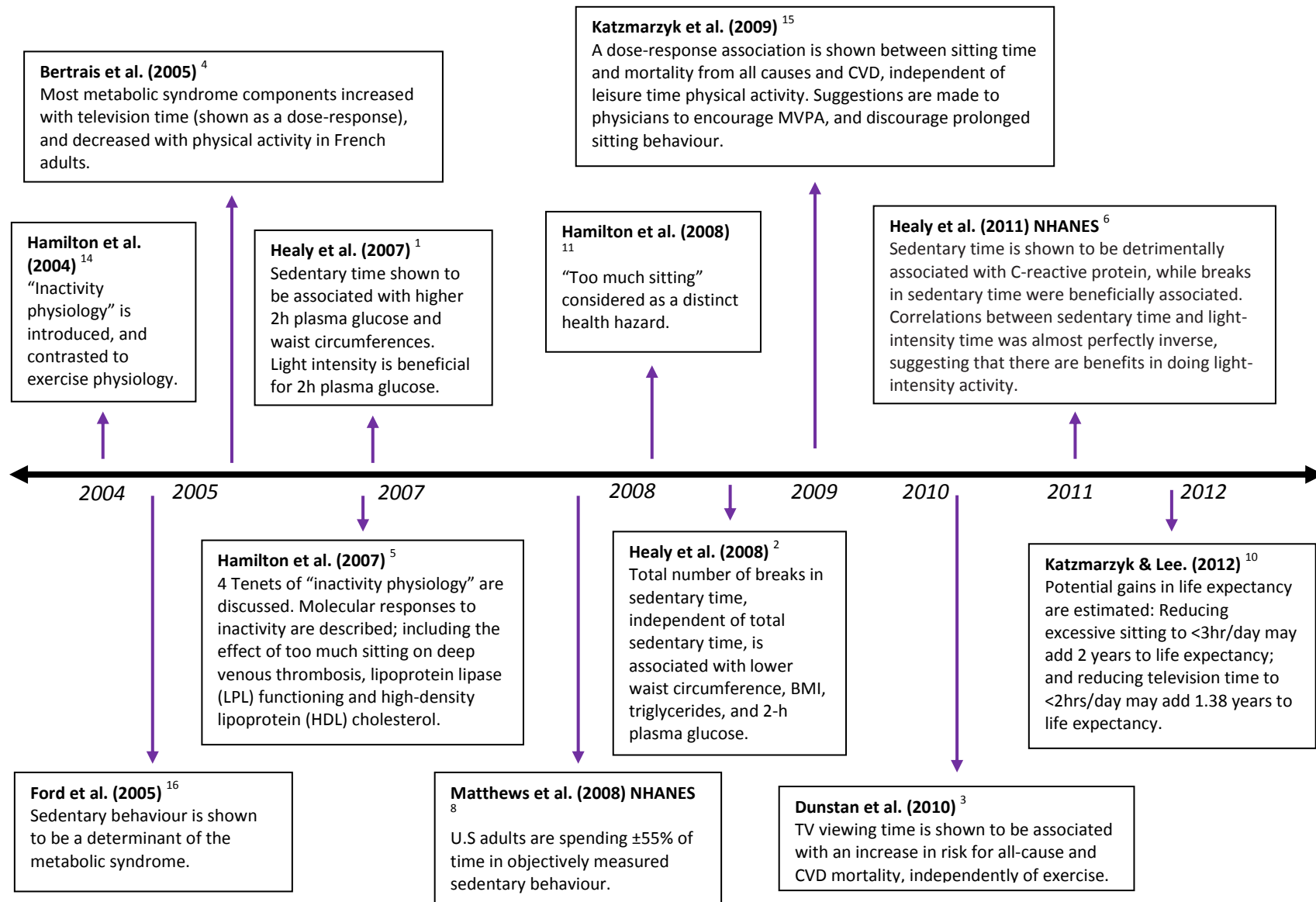
A review published in 2004 was performed in response to a growing body of evidence showing that the highest incidence of disease and mortality rates was evident in individuals who were physically inactive<sup>14</sup>. Increased sitting time and being less active associated with increased risk of all cause mortality was identified as the first tenet of inactivity physiology<sup>14</sup>. Hamilton et al proposed the need for determining the effects of prolonged sitting, and potentially evaluating prolonged sitting as a risk for diseases such as type-2 diabetes<sup>14</sup>.

Hamilton and colleagues described four tenets of inactivity physiology in 2007<sup>5</sup>, following the 2004 review<sup>14</sup>. The second tenet of inactivity physiology is that sitting time, leisure-time physical activity and exercise are distinct classes of behaviour, and as such have distinct determinants and independent effects on the risk of disease<sup>5</sup>. This second tenet ties in with research that has shown sedentary behaviour is a risk factor independent of engagement in physical activity<sup>15,31,32</sup>. The central and third tenet is based on the second tenet. Because sitting time is a distinctly different behaviour to that of exercise, the cellular processes responsible for metabolic risk factors are different and not simply the opposite of one another<sup>5</sup>. The fourth and final tenet proposes that people are unaware of the potential harm of sitting too much, and/or the benefits of maintaining low-intensity activity intermittently throughout the day<sup>5</sup>.

Subsequent researchers found that sedentary behaviour, particularly television viewing time, was associated with the metabolic syndrome<sup>16,4</sup>, 2-hour plasma glucose levels and waist circumference<sup>1</sup>. More recent research suggested that breaks in sedentary time were beneficially associated with waist circumference ( $\beta=0.16$ , 95%CI -0.31 to -0.02), BMI ( $\beta=-0.19$ , 95%CI -0.35 to -0.02), triglycerides ( $\beta=-0.18$ , 95%CI=-0.34 to -0.02), and 2-h plasma glucose ( $\beta=-0.18$ , 95%CI 0-.34 to -0.02), all  $p<0.03$ <sup>2</sup>. Following the evidence of the importance of breaking prolonged and uninterrupted sitting time,

Healy et al concluded that the need for public health recommendations for sedentary behaviour may be complimentary to current recommendations for physical activity.

**Figure 1.3: Timeline of research around sedentary behaviour and physical inactivity between 2004 and 2012.**



Recommendations for physical activity have largely been made on the basis of reducing the risk of diseases that are attributable to a lack of physical activity. Haskell et al<sup>34</sup> published physical activity guidelines for adults in 2007, following recommendations made by Pate et al in 1995<sup>35</sup>. Haskell et al stated that all healthy adults need moderate-intensity physical activity for a minimum of 30 minutes, five days weekly; or vigorous-intensity physical activity for a minimum of 20 minutes, three days weekly<sup>34</sup>. A combination of moderate intensity and vigorous intensity activity can be performed to meet this recommendation<sup>34</sup>. These guidelines are congruent with the current American College of Sports Medicine (ACSM) recommendations for physical activity<sup>21</sup>, as well as the physical activity guidelines for Americans (PAGA) (<http://www.health.gov/paguidelines/guidelines/chapter1.aspx>)<sup>36</sup>. Adults aiming to further reduce their risk for chronic diseases and/or disabilities, to improve their cardio-respiratory fitness, or who want to prevent unhealthy weight gain may benefit by exceeding the minimum recommended amounts of physical activity<sup>34</sup>. Furthermore, there is a dose response between physical activity and potential health and fitness benefits<sup>37</sup>.

It is important for researchers, policy makers and practitioners who prescribe physical activity to measure physical activity and inactivity levels as accurately as possible. Physical activity and sedentary behaviour can be measured with self-report and objective measures. [These two measures can however, provide two different results, and will be discussed further in this literature review.](#) The information gained can be used to inform members of the general population of their current levels of physical activity levels and sedentary behaviour. Additionally, measurement is necessary for the prescription of physical activity and educating individuals on reducing risk related to sedentary behaviour.

## **1.2 AIM OF THIS LITERATURE REVIEW**

Therefore the aim of this literature review is to provide a brief overview of objective and self-reported measurement of physical activity and sedentary behaviour. A summary of the factors effecting self-report with a greater emphasis on the role of cardiorespiratory fitness is included. Due to the limited scope of this review, an in-depth discussion of all the methods of measurement of cardiorespiratory fitness, sedentary behaviour and physical activity will not be addressed.

### 1.3 SEARCH STRATEGY

The Pub Med database was used and terms included in the search strategy were ‘*physical activity, sedentary behaviour, ActiGraph GT3X, GPAQ, physical activity questionnaires and self-reported measures*’. Due to the limited scope and depth of this literature review, systematic reviews and meta-analyses were included as references, in addition to empirical studies. The search for publications pertaining to sedentary behaviour, prevalence data and recommendations was limited to the last ten years.

### 1.4 SUMMARY OF LITERATURE

#### 1.4.1 Objective measures of physical activity and sedentary behaviour

Objective measures that have been used to **measure** PA include doubly labelled water <sup>38,39</sup>, pedometers <sup>40,41</sup> and accelerometers. The following section of the literature review will focus on the utility of accelerometers.

Accelerometers are small devices that use counts derived from accelerations to measure and quantify movement. The most common brand of accelerometers used in research includes the ActiGraph (ActiGraph, LLC, Fort Walton Beach, FL). The ActiGraph accelerometers have progressed from the initial ActiGraph model 7164 (used in the 1990s), to the newer models including the ActiGraph GT1M, GT3X and GT3X+. The older ActiGraph models have been used extensively in research and have been validated for measuring physical activity <sup>42,43,44,45,46,47,48</sup>. **Newer ActiGraph models are able to provide objective measure of sedentary behaviour <sup>49,46,47,48</sup>, although it is not the gold standard for the measurement of sedentary behaviour.** The ActiGraph GT3X is a tri-axial accelerometer, measuring accelerations in three planes of motion. The accelerometer records counts (from accelerations) within the set epoch length. Further details of this device can be viewed at <http://www.actigraphcorp.com/support/devices/gt3x/>.

The epoch length is a predetermined time interval, usually in seconds, over which a summed value of the activity is measured and averaged per epoch. The accepted practice is to set an accelerometer in 60-second epochs when **measuring** physical activity in adults, thereby providing an average sum of counts which is recorded “minute-to-minute” <sup>50</sup>. The counts recorded are reflected in the raw data files, and the levels of activity that the counts will ultimately represent are based on the choice of cut points used. Table 1.1 provides an overview of the count thresholds that have been used to determine the intensity of physical activity.

The Freedson equation was first developed to be applied with data collected from the CSA ActiGraph model <sup>51</sup>, and has since been used extensively in physical activity research <sup>52,1,53</sup>. This equation has been used in comparative studies between self-report and objective measures <sup>54</sup> (results shown in Table 1.2), in addition to being used in research comparing several models of ActiGraph monitors <sup>55</sup>. The Hendelman <sup>56</sup> and Swartz <sup>57</sup> equations were developed as “lifestyle” cut points, and therefore

**Table 1.1: Cut point thresholds for counts in accelerometry**

|                                  | Matthews <sup>58</sup> | Freedson <sup>51</sup> | Hendelman <sup>56</sup> | Swartz <sup>57</sup> | Troiano (NHANES) <sup>59,7</sup> |
|----------------------------------|------------------------|------------------------|-------------------------|----------------------|----------------------------------|
| Sedentary behaviour              | 100                    | -                      | -                       | -                    | -                                |
| Light intensity activity         | < 759                  | < 1952                 | <2190                   | <573                 | <2020                            |
| Moderate intensity activity      | 760 – 5998             | 1952 – 5724            | 2191 – 6893             | 574 – 4945           | 2020 - 5998                      |
| Vigorous intensity activity      | > 5999                 | 5725 - 9498            | >6893                   | >4945                | >5999                            |
| Very vigorous intensity activity | -                      | > 9498                 | -                       | -                    | -                                |

only provide an accurate estimate of time spent in “lifestyle” activities that are moderate intensity <sup>60</sup>. “Lifestyle” activities include household activities such as sweeping, washing dishes and mopping <sup>60</sup>. Because the Hendelman and Swartz equations are based almost entirely on moderate intensity activities, it has been reported that these cut points are likely yield less accurate measurements for light or vigorous intensity activities <sup>60</sup>.

Matthews and Troiano cut points are not limited to “lifestyle” activities, but rather include moderate and vigorous physical activity thresholds (Table 1.1). Troiano’s cut points have been used extensively in the ongoing NHANES research for the measurement of physical activity <sup>7,59,36</sup> (also shown in Table 1.2). Matthews (2005) cut points has been used in several studies for the calibration of ActiGraph accelerometers, including a study with Chinese adults <sup>61</sup> and females at risk for breast cancer <sup>62</sup>. Objectively measured and self-reported MVPA were compared and the level of agreement was 80 (IQR 58,106) and 94 (IQR 60,141) minutes per day, respectively <sup>62</sup>. The Matthews and Troiano cut points were recently compared to indirect calimetry and free-living conditions <sup>60</sup>. The Matthews cut point over-estimated sedentary time by 9.9% and moderate physical activity by 33.4% in comparison to free-living conditions. Similarly, **Troiano’s cut point under-estimated sedentary time by 8.3% and moderate physical activity by 50.4%**. Matthews cut points had under-estimated light and vigorous physical activity by 25.7% and 50.1% respectively <sup>63</sup>. Additionally, the Matthews cut

points had the lowest mean bias for time spent in MVPA, overestimating measured time spent in MVPA in comparison to indirect calimetry by 13.6 min (26.3%)<sup>63</sup>.

The most prominent limitation when using accelerometers is that there are several cut points, none of which have been regarded as a gold standard for physical activity measurement in adults. Consequently, comparing results from various studies with different cut-points can be challenging. Furthermore, as new devices are developed and technology becomes more sophisticated, researchers are faced with the challenge of choosing cut points that not only best suit their study sample, but also the device used.

There are far less variations of cut point thresholds used for the measurement of sedentary behaviour, with most researchers accepting a cut point of <100 counts for a minute as representing sedentary behaviour<sup>8,1,31,53,64,65</sup>. This cut point has been accepted for most models of the ActiGraph range. One of the first researchers to challenge the use of <100 counts per minute was Kozey-Keadle (2011), who compared different cut points (ranging from 50, 100, 150, 200 and 250 counts per minute) in the ActiGraph GT3X to direct observation<sup>66</sup>. These researchers found that the <100 counts per minute cut point underestimated sitting time by 4.9%, as opposed to using <150 counts per minute, which had the least bias (1.8%). The same research team have since found in a subsequent comparative study between two accelerometry devices that the <100 counts cut point was more accurate than the <150 counts cut point<sup>67</sup>. This inconsistency in the findings pertaining to the sedentary threshold may be why the <100 counts per minute threshold is still accepted for the measurement of sedentary behaviour.

The ActiGraph GT3X is able to **estimate** a participant's body position (classified as either lying down, sitting or standing) by using the inclinometer function. Therefore, the inclusion of **inclination** data **provides** researchers **with more information regarding** the individual's posture in addition to **estimating** the volume of physical activity. **In addition**, researchers **are able to measure** and further describe posture in a given intensity. For example, combining accelerometry and inclinometry identifies whether an individual is standing, whilst being sedentary, determined by less than 100 counts recorded in that minute. Conversely, one can be seated based on the position of the inclinometer, but moving about thereby achieving more than 100 counts per minute. The need for postural analysis has been mentioned<sup>68,69</sup>, although the inclusion of inclinometer data using the ActiGraph brand in research of sedentary behaviour and physical activity is limited. This might be due in part, to the inconsistencies in some published data using the inclinometer **function**. A small

validation study (n=10) comparing inclinometry to direct observation found that the ActiGraph GT3X had an accuracy of 96.5% for time spent in free-living sitting behaviour, provided the GT3X was placed on the right hip<sup>70</sup>. Accuracy levels were lower for free-living lying down (30%) and standing (90%), and these levels were dependant on the placement of the GT3X. A more recent and larger validation conducted by Hänggi et al. (2013) found that sitting was recorded accurately when compared to direct observation (94%) by the inclinometer function in children aged 10-15 years<sup>71</sup>.

Santos-Lazona et al published an article describing the use of the vector magnitude for analysis. The vector magnitude is the vector summed value of all three axes measured from the tri-axial GT3X, calculated as the square root of the total sum of each axis, squared ( $X^2 + Y^2 + Z^2$ ), then square rooted<sup>72</sup>. Other studies have used a similar approach with vector magnitude values<sup>118</sup>, including an abstract published by Sasaki et al, who concluded that the vector magnitude of the GT3X can be used to quantify PA. They further describe the use of vector magnitude cut points as <2491 counts/min for light PA, 2491 to 5944 counts/min for moderate PA, 5945 to 10,536 for vigorous PA and >10,536 counts/min for very vigorous PA<sup>118</sup>. This method has been used in international studies, including the International Physical Activity and Environment Network (IPEN) and Neighbourhood Quality of Life Study (NQLS)<sup>119</sup>.

Chastin and Granat developed and tested several techniques of sedentary behaviour analysis by use of complex equations and an ActivPAL device<sup>73</sup>. The different techniques of measurement included were 1. Global sedentary time, described as the summation of sedentary postures, 2. Distribution of the length of bouts of sedentary behaviour, looking at the density of sedentary bouts in a given time spans and then plotted on a log-scale against the bout length and 3. The measurement of accumulated sedentary time patterns which describes the fraction of total sedentary time that is accumulated in bouts<sup>73</sup>.

The ActiGraph GT3X has been used in recent studies to measure both physical activity and sedentary behaviour<sup>74,75,76</sup>, and has been shown to correlate well against oxygen consumption in a laboratory setting<sup>77</sup>. Furthermore, the ActiGraph GT3X has been shown to have good inter-instrument reliability<sup>72</sup>. The research team that conducted the reliability study compared each axis of eight ActiGraph GT3X monitors, placed on the left and right hips of a single participant<sup>72</sup>. Significant differences in left and right hip were observed in one axis for one of the treadmill conditions (jogging at 8km/hr,  $p < 0.001$ ), and for a different axis for the sit-to-stand action ( $p < 0.001$ )<sup>72</sup>. Furthermore, for all three axes, the lowest intra-class correlation was 0.925 and the highest ICC was 0.998; with all ICC values significant at  $p < 0.01$ . Other studies that have made use of the ActiGraph GT3X include

research on older adults<sup>78</sup>, individuals with chronic kidney disease<sup>79</sup>, as well as participants with chronic obstructive pulmonary disease<sup>80</sup> and multiple sclerosis<sup>81</sup>.

