Characterising the physical activity and sedentary behaviour patterns of patients with Peripheral Arterial Disease

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Declaration

I hereby declare that this submission is my own work and that it contains no material previously published or written by another person nor material which has been accepted for an award in any other university or institute of higher learning, except where due acknowledgement has been made in the text.

Signed______________________ Date______________________

Abstract

Characterising the physical activity and sedentary behaviour patterns of patients with Peripheral Arterial Disease (PAD).

By Rebecca Power

Background: Research has highlighted that sedentary behaviour is independently related to indicators of chronic disease. It has been suggested that breaking up sedentary time can be beneficial in offsetting the damage caused by prolonged sitting. Patients with Stage II Peripheral Arterial Disease (PAD) experience leg pain when walking. This can be alleviated by rest and so they are more likely to engage in long sitting periods.

Methods: Observational analysis of a case and control group was performed using 19 PAD patients (84% male, aged 62.9±8.8 years) from a vascular outpatient clinic and 22 controls with no history of vascular disease (77% male, aged 62.3±9.3 years) from the surrounding area. Data were collected for 7 days using a motion sensor (ActivPAL), daily activity diary, and a questionnaire. Functional ability was assessed using a 6-minute walk test and 30 second chair stand test. Vascular health was measured using Ankle Brachial Index and health status was recorded using a Peripheral Artery Questionnaire.

Results: ActivPAL mean daily activity time (1.46±.43 vs. 1.92±1.59 h; p=0.007) and mean number of steps/day (6801±2518 vs. 9357±3452; p=0.009) were significantly lower among cases than controls. ActivPAL mean daily sedentary time (9.59±1.74 vs. 9.51±1.77 h) was similar across cases and controls. Self-reported sedentary time via questionnaire was significantly lower among cases than controls (5.01±2.62 vs. 8.78±4.28 h; p=0.029). Sedentary patterns were similar, with the exception of morning time patterns which were longer in duration among cases. Mean number of breaks in sedentary time per day were lower (51.7±12.6 vs. 54.6±15) and the average duration of breaks were shorter (7.83±2.86 vs. 8.32±4.35 min) among cases than controls, but differences between the groups were not statistically significant. Mean scores from both functional ability tests (chair repetitions and walking test) were significantly lower among PAD patients (cases) than controls (p=0.003 and p=0.000, respectively).

Conclusion: Lower activity time among cases may be due to reduced functional ability as a result of their condition. Objectively measured sedentary time was not different between groups but subjective data suggested higher sedentary time in the control group.

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List of abbreviations

ABI – Ankle Brachial Index

BMI – Body Mass Index

CDC – Centers for Disease Control and Prevention

HDL – High Density Lipoprotein

IPAQ – International Physical Activity Questionnaire

MET – Metabolic Equivalent

PAD – Peripheral Arterial Disease

PAQ – Peripheral Artery Questionnaire

WHO – World Health Organisation

Chapter 1 Introduction

1.1 Introduction

Extensive amounts of research have highlighted that physical activity plays a major role in reducing the risk and stemming the progression of a number of illnesses such as cardiovascular disease, metabolic syndrome, and type 2 diabetes (World Health Organisation (WHO), 2010). As a result, public health bodies recommend regular participation in physical activity to accrue and sustain its associated health benefits. However, advances in technology and labour-saving devices have caused changes in society and reduced the need to be active. This has subsequently contributed to population level increases in the amount of time spent in sedentary behaviours (time spent sitting in different domains such as watching television (TV), at a desk while working, and driving). Research suggests that sedentary behaviours have an independent health effect, and that the positive health effects associated with physical activity may be undone if people spend the remainder of the time in sedentary activities (Hamilton, Hamilton & Zderic, 2004). Furthermore, it appears that the effects of prolonged sitting time (increased risk of all-cause mortality, diabetes mellitus, and a higher prevalence of metabolic syndrome) cannot be counteracted with recommended or even high amounts of physical activity (Healy et al. 2008a).

1.2 Statement of the topic

This research will establish the physical activity and sedentary behaviour patterns of individuals with Peripheral Arterial Disease (PAD) and controls. The severity of PAD and its relationship (if any) with habitual physical activity and sedentary behaviour patterns will also be examined.

1.3 Research questions

This study will investigate the following research questions:

1. What are the activity levels of individuals with Peripheral Arterial Disease in comparison to those without the condition?

2. What are the sedentary behaviour patterns of individuals with Peripheral Arterial Disease in comparison to those without the condition?

3. Is the severity of PAD related to physical activity and sedentary behaviour patterns?

4. What is the relationship between (a) objectively and (b) subjectively measured physical activity and sedentary behaviour?

1.4 Relevance of the study

Low levels of physical activity and high amounts of time spent sedentary are adding to the prevalence of chronic diseases. Peripheral Arterial Disease (PAD) is a chronic condition where peripheral circulation is inadequate to meet the metabolic requirement of the active leg muscles. This results in ambulatory dysfunction and a subsequent decline in daily physical activity. Because ambulation is one of the main physical activities performed by middle-aged and older adults, it is hypothesised that individuals with PAD are likely to spend a large amount of time sitting and adopt a sedentary lifestyle. Studies have reported lower amounts of daily physical activity among individuals limited by PAD compared to healthy controls (McDermott et al. 2000). However, to fully capture the habitual patterns of individuals with PAD, measures of both activity and sedentarism are necessary. This study will also provide contextual information about the PAD population group which is important for identifying intervention targets and public health messages.

1.5 Research methodology

This study carried out observational analysis of a case and control group, and used both objective (accelerometer) and subjective (questionnaire and activity diary) measurement tools to assess physical activity and sedentary behaviour patterns.

Vascular health and functional ability were also assessed to examine the effect of PAD severity on habitual activity and time spent sedentary.

1.6 Structure of the thesis

Chapter 1 – Introduction - this chapter will give an overview of the entire study.

Chapter 2 – Literature Review - this chapter will provide a background to the study and reviews previous literature in relation to:

1. Physical activity
2. Sedentary behaviour
3. Physical activity, sedentary behaviour, and chronic illness

Chapter 3 – Methodology - this chapter will outline the research design, the population sample chosen, and the recruitment procedures and instruments employed to gather objective and subjective data.

Chapter 4 – Results - this chapter will present the findings obtained from accelerometer, questionnaire, and activity diary data. Vascular health and functional ability results will also be reported.

Chapter 5 – Discussion - this chapter will review the main findings of the study and suggest provide possible explanations for the observed outcomes, as well as addressing study limitations, recommendations for future research and practice, and an overall conclusion of this research.

Chapter 2 Literature Review

2.1 Chapter outline

This chapter provides a background to the research and consists of three sections. The first section (section 2.2) will address the benefits associated with participating in regular amounts of physical activity and the health consequences of not being sufficiently active. In addition, a number of techniques used to measure physical activity are described. The second section (section 2.3) will review the characteristics of sedentary behaviour, as well as the adverse health effects associated with prolonged periods of time spent sedentary. A number of instruments used to measure sedentary behaviour are also discussed. The final section of this chapter (section 2.4) focuses on Peripheral Arterial Disease (PAD), and describes how this chronic illness is identified, treated, and measured.

2.2 Physical activity

Physical activity is operationally defined as:

> "any bodily movement produced by skeletal muscles that results in caloric expenditure" (Caspersen, Powell & Christenson, 1985, p.126).

This definition should not be mistaken with the term "exercise", which is a subcategory of physical activity that is planned, structured, and repetitive, with the aim of improving or maintaining physical fitness (Caspersen et al. 1985). Approximately 60% to 70% of total daily energy expenditure is derived from resting metabolic rate, 10% from the diet, and the remainder from physical activity (Bouchard, Blair & Haskell, 2007). Physical activity is a complex behaviour as it can be derived from a number of areas e.g. leisure, work and, there are many ways in which it can be quantified. It is most commonly characterised by type (static or dynamic), frequency (number of activity bouts performed, duration (hours or minutes which can be continuous or intermittent), and intensity (Howley, 2001; Welk et al. 2002). Physical activity intensity is usually quantified in metabolic equivalents (MET). One MET equates to resting energy expenditure, or approximately 3.5 ml/kg/min in terms of oxygen consumption (Ainsworth et al. 2011). As different intensity levels of activity require greater levels of oxygen consumption, activities can be quantified in terms of multiples of resting energy expenditure.

2.2.1 Benefits of physical activity

A considerable amount of scientific evidence exists to demonstrate that physical activity can reduce the risk, severity, and progression of a myriad of diseases (Physical Activity Guidelines Advisory Committee (PAGAC), 2008). The protective effects of an active lifestyle have been studied since the 1950s (Morris & Crawford, 1958; Morris, Heady, Raffle, Robert & Parks, 1953; Paffenbarger, Hyde, Wing, & Hsieh, 1986). Seminal research by Morris et al. (1953) associated occupation with cardiovascular disease risk. It was observed that men in more physically active jobs had a lower cardiovascular disease risk than those with less active occupations. Further work by Morris & Crawford (1958) also supported this finding as a higher coronary heart disease mortality was found among men aged 45-64 years that engaged in light work (porters and messengers) compared to men of the same age that performed heavy or more labour intensive work such as builders and dock labourers. Later, Paffenbarger et al. (1986) tracked almost 20,000 Harvard alumni aged 35-74 years for 16 years and reported that death rates decreased steadily as energy expenditure from different activities increased. Deaths rates were one quarter to a third lower among individuals that expended 2000 kcal or more per week compared to less active men. These studies created initial awareness and understanding about the need to be physically active for developing and maintaining good health.

In the interim, a growing body of research has suggested that higher levels of physical activity can substantially reduce the risk of all-cause mortality (Arrieta & Russell, 2008; Ford, Bergmann, Boeing, Li & Capewell, 2012; Schoenbron & Stommel, 2011; Wen et al. 2011), and a number of studies have consistently reported risk reductions in developing cardiovascular disease ranging from 29% to 35% among individuals that were regularly physically active during the week compared with those least active (Leitzmann et al. 2007; Nocon et al. 2008; Sofi et al. 2007; Shiroma & Lee, 2010). Physical activity has been shown to reduce cardiovascular risk by improving endothelial function (Hambrecht et al. 2000; Huang, Wang & Wu, 2011) and reducing blood coagulation, which is important in terms of limiting thrombosis (Linke, Erbs & Hambrecht, 2006). Physical activity is also beneficial for metabolic health. Metabolic syndrome includes abnormalities of at least three of the following cardio-metabolic risk factors: fasting plasma glucose, high-density lipoprotein (HLD) cholesterol, triglycerides, waist circumference, and blood pressure (Alberti et al. 2009). Physical activity has the ability to lower fasting triglyceride levels and increase concentrations of HDL cholesterol (Bosak, 2012; Janssen & Ross, 2012; Carroll & Dudfield, 2004). Moderate and high levels of physical activity can also reduce blood pressure and reduce adiposity, which is necessary for weight management (Bassuk & Manson, 2010). Regular physical activity is also important in reducing the onset of diabetes (Li et al. 2008; Lindstrom et al. 2006; Sigal, Kenny, Wasserman, Castaneda-Sceppa & White, 2006; Villegas et al. 2009).