Another accelerometer that has been used to measure physical activity and sedentary behaviour is the ActivPAL (PAL Technologies Ltd, Glasgow, Scotland). This accelerometer is an inclinometer-based, uni-axial accelerometer, and like the ActiGraph GT3X, it is able to detect walking, sitting and standing. The difference between the ActiGraph GT3X and the ActivPAL is that the ActivPAL is worn on the anterior aspect of the thigh<sup>82</sup>, whilst the ActiGraph GT3X is worn on the hips. The ActivPAL sums data in 15-second epochs, which is then computed as time spent in sedentary behaviour (sitting/lying), walking and standing<sup>83</sup>. More information for this device can be viewed at <http://www.paltech.plus.com/products.htm>. The ActivPAL has been regarded by some as the criterion measure for sedentary behaviour<sup>67, 84</sup>. In addition, the ActivPAL has been found to have excellent levels of agreement with direct observation for sitting, standing and stepping (100%, 98.1% and 99.2% respectively)<sup>76</sup>. Use of the ActivPAL has been encouraged in studies that have examined sedentary behaviour in detail<sup>24</sup>, in addition to being validated in the measurement of sedentary behaviour in adults<sup>66</sup>.

The ActiGraph GT3X and the ActivPAL have been compared in some research studies in order to establish which device provides a better measurement of physical activity and sedentary behaviour<sup>76,85,67,66,83</sup>. A research study comparing the use of the ActiGraph GT3X and the ActivPAL for the detection of breaks in sedentary time (versus direct observation) showed that time spent in sedentary time measured by the ActivPAL was significantly correlated with direct observation (%bias=1.6, 95%CI -0.1 - 3.4; correlation = 0.99)<sup>85</sup>. The ActiGraph GT3X performed poorly compared to the ActivPAL, with %bias=12.1, 95%CI 1.3 – 22.9; correlation = 0.58<sup>85</sup>. Another comparative study of the ActiGraph GT3X and ActivPAL found that the differences found in time spent in sedentary behaviour and time spent walking were significant<sup>83</sup>. This particular study did not have a criterion measure, but rather compared each device to the Bouchard Activity Record (BAR), which is an activity log used to assess physical activity and sedentary behaviour. The devices were worn concurrently, yet the GT3X consistently and significantly yielded more sedentary time (according to the <100 counts per minute threshold) than the ActivPAL ( $p < 0.001$ )<sup>83</sup>. This study concluded that the ActiGraph GT3X is limited in its capability of detecting time in standing behaviours specifically, while the ActivPAL does not have the capability of detecting time spent in MVPA<sup>83</sup>.

Neither of the comparative studies between the ActiGraph GT3X and ActivPAL discussed above used the inclinometer function in the GT3X<sup>83,85</sup>. This may explain the discrepancies found between these

two devices, because the ActivPAL primarily uses inclinometry for measurement. The ActiGraph GT3X uses counts primarily, and inclinometer data can only be obtained if the function is activated prior to the individual wearing the device. In essence, comparing the two devices without activating the inclinometer function in the ActiGraph GT3X means that the devices are not measuring the same thing.

In summary, the use of the inclinometer function in the ActiGraph GT3X has not been researched extensively, although it has been validated for the measurement of physical activity. The use of accelerometry with inclinometry allows the ActiGraph GT3X to measure sedentary behaviour in the same manner as the ActivPAL, which has been shown to be superlative in its capabilities of measuring sedentary behaviour, in addition to measuring physical activity. Therefore, more research is required to evaluate the inclinometer function of the GT3X.

#### **1.4.2 Self-reported measures of physical activity and sedentary behaviour**

Records, logbooks and questionnaires are examples of subjective measures of physical activity and sedentary behaviour<sup>40</sup>. Although logbooks may provide researchers with extensive detail of one's activity, they provide a great administrative load on both the researchers and participants<sup>40</sup>. Questionnaires have a lower administrative load, and can be self-, telephonically- or personally administered<sup>40</sup>. The International Physical Activity Questionnaire (IPAQ), the Global Physical Activity Questionnaire (GPAQ), and Sedentary Behaviour Questionnaires will be discussed in this review.

The International Physical Activity Questionnaire (IPAQ) was developed in response to the need for an international and reliable tool that measures total habitual physical activity, across multiple domains<sup>86</sup>. There are two versions of the IPAQ, the long 31-item and short 9-item version<sup>86</sup>. The long item includes the following domains of physical activity: Occupational, transport, garden, household and leisure<sup>86</sup>, all of which are reported on separately. The short-form of IPAQ considers all domains listed in the long item, however physical activity is reported on collectively, as one value. The short form IPAQ has been used to compare prevalence of sitting time between countries worldwide<sup>87</sup>, as well as physical activity<sup>88</sup>. Several limitations of the short IPAQ have been reported, including the fact that it is limited in its assessment of only total physical activity, and therefore it cannot detect changes in physical activity in any of the domains<sup>89</sup>. Misinterpretation of moderate intensity activity in the IPAQ has resulted in high prevalence estimates of moderate intensity physical activity, which is not accurate; as well as high variance in small study groups and general

over-reporting<sup>89</sup>. In an attempt to reduce these limitations in a surveillance tool, the Global Physical Activity Questionnaire was developed<sup>89</sup>.

The GPAQ was developed in 2002 as a global surveillance tool for physical activity<sup>90</sup> (Appendix A). In the GPAQ, participants estimate the amount of moderate and vigorous intensity physical activity performed, for at least 10 minutes at a time, in the various domains of physical activity; including the occupation, leisure, travel and domestic (household) domains<sup>90</sup>. In addition, participants report on the amount of time they spend sitting or lying down on a usual day, excluding sleeping. The GPAQ has been validated in South Africa<sup>91</sup> as well as other African countries<sup>92</sup>.

The GPAQ has several strengths when compared to the IPAQ. A study by Rzewnicki et al (2002) addressed over-reporting of physical activity in the IPAQ in response to the tendency for participants to over-report activity<sup>9</sup>. The IPAQ was administered telephonically to fifty participants (n=50), nearly half of which (47%) were classified as overweight or obese (BMI>25)<sup>9</sup>. This study found that almost half (n=23) of the participants had reported some amounts of physical activity in the IPAQ, when they should have actually reported doing no physical activity<sup>9</sup>. Other studies have also reported over-estimation of physical activity in the IPAQ, with the long-version producing higher estimates of physical activity<sup>86</sup>, and over-estimation of moderate and vigorous activity in HIV-infected individuals<sup>93</sup>.

Although the IPAQ and GPAQ are used primarily to quantify self-reported physical activity, each questionnaire includes only a single question for time spent sitting on a typical day<sup>86,90</sup>. The use of single questions in measuring sedentary behaviour has been shown to be significantly lower than objectively measured sedentary behaviour<sup>94</sup>. Clemes et al showed that both week day and weekend day sitting time was significantly under-estimated by a single question by -173±18 and -219±23 minutes per day, respectively<sup>94</sup>. Another study compared the IPAQ single item to the ActiGraph Model 7164 using <100 counts per minute to define sedentary behaviour. [They found that the correlation between the short-form IPAQ sitting time and accelerometer was low \(r=0.34\)](#)<sup>95</sup>.

Poor self-reported sedentary behaviour according to single-item questionnaires lead to researchers to identifying the need for domains-based sedentary behaviour questionnaires. Examples of sedentary behaviour domains are television viewing, occupation and computer use. Television viewing time has been identified as one of the most frequently reported sedentary behaviour of adults<sup>96</sup>. As a result, TV viewing has been used as a proxy for sedentary behaviour in some research studies<sup>97,3,98</sup>. Previous research has shown that a single question pertaining to television sedentary

time underestimated total sitting time, whereas the domain-specific questionnaire significantly overestimated sitting time (when compared to the ActivPAL)<sup>67</sup>. Therefore, the use of a single domain for the measurement of sedentary behaviour is not enough to account for total sitting time, and therefore a questionnaire that encompasses several sedentary behaviour domains is necessary.

The use of a domain-based questionnaire, with a distinction between week and weekend days has been justified by Marshall et al<sup>49</sup>. People appear to report sitting behaviour more accurately if the sitting is structured, such as done in travel or at work; and that sitting behaviour in the week was different to week-ends<sup>49</sup>. Furthermore, the researchers concluded that estimations of total sitting time are improved when it is summed up according to different domains, based on the domains-based questionnaire having good overall agreement with the objective measure of sedentary behaviour (ICC=0.64; t-test  $p>0.05$ )<sup>94</sup>.

In summary, a sedentary behaviour questionnaire that is inclusive of sedentary behaviour domains, such as occupation and television viewing, is necessary for a more accurate account of sedentary behaviour via self-report. However, one particular limitation of domains-based questionnaires has been highlighted by Kozey-Keadle et al<sup>67</sup>, in that some participants might double-report time spent in activities across more than one domain<sup>67</sup>. This is one factor amongst many that influence self-report, and will be discussed in the next section.

### **1.4.3 Factors influencing self-report**

As early as 1985, researchers identified some of the challenges of using self-reported physical activity in epidemiologic research<sup>99</sup>. Several practical considerations when selecting a self-report includes the study design and population, the time frame that respondents are required to remember, the details of any given activities as well as the method of data collection<sup>99</sup>. Figure 1.4 summarises the factors influencing self-reported sedentary behaviour from more recent peer-reviewed publications. Bubbles of the same colour, and that overlap in the figure, are indicative of factors that are linked. Due to the scope of this review, the factors in the figure will only be briefly discussed. However, there will be a more detailed discussion on the influence of cardiorespiratory fitness and physical activity on self-report.

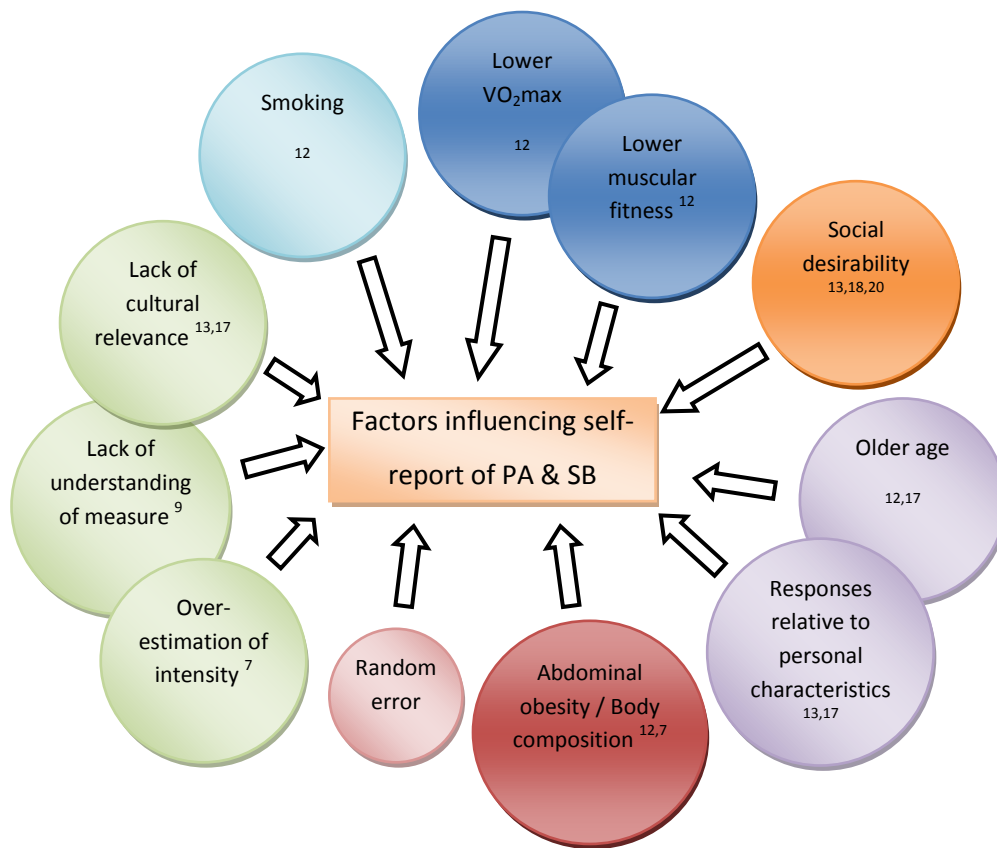
A recent study observed the associations between self-reported and objectively measured MVPA with physiological and anthropometrical biomarkers<sup>7</sup>. Participants in this study provided self-reported data for the intensity and time spent in recreational, household and transport physical

activity domains. In addition, they wore an ActiGraph 7164 which provided an objective measure of physical activity. Stronger associations were observed between objective MVPA and systolic blood pressure ( $p < 0.01$ ), BMI ( $p < 0.0001$ ), waist circumference ( $p < 0.0001$ ) and skinfolds (triceps and subscapular;  $p < 0.0001$ )<sup>7</sup>. Furthermore, this research team concluded that self-reported and objective measures differ because self-report captures physical activity behaviours as they are perceived by the participant. Therefore, an individual may misclassify or over-/under estimate the intensity of an activity<sup>7</sup>. Another reason for over- and/or under estimation in self report may be due to a lack of understanding questions<sup>9</sup>. This factor was observed in a study that probed each participant, asking them to describe their self-reported activity in addition to administering the IPAQ to the participants<sup>9</sup>. The answers and measurement of physical activity obtained through probing the participants was significantly lower than self-administered self-reporting activity<sup>9</sup>, meaning that probing a participant may be a more accurate method of obtaining self-reported physical activity.

#### **1.4.4 Cardiorespiratory fitness as a factor effecting self report**

There is a paucity of research studies examining the effects of cardiorespiratory fitness and physical activity on self-report. Fogelholm et al<sup>12</sup> assessed the validity of the IPAQ against cardiorespiratory fitness, in response to growing evidence of over-reporting in the IPAQ<sup>86,9</sup>. The study included adult Finnish men ( $n=967$ ), who completed a fitness test battery to measure their cardiorespiratory and muscular fitness<sup>12</sup>. Characteristics of over-reporters, included being older ( $p=0.02$ ), abdominal obesity (measured as waist circumference;  $p=0.02$ ), current smoking ( $p=0.03$ ) and having less than 12 years of education ( $p=0.02$ ). In addition, over-reporters had lower  $VO_2$ max scores ( $p < 0.001$ ) and lower abdominal, upper body and lower body muscular fitness ( $p < 0.001$ ;  $p=0.005$  and  $p=0.01$ , respectively).

**Figure 1.4: Factors influencing self-report measures of physical activity and sedentary behaviour.**



A recent study using NHANES data (n=3725) examined objectively measured variables, including MVPA and sedentary time, to self-reported MVPA (categorised as <150 or > 150min/week) and leisure-time sedentary behaviour (categorised as <3 or > 3hrs/day)<sup>100</sup>. Self-reported MVPA was evaluated with questions pertaining to transport, household and leisure time activity over the past 30 days; and sedentary time was evaluated with a categorical sentence that best described their sitting behaviour over the last 30 days. The self-report data was compared to 1 valid day of objectively measured activity using the ActiGraph 7164. This study found that participants that were reporting >150min/week of MVPA had significantly more objectively measured light, moderate, and vigorous intensity PA, than those who reported not meeting PA guidelines (all p<0.0018). Participants who reported spending >3hrs per day in leisure-time sedentary behaviour had significantly higher objectively measured sedentary time, in addition to having significantly lower objectively measured light and moderate intensity physical activity (all p<0.0018). These results suggest that physical activity levels, and more specifically compliance to PA guidelines, play a role in the ability to recall physical activity as well as sedentary behaviour<sup>100</sup>.

In summary, there are many factors that influence self-reported physical activity and sedentary behaviour. Specifically, there is limited data regarding the effect of cardiorespiratory fitness and physical activity on self-report. It is therefore necessary for more research to explore these factors, to help researchers understand all factors that may contribute to error in self-report.

#### **1.4.5 Comparisons of self-report and objective measures**

Table 1.2 summarises some of the data already presented, in addition to comparative research studies pertaining to self-report and objective measures. Only publications from the last 5 years have been included in the table. The summary of the studies has been ordered chronologically, according to the date of publication. The main findings in the table are those that relate to the comparison of self-report and objectively measured physical activity and sedentary behaviour. There are several commonalities between the studies presented in Table 1.2. Firstly, the common protocol to determine valid accelerometer data was at least 4 days of 600 minutes per day, per participant. This has been validated<sup>59</sup> and is accepted, although 7 days of wear has been shown to provide the most reliable measure of physical activity and inactivity<sup>52</sup>. Secondly, a limited amount of studies have used the newer ActiGraph models when comparing self-report and objective measures of physical activity and sedentary behaviour. This highlights an important gap in the research as it is important to know how these newer models compare to self-report measures. Lastly, there are few formally-developed and validated domains-based sedentary behaviour questionnaires. As this research area continues to grow, this is an area that should be explored to assist researchers with sedentary behaviour surveillance.

**Table 1.2: Selected summary of publications: Comparisons of self-reported and objective measures of sedentary behaviour and physical activity.**

| Aim of Study / Measurement of SB / PA?   | Participants included   | Objective measure           | Cut Points                                  | Valid days of wear used; Daily time accepted | Self-report measure   | Main findings  | Reference                    |
|--|---|-----------------------------|---|--|---|--|------------------------------|
| Examined the relationships of self-reported PA by domain, with objectively measured PA and sedentary time.<br><br>PA & SB measurement                          | n=141 (men=37%); French adults, 18-74yrs of age.                | ActiGraph 7164              | SB: <100 counts per min<br><br>PA: Freedson | 4 days of wear; 8hrs/day                     | MAQ (Modifiable Activity Questionnaire) and IPAQ (short)  | Objective measures: Average time in SB=52.8% of daily recording.<br><br>Total objective PA (in counts/day) was positively associated with self-reported PA in MAQ ( $r=0.19$ ; $p<0.05$ ).<br><br>Total objective SB was negatively associated with self-reported screen viewing time by MAQ ( $-0.13$ ; $p<0.1$ ).  | Jacobi, D 2009.<br><br>54    |
| Compared self-report and accelerometer PA outcomes, determined relationship between these two assessment tools.<br><br>PA measurement                          | n=3082 (men=49%); NHANES data – American adults, >20yrs of age. | ActiGraph 7164              | PA: Troiano                                 | 4 valid days; 10hrs/day                      | Not defined, stated as “...household interview and included a series of questions that required participants to recall physical activity behaviours during the past 30 days.” | Self-report data yielded estimates of 324.5min/week of moderate intensity PA and 73.6min/week of vigorous intensity PA. The corresponding objective measurements were 45.1min/week of and 18.6min/week respectively.<br><br>Participants who met guidelines according to self-report made up 62% of the sample. Objective measurement reduced the amount of adults meeting guidelines to 9.6%. | λ Tucker, JM 2011.<br><br>36 |
| Examined the independent associations of self-reported and objectively measured (MVPA with physiological and anthropometric biomarkers).<br><br>PA measurement | n=5797 (men=49%); NHANES data – American adults, >20yrs of age. | ActiGraph 7164              | PA: Troiano                                 | 4 days of wear; 10hrs/day                    | Not defined, stated as “questions assessing the mode, frequency, and duration of recreation, household and transport activity.”   | Average amount of self-reported MVPA was 54.8min/day, and the average amount of objectively measured MVPA was 6.7min/day.  | † Atienza, AA 2011.<br><br>7 |
| Examined the convergent validity of various tools used to measure  | n=13 (over weight/obese adults); 20-60yrs                       | ActivPAL and ActiGraph GT3X | SB: <100 and <150 counts per                | 4 days of wear; 10hrs/day                    | T-SQ (total sitting questionnaire), D-SQ (domain-specific 28  | The D-SQ significantly overestimated sitting time on weekdays by 176min and on weekend days by 157.6min when compared to the ActivPAL.   | Kozey-Keadle, A 2011.        |

|  |  |                          |   |   |   |   |  |
|--|--|--------------------------|---|---|---|---|--|
| sedentary time.<br>SB measurement  | of age.  |                          | minute                                  |   | questionnaire).   | The GT3X (<100 counts) significantly underestimated sedentary time by 40min. The GT3X (<100 counts) and ActivPAL correlated <b>moderately</b> for weekday measures (r=0.52; p<0.05), and <b>correlated well</b> for weekend day measures (r=0.68; p<0.05).  | <sup>67</sup>                                |
| Compared the cardio-metabolic risk factor dose-response relationships for PA and SB between self-report and objective measures.<br>PA & SB measurement | n=317 (men=44%); Chilean adults, 18-73yrs of age.  | ActiGraph<br>ActiTrainer | SB: <100 counts per min<br>PA: Freedson | 4 days of wear ;<br>10hrs/day                       | IPAQ (long)   | Mean self-reported sitting time was ±13% lower than objectively sedentary time (p<0.0001).<br><br>Self-reported estimates of moderate activity, vigorous activity and MVPA were 2.6-, 4.0- and 2.6-fold higher, respectively, than the corresponding objectively measure of the PA intensities (all p<0.0001).  | †Celis-Morales, CA<br>2012.<br><sup>46</sup> |
| Examined the convergent validity of two self-report measures of sitting time and objectively measured sedentary time.<br>SB measurement                | n=44 (men=30%); UK adults, 23-65yrs of age.        | ActiGraph<br>GT1M        | SB: <100 counts per min                 | 7 valid days;<br>10hrs/day (reported as 600min/day) | Not defined, first self-report measure stated as a single question in a diary: “how long have you been sitting for today?” Second self-report measure described as a domain-specific sitting questionnaire. | Self-reported measures for the domain-specific questionnaire showed that total sitting time was 626min/weekday and 616min/weekend day.<br><br>There was good overall agreement between total self-reported sitting time from the domain-specific questionnaire and objectively measured sedentary time on weekdays and weekend days.<br><br>Mean self-reported from the single item question was significantly lower on weekdays and weekend days than objectively measured sedentary time (both p < 0.001) | Clemes, SA<br>2012.<br><sup>94</sup>         |
| Compared self-reported and objectively measured MVPA.<br>PA measurement  | n=77 (men=51%); College students, 17-24yrs of age. | ActiGraph<br>GT3X+       | PA: Troiano                             | 4 days of wear;<br>10hrs/day                        | IPAQ (short)  | Self-reported MVPA averaged 66.14min/day. Objectively measured MVPA averaged 19.90min/day.<br><br>Self-reported and objectively measured MVPA were not significantly correlated, r(77)=0.21; p = 0.08.<br><br>Paired-samples t-test revealed that participants’ self-reported MVPA levels were significantly higher than objectively measured MVPA levels, t(68)=-6.69; p < 0.001.  | ‡Downs, A<br>2013.<br><sup>101</sup>         |

|  |   |   |  |                           |  |   |   |
|--|---|---|--|---------------------------|--|---|---|
| Validated self-report measures against objective measures of total sitting time.<br>SB measurement   | n=26 (office workers)   | ActiGraph GT3X+                                 | --                                     | --                        | --   | Bland-Altman plots showed poor agreement between objectively measured and self-reported sitting time (mean difference between 0.5 to -2.4h, limits of agreement 3.3-10.8h)  | Lagersted-Olsen, J<br>2013(Abst ract).<br>102 |
| Examined several variables of objectively measured activity against various categories of self-reported MVPA.<br>PA & SB measurement   | n=3725 (men=47.5%); NHANES data – American adults; >20yrs of age. | ActiGraph 7164                                  | SB: <100 counts per min<br>PA: Troiano | 1 valid day;<br>10hrs/day | Not defined, stated as “Participants were asked a series of questions regarding their transportation, household/domestic, and leisure-time physical activity and sedentary behaviour.” | Objective measurement showed that participants spent an average of 478.9min/day in sedentary behaviour.<br><br>Participants reporting ≥150 minutes/week of MVPA had significantly higher means for all objectively measured indicators of physical activity when compared to those reporting < 150 minutes/week (p<0.0018). | λ Schuna, JM<br>2013.<br>100                  |
| Reviewed articles that validated the short form IPAQ versus accelerometry or pedometers.   | n=23 (papers reviewed)  | Varied – review (accelerometers and pedometers) | Varied - review                        | Varied - review           | IPAQ (short)   | The short-form IPAQ has been found to have small correlations with objective measures of physical activity. This was shown in a variety of participants, including adults, older adults and school-going children.  | # Lee, PH<br>2011<br>103                      |
| † Papers have looked at effects of measurements on other health markers<br>‡ Paper included a cardiovascular fitness test as a component<br>λ Paper included categorisations for individuals according to reportedly meeting or not meeting activity guidelines<br># Paper is a review of other papers |   |   |  |                           |  |   |   |

## **1.5 SUMMARY**

In summary, research relating to sedentary behaviour and physical activity has increased and evolved over the years. The use of a domain-based questionnaire for the measurement of physical activity has been discussed, and the need for domain-specific questionnaires for the subjective measurement of sedentary behaviour has been identified.

This literature review has highlighted the importance of using objective measures for the measurement of physical activity and sedentary behaviour, specifically a device that accounts for intensity of activity as well as postural detection and changes. The ActiGraph GT3X has been validated for use in physical activity measurement, yet the use of an inclinometer has not yet been thoroughly investigated.

## **1.6 AIM OF MINI DISSERTATION**

Therefore, the aim this mini dissertation is to determine whether the level of agreement between self-report and objective measures of physical activity is influenced by cardiorespiratory fitness. Self-reported physical activity (from the GPAQ) and sedentary behaviour (from a domains-based SBQ) will be compared to objective measures of physical activity and sedentary behaviour obtained from the ActiGraph GT3X accelerometer.

The first aim (Chapter 2) is to compare self-reported and objectively measured moderate and vigorous physical activity between individuals with higher and lower fitness levels. The second aim (Chapter 3) is to measure the levels of agreement between self-reported and objective measures of sedentary behaviour. In addition, the effect of meeting physical activity guidelines on self-report and objective measures of sedentary behaviour will be examined.

## **CHAPTER 2:**

**CARDIOVASCULAR FITNESS IS ASSOCIATED WITH BIAS BETWEEN SELF-REPORTED AND OBJECTIVELY MEASURED PHYSICAL ACTIVITY.**

## **2.1 INTRODUCTION**

Physical activity can be quantified by both subjective and objective measures using self-report questionnaires and accelerometers, respectively. Self-report measures include logbooks, activity diaries and questionnaires <sup>40</sup> such as the GPAQ. The GPAQ is a domains-based physical activity questionnaire in which individuals report moderate and vigorous intensity physical activity that has taken place in bouts lasting a minimum on 10 minutes <sup>90</sup>. Accelerometers measure physical activity using counts derived from accelerations. Moderate and vigorous intensity physical activity is quantified using a set of predetermined cut points, such as Matthews <sup>58</sup> or Freedson <sup>51</sup> cut points (listed in Table 1.1, Chapter 1).

Several studies have investigated the difference in self-reported and objective measures of physical activity (listed in Table 1.2, Chapter 1). Self-reported measures have generally been found to yield greater amounts of time spent in moderate and vigorous physical activity than objective measures <sup>36,7,67,101</sup>, with one study reporting a 4-fold higher estimate for vigorous intensity physical activity <sup>46</sup>. Characteristics of over-reporters have been summarised in Figure 1.4 (Chapter 1), Studies show that persons who over-report physical activity in relation to objectively measured activity tend to be older, less than well-educated, are more likely to be smokers and have central obesity <sup>93,12,17,7,9</sup>. There is however, a paucity of research pertaining to the effect of cardiorespiratory fitness on self-reported physical activity.

Therefore, the purpose of this study was to determine the extent to which cardiovascular fitness influences self-reported moderate and vigorous intensity physical activity, in relation to objectively measured physical activity. We hypothesised that persons with higher fitness levels (HF) would report physical activity with greater accuracy than individuals who present with lower fitness levels (LF).

## **2.2 METHODS**

### **2.2.1 Participants**

A convenience sample of 113 men (n=52) and women (n=61) were recruited from individuals who volunteered to participate in an annual health and risk assessment (HRA) and fitness test, which formed part of a health insurance wellness programme. All participants provided signed informed consent prior to participating in the study. (Appendix B). The research study was approved by the

Human Research Ethics committee of the University of Cape Town (Ethics reference number 348/2008).

### **2.2.2 Measures**

#### *Health Risk Assessment (HRA)*

The HRA was comprised of questions pertaining to the participant's general demographic information, personal medical history, and family history of disease, medication, injuries sustained and exercise-induced symptoms. (Appendix C)

#### *Clinical measures and Anthropometry*

Blood pressure was measured one time following 5 minutes of sitting using a manual blood pressure cuff<sup>21</sup>. Height was measured in meters using an upright Seca stadiometer. Participants stood barefoot with their heels and head in contact with the wall and arms at their side. Weight was measured in kilograms using a Clover Scale (Model TCS-A300), with the value rounded to the nearest 100g. Body mass index (BMI) was calculated using the equation:  $BMI = \text{weight (kg)} / \text{height(m}^2)$ <sup>21</sup>. Waist circumference was measured narrowest point of the torso, between the xiphoid process and umbilicus, using a standard tape measure on the skin<sup>21</sup>. Body fat percentage was estimated, using measures from four different skinfolds sites, including: the biceps, triceps, subscapular and suprailiac regions using Harpenden skinfold callipers, as described by Durnin and Womersly (1974)<sup>104</sup>.

#### *Fitness Assessment*

A 25cm Reebok step was used to complete the 12-minute sub-maximal step test. The step test consisted of four, 2-minute stepping stages, where each stage was followed by a 1-minute rest period prior to commencing the next stage<sup>105</sup>. Participants were required to step up and down to the sound of a metronome, of which the cadence increased as the step test progressed from stage one to stage four (80, 96, 112 and 120steps/minute respectively). A Suunto heart rate monitor was used to record the heart rate response during the step test. The heart rate file was log analysed using the Suunto Training Manager and Suunto Monitor software (Suunto Oy; Finland). The heart rate response to exercise was then regressed to predict peak METS at age-predicted maximum heart rate. An estimated maximal oxygen uptake (ml/kg/min) was calculated, based on heart rate recovery at the end of the last stage, using the following equation:  $44.891 - (\text{age} * 0.262) - (\text{gender} * 0.855) + (\text{peak METS} * 0.994) + (\text{maximum reported MET hrs/wk of activity} * 0.163)$ <sup>106,107</sup>.

The normative values for  $\text{VO}_2\text{max}$  according to the American College of Sports Medicine (ACSM) Guidelines for Exercise Testing and Prescription were used to categorise participants in 2 groups, namely 'lower fit' (LF) and 'higher fit' (HF) <sup>21</sup>. Participants who fell below the 50th percentile (according to the ACSM (2010) gender-based norms for age predicted  $\text{VO}_2\text{max}$ ) were categorised as LF participants.

### *GPAQ*

The GPAQ is based on self-reported recall of moderate and vigorous intensity activities. Activities included in the report should be performed for at least 10 consecutive minutes, in a typical week, in each of the 4 domains, including: transport, occupational, leisure and domestic activities <sup>90</sup>. The GPAQ was administered to each of the participants individually.

### *Accelerometry*

The ActiGraph GT3X (ActiGraph, Shalimar, FL, USA) is a tri-axial accelerometer which has a pedometer as well as an inclinometer to determine a participant's body position (lying down, sitting or standing) was used in this research study. The device was set to measure motion in all three axes, and was initialised to record data in 60 second epochs <sup>50</sup>. Accelerometer data was captured and cleaned using the ActiLife Software Version 5 (ActiLife software; Pensacola, FL; USA). [Data from all three axes was captured and used in the analysis.](#) The accelerometer was given to the participants after the GPAQ was administered, and participants were requested to maintain their usual activity levels while wearing the device. Participants were requested to wear the accelerometer on their right hip for seven consecutive days during their waking hours, but not while bathing, showering or swimming. A minimum of four days of wear, with 600 minutes per day were required for data analysis. [Non-wear time was defined as 60 continuous minutes of no counts \(zeros\).](#) Four days of monitoring moderate and vigorous intensity activity has been found to provide 80% reliability <sup>52,50</sup>.

Moderate and vigorous intensity physical activity levels were estimated based on accelerometer counts using the cut-off points according to Matthews <sup>58</sup>. The Matthews equation stipulates that counts between 760 and 5998 (inclusive) represents moderate intensity physical activity and counts above 5999 is indicative of vigorous activity <sup>58</sup>. [Objective physical activity from the GT3X was analysed for any moderate-to-vigorous \(MVPA\) activity which took place in 10-minute bouts/intervals. MVPA was calculated by summing moderate and vigorous activity <sup>101</sup>.](#) Within each 10-minute bout of moderate and/or vigorous physical activity, 1 or 2 minutes of 'dropped' counts

were allowed<sup>108,109</sup>. An exercise bout was therefore excluded if the program detected a drop in counts for greater than 2 minutes within the 10 minute period.

The term 'delta' was used to describe the difference between the objective and self-reported measurements of physical activity, recorded as minutes. Minutes spent in physical activity reported in the GPAQ were subtracted from the minutes measured by the accelerometer (GT3X). Therefore, a positive value would mean that the participant under-reported and negative value would indicate over-reporting. A zero-value represents accurate reporting.

### **2.3 STATISTICAL ANALYSIS**

STATISTICA 9 software (Stasoft Inc., Tulsa OK, USA) was used for all statistical analyses. Descriptive statistics were applied to calculate the mean values and standard deviations of all demographic, physical fitness, GPAQ and ActiGraph GT3X accelerometer results. A custom Matlab (R2011b The Mathworks Inc) program was used to calculate the total amount of time spent doing moderate and vigorous intensity physical activity using 10-minute bouts.

T-tests for independent groups were used to determine significant differences between age, weight, Body Mass Index (BMI), Body Fat percentage (BF%), systolic and diastolic blood pressure (SBP and DBP respectively) for the HF and LF groups, as well as between the male and female participants. Spearman's (non-parametric) correlations were used to measure the relationship between the delta (discrepancy between objective and self-reported physical activity) and age, VO<sub>2</sub>max and body composition variables. [ANCOVA's were used to measure delta \(the difference between self-reported and objective measures\) between the HF and LF groups \(adjusted for gender\)](#). T-tests for independent variables were performed to compare self-reported moderate physical activity to objectively measured moderate activity; as well as for self-reported vigorous activity and objectively measured vigorous activity.

Bland-Altman plots were used to calculate the limits of agreement between the accelerometer counts (objective) and the GPAQ (self-report) for both the HF and LF groups.

## **2.4 RESULTS**

### **2.4.1 Demographic Characteristics**

The mean age of the participants was  $38.8 \pm 13.1$  and  $37.2 \pm 12.3$ , for the men ( $n=52$ ) and women ( $n=61$ ) respectively. The mean BMI for all participants was  $25.7 \text{ kg} \cdot \text{m}^{-2}$ . The men were significantly heavier ( $p < 0.001$ ), had lower body fat percentage ( $p < 0.001$ ) and had greater waist circumferences than the women ( $p < 0.001$ ) (Table 2.1). Subsequent General Linear Model analyses therefore co-varied for gender due to the significant differences between the men and women.