The risk of developing certain cancers can also be reduced by engaging in regular physical activity. Thirty minutes to an hour of moderate to vigorous intensity physical activity can help lower the risk of both bowel and breast cancer (Kruk & Aboul-Enein, 2006; WHO, 2010). Women that engage in regular physical activity can reduce their risk of developing breast cancer (Tehard, Friedenreich, Oppert & Clavel-Chapelon, 2006), with a greater risk reduction found for postmenopausal women (Friedenreich & Cust, 2006; Slattery et al. 2007). Across a range of studies reviewed by Lynch, Neilson, and Friedenreich (2011), physical activity was found to reduce the risk of breast cancer among women by an average of 25%. A study conducted by Parent et al. (2011) found that physical activity over the lifespan can reduce the risk of a number of cancers in men, with the strongest risk reductions for colon and prostate cancers. Research performed in the United States has suggested that physical activity can reduce individuals' risk of developing colon cancer by 30% to 40% (Schottenfeld & Fraumeni, 2006; Slattery, 2004). Other studies have also indicated a reduction in colon cancer among highly active individuals (Lee, 2003; Samad, Taylor, Marshall & Chapman, 2005). Furthermore, although it is not specifically known how physical activity results in improving mental health outcomes (Dishman & O'Connor, 2009), it has been associated with benefiting a number of mental health conditions, in particular depression (Abu-Omar, Rütten & Lehtinen, 2004; Dinas, Koutedakis & Flouris, 2011; Garber et al. 2011; Rethorts, Wipfi & Landers 2009) and anxiety (Carek, Laibstain & Carek, 2011; Jonsdottir, Rödjer, Hadzibajramovic, Börjesson & Ahlborg, 2010).

2.2.2 Physical activity as a methods of secondary prevention

Physical activity is also considered effective as a form of secondary prevention, with the main objective being to increase amounts of physical activity and improve physical functioning and overall well-being (Durstine et al. 2000). Physical activity can help limit the progression of a number of chronic illnesses such as cardiovascular disease, cancer, osteoarthritis, chronic obstructive pulmonary disease, and chronic lower back pain (Karmisholt & Gøtzche, 2005; Macera, Hootman & Sniezek, 2003). In terms of cardiovascular disease, physical activity can help reduce modifiable risk factors such as elevated blood pressure, blood cholesterol, and obesity, which in turn can reduce clinical manifestations of the disease (American College of Sports Medicine, 2010). Leon et al. (2005) reported that participation in exercise-based cardiac rehabilitation programmes reduced total mortality by a fifth and reduced cardiac mortality by 26%. Similarly for cancer, physical activity as a form of secondary prevention can help improve mortality rates among patients, for example, among breast cancer survivors. Holmes, Chen, Feskanich, Kroenke and Colditz, (2005) found that compared with women who performed less than 3 MET hours of activity per week, women that engaged in 9 or more MET hours per week reduced their mortality risk by 6% at 10 years follow up. More recently, Schmitz (2011) suggested that 3 or more hours of aerobic activity could help reduce breast cancer mortality rates among survivors. Physical activity is also considered very beneficial for diabetes mellitus as it has the capacity to increase sensitivity, and reduce diabetes related health complications. Colberg et al. (2010) highlighted that aerobic and resistance based training increase skeletal muscle proteins and enzymes associated with glucose metabolism. In addition, physical activity can also have a positive effect on co morbidities such as hypertension that commonly occur in individuals with type 2 diabetes (Sigal et al. 2006).

2.2.3 Physical activity and older adults

Physical activity is particularly beneficial for healthy ageing as it helps to maintain weight and physical function. Gebel, Ding and Bauman, (2014) found that a weekly accumulation of 150-299 minutes of moderate intensity activity had a 12% reduction in the odds of functional decline among older adults, and those that reported over 300 minutes of moderate physical activity had a 19% reduction. Walking is the most common type of physical activity performed by older adults (Centers for Disease

Control and Prevention, (CDC) 2012; Harris et al 2013), and has been shown to greatly lower the risk of cardiovascular disease in both older men and women (Bijnen et al. 1998; Manson et al. 2002). In addition, physical activity improves endothelial function and protects against the development of atherosclerosis in the vessel walls (Taylor et al. 2004). Regular physical activity also contributes to muscle strength, and joint structure and function. Weight-bearing and resistance forms of physical activity are particularly effective in improving muscle mass and promoting increases in bone mass density which are necessary to enhance balance and prevent the occurrence of falls and fall-related fractures (Singh, 2002; WHO, 2010). Finally, physically activity can also have a positive cognitive effect which is important among older adults in particular (Jak, 2012; Ratey & Loehr, 2011).

2.2.4 Physical activity guidelines

The optimum amount and types of physical activity are not clear (Gebel et al. 2014). Early recommendations mainly concentrated on promoting vigorous intensity physical activity (American College of Sports Medicine, 1975). However, as research and knowledge expanded it became evident that moderate and even low amounts of physical activity also provided health benefits (Lee, Rexrode, Cook, Manson & Buring, 2001; Manni et al. 2006; Manson et al. 2002; Pate et al. 1995). Current physical activity recommendations (WHO, 2010) state that adults should accumulate at least 150 minutes of moderate intensity aerobic physical activity per week (30 minutes/day on 5 days of the week) or at least 75 minutes of vigorous intensity activity per week. It is also suggested that any activity performed should be sustained in bouts of at least 10 minutes in duration (WHO, 2010). For older adults, at least 30 minutes of moderate intensity activity 5 days per week is also recommended, with emphasis placed on muscle strengthening and balance to reduce the risk of falls. Older adults with a chronic illness or disability are encouraged to be as active as possible. These recommendations have been adopted by many countries including Ireland (Department of Health and Children & Health Service Executive, 2009). Moderate intensity is recognised as any activity with an energy cost of 3-6 METs, and is recommended not only because it has been shown to benefit health but also because it was believed that this level of intensity might be a more realistic goal and achieved more easily (Murphy, Blair & Murtagh, 2009). While not part of the public health recommendations, the "accumulation of 10,000 steps per day guideline” which originated in Japan in the 1960s (Hatano, 1993) has been emphasised in research studies and in the public domain (Tudor-Locke & Bassett, 2004). It has also been shown to be more effective in increasing physical activity levels than the 30 minutes per day recommendation (Hultquist, Albright & Thomoson, 2005; Samuels, Raedeke, Mahar, Karvinen & DuBose, 2011).

2.2.5 Physical inactivity

Although the significance of participating in regular physical activity is well documented, a high percentage of the population are insufficiently active. In Ireland, data from the National Survey of Lifestyles Attitudes and Nutrition (SLÁN) (Ward, Evenson, Vaughn, Brown Rodgers, & Troiano, 2007) showed that less than half (41%) of Irish adults engaged in moderate intensity physical activity for a minimum of 20 minutes per day three or more times per week. Individuals that do not meet these recommendations are considered “physically inactive”. As indicated earlier, physical inactivity is a major threat to individual and public health. It is attributed to 3.2 million deaths worldwide, with the highest number of deaths (1.6 million) occurring in middle-income countries. It also accounts for approximately 20-25% of the breast and colon cancer burden, over a quarter of the diabetes burden, and 30% of the ischemic heart disease burden (WHO, 2010). In 2008, the WHO estimated that the global prevalence of physical inactivity ranged from 15% to almost 50%, with the lowest prevalence in the South East Asian region and the highest in the American and Eastern Mediterranean regions. Among all regions, women were more inactive than men (WHO, 2014). According to the CDC (2011), age-adjusted estimates of physical inactivity among American adults ranged from 10% to 43%. In 2010, the CDC reported (through self-report measures) that between 44% and 65% of American adults achieved the recommended amount of physical activity. However, studies that measured activity levels using objective measures (accelerometers) have found that only about 5% of adults attain the recommended levels of physical activity (Troiano et al. 2008).

2.2.6 Physical inactivity and older adults

Levels of physical activity begin to decline with age (Ingram, 2000). A study of European adults highlighted that almost 80% of individuals aged 65 years and over did not perform any vigorous physical activity over the previous week and that almost 56% did not engage in any moderate intensity physical activity over the previous 7 days (European Opinion Research Group, 2003). Results from the Irish Longitudinal Study on Ageing (TILDA) found that half of Irish adults aged 75 years and over reported low levels of physical activity (Cronin, O'Regan, & Kenny, 2011). For older adults, this decrease in activity can be attributed to the process of ageing which results in a number of changes to the body. Ageing causes progressive structural and functional changes to the cardiovascular system (both the central and peripheral) which can lead to problems such as impairments in cardiac filling, an increased resistance to ejecting blood from the heart, and a decreased heart rate (Taylor et al. 2004). Ageing also causes a decrease in muscle mass over time i.e. sarcopenia, with approximately 3% to 6% of loss of muscle mass per decade (DiPietro, 2007). This reduces the basal metabolic rate, and together with the deterioration of the cardiovascular system adds to the decline in maximal aerobic capacity that is associated with advancing in age. Musculoskeletal fitness which includes muscle strength and endurance, flexibility, balance, and bone health also wanes with increasing age, beginning to decline at just 30 years (Deschenes, 2004; Katzmarzyk, 2007). Musculoskeletal pain is common among adults and the elderly and can greatly reduce functioning and activity levels (Scudds & Robertson, 1998). Ageing is also associated with an increase in chronic illness and disability. This may also contribute to lower activity levels among the older adult population group as they may experience greater functional impairment (Schuit, 2006). Therefore, it is unsurprising that physical activity levels are lower among older adults compared to other population groups.

An ageing population is one of a number of aspects cited by the WHO (2009) that is influencing the health of individuals worldwide. Improvements in life expectancy mean that people are living longer and subsequently, there has been an increase in the total number of older people worldwide. In 2011, life expectancy at birth in Ireland was estimated to be 78.3 and 82.8 years for men and women, respectively (Department of Health, 2013). Population projections indicate that the number of individuals per thousand in Ireland aged 65 years and over will rise from 549,000 in 2012 to 855,000 by 2026 and to 1,419,000 by 2046 (Department of Health, 2013). This has huge significance in terms of health including an increase in age-related diseases and the number of frail older adults that may no longer be able to live independently (Hardman & Stensel, 2003).

2.2.7 Measurement of physical activity

The accurate measurement of physical activity is important to: examine the dose-response relationships between physical activity and health outcomes (Dale, Welk & Matthews, 2002), identify and monitor activity levels within populations (Wareham & Rennie, 1998), and assess the effectiveness of interventions aimed at increasing activity levels (Prince et al. 2008). A myriad of instruments to measure physical activity exist. However, there is currently no one superior method for assessing physical activity across populations in all domains (Jorgensen et al. 2009; Scheers, Philippaerts & Lefevre, 2012). Physical activity can be measured through direct observation or by using objective or subjective methods, or a combination of the two. Objective measurement tools include activity monitors (pedometers and accelerometers), heart rate monitors, doubly-labelled water, and indirect calorimetry. Subjective measures involve using self-report instruments such as diaries, logs or questionnaires which can be either self-administered or interview based. Each of these techniques has favourable qualities but also possess problems that limit either their practicality or validity when assessing physical activity. In the following sections, a sample of the numerous physical activity collection methods available and their specific features and drawbacks is discussed.

2.2.7.1 Doubly-labelled water and Indirect Calorimetry

The doubly-labelled water (DLW) method is regarded as the “gold standard” technique for assessing energy expenditure in free-living individuals. It is a measure of carbon dioxide production which is tracked using specific isotopes in the labelled water (Westerterp, 2013). Despite its high accuracy in estimating energy expenditure (Schoeller & van Santen, 1982; Seale, Conway & Canary, 1993), this method is expensive to perform due to the need for laboratory equipment and trained technicians and so it may be impractical to adopt for certain studies. In addition, it requires a high level of engagement and responsibility on the participant which may become burdensome. Indirect calorimetry (IC) is a similar technique and involves quantifying energy expenditure by measuring heat production or heat loss. However, similar to the DLW method, it requires trained technicians and is therefore quite expensive to perform.

2.2.7.2 Pedometers

Pedometers are an inexpensive way of measuring physical activity objectively. These devices quantify physical activity in terms of cumulative steps taken. They are small, easy to use, and can be used as a measurement or self-motivation tool in intervention studies (De Cocker, De Bourdeaudhuij, Brown & Cardon, 2007; Wilcox & Ainsworth, 2009). Evangelista et al. (2005) found that pedometers correlated well with an activity diary (r=0.594), Vo2 max (r=0.444), and a 6-minute walk test (r=0.457) when used to measure exercise adherence among patients with heart failure. However, notable disadvantages limit their ability to measure physical activity accurately. Pedometers cannot discriminate between different walking intensities e.g. walking and running nor can they detect energy expended as a result of upper body movements such as carrying objects or pushing. Hence, their ability in predicting energy expenditure is limited (Tudor-Locke, Ainsworth, Thompson & Matthews, (2002). More importantly, pedometers do not contain an internal clock or the ability to store data, and so they cannot provide information on patterns of physical activity (Berlin, Storti & Brach, 2006).

2.2.7.3 Accelerometers

Accelerometers are more advanced measurement tools. These small, non-invasive devices provide objective information on the amount, frequency, intensity, and duration of physical activity (Berlin et al. 2006; Plasqui & Westerterp, 2007). The basic principle of accelerometry is based on a mechanical sensing element consisting of a seismic mass attached to a mechanical suspension system. When acceleration occurs, the mass responds by applying force to a spring, causing it to stretch or compress. This displacement is then measured to calculate acceleration (Yang & Hsu, 2010). Accelerometers can accurately differentiate stationary and dynamic activities (Godfrey, Culhane & Lyons, 2007) and have been established as suitable and functional tools for quantifying long-term physical activity in laboratory or free-living environments (Mathie, Coster, Lovell & Celler, 2004). There are a wide range of accelerometers to choose from, many of which have been validated and tested in different settings among varying population groups (de Vries, Bakker Hopman-Rock, Hirasing & van Mechelen, 2006; Plasqui, Bonomi & Westerterp, 2013; Taraldsen, Chastin, Riphagen, Vereijken & Helbostad, 2012). As acceleration picked up by the monitor is proportional to external force, it can reflect the intensity and frequency of movement and can be used to detect movement and classify body postures (Dijkstra, Kamsma & Zijlstra, 2010; Mathie, Coster, Lovell & Celler, 2003; Najafi et al. 2003). Accelerometers can also provide an accurate estimation of energy expenditure using regression equations (Plasqui, Joosen, Kester, Goris, & Westerterp, 2005; Stec & Rawson, 2012; Van Hees et al. 2011). However, no single regression equation works consistently well in predicting energy expenditure (Crouter & Churilla, 2006). Accelerometers also have the capacity to reliably calculate the number of steps, walking cadence, and sit-to-stand transitions performed (Dahlgren, Carlsson, Moorhead, Häger-Ross & McDonough, 2010; Dall & Kerr, 2010).

2.2.7.4 Selecting an Accelerometer

There is quite a lot of variety in the types of accelerometers available, in relation to how output is presented, and in their validity at assessing activities (Plasqui et al. 2013). All monitors have some evidence of being valid and reliable and so careful deliberation of the objectivity and quality of evidence to support these claims is necessary. There are also a number of technical issues to consider before choosing an accelerometer including the specifications of the monitor, sensor placement, the epoch length, and length of monitoring frame. Other important factors to consider are the likelihood of reactivity, and the comparability of results with other research (Garatachea, Torres Luque & González Gallego, 2010; Trost, McIver & Pate, 2005). Orientation and placement of accelerometers are important because it affects monitor output (Mathie et al. 2004; Welk, 2005). Typically, they are worn on the part of the body where movement is being studied e.g. attached to the ankle to monitor leg movement during walking, and it is also recommended that the monitor is placed as close as possible to the body's centre of mass (Plasqui et al. 2013). Many accelerometers can be attached directly to the skin (Lindemann, Hock, Stuber, Keck & Becker, 2005) or by indirect attachment such as straps or pouches (Berlin et al. 2006).

The accelerations generated by activity monitors are converted into units of measurement referred to as counts. These counts represent the estimated intensity of activity which is collected over specific time intervals known as epochs. The length of the sampling period (or epoch) is commonly set at 1 minute intervals, however this varies between monitors. To improve comparability of results between studies it is recommended that counts are sampled in as short an epoch length as possible. Short epoch lengths can be transformed into longer epoch lengths whereas longer epochs cannot be broken down into shorter epochs (Atkin et al. 2012). Count thresholds can then be applied at certain points to determine the intensity level of the activity being performed (Trost et al. 2005). The length of time subjects are instructed to wear the monitor is also necessary to consider. It is vital to operationally define a "day" and what represents a valid day of recording (Ward et al. 2005). It is also important to clarify wear time, non-wear time, and the average number of valid days that will be used in the research (Mâsse et al. 2005). Although the recommended number of monitoring days differs slightly between authors (Esliger, Copeland, Barnes & Tremblay, 2005; Hart, Swartz, Cashin & Strath, 2011; Matthews, Ainsworth, Thompson & Bassett, 2002), the length of the monitoring period should be substantial enough to accurately reflect the habitual levels of physical activity among the population of interest (Garatachea et al. 2010). Inclusion of both week and weekend days are recommended as studies have shown differences in patterns of activity between these two types of days (Metzger et al. 2008).

2.2.7.5 Merits and drawbacks of accelerometers

Accelerometers are compact in size and are discrete, making them suitable to wear on a number of areas on the body (Berlin et al. 2006). Advances in accelerometer technology allow most monitors to store and record activity for extended periods of time. In addition, they have the ability to time-stamp all information being recorded and so activities can be separated and studied independently (Welk, 2002). Accelerometers can measure most types of physical activity that involve lower-extremity movements or trunk acceleration such as walking or running. However, similar to pedometers a limitation of accelerometers is their inability to measure upper arm movements e.g. lifting, carrying, or pushing, as acceleration remains unchanged during these actions (Crouter & Churilla, 2006; Dale, et al. 2002). In addition, they are unable to distinguish between changes in surface terrain or stairs climbing (Terrier, Aminian & Schutz, 2001). This can result in an underestimation of activity and so the data recorded by the monitor may not be a true reflection of the total energy expended. A number of cut-point ranges have been developed to quantify physical activity (Brage, Wedderkopp, Franks, Anderson & Froberg, 2003; Freedson, Melanson & Sirard, 1998; Hendelman, Miller, Baggott, Debold &

Freedson, 2000; Matthews et al. 2008; Swartz et al. 2000). Although using cut-points helps give meaning to large volumes of data, Welk (2002) highlighted that this practice creates artificial categories of data that by nature are continuous. The high level of inter-individual variability is also problematic and can create bias as, for example, the number of counts will differ between tall and short people (Welk, 2002). Counts are arbitrary and device specific (Paul, Kramer, Moshfegh, Baer & Rumpler, 2007) and there is poor agreement between cut-points at light and moderate activity levels (Thiese, Hegmann, Behrens, Garg & Porucznik, 2014). Strath, Bassett and Swartz (2003) illustrated how the use of different cut-points for intensity on the same data set presented very different results. In addition, the classification of intensity using accelerometer cut-points determined from calibration studies that use young, healthy participants may not be suitable for middle-aged adults (Miller, Strath, Swartz & Cashin, 2010; Troiano et al. 2008). Finally, the lack of standardised methods for data reduction creates difficulty when comparing results across studies (Troiano, 2005). Problems also arise when different decision rules are used to process the data, such as the minimum number of days the monitor is worn. Collectively labelled as post-data collection processing rules (Edwardson & Gorely, 2009), these can affect important outcome variables, such as physical activity (Mâsse et al. 2005).