**Table 2.1: Participant Characteristics: Demographic and Clinical Results. Presented as mean±(SD).**

| Clinical and Anthropometric Measures  | All n=113       | Men n=52     | Women n=61   | Higher Fitness (HF) n=71 | Lower Fitness (LF) n=42 |
|---|-----------------|--------------|--------------|--------------------------|-------------------------|
| Age (years)   | 37.9 (12.7)     | 38.8 (13.1)  | 37.2 (12.3)  | 36.9 (12.5)              | 39.7 (12.9)             |
| Waist (cm)  | 82.0 (13.3)***† | 89.6 (12.3)  | 75.4 (10.3)  | 78.6 (10.9)              | 87.4 (15.1)             |
| BMI (kg.m <sup>-2</sup> )   | 25.7 (4.4)***†  | 26.7 (4.2)   | 24.9 (4.4)   | 24.1 (3.4)               | 28.3 (4.7)              |
| Body fat (%)  | 25.4 (7.3)***†  | 20.9 (6.0)   | 29.3(5.8)    | 22.6 (6.7)               | 30.3 (5.4)              |
| Systolic Blood Pressure (mmHg)  | 118.7 (12.9)*†  | 123.2 (12.9) | 114.8 (11.7) | 116.6 (9.9)              | 122.2 (16.4)            |
| Diastolic Blood Pressure (mmHg)   | 70.2 (10.1)**   | 71.0 (10.6)  | 69.5 (9.6)   | 67.9 (8.9)               | 74.1 (10.8)             |
| *P<0.05 for differences between HF and LF<br>**P<0.005 for differences between HF and LF<br>***P<0.0005 for differences between HF and LF<br>† for differences in men and women |                 |              |              |                          |                         |

**Table 2.2: HF versus LF for GPAQ Data. Represented as a 7-Day average in minutes; mean±(SD).**

| Domain  | All Valid n=113 | High Fit (HF) n=71 | Low Fit (LF) n=42 | Diff between HF and LF group (p=) |
|---|-----------------|--------------------|-------------------|-----------------------------------|
| Vigorous Occupational Activity  | 6.90 (49.26)    | 10.99 (61.95)      | 0.00 (0.00)       | 0.254                             |
| Moderate Occupational Activity  | 11.68 (48.68)   | 16.06 (57.33)      | 4.29 (27.77)      | 0.216                             |
| MVPA Occupational   | 18.58 (90.39)   | 27.04 (111.46)     | 4.29 (27.77)      | 0.197                             |
| Travelling Activity   | 11.72 (23.79)   | 15.35 (27.27)      | 5.60 (14.66)      | 0.035*                            |
| Vigorous Leisure Time Activity  | 42.61 (34.04)   | 52.11 (33.54)      | 26.55 (28.70)     | 0.00007***                        |
| Moderate Leisure Time Activity  | 50.71 (45.35)   | 57.11 (46.79)      | 39.88 (41.08)     | 0.0504                            |
| MVPA Leisure Time Activity  | 93.32 (63.51)   | 109.22 (63.13)     | 66.43 (55.08)     | 0.0004***                         |
| Total Vigorous Activity (All Domains)   | 184.25 (237.35) | 247.75 (271.38)    | 76.90 (96.75)     | 0.0001***                         |
| Total Moderate Activity (All Domains)   | 241.33 (328.76) | 304.86 (382.76)    | 133.93 (162.22)   | 0.007*                            |
| Total MVPA (All Domains)  | 425.58 (500.77) | 552.61 (578.69)    | 210.83 (195.20)   | 0.0003***                         |
| * p<0.05 for differences between HF and LF groups<br>*** p<0.0005 for differences between HF and LF groups<br>MVPA: Moderate and Vigorous Physical Activity |                 |                    |                   |                                   |

### 2.4.2 Fitness Test Results

The predicted VO<sub>2</sub>max scores for the total sample ranged between 20.9 ml/kg/min and 69.4 ml/kg/min. This score was significantly higher for the men than for the women, 43.9 ml/kg/min vs. 35.0 ml/kg/min, respectively,  $p < 0.00001$ . Participants achieving a VO<sub>2</sub>max below the 50th percentile (based on ACSM criteria <sup>21</sup>) were placed in the LF group (n=42). Seventy one participants (62.8%) were categorised as HF; with 69.2% (n=36) of the men and 57.4% (n=35) of the women falling in the HF category, respectively. Therefore, by design, mean VO<sub>2</sub>max for the HF and LF group were 43.9 ml/kg/min and 30.8 ml/kg/min respectively, ( $p < 0.001$ ).

### 2.4.3 Self-reported physical activity results: GPAQ

Table 2.2 illustrates all differences between the HF and LF group for self-reported physical activity. Seven participants referred to themselves as currently 'inactive', and recalled no moderate or vigorous activity in the leisure domain. The remaining participants (n=106) all reported doing a minimum of 10 minutes of exercise (moderate or vigorous) during their leisure time.

Average time spent in self-reported vigorous activity in the leisure domain for the total group per day was 43±34 minutes, 95%CI=36; 49 minutes, median=45 minutes. The HF group reported significantly more minutes of leisure time vigorous physical activity (52±34 minutes) per day than the LF group (27±29 minutes;  $p < 0.001$ ). Similarly, total time spent in vigorous activity, which includes all domains for a 7-day week, was significantly different between groups, with the HF group reporting more minutes (248±271 minutes) than the LF group (77±97 minutes);  $p = 0.0001$ .

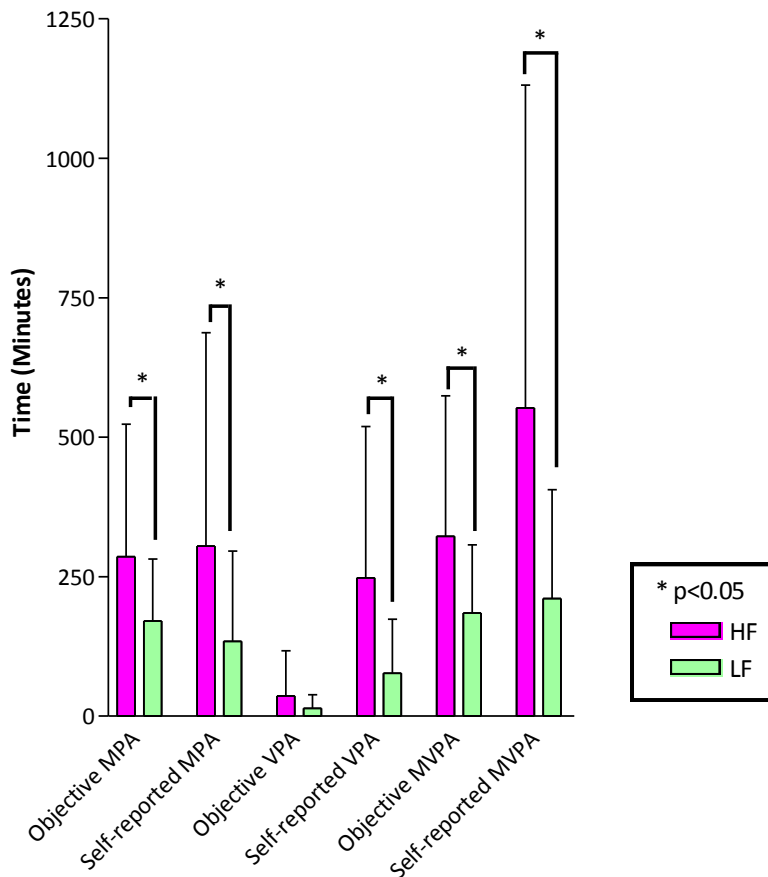
Average time spent in self-reported moderate intensity activity per day for the total sample was 51±45 minutes, 95%CI=42; 59 minutes, median=45 minutes. The HF group reported significantly more total moderate intensity physical activity, measured for all domains for a 7-day week, than the LF group ( $p < 0.001$ ). There were no significant differences between the men and women for any self-reported moderate or vigorous intensity activity.

### 2.4.4 Objective measures of physical activity

Participants wore the accelerometers for an average of 6.1±1.5 days. In cases where participants wore the accelerometer for more than 7 days, only the first 7 days of data were used in the statistical analyses. There were no significant differences between men and women for objectively measured vigorous intensity or moderate intensity physical activity. However, there was a significant difference in objectively measured moderate intensity physical activity between the HF and LF group

( $p=0.003$ ) (Figure 2.1). The difference between the HF and LF group for objectively measured vigorous intensity activity approached significance ( $p=0.08$ ). The HF group did significantly more objectively measured MVPA (measured as total physical activity) than the LF group ( $p=0.001$ ; shown in Figure 2.1).

**Figure 2.1: Differences in objectively measured and self-reported physical activity between the HF and LF groups.**



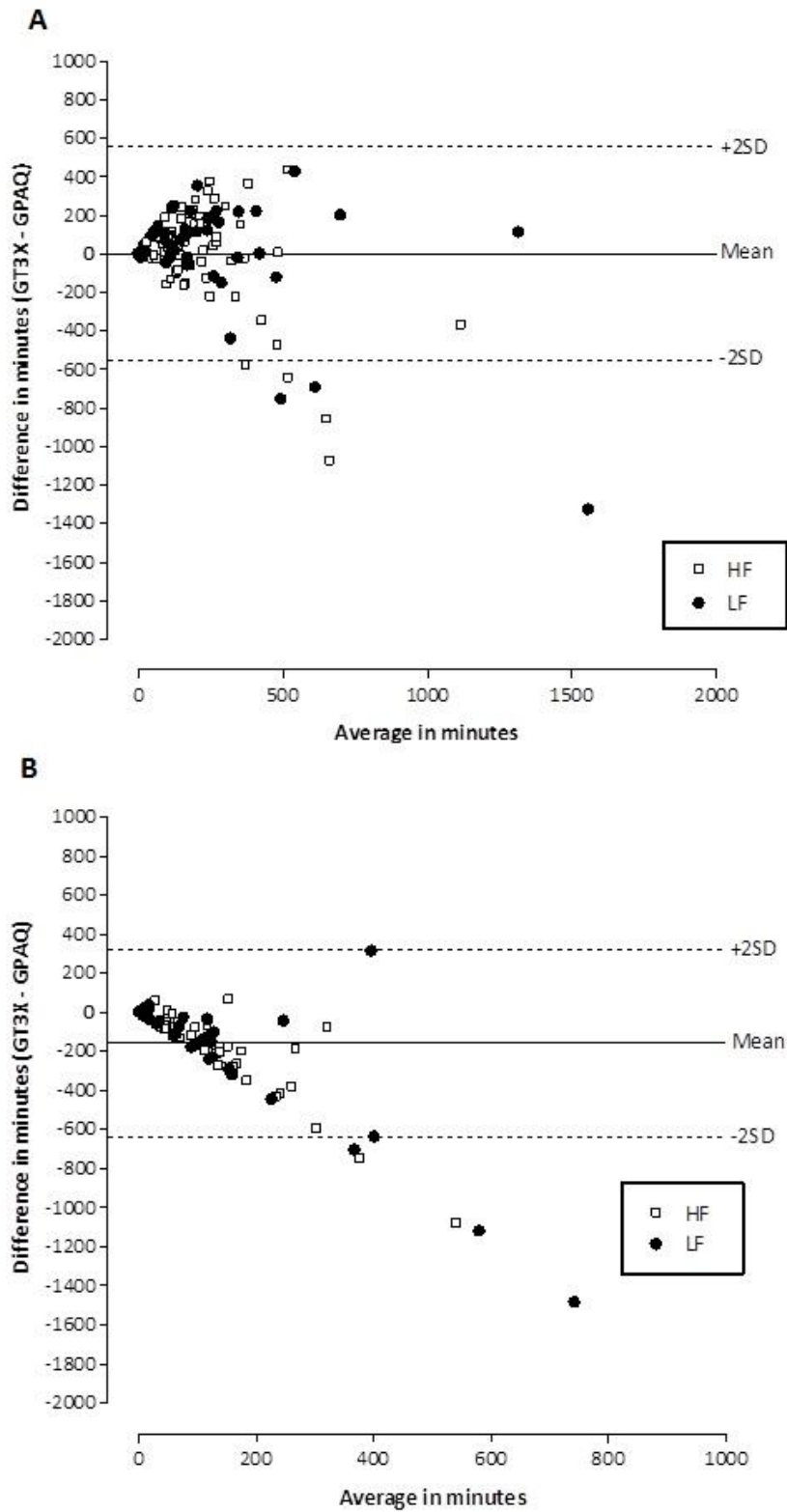
### 2.4.5 Bland-Altman Plots

Figure 2.2 (A) represents the difference between self-reported and objectively measured moderate intensity physical activity. Only 2 participants accurately reported moderate intensity activity ( $\Delta=0$ ). Just over a third of the total sample (34.5%,  $n=39$ ) over-reported moderate physical activity, with more over-reporters being in the HF group ( $n=25$ ).

Figure 2.2 (B) represents the difference in reported vigorous physical activity values from the GPAQ and objectively measured vigorous minutes. Few participants 14.2% ( $n=16$ ) reported vigorous intensity activity accurately. However, these participants didn't do any vigorous intensity activity according to the accelerometer, and because they had reported no vigorous activity in the GPAQ,

their report was accurate. There were 82 participants (72.6% of the total sample) who over-reported vigorous physical activity. Figure 2.2 (B) represents a homoscedastic distribution: As the duration of reported vigorous activity increased, so did the discrepancy between reported and measured vigorous activity increase.

**Figure 2.2:** Bland-Altman plots showing the difference the HF and LF group for A: bouts moderate intensity and B: bouts vigorous intensity physical activity.



#### 2.4.6 Objective versus self-reported physical activity results (Delta)

Delta minutes were not significantly different between the HF and LF groups for moderate intensity physical activity (37min vs. -19min;  $p=0.304$ ). The LF group over-reported vigorous activity to a significantly lesser extent than the HF group (-63min vs. -211min;  $p=0.001$ ). Similarly, delta for MVPA was significantly different between the HF and LF groups (-26min vs. -230min;  $p=0.012$ ).

### 2.5 DISCUSSION

The first important finding of this research study is that the level of agreement between self-reported activity and objectively measured vigorous activity was poorer in the HF group. This suggests that the HF group over-estimated their time spent in vigorous intensity physical activity, or possibly may misclassify moderate activity to be of a more vigorous nature. Our findings are contradicted by previous research which has shown that self-reported physical activity measured using the IPAQ were well correlated with objectively measured vigorous intensity physical activity<sup>110</sup>. With respect to moderate physical activity; the same study by Hagstromer et al supported our findings, although they used the IPAQ, which was found to correlate poorly with moderate intensity physical activity<sup>110</sup>. However, there is limited data describing the extent to which fitness may impact on difference in self-reported and objectively measured activity. Irwin et al concluded that physical activity may influence estimation of energy expenditure. Their protocol used doubly-labelled water and a 7-day physical activity recall, and lacked an objective measure of fitness<sup>111</sup>. These researchers' findings also suggested that more active individuals were more likely to under-report activity, specifically vigorous physical activity. Thus, these findings are contrary to those observed in our study. These differences may be due to the fact that doubly-labelled water is considered the criterion method for objective physical activity measurement<sup>38</sup>, and therefore might yield different results for activity than accelerometry. The Irwin study only collected data from adult males<sup>111</sup>.

Another possible explanation for the over-estimation of vigorous intensity physical activity may be that the HF group participate in more physical activity than LF individuals, creating more room for recall error. Field notes and general comments from participants suggested that attending gym, jogging and doing activities such as aerobics were classified as vigorous. However, it is possible that the accelerometer may not capture these activities as vigorous intensity. Many of our participants reported engaging in weight and/or strength training, but because this mode of training does not commonly involve continuous ambulation, an accelerometer attached to one's hip would not be sensitive to weight training activities such as a bench press or a bicep curl<sup>58</sup>. Another limitation of

using accelerometers includes the inability to wear the accelerometer under water<sup>112</sup>; however, this limitation may have impacted on only a small number of participants in this study.

Our sample self-reported  $\pm 60.79$  min/day of MVPA which is similar to that reported in the recent USA NHANES study ( $54.8 \pm 1.9$  min/day)<sup>7</sup>. However, the objectively measured MVPA in our study was higher than what was observed by accelerometry in USA NHANES ( $\pm 38.74$  vs.  $6.7$  min/day)<sup>59</sup>. This may be due to the fact that USA NHANES researchers used the Troiano's cut points, whereas we used the Matthews cut points. The Matthews cut points for moderate PA is lower than that of Troiano, 760 – 5998 counts per minute versus 2020 and 5998 counts per minute, respectively. Consequently, our data analysis would have resulted in more physical activity being classified as moderate intensity.

Another reason for the HF groups' over-reporting could relate to the manner in which the data was analysed. Depending on the cut point used, an activity that measures as moderate intensity may be classified as vigorous intensity according to another cut point. This paper used the Matthews cut points<sup>58</sup>. However, there are many methods and equations used to analyse and making accelerometer data meaningful, as well as many different sets of cut points. Currently, there are no specific equations or data reduction methods used for different ActiGraph models. Therefore, it may be necessary to use validated cut points for the newer models. Equations may need to be more attentive to the new technology found in the newer generation ActiGraph models.

## **2.6 LIMITATIONS AND STRENGTHS**

One of the limitations of this research study was that the participants comprised of individuals who were completing the health and fitness assessment for their medical insurance company. This could have resulted in some bias as people who are of a higher fitness level or more physically active being more likely to volunteer compared to a lower fit individual. In an attempt to address the limitations of the small sample size as well as large difference in numbers in the HF and LF groups, we co-varied for confounding variables in the statistical analysis of the data. To the knowledge of the researchers, this is the first research study to look at the impact of cardiovascular fitness on the difference between self-report and objective measures of physical activity.