2.2.7.6 ActivPAL

The activPAL (PAL Technologies Ltd, Glasgow, Scotland) is one of several activity monitors on the market used to measure ambulatory activity. This uni-axial accelerometer is compact and lightweight, measuring 53 x 35 x 7 mm and weighing 15 grams. It provides data on activity and step counts which can be used to determine physical activity, and information on thigh inclination which is used to distinguish postures. The activPAL samples acceleration at 10 Hz and has a recording period in excess of 7 days which allows for both detailed and long term monitoring of activity. Data are recorded in 15 second epochs and classified as time spent in sedentary behaviour, standing, and walking. Epochs are then summed to provide information on accumulated time in each category. Information is also gathered on step counts, energy expenditure, and posture transitions. The monitor is attached to the anterior aspect of the thigh using a double-sided hydrogel adhesive patch known as a “PAL stickie”. Due to their multi-stick property these can be easily removed and reattached to the skin multiple times. A number of studies have examined the validity and reliability of the activPAL accelerometer and deemed it to be a sensitive and accurate measurement tool in classifying movement (Godfrey et al. 2007; Grant, Ryan, Tigbe & Granat, 2006; Ryan, Grant, Gray, Newton & Granat, 2008). Godfrey et al. (2007) indicated that the monitors' accuracy in recording different postures was 98%. Additionally, Grant et al. (2006) reported an inter-observer reliability >0.97 for all postures and found that posture transitions recorded by the monitor and through direct observation were identical. The activPAL is also regarded as a valid tool for measuring the amount of steps taken and walking cadence (Busse, van Deursen & Wiles, 2009; Dahlgren et al. 2010; Grant, Dall, Mitchell & Granat, 2008; Harrington, Welk & Donnelly, 2011; Maddocks, Petrou, Skipper & Wilcock, 2010). For treadmill walking at 4.5 km/h flat and with an incline, Dahlgren et al. (2010) reported very high test-retest reliability of the activPAL (ICC=0.94 and 0.95, respectively). Correlations were also high for treadmill walking at 3.2 km/h, treadmill jogging at 8 km/h and stairs walking (ICC=0.88, 0.81 and 0.70, respectively). The monitor also has the capacity to record steps taken at varying walking speeds (Kanoun, 2009; Ryan, Grant, Tigbe & Granat, 2006) and posture transitions (Grant et al. 2006; Ryde, Gilson, Suppini & Brown, 2012; Skipworth et al. 2011).

2.2.7.7 ActivPAL measurement issues

Like most activity monitors the activPAL has difficultly recording some types of activity. Tests carried out by Dahlgren et al. (2010) showed low relative and absolute reliability for cycling. This activity is difficult for the activPAL to classify as it is neither a fully upright nor a fully sitting activity. Measuring very slow walking speeds can also be problematic as the low acceleration amplitudes may not be detected by the monitor (Skipworth et al. 2011). Grant et al. (2006) also highlighted that some very short walking periods that have short intervals between them can sometimes be interpreted as one continuous walking period by the activPAL. This may give a higher estimation of walking and a lower estimation of standing. No specific cut-points for the activPAL have been established to classify individuals based on the amount of activity they perform. Cut-points from other activity monitors could potentially be adopted and applied to the activPAL. However, as noted earlier, using different cut-points on the same data can cause results to differ substantially (Strath et al. 2003). Despite these limitations, the activPAL is still regarded as an accurate and valid accelerometer for assessing activity among individuals.

2.2.7.8 Questionnaires

Subjective methods such as questionnaires are also used to assess physical activity. Despite developments in measuring physical activity using objective methods, many research studies still rely on self-report instruments as the primary form of data collection (Bowles, 2012). Similar to accelerometers, an assortment of physical activity questionnaires are available, making the decision of which one to use difficult. Physical activity questionnaires have been tested and validated successfully among different population groups. Stel et al. (2004) found repeatability ranging from 0.65 to 0.75 for a physical activity questionnaire (Longitudinal Ageing Study Amsterdam Questionnaire) used with older adults aged 69-92 years. In addition, the questionnaire correlated strongly with an activity diary (r=0.68) and correlated moderately with a pedometer (r=0.56). Another physical activity questionnaire (Short QUestionnaire to ASsess Health-enhancing physical activity (SQUASH)) used among adults aged 27-58 years also displayed good reliability ranging from 0.44 to 0.96. However, relative validity was only moderate as a Spearman's correlation coefficient of 0.45 was observed between the questionnaire and the Computer Science and Applications (CSA) activity monitor (Wendel-Vos, Schuit, Saris & Kromhout, 2003). In contrast, Corder et al. (2009) examined the validity and reliability of four self-report questionnaires in assessing the physical activity of children aged 4 to 17 years and reported varying levels of validity (r=0.09-0.46), with only two of the four questionnaires showing good ranges of repeatability (r=0.64-0.92). The large variability evident between questionnaires may be due to measurement error of questionnaires which will be discussed subsequently.

2.2.7.9 Merits and drawbacks of questionnaires

Questionnaires are feasible, easy to administer, and can be used among large sample sizes (Aadahl & Jorgensen, 2003; Atkin et al. 2012; Kwak, Kremers, Brug & Van Baak, 2007). They have the capacity to capture both qualitative and quantitative information and can record activities that are not captured by accelerometers e.g. weight-lifting, cycling (Dale et al. 2002). Despite their many advantages, questionnaires can be somewhat arbitrary as they rely on the individuals' ability and accuracy to recall events. This can result in an under- or over-estimation of energy expenditure. Research suggests that individuals are much better at recalling structured bouts of vigorous intensity activity, and less able to remember routine or spontaneous activities that are of a light or moderate intensity (Sallis & Saelens, 2000; Welk, 2002). Certain personality characteristics may also cause misreporting of activity. Social desirability which is defined as:

> "the defensive tendency of individuals to portray themselves in keeping with perceived cultural norms" (Hebert et al. 1997, p.1046)

has been found to influence participants' reporting of activity levels and can cause under-reporting of socially undesirable characteristics or over-reporting of socially desirable behaviours (Adams et al. 2005; Shepard, 2003). Furthermore, the classification of intensity, which is required for most questionnaires, is a complicated issue and is dependent on age and familiarity with the activity (Lagerros & Laqiou, 2007; Vaz & Bharathi 2004; Welk, 2002), and may differ between those with a higher body weight or better fitness level (Trost et al. 2005).

2.2.7.10 International Physical Activity Questionnaire

The International Physical Activity Questionnaire (IPAQ) is a widely used physical activity questionnaire. It was developed in response to the recognised role of physical activity in the worldwide increases in non-communicable diseases, and to act as a public health surveillance indicator for large scale representative surveys (Bauman et al. 2009a). It was also created to fill the niche for a population measure of physical activity that was comparable across countries. Both long and short formats of the questionnaire were created and intended to be used among adults aged 18-65 years. The IPAQ long form (IPAQ-LF) provides comprehensive information on the duration (hours and minutes) and frequency (days) in vigorous and moderate intensity physical activity and walking performed across four different domains over the previous week: leisure, domestic and gardening, work, and transportation. The short form of the questionnaire (IPAQ-SF) poses questions about overall participation in activities in both vigorous and moderate intensity and walking. Summations and calculations of time spent in specific categories (and domains for IPAQ-LF) can be attained using a standardised scoring protocol that was developed with the questionnaire (IPAQ, 2005). Since its introduction, the IPAQ has become the most frequently used questionnaire when quantifying physical activity (van

Poppel, Chinapaw, Mokkink, van Mechelen & Terwee, 2010). It has been used to estimate physical activity prevalence at population level (Bauman et al. 2009b) and provide European estimates of physical activity and worldwide prevalence levels of physical inactivity (Guthold, Ono, Strong, Chatterji & Morabia, 2008; Sjöström, Oja, Hagströmer, Smith & Bauman 2006).

2.2.7.11 IPAQ reliability and validity

Shortly after its development, a comprehensive 12-country study with a sample size exceeding 2000 participants was conducted by Craig et al. (2003) to test the validity and reliability of the IPAQ. Tests of four long and four short versions of the questionnaire were performed in 14 centres across 12 countries using standardised translation and adaptation methods. Test-retest reliability for the IPAQ-LF and IPAQ-SF versions demonstrated high and acceptable levels of repeatability, respectively. Although correlations of the IPAQ-SF ranged from 0.32 to 0.88, over three quarters of these were above 0.65. The inter-class correlation coefficient between short and long forms was 0.67 and for different short versions was 0.58. However, in terms of criterion validity (which was assessed using the CSA activity monitor), only fair to moderate agreement was observed, as correlations ranged from 0.26 to 0.39 for the long form and 0.23 to 0.36 for the short form. Lee et al. (2011) suggested that these low scores may be due to demographic or cultural differences between participants. Other studies have also found good test-retest reliability of the IPAQ (Brown, Trost, Bauman, Mummery & Owen, 2004; Deng et al. 2008; Macfarlane, Lee, Ho, Chan & Chan, 2007; Pedišić, Jurakić, Rakovac, Hodak & Dizar, 2011; Roman-Viñas et al. 2010).

A number of other studies that have measured the criterion validity of the IPAQ-LF have mostly generated low to acceptable results (Boon, Hamlin, Steel & Ross, 2010; Hagströmer & Sjöström, 2006). Since the research of Craig et al. (2003), the IPAQ-SF has been validated more times than any other physical activity questionnaire (van Poppel et al. 2010). Ekelund et al. (2006) reported moderate correlations for the IPAQ-SF while a systematic review of 23 studies carried out by Lee et al. (2011) highlighted small correlations (r=0.09-0.39) between the IPAQ-SF and objective physical activity measures.

2.2.7.12 Merits and drawbacks of the IPAQ

The IPAQ questions were modified to be culturally appropriate and country-specific examples were used to help define physical activity (Craig et al. 2003). In addition, standardised approaches have been established for data handling, treating, missing values, and for classifying individuals into an activity category (IPAQ, 2005). Although compliance to these standardised methods cannot be guaranteed, if adhered to, the comparability of data between studies improves. Questionnaires which focus on leisure-time activity may omit considerable physical activity that occurs for work or travel purposes. The IPAQ-LF assesses physical activity performed in multiple domains, allowing it to fully capture daily activities requiring varying levels of energy expenditure. This is important when documenting and comparing activity levels in developing countries (Shepard, 2003). Although the IPAQ-SF gathers less information than the IPAQ-LF and cannot estimate changes in physical activity in any specific domain (Boon et al. 2010), it is useful in providing a brief estimate of overall total physical activity and for monitoring entire populations.

Over-reporting is a key limitation of questionnaires, and it is also prevalent in the IPAQ (Boon et al. 2010; Ekelund et al. 2006; Johnson-Kozlow, Sallis, Gilpin, Rock & Pierce, 2006; Sebastião et al. 2012). It has been suggested that features of the IPAQ may encourage over-reporting. Rzewnicki, Auweele and De Bourdeaudhuij (2003) proposed that when asked to provide an average time spent completing an activity on one of the previous seven days, individuals are likely to choose a day where the activity of interest was carried out the most. In this study participants also cited difficulty with the IPAQ time criterion as they did not take into consideration the condition of only including walking time that was greater than 10 minutes which could also contribute to incorrect estimations of physical activity. Measurement error is also apparent between IPAQ and accelerometer scores and has been found to increase as the time in activity and sitting increase (Boon et al. 2010; Hagströmer, Ainsworth, Oja & Sjöström, 2010).

2.2.7.13 Activity diaries

Activity diaries are another form of self-report and involve periodic recording of all activities. They are one of the main methods for depicting information on how people use their time throughout the day (Crosbie et al. 2006). They can be researcher-administered which involves direct observation, or interview-or self-administered (Crosbie et al. 2006). Activity diaries which are self-administered are often preferred as interviews may be impractical for researchers. Ideally participants fill in the information intermittently throughout the day. Diaries can have an open format where individuals record activities in their own words. Alternatively, a more structured approach can be used where activities are listed or categorised and the participant highlights activities that are applicable i.e. a physical activity log. It has been suggested that although they are more cumbersome for participants, diaries provide more detail than logs about the type, intensity, and patterns of activities performed (Welk, 2002).

2.2.7.14 Application of activity diaries

Activity diaries have been used as independent measures (Bharathi et al. 2009; King, Haskell, Young, Oka & Stefanick, 1995; Sääkslahti et al. 2004) however; they are more commonly used as an additional assessment or validation tool rather than the main measure of physical activity. A study carried out by Bringolf-Isler et al. (2009) involved the combination of accelerometer time and activity diary data which resulted in an accurate quantification of both the intensity and the duration of children's habitual physical activity. Other studies have also used activity diaries as supplementary physical activity measurement tool (Harris et al. 2013; Ottevaera et al. 2011; Perry et al. 2010). Activity diaries have been used successfully in measuring physical activity among different population groups including children (Rodriguez et al. 2002; Wen, van der Ploeg, Kite, Cashmore & Rissel, 2010; Wendy et al. 2011), adolescents (Aerenhouts, Zinzen & Clarys, 2011; Pfitzner et al. 2013), and individuals with a chronic condition (Klassen, Schachter & Scudds 2008; van Nimwegen et al. 2013). Data obtained from activity diaries has also been shown to correlate adequately with questionnaire data (r=0.32 for total activity and r=0.41 for vigorous intensity activity) (Carter-Nolan et al. 2006). A pre-categorised diary developed by Bouchard et al. (1983) displayed good reliability for both mean kcal of energy expenditure over 3 days (r=0.96) and for daily energy expenditure (r=0.86-0.95). Modified versions of the Bouchard activity diary have also provided accurate estimates of energy expenditure when compared with other physical activity measures (Bratteby, Sandhagen, Fan & Samuelson, 1997; O'Connor et al. 2003).

2.2.7.15 Merits and drawbacks of activity diaries

Activity diaries offer similar advantages as other self-report instruments. They are easy to use and are relatively inexpensive to administer (Kwak et al. 2007). They also provide a great amount of detail about the type of activity performed and provide an insight into activity patterns (Bringolf-Isler et al. 2009). However, like other self-report measures of physical activity, activity diaries are subject to over-reporting (Duncan, Sydeman, Perri, Limacher & Martin, 2001). A further major limitation of activity diaries is that they are labour intensive and require regular engagement by the individual. This burden on participants may impact compliance and the response rate of the study. Furthermore, the act of recording activities in a diary may interfere with habitual physical activity patterns (Bratteby et al. 1997; Hu, 2008). Individuals may alter their behaviour and so the data provided may not be truly representative i.e. the Hawthorne Effect where individuals change their behaviour in response to a change in their environment and not due to the effect of change itself (Franke & Kaul, 1978). In addition, diaries that use a specific coding system cannot be used the same way as an open diary (Bouchard et al. 1983). The accuracy and validity of diary data is heavily reliant on the active engagement and participation of individuals, and the specificity of instructions given to participants (Bratteby et al. 1997). The comparative reliability of the data is also an issue as the level of detail provided could range from minimal to exact, depending on the participant (Marshall, 1998 as cited in Crosbie, 2006, p.3). Reporting bias is also a problem with activity diaries as only information that is written down by participants can be analysed. Participants may purposely omit information, forget to write down short activities, or over-state the amount performed, resulting in an under- or over-estimation of these activities in the diary (Scheers et al. 2012).

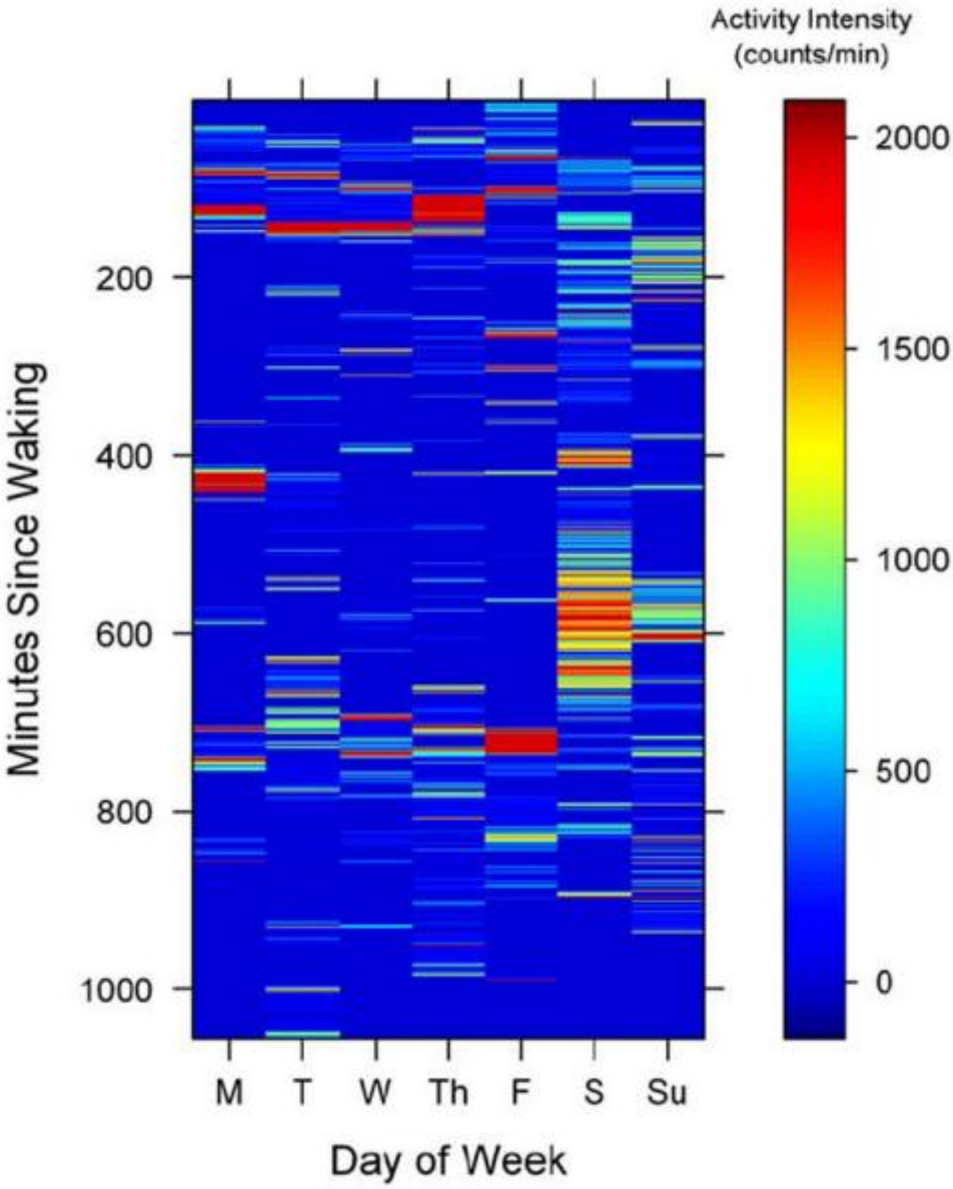
2.3 Sedentary behaviour

While the health consequences of not achieving enough physical activity have been well established, the negative health effects of sedentary behaviour, independent of physical activity, are also becoming apparent. Compared to physical activity, less literature is available on sedentary behaviour. Within this literature, definitions of sedentary behaviour are somewhat inconsistent. Behaviours recognised as sedentary include time spent sitting, reclining, or lying down during waking hours (Dietz, 1996; Owen, Leslie, Salmon & Fotheringham, 2000) whereas a review carried out by Bennett, Winters-Stone, Nail and Scherer (2006) highlighted that a large amount of studies have referred to sedentary behaviour as not being physically active, and viewed it as the opposite end of a physical activity continuum. However, a growing body of research indicates that sedentary behaviour is not merely the absence of low, moderate, or vigorous intensity activity and is instead a unique collection of behaviours with distinct environmental determinants and health consequences (Owen, Healy, Matthews & Dunstan, 2010). This new perspective is referred to as inactivity physiology and is defined as:

> "the acute and chronic physiological effects of sedentary behaviours" (Hamilton, Hamilton & Zderic, 2007, p.2658).

Inactivity physiology or sedentary physiology as it has more recently been described (Tremblay, Colley, Saunders, Healy & Owen, 2010), illustrates how the cellular and molecular processes that occur during sedentary behaviours are qualitatively different from processes that occur during exercise or exercise physiology (Hamilton et al. 2007). Simply put, too much sitting is distinct and independent from too little exercise and both have different health consequences and effects on the body (Varo et al. 2006; Zderic & Hamilton, 2006). A compelling body of research carried out by Hamilton et al. (2004) showed the clinical effects of too much sitting (inactivity physiology). This research found that local contractile stimulation was lost during prolonged sitting over the time course of a day and resulted in the suppression of skeletal muscle lipoprotein lipase (LPL) activity (needed for triglyceride uptake and production of HDL cholesterol) and also reduced glucose uptake. Tests performed on rats also found that plasma triglyceride and HDL cholesterol clearance was impaired when activity was reduced (Bey & Hamilton, 2003). A 90% reduction was observed in the skeletal muscle lipoprotein lipase activity in the legs. Importantly, these effects were not observed in the animals when they engaged in incidental, light-intensity activity. Moreover, sedentary behaviour has been associated with mitochondrial dysfunction, deregulation of cellular redox status, and increased inflammation in sedentary older adults (Safdar et al. 2010). Recognising sedentary behaviour in this way is important due to its distinct nature (Tremblay et al. 2010). Individuals can obtain high or recommended amounts of physical activity but still spend a considerable amount of time in sedentary behaviours. Alternatively, individuals may not achieve the recommended levels of physical activity but engage in large volumes of light intensity or non-exercise activities such as household chores and have low amounts of sedentary time. Hence high/low amounts of activity time are not suggestive of high/low sedentary time (Sugiyama, Healy, Dunstan, Salmon & Owen, 2008a). This is supported by research by Healy et al. (2008a) where low correlations (r=-0.002 for men and r=-0.09 for women) were found between television viewing time and physical activity time, showing that both are separate domains that can coexist. Therefore, defining sedentary behaviour in terms of a lack of physical activity is incorrect and misleading. Figure 1 below which was adopted from Owen, Healy, Matthews, and Dunstan (2011) provides a graphical representation of activity and sedentary time recorded over one week by an accelerometer. The dark blue shading shows accelerometer counts per minute for sedentary time that are less than 100. The pale-blue through to yellow shading represent light-intensity through to moderate intensity physical activities, and the yellow through to red indicate moderate-to-vigorous physical activity. The figure illustrates that the subject accumulated 31 minutes of moderate to vigorous physical activity but spent 71% of their waking hours in sedentary activities.