## **2.7 SUMMARY**

Cardiovascular fitness appears to play a role in the accuracy of self-reported total, moderate- and vigorous intensity physical activity levels. The findings of this research study did not support our original hypothesis that the HF group would have better agreement than the LF group. This may be due to HF individuals doing more physical activity, and therefore having more room for reporting error. Furthermore, it may be beneficial to examine the effect that cardiorespiratory fitness and/or physical activity may have on self-reported sedentary behaviour. However, having a higher cardiorespiratory fitness does not necessarily mean that an individual is not sedentary. This has become evident with sedentary behaviour being identified as a risk for disease and all-cause mortality, independent of reported time spent in physical activity<sup>15,31,32</sup>. Therefore, accuracy of self-reported sedentary behaviour should be investigated, as is done in physical activity research, and compared to objective measures of physical activity.

## **CHAPTER 3:**

### **SELF-REPORTED AND OBJECTIVE MEASURES OF SEDENTARY BEHAVIOUR IN ADULTS**

### 3.1 INTRODUCTION

Chapter 2 of this dissertation showed that cardiorespiratory fitness influences self-reported physical activity, and that over-reporting was greater with an increase in higher fitness levels. Because the focus of Chapter 2 was physical activity and cardiorespiratory fitness, time spent in sedentary behaviours was not addressed. Sedentary behaviours are defined as activities that involve sitting, lying down or expending low levels of energy, equivalent to between 1.0 and 1.5 METs/min<sup>23,24,25</sup>. Examples of sedentary behaviours include watching television and using a computer<sup>23</sup>, with television viewing time being the most common leisure-time sedentary behaviour<sup>96</sup>. Recent evidence has shown that sedentary behaviour is an independent risk factor for metabolic disease, the metabolic syndrome and all-cause mortality, even after adjusting for time spent in moderate to vigorous intensity physical activity<sup>15,31,32</sup>. However, research pertaining to sedentary behaviour is relatively new, especially in comparison to physical activity research.

Much like physical activity, sedentary behaviour can be quantified using both self-report and objective measures, using questionnaires and accelerometers, respectively. The GPAQ is an example of a physical activity questionnaire that includes one question for self-reported time spent sitting on a typical day<sup>90</sup>. However, research has shown that self-reported sitting behaviour derived from asking a single question was significantly lower than objectively measured sedentary behaviour measured using accelerometry<sup>94</sup>. Thus, a need for domains-based sedentary behaviour questionnaires was identified.

Marshall et al (2010) developed a five-item questionnaire that dis-aggregated sedentary time into different domains including, travelling, working, watching television, using a computer and leisure time (excluding television time)<sup>49</sup>. Domains were further divided into weekdays and weekend days. These researchers confirmed the importance of measuring sitting behaviour in different domains, as people reported sitting behaviour more accurately if the sitting is structured, such as done in travel or at work. Furthermore, the same study found that sitting behaviour in the week was different to week-ends, underscoring the need to measure sitting time for both week and week-end days<sup>49</sup>.

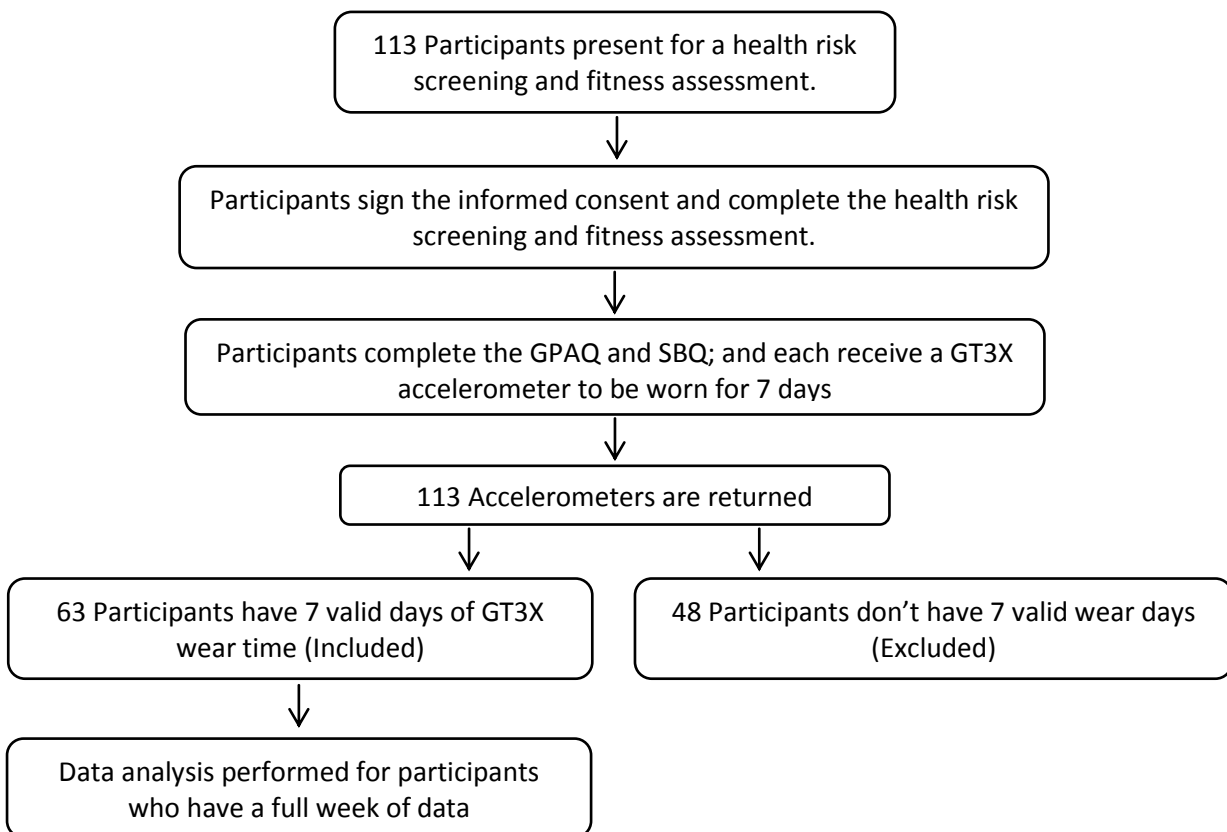
The ActiGraph GT3X is an example of one of the newer models of accelerometers which have an inclinometer that uses a 'tilt angle' to determine a person's body position. Therefore, the inclinometer records whether the person is lying down, sitting or standing based on the angle of tilt. There is limited research regarding the use of the inclinometer function in the GT3X, with a general lack of consistency in findings<sup>70,113</sup>.

Therefore, the primary aim of this study was to investigate whether a cut point rule of <100 counts per minute for accelerometry, used in conjunction with the measured inclination, was more comparable to self-reported sedentary time than using counts per minute exclusively. This novel approach allowed us to compare sitting and non-sitting sedentary time. We hypothesised that the agreement between objective and self-reported measures of sedentary behaviour would be improved when using inclinometry together with accelerometer counts, than when using counts alone. Additionally, we examined the association between self-report and objectively measured sedentary time, in those individuals meeting physical activity guidelines, compared to those who were insufficiently active.

### 3.2 METHODS

The same sample of participants described in Chapter 2 was used for this study. Figure 3.1 illustrates the inclusion and exclusion criteria for this research study.

**Figure 3.1:** Methods for participant inclusion and exclusion.



Based on the study inclusion criteria, sixty three (n=63) participants had 7 valid wear days. Matthews has described the importance of having 7 valid wear days<sup>52</sup>; in addition to our requirement for a more accurate comparison of self-report and accelerometry, as the questionnaires used in this study require a weekly report of physical activity and sedentary behaviour..

### **3.2.1 Measures**

The following measures were completed in addition to those already described in Chapter 2:

#### *Global Physical Activity Questionnaire (GPAQ)*

In addition to the physical activity component of the GPAQ described in Chapter 2, participants reported on the amount of time they spent sitting or lying down on a usual day, excluding sleeping. This question forms the basis of the self-report sedentary behaviour extracted from the GPAQ.

#### *Sedentary Behaviour Questionnaire*

A five-item sedentary behaviour questionnaire (SBQ) described earlier<sup>49</sup> was adapted for the South African setting. (Appendix D). The domains in the adapted SBQ includes time spent watching television, working in a seated position, using the computer outside of working hours, travelling by vehicle and socialising. However we adapted the SBQ by including questions around the number of days spent working, and describing leisure time sedentary behaviour as socialising, eating and relaxing. All five domains were divided into week and weekend day components.

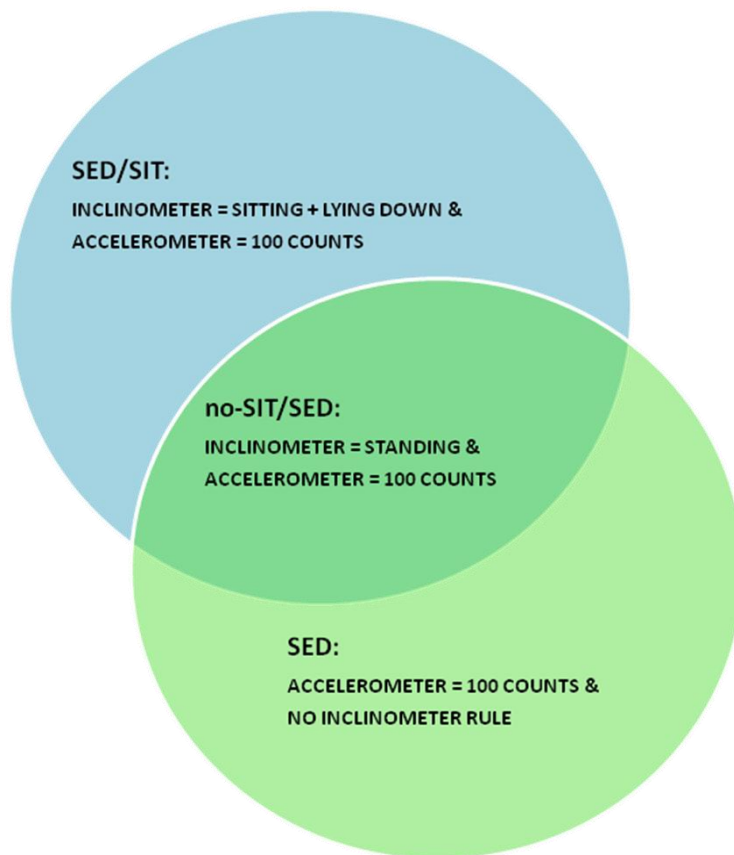
The researcher administered the GPAQ and SBQ to each of the participants individually, which took approximately 20 minutes to complete.

#### *Accelerometry*

In addition to the methods discussed in Chapter 2, the accelerometer was initialised with the inclinometer function activated<sup>50</sup>. The inclinometer function estimates whether the participant is seated, standing (vertically positioned) or lying down (horizontally positioned), and is also used to determine non-wear time ("off"). All "off" data measured by the inclinometer function has been excluded from the analysis. Three different methods were applied to calculate time spent in sedentary behaviour, illustrated in Figure 3.2. Firstly, sedentary behaviour was quantified using only the 100-counts per minute cut point rule<sup>86,1,53,8</sup>, referred to as SED. SED would therefore include all behaviour that elicited less than 100 counts, regardless of body position. The second calculation was

based on both data from the inclinometer that recorded sitting and reclining behaviour, together with <100 counts per minute (SIT/SED) <sup>86,1,53,8</sup> . Thus, 'SIT/SED' would refer to sedentary sitting/reclining time. The third method of analysis was no-SIT/SED, which was the difference between SED and SIT/SED, which represents non-sitting (or standing) sedentary behaviour. This variable used the <100 counts cut point rule, but included standing-only data recorded by the inclinometer. *Although by accepted definition <sup>26</sup> one cannot be standing and sedentary, the term no-SIT/SED is used to describe standing still – the counts are below 100 (per minute), but the inclination suggests that the participant is standing. This behaviour has not been thoroughly investigated.*

**Figure 3.2: Variables of sedentary behaviour analysis**



### 3.3 STATISTICAL ANALYSIS

STATISTICA 9 software (Stasoft Inc., Tulsa OK, USA) was used for all statistical analyses. Descriptive statistics were applied to calculate the mean values and standard deviations of all demographic, GPAQ, SBQ and ActiGraph GT3X accelerometer and inclinometer results. GPAQ and SBQ data were recorded in weekly format, and the calculated to get an average daily value to be used in the

statistical analyses. SBQ data for weekdays and weekends were divided by 5 and 2 for weekday and weekend day averages, respectively. The domain-based estimates of sedentary behaviour obtained from the SBQ were not used in further analyses as these values are used to calculate total weekly sitting time. [T-tests for independent groups were used to determine significant differences in SBQ, GPAQ and GT3X between the male and female participants.](#)

One-way ANOVA tests were used to determine differences between the men and women for age and BMI. One-way ANOVA analyses were used to determine differences in self-reported measures (SBQ and GPAQ) of sedentary behaviour between men and women. Pearson's correlation analysis was used to determine how well the questionnaires correlated for the measurement of sedentary behaviour. [Two-way ANCOVAs for repeated measures were used to determine the influence of gender in the differences between sedentary behaviour measured by the SBQ and GPAQ.](#)

The MATLAB programme was used to quantify the objectively measured time spent in sedentary behaviour, including the SED, SIT/SED, and no-SIT/SED analyses respectively. These data were then used in the ANOVA analyses to determine differences in objective measures (GT3X) of sedentary behaviour between men and women. In addition, Bland-Altman <sup>114</sup> plots were used to determine the limits of agreement between the GT3X (objective measures, including the measures of SED and SIT/SED), the SBQ (self-reported) and the GPAQ (self-reported) measures. Because there were some significant gender differences for self-reported measures of sedentary behaviour, the Bland-Altman analyses were performed separately for the men and women. [Relative \(calculated as % of the day spent in SED, light and MVPA\) and absolute mean bias values were used in conjunction with the Bland Altman plots to establish the limits of agreement. In addition to the methods discussed in Chapter 2, the accelerometer was initialised with the inclinometer function activated <sup>50</sup>. The inclinometer function estimates whether the participant is seated, standing \(vertically positioned\) or lying down \(horizontally positioned\), and is also used to determine non-wear time \("off"\). All "off" data measured by the inclinometer function has been excluded from the analysis.](#)

Analyses of variance (ANCOVA) for repeated measures were performed to determine if there were any differences between the SED and SIT/SED groups. A post-hoc Tukey HSD analysis was performed to see which of the groups differ from each other; and more specifically, to determine the effects of the inclinometer when comparing SED to SIT/SED measures, as well as the SBQ versus the GPAQ.

Analysis of co-variance analyses (ANCOVA) were used to analyse differences in sedentary behaviour (adjusting for gender), in persons who were currently meeting physical activity guidelines versus

those who were not meeting physical activity guidelines <sup>21</sup>. Participants were categorised as either sufficiently or insufficiently active according to the amount of moderate and vigorous activity measured by the accelerometer. Moderate and vigorous intensity physical activity levels were estimated based on accelerometer counts using the cut points established by Matthews et al. <sup>58</sup>, as described in Chapter 2.

### 3.4 RESULTS

#### 3.4.1 Demographic Characteristics and Clinical measures

The participants included in the analysis (n=63) comprised of twenty-eight men and thirty-five women with a mean age of 40.1±12.1 years. The mean BMI was 26.7±4.6kg.m<sup>-2</sup>, and was similar for men and women (p>0.05). Nineteen participants (30.2% of the sample) were classified as insufficiently active, as they did not achieve the ACSM's PA guidelines of 150 minutes of moderate PA, 75 minutes of vigorous PA per week, or an equivalent combination thereof <sup>21</sup>.

The mean reported MVPA per week for the total sample (n=63) was 418.2±436.5 minutes/week; which equates to 7.0±7.3 hrs/week (Table 3.1). There was no significant difference between the men and women for self-reported MVPA.