Figure 1: Cluster heat map of activity and sedentary time



Sedentary behaviour is also commonly defined as activities requiring an energy expenditure threshold of 1-1.5 MET (Brown, Williams, Ford, Ball & Dobson, 2005; Gunn et al. 2002; Pate, O'Neill & Lobelo, 2008). However, this definition may be problematic for measurement as accelerometers can underestimate the amount of energy expended and results can be influenced by the specific cut-off point chosen (Chastin & Granat, 2010). Furthermore, a MET value of 1.5 can also incorporate quiet periods of standing which as outlined by Hamilton et al. (2007) is different physiologically to sedentary behaviour. Alternatively, sedentary behaviour can be classified as a lack of movement or posture allocation in terms of non-upright activity (Chastin & Granat, 2010; Troiano, Pette Gabriel, Welk, Owen & Sternfeld, 2012). Sedentary behaviour is typically reported as the total time spent sitting over the previous day or week, or assessed with reference to a specific type of sedentary behaviour such as television (TV) viewing or computer use.

2.3.1 Prevalence of sedentary behaviour

Research suggests that sedentary behaviours differ by sex, age group, ethnicity, education level, and BMI. Results from the National Health and Nutrition Examination Survey (NHANES) 2009/2010 showed that Mexican-Americans reported significantly lower sitting time compared to non-Hispanic White and non-Hispanic Black ethnic groups (Harrington, Barreira, Staiano & Katzmarzky, 2013). No overall difference in sitting time was observed between genders, however; when stratified by sex, differences in sedentary levels by age became apparent. Among women, sitting time increased with age with the exception of the 40-49 years age group which reported significantly less sitting time than the higher age categories. Similarly, older men (70+ years) reported significantly more sitting time than younger males in their 30s. In a previous NHANES study, Matthews et al. (2008) also found increases in sedentary time with advances in age. Bauman et al. (2011) found that increasing age and higher education levels were predictors of high amounts of sitting time, however, four studies reviewed by Rhodes, Mark and Temmel (2012) found that sitting was unrelated to education. In terms of TV viewing (which is regarded as the most common sedentary behaviour), research suggests that individuals with a low education level and low income are more likely to engage in higher amounts (Bowman, 2006; Clark et al. 2010; Shields and Tremblay 2008). In addition, fourteen out of fifteen studies reviewed by Rhodes et al. (2012) indicated a positive relationship between high amounts of TV viewing and employment status, with one study reporting that retired individuals were twice as likely to engage in prolonged bouts of TV viewing compared to individuals that were still employed.

2.3.2 Characterising sedentary behaviour

According to Tremblay et al. (2010), sedentary behaviours can be characterised by frequency (number of bouts), time, type, and interruptions (breaks) in sedentary activities. Sedentary behaviours are pervasive and have been engineered into our daily lives. They occur in many different domains such as during commuting, the work place, the household, and during leisure time. Common sedentary activities include driving, working at a desk, sitting eating a meal, or watching TV (Katzmarzyk et al. 2009; Owen, Bauman & Brown, 2008). Advances in technology and labour-saving devices have lessened the need to be active (Lanningham-Foster, Nysse & Levine, 2003) and it is plausible to suggest that further technological developments will contribute even more to engaging in activities of a sedentary nature (Owen, Leslie, Salmon & Fotheringham, 2000). Of the many sedentary activities, TV viewing is the most common (Hamilton, Healy, Dunstan, Zderic & Owen, 2008) and consequently it is frequently studied (Salmon, Owen, Crawford, Bauman & Sallis, 2003). Although TV viewing may be the most prominent sedentary behaviour performed, long bouts of sitting are also prevalent in the workplace. Most adults spend 7 to 10 hours per day in sedentary behaviour (Healy et al. 2008b; Matthews et al. 2008) with occupational sitting acting as a key contributor (Jans, Prpoer & Hildebrandt, 2007).

2.3.3 Sedentary behaviour and other lifestyle behaviours

Objectively recorded data from NHANES found that a high percentage of the population in the United States engaged in high amounts of sedentary behaviour. Over half (54.9%) of individuals' waking day was comprised of sedentary behaviours equating to approximately 7.7 hours per day. Older adults were one of the most sedentary groups, spending about 60% of their day in sedentary activities (Matthews et al. 2008). Data showed that adults aged 60-69 years were sedentary for 8.4 hours per day and this increased to over 9 hours for individuals aged 70-85 years. Time spent in sedentary behaviours has also been reported as high among Australian adults. Healy et al. (2007) reported that adults with a mean age of 53.3 years spent 57% of their time in sedentary behaviours. European data has indicated somewhat lower amounts of time spent sedentary with mid-older adults spending between 4.8 and 5.2 hours per day sitting (Bennie et al. 2013). However, this data were collected using the IPAQ-SF which has been shown to display only fair to moderate criterion validity (Craig et al. 2003; Lee et al. 2011). In addition, misreporting is a common feature of questionnaires (Adams et al. 2005; Welk, 2002) and so individuals may have under-estimated the amount of time spent sitting.

As well as identifying the prevalence of sedentary behaviours among population groups, identifying the amount of time individuals spend in sedentary activities is important as it has been suggested that sedentary behaviour displaces time spent in physical activity which contributes to overall reductions in activity levels. Owen et al. (2010) gives the example that replacing 2 hours per day of light intensity activity with a sedentary behaviour would equate to the displacement of energy expenditure associated with a 30 minute walk per day. Sugiyama, Healy, Dunstan, Salmon & Owen (2008b) observed that women who spent more time watching TV also spent more time in other leisure-based sedentary activities and less time in physical activity, and suggested that TV viewing may be a strong marker of a sedentary lifestyle among women.

2.3.4 Health consequences of sedentary behaviour

There are increasing amounts of research indicating that sedentary behaviour is a distinct risk factor for an array of adverse health outcomes in adults. The premise that prolonged bouts of sitting is deleterious to health has been proposed as early as the 17th century, where Ramazzini found that occupations involving sitting for long hours had a detrimental effect on workers' health (Franco, 1999). Further research by Morris and Crawford (1958) supported this finding as a higher incidence of cardiovascular disease was observed among workers who were required to sit for prolonged periods compared to workers that ambulated more. In the last number of years attention has been given to researching sedentary behaviours, resulting in a collection of epidemiological evidence that highlights sedentary behaviour as an independent risk factor for numerous poor health outcomes.

Prolonged engagement in sedentary behaviours has been shown to increase the risk of all-cause mortality in both men and women independent of participation in physical activity (Katzmarzyk et al. 2009; Seguin et al. 2014). Koster et al. (2012) reported that individuals that had the highest sedentary time recorded using an accelerometer had a 3.3 times increased risk of all-cause mortality compared to individuals with the lowest recorded sedentary time, independent of moderate-vigorous intensity activity (hazard ratio = 4.93). As well as all-cause mortality, studies have consistently reported a relationship between time spent in sedentary behaviours and cardiovascular mortality (Chomistek et al. 2013; Patel et al. 2010; van der Ploeg, Chey, Korda, Banks & Bauman, 2012; Wijndaele et al. 2010). A study by Matthews et al. (2012) found that individuals that reported over 7 hours per week of moderate to vigorous intensity activity but also watched large amounts of

TV daily (7+ hours) had a 50% greater risk of death from all causes and twice the risk of death from cardiovascular disease compared to individuals that completed the same amount of physical activity but watched less TV (less than 1 hour).

Results from the Australian Diabetes Obesity and Lifestyle Study (Gardiner et al. 2011) found that high amounts of sedentary behaviours were associated with a higher prevalence of metabolic syndrome. Overall sitting time was associated with a greater risk of high triglyceride levels in both men and women, HDL cholesterol in men, and abdominal obesity in women. TV viewing time in particular was associated with lower HDL cholesterol levels and glucose intolerance in women. A subset of the population sample had their sedentary time measured objectively. Results further portrayed the harmful effects of sedentary time which was negatively associated with waist circumference, 2-hour plasma glucose, and triglycerides (Healy et al. 2007; Healy et al. 2008b). An elevated risk for metabolic syndrome has also been observed in individuals that meet physical activity guidelines. Significant dose–response associations were detected between TV viewing and metabolic risk variables including waist circumference, systolic blood pressure, and 2-h plasma glucose (Bertrais et al. 2005; Ford, Kohl, Mokdad & Ajani, 2005; Healy et al. 2008a). A study by Dunstan et al. (2005) found that each 1 hour increase in TV viewing per day was associated with a 26% increase in the prevalence of metabolic syndrome in women.

The amount of time spent in sedentary behaviours is also associated with an increased risk of diabetes mellitus (Fu, Li, Colditz, Willett & Manson, 2003; Zhang, Solomon, Manson & Hu, 2006) and site specific cancers including endometrial (Gierach et al. 2009) and colon cancers (Howard et al. 2008). Studies have also shown that high levels of sedentary behaviour are associated with weight gain, even when accounting for levels of physical activity (Oken, Taveras, Popoola, Rich-Edwards & Gillman, 2007; Raynor, Phelan, Hill & Wing, 2006). Sugiyama et al. (2008a) found that individuals that spent more time in sedentary behaviours and were not sufficiently physically active had an increased likelihood of being overweight or obese (odds ratio (OR); 2.3 and 3.7, respectively). Occupational sitting has been associated with a higher BMI and obesity (Brown, Miller & Miller, 2003; Clark et al. 2009; Mummery, Schofield, Steele, Eakin & Brown, 2005). However, some studies (Crawford, Jeffery & French 1999; Jeffery & French, 1998) have observed no association with objectively measured weight gain. As findings among studies have been inconsistent, it is not certain whether or not there is a relationship between sedentary behaviour and the risk for overweight or obesity (Proper, Singh, van Mechelen & Chinapaw, 2011).

2.3.5 Breaks in sedentary time

Given the harmful effects of sedentary behaviours, research is emerging on the benefits of breaking up prolonged periods of time spent sedentary. “Breaks” are recognised as interruptions in sedentary time usually resulting from a posture transition from sitting to standing or from standing still to walking (Owen et al. 2010). Breaks in sedentary time have been shown to be positively associated with metabolic biomarkers including waist circumference, BMI, triglycerides and 2-h plasma glucose, with these associations appearing to be stronger for women than for men (Brown et al. 2005; Healy et al. 2008c). Findings on the benefits of breaking up sedentary time highlight that in addition to knowing how much sedentary time individuals engage in, the way in which it is accumulated is also important as even short interruptions of light intensity can be beneficial in terms of metabolic health (Healy et al. 2008c).

2.3.6 Recommendations on sedentary behaviour

Unlike physical activity, specific recommendations on minimum levels of sedentary time are unclear, but provisional and general recommendations have started to emerge. As well as providing recommendations on physical activity, the UK 2011 Start Active, Stay Active document (Davies, Burns, Jewell & McBride, 2011) advises avoiding lengthy periods of sitting, and guidelines in the United States encourage individuals to reduce sedentary time and perform short bouts of activity in between sedentary activities (Garber et al. 2011). Similarly, Australian guidelines encourage individuals to minimise the amount of time spent sitting and to break up prolonged sitting periods (Australian Government Department of Health, 2014). The Canadian Pediatric Society (2003) and American Academy of Pediatrics (2001) provide recommendations on screen time and advise that children should not engage in screen-based activity for more than 2 hours per day. This is also echoed by the Australian Department of Health guidelines who also recommend that children and adolescents frequently break up long periods of sitting.

2.3.7 Measurement of sedentary behaviour

Sedentary activities can occur in a variety of settings and can be of a sporadic nature. Therefore, the measurement of sedentary behaviour is complex. Similar to physical activity, no single measurement tool is regarded as superior for assessing sedentary time. Early research into sedentary behaviour relied on self-report measures (questionnaires), which have been successful in finding associations between sedentary time and adverse health conditions such as cardiovascular mortality (Katzmarzyk et al. 2009) and metabolic syndrome (Dunstan et al. 2005). Overall sedentary time is commonly assessed as total time spent sitting, but as noted earlier, TV viewing is considered the most prominent sedentary activity and consequently it is frequently used as a proxy measure to assess overall sedentary time (Clark et al. 2008; Matton et al. 2007).

A number of existing questionnaires have been employed to assess sedentary time. In addition to measuring physical activity, the IPAQ is also used to determine time spent sedentary. The IPAQ-LF asks about overall time spent sitting over the previous week and weekend. Time spent sitting in a motor vehicle is excluded as it is assessed in another part of the questionnaire (IPAQ, 2005). Similarly, the IPAQ-SF includes a question about time spent sitting over the previous week, but weekends are not included. Measurement properties of the sitting question are considered acceptable (Rosenberg, Bull, Marshall, Sallis & Bauman, 2008). However, Mader, Martin, Schutz, and Marti (2006) found the criterion validity of the IPAQ-SF to be poor at just 0.22.

To provide a better indication of the amount and types of sedentary behaviour performed, researchers have developed other questionnaires incorporating a wide range of sedentary activities for participants to select if applicable. A questionnaire developed by Salmon et al. (2003) examined the reliability and validity of a number of common sedentary activities. Due to some items showing poor reliability, Gardiner et al. (2011) modified the questionnaire and used it to assess sedentary time among a group of Australian older adults. Not only did the questionnaire provide an overall estimate of time spent sedentary but it also allowed a more detailed insight into the types and most common sedentary activities performed. As noted earlier in the chapter, (p.20) questionnaires are not without their errors and are subject to recall bias and misreporting. Nevertheless, they are commonly used to assess sedentary behaviour and provide a good indication of the amount of time spent in sedentary activities and the types performed.

Although recent advances in technology are reducing the need for people to be active, they can however help overcome the limitations of self-report and improve the way in which we measure sedentary time (Katzmarzyk et al. 2009; Owen et al. 2010). As well as measuring physical activity patterns, activity monitors are also capable of documenting sedentary behaviours (Matthews et al. 2008; Kozey-Keadle, Libertine, Lyden, Staudenmayer & Freedson, 2011). They can be used to estimate how long a person is inactive and specifically record when periods of inactivity are broken by bouts of activity which can be useful in identifying patterns of sedentary behaviour. Sedentary time is commonly inferred from accelerometers using an activity count cut-point of <100 counts per minute (Gardiner et al. 2011, Healy, Matthews, Dunstan, Winkler & Owen, 2011a; Matthews et al. 2008). This cut-point has shown to be accurate in classifying sedentary behaviour but it may also under- or over-estimate some sedentary behaviour (Kerr et al. 2013). Indeed, it is important to note that there is no ideal accelerometer cut-point for adults (Gardiner et al. 2011) and debate remains about the choice of cut-point among different population groups to identify sedentary time (Owen et al. 2010). Some studies have shown that only 50% to 60% of sedentary behaviour is accurately categorised using established cut-points (Dijkstra, et al. 2010; Hart et al. 2011). For example, a standing posture may sometimes be misclassified as sedentary behaviour if researchers employ a <100 activity counts per minute cut-point (Kerr et al. 2013).

The activPAL accelerometer has the capacity to specifically identify sedentary time and patterns as it distinguishes sitting or lying from standing and walking. It has been used in a number of studies to identify time spent in sedentary positions (Chastin et al. 2011; Hart et al. 2011; Kozey-Keadle et al. 2011; Lord et al. 2011). Kozey-Keadle et al. (2011) found that the activPAL was highly accurate at recording sedentary positions as it underestimated sitting/lying postures by just 2.8%. As outlined earlier, (p.16) similar to other activity monitors the activPAL has some limitations but overall it is regarded as an accurate and effective measure of sedentary time. With advances in technology, direct observation may also be considered a method for accurately measuring sedentary time. The Microsoft

SenseCam was recently used by Kerr et al. (2013) to objectively measure sedentary time in free-living conditions. The device is worn around the neck and automatically captures photographic images from the wearers' point of view. In addition to providing regular, time-stamped information about activities, it also provides contextual information about where the sedentary activity was performed (e.g. occupational, leisure) and the type of activity.

2.4 Physical inactivity, sedentary behaviour, and chronic disease

Participating in physical activity is essential for good health and not obtaining sufficient amounts can have serious health consequences. Additionally, prolonged uninterrupted periods of sitting can have detrimental effects on individuals' health, irrespective of the amounts of physical activity achieved. This combination of insufficient activity and high sedentary time, together with an ageing population, acts as a catalyst for a greater prevalence of chronic disease. Age and activity are inherent in the major risk factors for mortality which include: high blood pressure (13%), tobacco use (9%), a high blood glucose level (6%), physical inactivity (5.5%), and being overweight or obese (5%) (WHO, 2009). Each of these has a significant impact on public health and contributes to the development of non-communicable/chronic diseases such as cardiovascular diseases, cancers, and diabetes. Although these leading risk factors are mostly associated with high-income countries, the majority of the global burden of disease that they cause exists in low- and middle-income countries (WHO, 2009). Non-communicable/chronic diseases are long lasting conditions that can be controlled and treated but not cured. Although they are more common among older adults they can occur among all age groups. Cardiovascular disease, cancers, respiratory diseases, and diabetes are the four most common conditions and together account for approximately 80% of all chronic illness deaths (WHO, 2013).

2.4.1 Peripheral Arterial Disease

Peripheral arterial disease (PAD), also referred to as peripheral vascular disease, or peripheral artery occlusive disease, is a chronic disease where the vessels of the legs or lower extremities are narrowed or blocked due a build up of atherosclerotic plaque (CDC, 2013). Atherosclerosis is a chronic and systemic disease characterised by the deposition of calcium and fatty materials on the inner walls which prevents the cardiovascular system from transporting oxygenated blood (Brenner, Parry & Brown, 2012; Lerman & Zeiher, 2005). Although many individuals may be asymptomatic or present atypical symptoms (Doyle & Creager, 2003), this obstruction in the lower extremities can cause symptoms ranging from pain on exertion that lessens with rest, to pain at rest, or to ulceration or gangrene of the limb(s) (Irish Heart Foundation, 2004). The onset of pain in the leg muscles while walking that is relieved by rest is known as intermittent claudication or Fontaine classification stage II (Fontaine, Kim & Kieny, 1954). This is the most common clinical presentation of PAD (Meru, Mittra, Thyagarajan & Churg, 2006; Ouriel 2001; Rose 1962) and occurs whenever the energy demand of the active muscle exceeds the capacity of the peripheral circulation system to deliver oxygen (Gardner et al. 2001a). It results in a cramping or tightness sensation in the calf, thigh, or buttock which can only be improved by rest.

Regardless of symptom presence, individuals with PAD have a higher mortality and morbidity risk than individuals without the disease. Co-morbidities such as back disease or arthritis are an issue for individuals with PAD as not only do they increase mortality risk but they may also mask the presence of PAD symptoms (McDermott et al. 2001). This may explain why PAD is commonly undiagnosed as individuals may attribute leg pain to musculoskeletal symptoms of ageing (Treat-Jacobson et al. 2002). According to the Irish Heart Foundation (2004), up to 30% of patients diagnosed with severe PAD will die within 5 years and only 1 in 4 individuals will be alive in 10 years while the 15-year mortality rate is approximately 70% (Department of Health and Children, 2010).

A 10 year study by McDermott et al. (2003a) showed that individuals with PAD had a three and seven fold increased risk of all-cause and cardiovascular mortality, respectively, compared to individuals without the condition. Other studies have also shown that a higher mortality and morbidity risk is prevalent among people with severe PAD (Criqui, Ninomiya, Wingard & Fronek, 2008; Daoud et al. 2011; Suominen, Uurto, Saarinen, Venermo & Salenius, 2010). This increased risk may be due to the presence of atherosclerosis in other areas of the body, which raises the risk of cardiovascular and cerebrovascular events (Irish Heart Foundation, 2004; Steg et al. 2007). In addition, endothelial function is impaired among individuals with PAD compared to those without the condition (Harris et al. 1995). Endothelial function plays a key role in regulating vascular tone, growth, blood clotting, and inflammation and its impairment is associated with cardiovascular events and morbidity (Gokce et al. 2002; Huang et al. 2007; Lerman & Zeiher, 2005).