**Table 3.1: Self-reported sitting time (hours per day) according to domains in SBQ. Presented as mean±(SD).**

| Domains  | Total<br>n=63      | Men<br>n=28        | Women<br>n=35      |
|--|--------------------|--------------------|--------------------|
| <b>Total Sitting Time (7-Day week)†</b>                            | <b>72.7 (23.8)</b> | <b>78.3 (24.1)</b> | <b>68.2 (22.9)</b> |
| <b>Total Sitting Time (Weekend Day)</b>                            | <b>10.6 (3.6)</b>  | <b>9.5 (4.1)</b>   | <b>10.0 (5.2)</b>  |
| <b>Total Sitting Time (Week Day)</b>                               | <b>9.8 (4.8)*</b>  | <b>11.8 (3.8)</b>  | <b>9.7 (3.2)</b>   |
| Occupational Sitting Time (Weekend Day)                            | 1.5 (2.2)          | 1.5 (2.1)          | 1.7 (2.3)          |
| Occupational Sitting Time (Weekday)                                | 5.3 (2.5)          | 5.9 (2.4)          | 4.7 (2.5)          |
| Television Sitting Time (Weekend Day)                              | 2.6 (1.8)          | 2.6 (1.5)          | 2.7 (2.0)          |
| Television Sitting Time (Weekday)                                  | 1.5 (0.8)          | 1.5 (0.7)          | 1.5 (0.9)          |
| Computer Sitting Time (Weekend Day)                                | 1.0 (1.1)          | 1.2 (1.2)          | 0.8 (1.0)          |
| Computer Sitting Time (Weekday)                                    | 1.0 (1.7)*         | 1.6 (2.3)          | 0.6 (0.6)          |
| Travelling Sitting Time (Weekend Day)                              | 1.1 (0.8)          | 1.1 (0.8)          | 1.1 (0.8)          |
| Travelling Sitting Time (Weekday)                                  | 1.2 (0.9)          | 1.2 (0.9)          | 1.2 (0.9)          |
| Eating/Relaxing Sitting Time (Weekend Day)                         | 3.5 (2.7)          | 3.1 (2.5)          | 3.7 (2.9)          |
| Eating/Relaxing Sitting Time (Weekday)                             | 1.6 (1.2)          | 1.7 (1.0)          | 1.6 (1.4)          |
| †Value presented as hours per week and not hours per day.          |                    |                    |                    |
| *Indicates significant difference between men and women; (p<0.05). |                    |                    |                    |

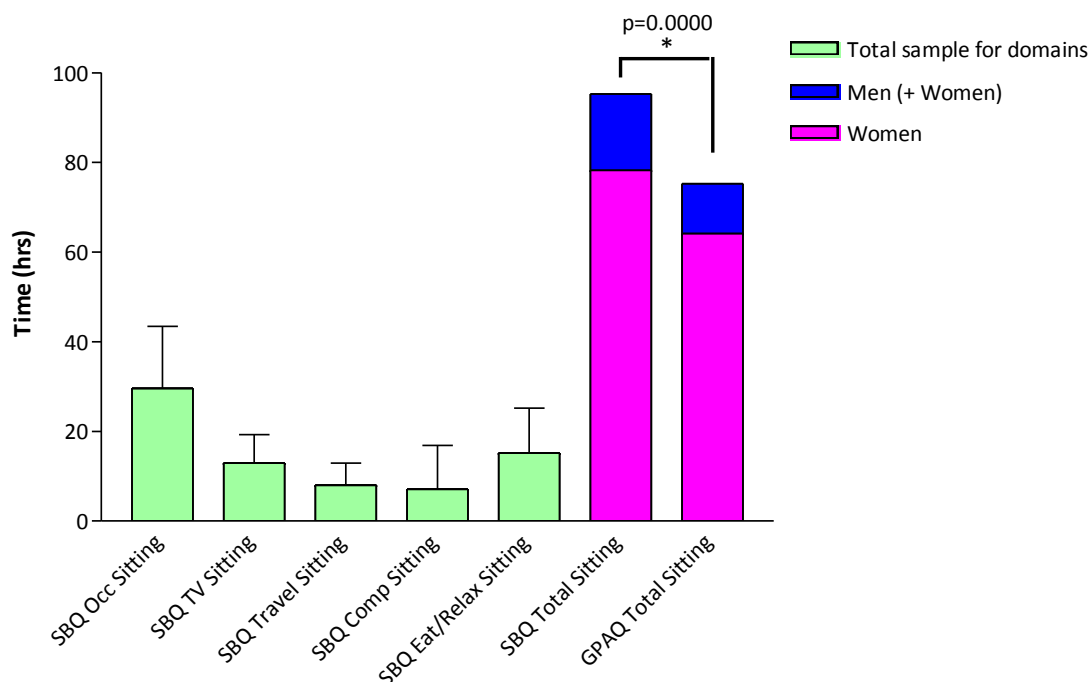
### 3.4.2 Self-reported measures of sedentary behaviour

The average self-reported sedentary time was  $8.3 \pm 3.3$  hours of per day, based on the single sedentary behaviour question in the GPAQ. This was further calculated as a mean value of  $57.9 \pm 23.0$  weekly hours of sedentary time for the sample. **There was no significant difference in self-reported sedentary time between the men and women ( $p=0.06$ ).** Likewise, the average total time spent sitting as reported in the SBQ was  $10.8 \pm 3.4$  hours per day, and was not significantly different between men and women ( $78.3 \pm 24.1$  vs.  $68.2 \pm 22.9$  hours per day;  $p=0.09$ ) (Table 3.1). Mean total sedentary time for the total sample for typical week-days (Monday to Friday) was  $10.6 \pm 3.6$  hours per day, with the men reporting significantly more week day sitting than the women;  $11.9 \pm 3.8$  vs.  $9.7 \pm 3.2$  hours per day;  $p=0.02$ . The men and women reported similar total weekend sitting time,  $9.5 \pm 4.2$  and  $9.9 \pm 5.3$  hours per day, respectively. Figure 3.3 shows the different reporting values within each domain in the SBQ, and how the total reported time in the SBQ compares to the GPAQ.

**Table 3.2: Objectively measured (GT3X) time spent in SED and MVPA. Presented as hours per day; mean $\pm$ (SD).**

| Variable   | All participants<br>n=63 | Men<br>n=28       | Women<br>n=35     |
|------------|--------------------------|-------------------|-------------------|
| MVPA       | 2.0 (0.7)                | 2.0 (0.6)         | 1.9 (0.8)         |
| SED:       | <b>13.0 (3.3)</b>        | <b>12.2 (3.7)</b> | <b>13.5 (2.9)</b> |
| SIT/SED    | 9.9 (2.7)                | 9.6 (2.9)         | 10.2 (2.5)        |
| no-SIT/SED | 3.0 (1.8)                | 2.7 (1.5)         | 3.3 (1.9)         |

**Figure 3.3: Total Week Sitting Times for the SBQ and GPAQ**



For the total sample, self-reported weekly sitting time was significantly higher in the SBQ ( $72.7 \pm 23.8$ ) than in the GPAQ ( $57.9 \pm 23.0$ ;  $p=0.0005$ ). Despite the absolute differences in sitting time reported in the SBQ and GPAQ, the sitting time for the week correlated *moderately* ( $r=0.52$ ;  $p<0.05$ ) for these two questionnaires. The last 2 bars of Figure 3 show that, although not statistically significant, the women reported less sedentary behaviour than the men. Two-way ANOVA for repeated measures showed that, irrespective of the questionnaire used, the men reported more sedentary behaviour; and that the SBQ yielded higher self-reported sedentary time than the GPAQ, irrespective of gender. There was however, no interaction effect ( $p=0.851$ ).

### 3.4.3 Objective measures of sedentary behaviour

Average wear time for the total sample was  $18.3 \pm 3.4$  hours per day. Table 3.2 presents data for objectively measured time spent in MVPA and SED (which is comprised of SIT/SED and no-SIT/SED). The average percentage of time spent in MVPA was  $11.3 \pm 5.5\%$  for the total sample and there were no significant differences between the men and the women. In addition, daily times spent in SED, SIT/SED and no-SIT/SED activity was not statistically different for men and women.

Figure 3.4 illustrates the proportion of time spent in SED activity (which is the sum of SIT/SED and no-SIT/SED), light activity and MVPA. Participants spent an average of almost 70% of total wear time in sedentary (SED) behaviour. This was comprised of  $54.0 \pm 10.0\%$  of total wear time in seated sedentary time (SIT/SED) and  $15.9 \pm 8.1\%$  of total wear time in non-sitting sedentary time (no-SIT/SED). There were no significant differences between the men and women for percentage of time spent in SED, SIT/SED, no-SIT/SED or MVPA. The light intensity physical activity data will not be addressed in this paper.

Figures 3.5 (A) to (D) are scatter plots illustrating the level of agreement between the self-reported (GPAQ and SBQ), and objective measurements (from the GT3X, but specifically for SED and SIT/SED behaviour) of sedentary behaviour. A zero value on the y-axis represents exact agreement, meaning that the self-reported sedentary behaviour was the same as the amount of objectively measured sedentary behaviour. Points above zero represent the participants who under-reported sitting behaviour, while participants with scatter points below zero over-reported their sedentary behaviour.

All four graphs show that there is a greater amount of under-reporting of SB than over-reporting for the week. Figure 3.5 (D) is the only graph to indicate a mean over-report of sedentary behaviour ( $-3 \pm 26.3$  hours per week). Table 3.3 presents the absolute and relative mean values for all graphs. The graphs that compare SIT/SED (Figures 3.5 (B) and 3.5 (D)) have narrower standard deviation lines, indicating a better level of agreement of the SIT/SED data with the SBQ and GPAQ than using the SED data only. Furthermore, the best level of agreement can be viewed in Figure 3.5 (D), between the SBQ and SIT/SED measurements. The smaller standard deviation and increased number of scatter points around zero suggest better agreement. The least level of bias is evident in Figure 3.5 (D) (mean bias  $-3.2 \pm 26.3$ ), where the SBQ has been used as a self-reported measure of sedentary behaviour, and the inclinometer function is included in the calculation and analysis of accelerometry-derived sedentary behaviour. There are cases in each figure where the bias is up to almost 100 hours per week (evident in Figure 3.5 (A), shown in Table 3.3). That is indicative of almost 4 days of unaccounted sedentary behaviour by several participants, when the GPAQ and SED analyses are compared. In Figure 3.5 (D) (SBQ vs. SIT/SED), the bias is greater than 2 days in both directions; indicating that under-reporting participants are not accounting for 2 days worth of sitting, and over-reporting participants are grossly over-estimating their sitting time in the SBQ. When represented as a relative value, Figure 3.5 (D) still shows these least bias ( $-7.5 \pm 42.5\%$ ). *Post-hoc*

Tukey HSD analysis showed that the combination of the SBQ and SIT/SED method (Figure 5D) was significantly less biased ( $p < 0.001$ ) for all interactions (refer to Table 3.3).

**Table 3.3: Measurements of absolute and relative bias and lines of agreement in addition to the Bland-Altman scatter plots.**

| Measurement variables   | Mean bias (hrs)<br>mean±(SD) | 95% Lines of Agreement | Relative bias (%)<br>mean±(SD) |
|---|------------------------------|------------------------|--------------------------------|
| SED – GPAQ (Fig. 5A)  | 32.8 (32.7)                  | -33 – 98               | 81.9 (81.7)                    |
| SIT/SID – GPAQ (Fig. 5B)  | 11.6 (29.3)                  | -47 – 70               | 13.6 (51.2)†                   |
| SED – SBQ (Fig. 5C)   | 18.0 (31.6)                  | -45 – 81               | 21.8 (35.3)†                   |
| SIT/SED – SBQ (Fig. 5D)   | -3.2 (26.3)                  | -56 – 50               | -7.5 (42.5)*                   |
| * Indicates that $p < 0.001$ for all interactions                             |                              |                        |                                |
| † Indicates that SIT/SID – GPAQ and SED – SBQ interaction was not significant |                              |                        |                                |

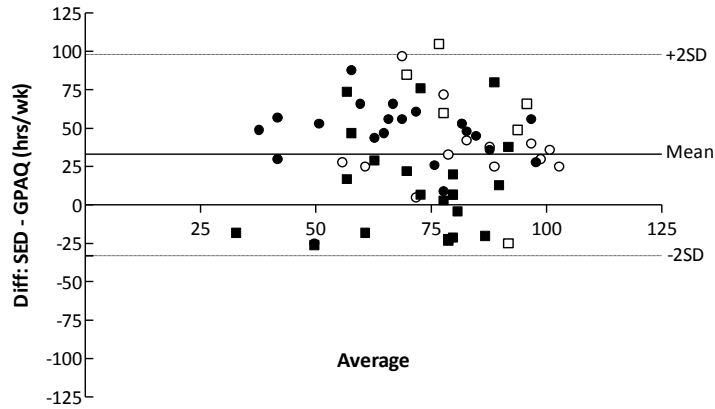
**Figure 3.4:** Percentages of time spent in SED, light and MVPA for each participant



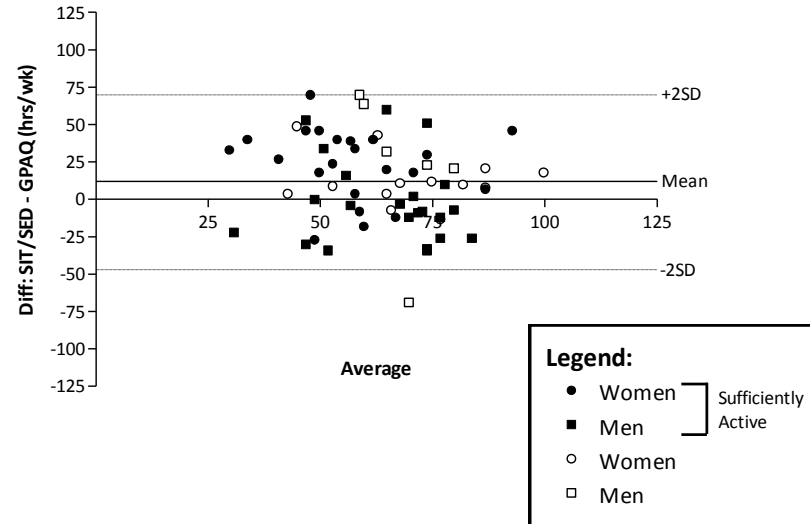
\*Participants meeting ACSM's guideline of 150mins MPA and/or 75mins VPA per day; or an equivalent combination of MVPA.

**Figure 3.5: Bland-Altman plots: Self-report versus objective measures**

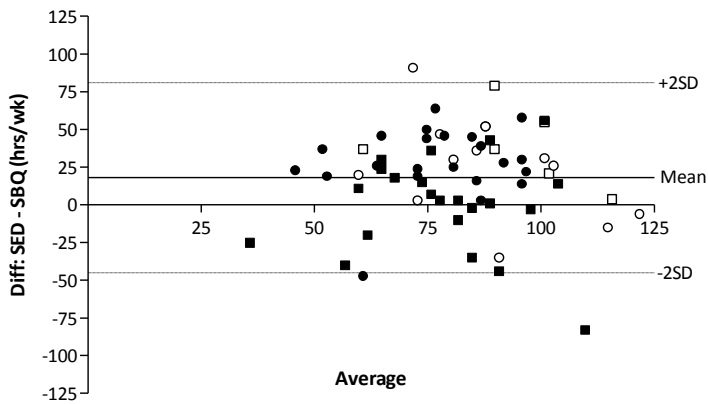
**Figure 5A: GPAQ vs. SED**



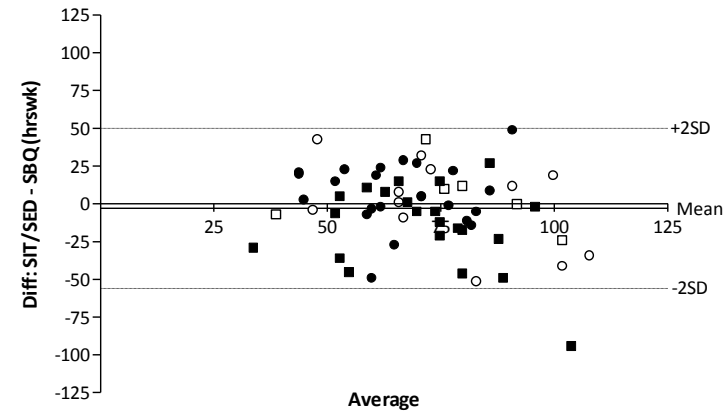
**Figure 5B: GPAQ vs. SIT/SED**



**Figure 5C: SBQ vs. SED**



**Figure 5D: SBQ vs. SIT/SED**



When comparing the physically active participants to those who were insufficiently active, there were no significant differences in any of the self-reported measures of sedentary behaviour. By design of this analysis, the sufficiently active participants did a significantly higher percentage of MVPA than the insufficiently active participants (13.3% vs. 6.7%;  $p < 0.000$ ). The only other difference between sufficiently active and insufficiently active participants was for percentage of time in no-SIT/SED (20.1% vs. 14.1%;  $p = 0.009$ ; adjusted for gender). The first forty-four bars of Figure 3.4 represent the sufficiently active participants ( $n = 44$ ; 69.8%).

### 3.5 DISCUSSION

The aim of this study was to compare self-reported and objective measures of sedentary behaviour in adults. In particular, this study interrogated the additional accuracy that may be provided by parcelling out objectively measured sedentary behaviour into its sitting and non-sitting components. According to our Bland-Altman plots, the use of the domain-based sedentary behaviour questionnaire (SBQ) had better agreement with the seated sedentary (SIT/SED) measurement, suggesting that the inclusion of inclinometer data when analysing sedentary behaviour provides value to sedentary behaviour analysis. To the best of the researchers' knowledge, this study is among the first to compare self-report measures of sedentary behaviour to different methods of analysing objectively measured sedentary behaviour by accelerometry.

Our study has shown that the inclinometer provides meaningful data when used in combination with the 100 counts per minute rule. Furthermore, when compared to self-reported sedentary behaviour in a domain-based questionnaire, such as the SBQ used in this research study; using SIT/SED data from the inclinometer has significantly less bias and better agreement. Previous research investigating the feasibility of inclinometry in research have been inconsistent<sup>69,71,70,113</sup>. Carr et al<sup>69</sup> examined the accuracy of the inclinometer function of several of the ActiGraph models, including GT3X+, in thirty-six adults. They found that the inclinometer identified correct anatomical position between 60.6 and 66.7% of the time in four different sedentary activities. This study did not combine the use of counts with the inclinometer, but did conclude that there is warrant to use the counts and inclinometry in combination<sup>69</sup>. McMahon et al (2010) concluded in his research that the inclinometer function of the ActiGraph GT3X had limited validity in postural detection in ten healthy adults<sup>70</sup>. They concluded that there were limitations in using the GT3X accelerometer's inclinometer, despite the high accuracy of the inclinometer measuring free-living sitting (96.5% accurate)<sup>70</sup>. An abstract published by Clemes et al<sup>113</sup> described a study where participants ( $n = 50$ )

wore an ActiGraph GT3X+, the ActiGraph model after the GT3X used in this study, for one day to compare inclinometer values and cut points for sedentary behaviour to the ActivPAL3 inclinometer. They found that the 100 counts per minute cut point significantly underestimated sedentary time (in comparison to the ActivPAL3), and that the 50 counts per minute was the best estimate of sedentary behaviour. Our research study did not investigate the use of different cut points in comparison to the inclinometer, but this is a gap in the research that may be investigated in the future.

Another finding was that self reported sitting time was significantly higher in the domain based SBQ compared to the single question in the GPAQ. Yielding higher values from a domain based questionnaire is consistent with the findings of Clemes et al (2012)<sup>94</sup>. A possible reason for the higher SBQ reported sitting times may be that the single sedentary behaviour question in the GPAQ does not allow for participants to recall specific sedentary behaviours. The SBQ prompts participants to think about how much time they spend sitting in various activities or domains, as opposed to trying to estimate total daily sitting time. Disaggregating measures of total sitting time into time spent engaging in specific sedentary behaviours (across specific domains) may help persons recall a more realistic total measure of sedentary time<sup>94</sup>.

Additionally, our results show that the SBQ yielded higher self-reported sedentary time measurements independent of gender. The men in this research study reported more sitting time, irrespective of questionnaire used. This shows that despite gender differences, the SBQ will yield greater amounts of reported sedentary time, and according to this research study, the report will also have better agreement with objective measures. This may assist other researchers in deciding how best to use self-report and objective measures in future studies.

This study is amongst the first in which sedentary behaviour is examined in participants categorised according to physical activity levels. When comparing the sufficiently active participants to the insufficiently active participants, we found that the insufficiently active participants were spending significantly more time in non-sitting sedentary behaviour (no-SIT/SED). However, the differences in self-reported measures were not significant between those meeting and those not meeting guidelines.

In the present study, we used objective MVPA to classify participants as meeting or not meeting guidelines, as opposed to Schuna et al, who used self-reported MVPA in a large sample size (n=3275) for the NHANES study. They found no difference in objective sedentary time between those who

reported less than 150 minutes of MVPA per week and those who reported more than 150 minutes per week (488.9 min vs. 471.9 min, respectively). The differences in our findings and Schuna et al <sup>100</sup> could be due to their classification method differing from our research study, the NHANES study having a far greater sample size for comparison, as well as them only using a single day of accelerometry data <sup>100</sup>. Future studies should be done to ascertain the best way to collect accelerometry data, and how many days of wear to include for analysis. These results underscore the importance of using self-report when collecting sedentary behaviour data, in addition to objective measures. Despite the advantage of having objective measures of sedentary behaviours, measurements between self-reported and objective measures are still very different, and therefore self-report methods are not redundant.

### **3.6 STRENGTHS AND LIMITATIONS**

This research study is among the first compare self reported sedentary behaviour with objective measures of sedentary behaviour which includes both counts per minute cut points and the inclinometer function in accelerometers. Strength of this research study include the exclusion of participants who did not have 7 valid wear days of accelerometry data, in addition to having a high mean of daily wear time from the participants. [The fact that the mean daily wear time found in this study is unusually high, we acknowledge that there may have several participants presenting with very long wear times that may have including some sleeping hours. This may have implications for the amount of sedentary behaviour captured. More specifically, the sedentary time captured may be increased because sleep time would be counted as extra sedentary time.](#) This research study also included two different questionnaires, which provided us with two different types of sedentary behaviour questionnaires, namely single question and domains-based questionnaire.

This study has several limitations, including the bias of the sample. We used a convenience sample that comprised of individuals presenting for a health risk assessment, and therefore the results of this study cannot be applied to the general population. However, our convenience sample provided us with sufficiently active participants, allowing us to compare the differences in sedentary behaviour between individuals who were sufficiently active and insufficiently active. This research study is among the first studies to analyse sedentary behaviour using counts and inclinometry, as well as address self-reported and objective measures of sedentary behaviour in sufficiently active and insufficiently active adults.

### **3.7 CONCLUSION**

Findings of this research study suggest that a domain-based questionnaire is preferred when measuring sedentary behaviour. In addition, our findings show that the inclusion of inclinometer data when analysing sedentary behaviour is essential for sedentary behaviour data collection and analysis. Future accelerometry-based research studies may find better agreement when including inclinometry to differentiate between objectively measured sitting and non-sitting sedentary behaviour. Considering that sedentary behaviour has been identified as an independent risk for all-cause mortality, it would be informative to see how non-sitting sedentary behaviour (described as no-SIT/SED in this paper) relates to health outcomes, instead of looking at sedentary behaviour as a collection of sitting behaviours.

## MINI DISSERTATION

### SUMMARY AND CONCLUSIONS

Some of the gaps in the literature identified in Chapter 1 suggest that there has been limited research investigating the influence that cardiorespiratory fitness and physical activity might have on the accuracy of self-report of physical activity and sedentary behaviour. Other determinants of self-reported activity have been researched and described in Chapter 1, however there is less evidence pertaining to how cardiorespiratory fitness and physical activity influences self report of physical activity. The measurement of sedentary behaviour is a relatively new area of research, and there does not appear to be a globally accepted gold standard to [measure](#) sedentary behaviour.

Manufacturers of newer accelerometers claim that new accelerometers are capable of measuring sedentary behaviour, using counts as well as inclinometry.

The aim of this dissertation was to describe the difference between self-reported and objective measures of physical activity and sedentary behaviour. The role of cardiorespiratory fitness and physical activity as factors influencing self-report were addressed.

In the first study (Chapter 2), we recruited a convenience sample of participants who performed a sub-maximal step test, which allowed us to categorise them based on their estimated cardiorespiratory fitness. Primarily, this research study showed that cardiorespiratory fitness does play a role in the accuracy of self-reported moderate intensity and vigorous intensity physical activity, with individuals presenting with lower levels of fitness having better levels of agreement between [self-report](#) and objective measures, and therefore reporting physical activity more accurately than fitter participants. This may be because fitter individuals are actually doing more activity; resulting in more room for error by simply doing more activity, or by misclassification of the intensity of activity performed. For researchers and practitioners, this finding is important because knowing the effect of cardiorespiratory fitness and physical activity on self-report will help researchers understand and interpret self-reported physical activity and sedentary behaviour data.

We acknowledge that some of the limitations of this study include bias in having a convenience sample may have contributed to this outcome. However, having a sample of participants presenting with varying levels of fitness and physical activity levels allowed us to compare sufficiently active to insufficiently active participants in study 2(Chapter 3). Another strength of this study is that we obtained 7 days of valid accelerometry wear from a large portion of our sample, allowing for a better comparison between our self-report and objective measurements of sedentary behaviour. [Having a](#)

convenience sample proposed another limitation in that it was not possible to obtain self-reported and objectively measured data from the same set of 7 days. Our research team identified this limitation during the data collection phase of the research study, and I therefore ensured that each participant's objective data was collected within a week of self-reported measurement (questionnaire administration). Furthermore, participants were asked to report activity in the GPAQ and SBQ as they would do in a typical week, and not the last 7 days.

We conducted a posteriori sample size calculation to determine whether or not we were underpowered to detect differences between groups, or in over- or under-reporting. Based on a study by Tucker et al <sup>36</sup>, who compared self-reported MVPA with MVPA measured with accelerometry, the differences in over-reporting between normal weight individuals and obese persons (BMI > 35) were almost 3-fold (5.8 + 3.1 vs. 15.0 + 12.2, representing the degree of over-reporting, by dividing self-report by accelerometry measured MVPA). In order to detect 3-fold differences between groups, we found that we would require a minimum of 20 persons per group, to achieve a statistical power of 80%. But even to detect a difference of 1.5-fold, we would only require 35 persons per group. The studies in this manuscript were therefore sufficiently powered.

A second important finding from this mini dissertation was that the combination of inclinometry and accelerometry (using < 100 counts per minute) to measure sedentary behaviour resulted in better agreement with a domain-specific sedentary behaviour questionnaire. Based on the findings in study 2 (Chapter 3), researchers making use of objective measures of sedentary behaviour may want to consider the inclusion of inclinometry, or the use of devices that can detect posture for surveillance purposes. Furthermore, accurate measurement may assist researchers with the development of sedentary behaviour interventions or sitting guidelines. This in particular is an area that has not been researched thoroughly. Furthermore, it would be informative to see how the different types of sedentary behaviour (described in Chapter 3) relate to health outcomes, instead of looking at sedentary behaviour as a collection of sitting behaviours. Future research may want to replicate this study in a larger sample of participants with a greater range of fitness and varying levels of physical activity.



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## APPENDICES

Global Physical Activity Questionnaire

| NO.  | QUESTIONS AND FILTERS  | CODING CATEGORIES  | SKIP      |
|--|--|--|-----------|
| <p>The next questions are about the time you spend doing different types of physical activities. This includes activities you do <b>at home, at work, travelling from place to place and during your spare time</b>. You are requested to answer the questions even if you don't consider yourself to be an active person.</p> |  |  |           |
| <p><b>Occupation-Related Physical Activity (paid or unpaid work):</b> When answering the following questions, think back over the <b>past 12 months</b> and consider (think of) <b>a usual week</b>.</p>   |  |  |           |
| 1  | Does your work involve <u>mostly</u> sitting or standing still, <b>OR</b> walking for very short periods (less than 10 minutes)?                   | MOSTLY SITTING .....1<br>MOSTLY STANDING STILL .....2<br>MOSTLY WALKING FOR VERY SHORT PERIODS.....3<br>MOSTLY DOING MODERATE/VIGOROUS ACTIVITY .....4<br>NONE OF THE ABOVE .....5   | →4<br>→5A |
| 2A   | Does your work involve <u>vigorous</u> activities, (like heavy lifting, digging, or heavy construction) for <b>at least 10 minutes</b> at a time?  | YES .....1<br>NO .....2  | →3A       |
| 2B   | In a <b>usual week</b> , how many days do you do <u>vigorous</u> activities as part of your work?  | DAYS..... <input style="width: 30px; height: 20px;" type="text"/> <input style="width: 30px; height: 20px;" type="text"/>  |           |
| 2C   | On a <b>usual day</b> on which you do <u>vigorous</u> activities, how much time do you spend doing such work?                                      | HOURS .....1 <input style="width: 30px; height: 20px;" type="text"/> <input style="width: 30px; height: 20px;" type="text"/><br>MINUTES .....2 <input style="width: 30px; height: 20px;" type="text"/> <input style="width: 30px; height: 20px;" type="text"/> <input style="width: 30px; height: 20px;" type="text"/> |           |
| 3A   | Does your work involve <u>moderate-intensity</u> activities (like brisk walking or carrying light loads) for <b>at least 10 minutes</b> at a time? | YES .....1<br>NO .....2  | →4        |
| 3B   | In a <b>usual week</b> , how many days do you do <u>moderate-intensity</u> activities as part of your work?  | DAYS..... <input style="width: 30px; height: 20px;" type="text"/> <input style="width: 30px; height: 20px;" type="text"/>  |           |
| 3C   | On a <b>usual day</b> on which you do <u>moderate-intensity</u> activities, how much time do you spend doing such work?                            | HOURS .....1 <input style="width: 30px; height: 20px;" type="text"/> <input style="width: 30px; height: 20px;" type="text"/><br>MINUTES .....2 <input style="width: 30px; height: 20px;" type="text"/> <input style="width: 30px; height: 20px;" type="text"/> <input style="width: 30px; height: 20px;" type="text"/> |           |
| 4  | How long is your usual workday?  | HOURS .....1 <input style="width: 30px; height: 20px;" type="text"/> <input style="width: 30px; height: 20px;" type="text"/><br>MINUTES .....2 <input style="width: 30px; height: 20px;" type="text"/> <input style="width: 30px; height: 20px;" type="text"/> <input style="width: 30px; height: 20px;" type="text"/> |           |

| NO.  | QUESTIONS AND FILTERS   | CODING CATEGORIES  | SKIP |  |  |  |  |  |
|--|---|--|------|--|--|--|--|--|
| <p><b>Travel-Related Physical Activity:</b> Other than activities that you've already mentioned, I would like to ask you about the way you travel to and from places (to work, to shopping, to market, to church, etc.).</p>   |   |  |      |  |  |  |  |  |
| 5A   | Do you walk or use a bicycle (pedal cycle) for <b>at least 10 minutes</b> at a time to get to and from places?  | YES .....1<br>NO .....2  | →6   |  |  |  |  |  |
| 5B   | In a <b>usual week</b> , how many days do you walk or cycle for at least 10 minutes to get to and from places?  | DAYS..... <table border="1" style="display: inline-table; vertical-align: middle;"><tr><td style="width: 20px; height: 20px;"></td><td style="width: 20px; height: 20px;"></td></tr></table>   |      |  |  |  |  |  |
|  |   |  |      |  |  |  |  |  |
| 5C   | On a <b>usual day</b> , how much time do you spend walking or cycling for travel?   | HOURS .....1 <table border="1" style="display: inline-table; vertical-align: middle;"><tr><td style="width: 20px; height: 20px;"></td><td style="width: 20px; height: 20px;"></td></tr></table><br>MINUTES .....2 <table border="1" style="display: inline-table; vertical-align: middle;"><tr><td style="width: 20px; height: 20px;"></td><td style="width: 20px; height: 20px;"></td><td style="width: 20px; height: 20px;"></td></tr></table> |      |  |  |  |  |  |
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|  |   |  |      |  |  |  |  |  |
| <p><b>Non-Work Related and Leisure Time Physical Activity:</b> The next questions ask about activities you do in your leisure or spare time, for recreation or fitness. Do not include the physical activities you do at work or for travel already mentioned.</p>   |   |  |      |  |  |  |  |  |
| 6  | In your leisure or spare time do you do any vigorous or moderate-intensity physical activity lasting <b>more than 10 minutes</b> at a time?                           | YES .....1<br>NO .....2  | →9   |  |  |  |  |  |
| 7A   | In your leisure or spare time, do you do any <u>vigorous</u> activities (like running or strenuous sports, weightlifting) for <b>at least 10 minutes</b> at a time?   | YES .....1<br>NO .....2  | →8A  |  |  |  |  |  |
| 7B   | In a <b>usual week</b> , how many days do you do <u>vigorous</u> activities as part of your leisure or spare time?  | DAYS..... <table border="1" style="display: inline-table; vertical-align: middle;"><tr><td style="width: 20px; height: 20px;"></td><td style="width: 20px; height: 20px;"></td></tr></table>   |      |  |  |  |  |  |
|  |   |  |      |  |  |  |  |  |
| 7C   | How much time do you spend doing this on a <b>usual day</b> ?   | HOURS .....1 <table border="1" style="display: inline-table; vertical-align: middle;"><tr><td style="width: 20px; height: 20px;"></td><td style="width: 20px; height: 20px;"></td></tr></table><br>MINUTES .....2 <table border="1" style="display: inline-table; vertical-align: middle;"><tr><td style="width: 20px; height: 20px;"></td><td style="width: 20px; height: 20px;"></td><td style="width: 20px; height: 20px;"></td></tr></table> |      |  |  |  |  |  |
|  |   |  |      |  |  |  |  |  |
|  |   |  |      |  |  |  |  |  |
| 8A   | In your leisure or spare time, do you do any <u>moderate-intensity</u> activities (like brisk walking, cycling or swimming) for <b>at least 10 minutes</b> at a time? | YES .....1<br>NO .....2  | →9   |  |  |  |  |  |
| 8B   | In a <b>usual week</b> , how many days do you do <u>moderate-intensity</u> activities as part of your leisure or spare time?  | DAYS..... <table border="1" style="display: inline-table; vertical-align: middle;"><tr><td style="width: 20px; height: 20px;"></td><td style="width: 20px; height: 20px;"></td></tr></table>   |      |  |  |  |  |  |
|  |   |  |      |  |  |  |  |  |
| 8C   | How much time do you spend doing this on a <b>usual day</b> ?   | HOURS .....1 <table border="1" style="display: inline-table; vertical-align: middle;"><tr><td style="width: 20px; height: 20px;"></td><td style="width: 20px; height: 20px;"></td></tr></table><br>MINUTES .....2 <table border="1" style="display: inline-table; vertical-align: middle;"><tr><td style="width: 20px; height: 20px;"></td><td style="width: 20px; height: 20px;"></td><td style="width: 20px; height: 20px;"></td></tr></table> |      |  |  |  |  |  |
|  |   |  |      |  |  |  |  |  |
|  |   |  |      |  |  |  |  |  |
| <p><b>Sitting / Resting Activity:</b> Now I would like to ask you about the time spent sitting or resting, not including sleeping, <b>in the past 7 days</b>. This may include time sitting at a desk, visiting friends, reading, or sitting down to watch television <b>during working hours and leisure or spare time</b>.</p> |   |  |      |  |  |  |  |  |
| 9  | Over the <b>past 7 days</b> , how much time did you spend sitting or reclining (lying) on a <b>usual day (excluding sleeping)</b> ?                                   | HOURS .....1 <table border="1" style="display: inline-table; vertical-align: middle;"><tr><td style="width: 20px; height: 20px;"></td><td style="width: 20px; height: 20px;"></td></tr></table><br>MINUTES .....2 <table border="1" style="display: inline-table; vertical-align: middle;"><tr><td style="width: 20px; height: 20px;"></td><td style="width: 20px; height: 20px;"></td><td style="width: 20px; height: 20px;"></td></tr></table> |      |  |  |  |  |  |
|  |   |  |      |  |  |  |  |  |
|  |   |  |      |  |  |  |  |  |



## Department of Human Biology

UCT/MRC RESEARCH UNIT FOR EXERCISE SCIENCE & SPORTS MEDICINE  
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Thank you for showing an interest in this research study.

The University of Cape Town's Exercise Science and Sports Medicine Research Unit (ESSM) is conducting a research study which aims to describe the relationship between your self-reported physical activity and that which is measured by an accelerometer.

Following your Virgin Life Care Health Risk Assessment (HRA), you will answer a 9-item Global Physical Activity Questionnaire (GPAQ) and a Sedentary Behaviour Questionnaire (SBQ). The GPAQ requires you to recall the physical activity you perform in a typical week. The SBQ requires you to recall how much time you spend seated while at work, travelling, watching television and relaxing on a typical week day and weekend.

An ActiGraph accelerometer will be given to you to wear for a total of seven days, after which you will have to return it. The accelerometer is used to measure movement in 3 planes of motion. It will be used to measure your physical activity. We ask that you wear it for 7 consecutive days on your hip.

All data collected from the assessment and questionnaires will be kept strictly confidential. Results derived from this research will be used to provide feedback to you, as the participant, on your subjective and objective measure of fitness. We hope to extend the knowledge gained from this study to the general public.

### Risks and benefits of study:

The ActiGraph accelerometer is a simple device and presents no risk during use. Benefits include the use the device for a full week, from which you will get feedback of your habitual physical activity.

### Participant Consent:

I, \_\_\_\_\_ confirm that I have read through the procedures and understand them fully. I acknowledge that all data collected will be kept confidential, and that all information regarding my assessment will be accessible to me. I understand that I may feel free to ask any questions regarding the trial at any time, and may withdraw my participation should I no longer want to partake in the research study.

I have read and understand the purpose and procedure of the study, and agree to participate in this research project.

In addition, I understand that the ActiGraph accelerometer must be returned to ESSM in 7 days time.

Name and Surname of Participant \_\_\_\_\_

Signature of the Participant \_\_\_\_\_

Date \_\_\_\_\_

Name and Surname of Researcher \_\_\_\_\_

Signature of Researcher \_\_\_\_\_

Name and Surname of Witness \_\_\_\_\_

Signature of Witness \_\_\_\_\_

Contact Details:

Senior Investigator: Tracy Kolbe-Alexander: Email: tracy.kolbe-alexander@uct.ac.za

Junior Investigator: Simone Tomaz: Email: simone.tomaz@live.co.za

Chair of UCT Ethics Committee: Marc Blockman: Email: marc.blockman@uct.ac.za



# Health and Fitness Assessment Questionnaire (Vitality)

## SECTION 1. DEMOGRAPHICS

1.1 Details: Please print in capital letters using black ink and tick the relevant box(es).

First name  Age  Gender  M -  F Male - Female

Surname

ID Number  Title  Birth Date  DD /  MM /  YYYY

Medical Aid  Medical aid membership number

Work number (  ) -  -  Home number (  ) -  -

Cell phone number (  ) -  -  Fax number (  ) -  -

Email  @

## SECTION 2. MEDICAL HISTORY

2.1 Family History: Do you have a family history (parents or siblings) of any of the following medical conditions?

|                                |                              |   |                     |                              |   |
|--------------------------------|------------------------------|---|---------------------|------------------------------|---|
| Heart Disease                  | <input type="checkbox"/> Yes | <input type="checkbox"/> Before or at the age of 50 | High Cholesterol    | <input type="checkbox"/> Yes | <input type="checkbox"/> Before or at the age of 50 |
| Insulin Dependant Diabetes     | <input type="checkbox"/> Yes | <input type="checkbox"/> Before or at the age of 50 | High Blood Pressure | <input type="checkbox"/> Yes | <input type="checkbox"/> Before or at the age of 50 |
| Non Insulin Dependant Diabetes | <input type="checkbox"/> Yes | <input type="checkbox"/> Before or at the age of 50 | Stroke              | <input type="checkbox"/> Yes | <input type="checkbox"/> Before or at the age of 50 |
| Peripheral Vascular Disease    | <input type="checkbox"/> Yes | <input type="checkbox"/> Before or at the age of 50 | Cancer              | <input type="checkbox"/> Yes | <input type="checkbox"/> Before or at the age of 50 |

Type:

2.2. Personal Medical History: Have you suffered, or do you suffer from any of these medical conditions?

|                            |                              |                                |                              |                         |                              |
|----------------------------|------------------------------|--------------------------------|------------------------------|-------------------------|------------------------------|
| High Cholesterol           | <input type="checkbox"/> Yes | Heart Disease                  | <input type="checkbox"/> Yes | Exercise Induced Asthma | <input type="checkbox"/> Yes |
| Insulin Dependant Diabetes | <input type="checkbox"/> Yes | Non Insulin Dependant Diabetes | <input type="checkbox"/> Yes | Asthma                  | <input type="checkbox"/> Yes |
| High Blood Pressure        | <input type="checkbox"/> Yes | Peripheral Vascular Disease    | <input type="checkbox"/> Yes | Stroke                  | <input type="checkbox"/> Yes |
| Cancer                     | <input type="checkbox"/> Yes | Type: <input type="text"/>     |                              |                         |                              |

**Diagnosed by?**  cardiologist  specialist physician  medical practitioner  blood test

**Diagnosed when?**  in the past year  1 - 5 years ago  > 5 years ago

**Specific Intervention?**  healthy dietary habits  medication  regular activity

2.3. Medication

Are you currently on medication for heart disease, peripheral vascular disease, cholesterol and/or blood pressure?  Yes  No

If yes, please write your medical condition, name of medication and dosages, below:

| Condition: eg. Cholesterol | Medication: eg. Lipitor | Dosage: eg.10mg 1 / day |
|----------------------------|-------------------------|-------------------------|
| <input type="text"/>       | <input type="text"/>    | <input type="text"/>    |
| <input type="text"/>       | <input type="text"/>    | <input type="text"/>    |
| <input type="text"/>       | <input type="text"/>    | <input type="text"/>    |

2.4. Preclusions

Present Symptoms: Do you suffer from any of these medical conditions?

|   |  |  |  |
|---|--|--|--|
| Chest pains while exercising                      | <input type="checkbox"/> Yes <input type="checkbox"/> No | Frequent fainting and/or dizzy spells        | <input type="checkbox"/> Yes <input type="checkbox"/> No |
| Any flu-like symptoms (fever and/or muscle pains) | <input type="checkbox"/> Yes <input type="checkbox"/> No | Palpitations                                 | <input type="checkbox"/> Yes <input type="checkbox"/> No |
| Frequent wheezing /coughing                       | <input type="checkbox"/> Yes <input type="checkbox"/> No | Shortness of breath at rest or with activity | <input type="checkbox"/> Yes <input type="checkbox"/> No |
| Ankle edema                                       | <input type="checkbox"/> Yes <input type="checkbox"/> No | Intermittent claudication                    | <input type="checkbox"/> Yes <input type="checkbox"/> No |
| Known heart murmur                                | <input type="checkbox"/> Yes <input type="checkbox"/> No | Unusual fatigue with usual activities        | <input type="checkbox"/> Yes <input type="checkbox"/> No |

Physical Injury: Do you currently suffer from any physical ailment that would preclude you from performing this assessment?

|                       |  |          |  |
|-----------------------|--|----------|--|
| Neuromuscular Disease | <input type="checkbox"/> Yes <input type="checkbox"/> No | Ligament | <input type="checkbox"/> Yes <input type="checkbox"/> No |
| Bone                  | <input type="checkbox"/> Yes <input type="checkbox"/> No | Muscle   | <input type="checkbox"/> Yes <input type="checkbox"/> No |
| Joint                 | <input type="checkbox"/> Yes <input type="checkbox"/> No | Other    | <input type="checkbox"/> Yes <input type="checkbox"/> No |

Assessor's comment (based on ACSM's risk factors for exercise testing)

In your professional opinion, is the member fit to continue with this assessment?  Yes  No

COMMENT:

2.5. Pregnancy

Are you currently pregnant?  Yes  No

If yes, how many months pregnant are you? (e.g. 5)  months

Do you have clearance from your gynaecologist to perform this assessment?  Yes  No



### SECTION 3. HEALTH HABITS

#### 3.1. Smoking Status: Please tick the appropriate box relating to your smoking

Never smoked

less than 3 months

1 - 5 years

11 - 15 years

How long have you been an ex-smoker?

less than 1 year

6 - 10 years

more than 15 years

Current smoker

< 10 per day

10 - 20 per day

21 - 30 per day

> 30 per day

Cigar

Pipe

Cigarettes

Chewing Tobacco

#### For Smokers only: Please tick only one of the options that best describe your current smoking situation

I have no intention of becoming tobacco free in the next 6 months.

I intend to become tobacco free in the next 6 months.

I am trying to become tobacco free, but I am not always successful.

Although I am currently using tobacco again, in the past I have been tobacco free for more than 3 months.

#### Non Smoking

I confirm that I am a non-smoker and that:

1. I do not smoke and have not smoked any tobacco products, regularly or occasionally, within the last 3 months.

2. I agree to inform my insurers within 3 months of commencing smoking. I also agree to the reversal of any points that may have been awarded for being a non-smoker, if they are awarded within the same calendar year in which I commenced smoking.

3. I agree to undergo an u-cotinine test to prove my non-smoker status should my insurer request one. I understand that such requests are made randomly.

Please sign here to accept this declaration.

#### 3.2. Alcohol Use: Please make the appropriate selection relating to your weekly alcohol consumption.

I don't have any alcoholic drinks

Never more than 1 - 2 drinks per occasion or per day.

3 - 4 drinks in a day, only 2 - 3 per month.

3 - 4 drinks in a day, 4 times per month

3 or more drinks in a day, more than once a week and / or more than 4 drinks at a time.

#### 3.3. Sleep: Please make the appropriate selection relating to your sleeping pattern.

Undisturbed sleep

Disturbed sleeping pattern, 3-4 nights per week

Disturbed sleeping pattern, 1-2 nights per week

Disturbed sleeping pattern, 5-7 nights per week

In general, I wake up:

Refreshed

Unrefreshed

#### 3.4 Stress Management:

Are you coping with your daily stress?

No, and I have no intention to implement coping strategies in the next 6 months.

No, but I intend to learn how to cope with my daily stress in the next 6 months.

I am trying to cope but I do not always cope successfully.

Yes, I have been coping with my daily stress, but for LESS than 6 months.

Yes, I have been coping with my daily stress for MORE than 6 months.

Although I am not coping well with my daily stress, in the past I have coped well for more than 3 months.

#### 3.5 Dietary Assessment

Think about your eating habits over the past year or so. Approximately how often do you eat each of the following foods? Tick one box for each food.

| Meat/Snack   | Never/Once or less than once per month | 2-3 times per month      | 1-2 times per week       | 3-4 times per week       | 5+times per week         |
|--|--|--------------------------|--------------------------|--------------------------|--------------------------|
| Hamburgers or cheeseburgers                                      | <input type="checkbox"/>               | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Red meat, e.g. beef and mutton                                   | <input type="checkbox"/>               | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Fried chicken (with skin)  | <input type="checkbox"/>               | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Hot dogs, frankfurters, salami, Russians, sausages               | <input type="checkbox"/>               | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Cold meats, e.g. polony, cheese / olive loaf, beef (+ fat), etc. | <input type="checkbox"/>               | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Salad dressing, mayonnaise                                       | <input type="checkbox"/>               | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Margarine or butter  | <input type="checkbox"/>               | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Eggs   | <input type="checkbox"/>               | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Bacon or pork sausage  | <input type="checkbox"/>               | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Cheese or cheese spread  | <input type="checkbox"/>               | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Full-cream milk  | <input type="checkbox"/>               | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Potato chips ("slap chips")                                      | <input type="checkbox"/>               | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Potato crisps, corn chips, popcorn, etc                          | <input type="checkbox"/>               | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Ice cream  | <input type="checkbox"/>               | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Doughnuts, cake, cookies, puddings, etc                          | <input type="checkbox"/>               | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |



### Fruit/Vegetables/Fibre

|   | Never/Less than once per week | about once per week      | 2-3 times per week       | 4-6 times per week       | Every day                |
|---|-------------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| Brown rice / wholewheat pasta                                 | <input type="checkbox"/>      | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Fruit (not counting juice)                                    | <input type="checkbox"/>      | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Green salad   | <input type="checkbox"/>      | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Potatoes with skin  | <input type="checkbox"/>      | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Dried beans, e.g baked beans, Kidney beans, legumes           | <input type="checkbox"/>      | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Other vegetables  | <input type="checkbox"/>      | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| High-fibre/bran cereal or high-fibre porridge or oat porridge | <input type="checkbox"/>      | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Wholewheat, brown or high-fibre bread (e.g. rye)              | <input type="checkbox"/>      | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

#### Do you currently feel that you are following a healthy diet?

- No, and I have no intention of following a healthy diet in the next 6 months.
- No, but I intend to follow a healthy diet in the next 6 months.
- I am trying to follow a healthy diet, but I am not always successful.
- Yes, I have been following a healthy diet, but for LESS than 6 months.
- Yes, I have been following a healthy diet for MORE than 6 months.
- Although I am currently following a less healthy diet, in the past I have followed a healthy diet for more than 3 months.

## SECTION 4. PHYSICAL ACTIVITY ASSESSMENT

### 4.1. Current Physical Activity Levels: Please tick the most appropriate description of your current level of physical fitness.

- Poor     Fair     Acceptable     Good     Excellent

### 4.2. Work and/or daily activities: Please tick the box that best describes your activities in the working day {e.g. office and home based} - not your leisure time physical activity.

- I sit down and do not walk about much.                       I walk about a lot, but do not carry heavy loads.  
 I mostly walk and also lift heavy loads or climb stairs.     I do heavy manual work and physically strain myself.

### 4.3. Physical Activity Status: A typical exercise session consists of 20-30 minutes of exercise.

Over the past three months I would describe myself as having been:

- Inactive ( please go straight to 4.4 )                       Reasonably active - "at least 2-3 sessions per week"  
 Occasionally active - "at least 1-4 sessions per month"     Active - "at least 3-4 sessions per week"  
 Somewhat active - "at least 1-2 sessions per week"         Very active - "more than 4 sessions per week"

Over the past three months, the duration of my exercise sessions and/or recreational activity has ranged between a **minimum** of, and a **maximum** of:

| (Minimum) Column A                     | (Maximum) Column B                     | On average, my total exercise time for the week is: | On average, I would describe the intensity of these sessions as: |
|--|--|---|--|
| <input type="checkbox"/> 0-15 minutes  | <input type="checkbox"/> 0-15 minutes  | <input type="checkbox"/> <60 minutes per week       | <input type="checkbox"/> Very light (seated activity)            |
| <input type="checkbox"/> 15-30 minutes | <input type="checkbox"/> 15-30 minutes | <input type="checkbox"/> 60-90 minutes per week     | <input type="checkbox"/> Light (eg: housework)                   |
| <input type="checkbox"/> 30-60 minutes | <input type="checkbox"/> 30-60 minutes | <input type="checkbox"/> 90-120 minutes per week    | <input type="checkbox"/> Light sweat                             |
| <input type="checkbox"/> 1-2 hours     | <input type="checkbox"/> 1-2 hours     | <input type="checkbox"/> 2-3 hours per week         | <input type="checkbox"/> Sweating                                |
| <input type="checkbox"/> >2 hours      | <input type="checkbox"/> >2 hours      | <input type="checkbox"/> 3-4 hours per week         | <input type="checkbox"/> Vigorous                                |
|  |  | <input type="checkbox"/> >4 hours per week          |  |

### 4.4. Please tick only one of the six options that best describe your current situation or what you intend to do regarding physical activity in the future.

#### Are you moderately physically active?

- No, and I have no intention of becoming moderately physically active in the next 6 months.
- No, but I intend to become moderately physically active in the next 6 months.
- I am trying to become moderately active, but my exercise routine is irregular.
- Yes, I have been moderately physically active, but for LESS than 6 months.
- Yes, I have been moderately physically active for MORE than 6 months.
- Although I am currently inactive, in the past I have been physically active for more than 3 months.

## SECTION 5. EXERCISE PROGRAMME

### 5.1. Please select **ONE** 12 week exercise programme

#### A. Lose Weight

- \*General Cardio + toning     Lose Weight & walk 5-10km     Lose weight & walk 10-15km     Lose weight & run 5-10km  
 Lose weight & run 21 km     Lose weight & cycle 40-60km     Lose weight & cycle 80-120km

#### B. Gain Weight (muscle)

#### C. \*Stay Healthy

#### D. \*Look after health condition

#### E. \*Become generally fitter

#### F. \*Get bootcamp fit

#### G. \*Get my body back in shape

#### H. Improve my fitness for walking:

- 5km     10km     15km     21km

#### I. Improve my fitness for running:

- 5km     10km     21km     42km

#### J. Improve my fitness for cycling:

- 40km     60km     80km     100km     120km     200km

#### K. Improve my fitness for swimming:

- 600m     1000m     1600m

#### L. Improve my fitness for triathlon:

- Sprint triathlon     Standard triathlon

#### \* Would you prefer to exercise in a gym or home environment?

- Gym     Home

Note: the sports specific plans are outdoor-specific



## Sedentary Behaviour Questionnaire

Participant Name: \_\_\_\_\_

Participant Code: \_\_\_\_\_

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

**Interviewer:** Please ask the respondent the following questions which relates to the time they spend sitting during various activities.

Ask them to think about a **usual day** or a normal day for each of the questions.

All answers are per day.

We are very interested in the amount of time people spend sitting. I am going to ask you a few questions about your sitting behavior. These questions all refer to a usual day, and please answer in hours and minutes per day.

| Question   | Week day<br>(hours:<br>minutes) | Week end day<br>(hours:<br>minutes) |
|--|---------------------------------|-------------------------------------|
| <b>1a.</b> How much time do you spend sitting while you are at <b>work</b> ? (per day)   | Hrs:<br>Min:                    | Hrs:<br>Min:                        |
| <b>1b.</b> How many days per week do you work?<br>_____ days   |                                 |                                     |
| <b>1c.</b> Do you work on the week-end? (Please circle answer)<br>Yes      No  |                                 |                                     |
| <b>2.</b> How much time do you spend sitting while <b>watching TV</b> per day?   | Hrs:<br>Min:                    | Hrs:<br>Min:                        |
| <b>3.</b> How much time do you spend sitting while using the <b>computer</b> per day, excluding your normal working hours      | Hrs:<br>Min:                    | Hrs:<br>Min:                        |
| <b>4.</b> How much time do you spend sitting while <b>travelling</b> from place to place (e.g. in car, bus, train)             | Hrs:<br>Min:                    | Hrs:<br>Min:                        |
| <b>5.</b> How much time do you spend sitting while <b>eating and socialising and relaxing</b> on a week day (Monday – Friday)? | Hrs:<br>Min:                    | Hrs:<br>Min:                        |
| <b>Sleep</b><br>The following question relates to the amount of time you spend sleeping.                                       |                                 |                                     |
| <b>6.</b> How many hours per day do you <b>sleep</b> ?   | Hrs:<br>Min:                    |                                     |