Also, as PAD affects the lower extremities, individuals with the condition have poorer leg function and reduced walking performance than those without the disease (Crowther, Spinks, Leicht, Quigley & Gollegde, 2007; Gardner, Forrester & Smith, 2001b; McDermott et al. 2001; McDermott et al. 2003b). A study by McDermott et al. (2012) found that lower calf muscle density, weaker calf and ankle muscle strength, and poorer knee extension power were associated with increased mortality among individuals with PAD. Studies also suggest that individuals with PAD experience symptoms of depression which may also contribute to functional impairment (Cherr, Wang, Zimmerman & Dosluoglu, 2007; McDermott et al. 2003a).

As well as an increased mortality risk, individuals with PAD are more likely to have lower daily activity levels (Gardner, Montgomery, Scott, Afaq & Blevins, 2007; McDermott et al. 2000; Sieminski & Gardner 1997) and high sedentary time (Lauret, Fokkenrood, Bendermacher, Scheltinga, and Teijink, 2014) compared to healthy individuals. This contributes even further to the mortality risk which is more than three times higher for inactive individuals (Manni et al. 2006; Garg et al. 2006; Paffenbarger et al. 1986). It is therefore unsurprising that individuals with PAD report having a low quality of life (Leicht, Crowther, Muller & Golledge, 2011; Marrett, daCosta DiBonaventura & Zhang, 2013).

2.4.2 Prevalence of PAD

After coronary artery disease and stroke, PAD is the most common manifestation of atherosclerosis (Selby, 2008). A comprehensive systematic review by Fowkes et al. (2013) estimated that the global prevalence of PAD in both low-middle and high income countries grew from 164 million cases in 2000 to 202 million cases in 2010, an increase of almost 25% over a decade. Other population studies have reported PAD prevalence in the United States and Europe of being between 4% and 8% among individuals aged 40 years and over (Alzamora et al. 2010; Ramos et al. 2009; Selvin & Erlinger, 2004). Peripheral arterial disease is poorly quantified in Ireland but it is suggested that more than 1 in 6 over the age of 55 have the condition, with a third of these presenting with classical intermittent claudication (Irish Heart Foundation, 2004; Weitz et al. 1996). According to the Department of Health and Children (2010), PAD accounted for 12% of cardiovascular disease hospital discharges in 2006, representing 15% of bed days. Furthermore, 20% to 50% of individuals with PAD are asymptomatic while a high percentage (40-50%) present with atypical symptoms.

PAD is relatively uncommon among individuals younger than 40 years and becomes more prevalent with age, affecting approximately 1 in 10 people aged 70 years and 1 in 6 people older than 80 years (Fowkes et al. 2013). Peripheral arterial disease is more common in men; however prevalence becomes more similar in both sexes with increasing age (Kannel, Skinner, Schwartz & Shurtleff, 1970; Sigvant et al. 2007). In general, women experience symptoms associated with cardiovascular conditions differently to men (DeVon, Ryan, Ochs & Shapiro, 2008). In relation to PAD, women are more likely to be asymptomatic (Aronow, 2009) and have fewer cardiovascular co morbidities (McDermott et al. 2003b). Hence, the prevalence is higher among men (Brenner et al. 2012). In addition, women with PAD have poorer leg function. This may be due to co morbidities or weaker leg muscles in women compared to men (McDermott et al. 2003b).

2.4.3 Risk factors for PAD

While gender is not a risk factor for PAD, ethnicity is. Studies have illustrated that Black ethnicity is a strong risk factor for PAD and that Hispanic ethnicity poses as a slightly elevated risk factor compared to Caucasians (Criqui et al. 2005; Ix, Allison, Denenberg, Cushman & Criqui, 2008; Meadows et al. 2009). Peripheral arterial disease is preventable and a number of modifiable risk factors associated with the condition have been identified. The recognition of smoking as the single most important risk factor in the development of PAD has been widespread (Conen et al. 2011; Kannel & Shurtleff, 1973; Powell et al. 1997; Willigendael et al. 2004). Not only does smoking aggravate the symptoms of PAD but it also leads to a two-fold increase in the risk of developing the condition (Hirsch et al. 2006). Another major risk factor for PAD is diabetes mellitus. The prevalence of PAD is high in patients with type II diabetes (Bianchi et al. 2007) and individuals with diabetes are twice as likely to develop PAD also (Tapp et al. 2007; Wattanakit et al. 2005). Other prominent risk factors for PAD include hypertension and hyperlipidaemia (Carbayo et al. 2007; Norgren et al. 2007) as well as physical inactivity. While gender is not a risk factor for PAD, using the population sample from the Edinburgh Artery Study, Housley, Leng, Donnan and Fowkes (1993) found a significant association between lower levels of exercise and increasing disease levels in the population sample as a whole and in men but not women.

2.4.4 Activity and sedentary levels among individuals with PAD

A number of studies have examined the activity levels of individuals with PAD and have all observed lower levels of physical activity among these group of patients compared to individuals without the condition. A study by Sieminski & Gardner, (1997) found that daily energy expenditure was 42% lower among individuals with PAD compared to healthy controls (357±238 vs. 616±363 kcal/day). In addition, the number of steps taken per day was 45% lower among PAD patients compared to individuals without the condition (4737±2712 vs. 8672±4235 steps per day). Furthermore, the rate of decline in free-living physical activity was 42 kcal/day and 612 steps per 0.10 drop in ABI score. Using both objective and subjective measures McDermott et al. (2000) also observed lower amounts of activity among PAD patients compared to healthy controls. Accelerometer data indicated that individuals with PAD accumulated 803±364 kcal/week compared to 1750±1296 kcal/week performed by individuals without the condition. Self-reported activity time was also lower among PAD patients, with the leisure time physical activity questionnaire recording 609±576 kcal/week among individuals with PAD and 832±784 kcal/week among healthy individuals. Research by Gardner et al. (2007) found that patients with PAD took fewer strides per day (3149±1557 vs. 4230±1708) and spent less time ambulating (264±109 vs. 312±96 minutes per day) than non-PAD individuals. A lower daily cadence was also observed among PAD patients (11.8±2.9 vs. 13.5±3.1 strides/minute). Individuals with intermittent claudication had a lower BMI (28.3±6 vs. 30.3±6.3; $p=0.031$) but a higher waist/hip ratio (0.93±0.10 vs. 0.88±0.10; $p=0.033$) than controls. However, in order to adjust for potential confounding, these variables were treated as covariates in subsequent analysis performed by the authors. Clarke, Holdsworth, Ryan, and Granat, (2013) also reported that individuals with PAD performed fewer steps per day than healthy individuals (6524±2710 vs. 8664±3110). Both groups were matched well in terms of gender, mean age (67.2±9.7

vs. 66.8±10.5 years; PAD vs. controls, respectively) and BMI (26.2±4 vs. 26±4.4; PAD vs. controls, respectively). However, both groups differed in terms of employment status, with almost twice as many controls than cases employed (36.7% vs. 20%). Finally, a study by Lauret et al. (2014) found lower daily activity levels among individuals with PAD versus individuals without the condition (387±198 and 500±156 MET/min, respectively). Both PAD patients and controls also recorded high amounts of sitting time, with controls spending slightly more time per day sitting than patients with PAD (9.2 vs. 8.28 hours per day). Details about demographic characteristics were not provided, with the exception of age which differed significantly between PAD patients and controls (p=0.002). These studies indicate that lower levels of activity are common among individual with PAD compared to healthy individuals. A summary of the studies discussed is provided in *Table 1*.

Table 1: Summary of studies examining activity and sedentary levels among PAD patients

Author	**Study design**	**Sample size**	**Main findings**
Clarke et al. (2013)	Cross-sectional	30 PAD 30 non-PAD	Lower steps/day among PAD patients vs. individuals without PAD
Gardner et al. (2007)	Case-control	98 PAD 129 non-PAD	Lower steps/day among PAD patients vs. controls Lower daily average cadence among PAD patients vs. controls Lower amount of times spent ambulating among PAD patients vs. controls
Lauret et al. (2014)	Case-control	56 PAD 27 non-PAD	Lower mean daily activity levels among PAD patients vs. controls PAD patients spent less time/day sitting vs. individuals without PAD
McDermott et al. (2000)	Case-control	21 PAD 21 non-PAD	Lower weekly physical activity levels among PAD patients vs. controls Self-reported weekly physical activity was lower among PAD patients vs. controls
Sieminski & Garnder, (1997)	Case-control	85 PAD 59 non-PAD	Energy expenditure was 42% lower among PAD patients vs. controls Steps per day was 45% lower among PAD patients vs. controls Rate of decline in free-living physical activity was 42 kcal/day and 612 steps/day per 0.10 drop in ABI score

2.4.5 Treatment for PAD

Clinical guidelines on the treatment of PAD have been established and are tailored towards the patient based on their level of severity (American College of Cardiology Foundation & American Heart Association, 2011). Individuals with no functional disability are re-examined annually to monitor any development of their symptoms. Patients who experience symptoms which limit their day to day activities are referred to a supervised exercise program for three months. Pharmacological therapy (Cilostazol) is also provided for a three month period. Annual follow-up visits are then performed to monitor their symptoms. Patients that experience symptoms which limit their daily activities and also present with gluteal or thigh claudication (inflow disease) undergo additional examination and may be referred for endovascular therapy. Patients that display a significant disability despite medical or endovascular therapy are assessed for endovascular or surgical revascularisation. The aim of treatment in asymptomatic and symptomatic patients is to limit the progression of the condition and usually involves lifestyle changes in order to reduce risk factors. Risk factor treatment usually includes smoking cessation programs, diet modification, and increasing levels of physical activity. Medications are also prescribed e.g. statins, aspirin, clopidogrel. In addition, for individuals with symptomatic PAD, the goal is to address lower extremity symptoms by implementing interventions such as exercise programs, endovascular therapy, or surgery. Exercise programs are essential to the treatment of PAD as they help improve ambulatory function and peripheral circulation. It is advised that patients aim to accumulate 40 minutes of aerobic activity three times per week (Askew, Parmenter, Leicht, Walker & Golledge, 2011). A study by Gardner et al. (2001a) reported that their exercise rehabilitation program improved the distance walked to pain onset by 134%, to maximal claudication pain by 77%, and to onset of pain during a 6-minute walk test by 44%. The study also found that maximal calf blood flow also improved after the intervention.

In a further assessment, Gardner, Montgomery and Parker (2008a) found that minimal levels of physical activity performed at moderate intensity were beneficial for individuals with PAD. None of the 434 patients had previously engaged in an exercise program and participated in the study to receive information about their level of physical function and physical activity. Participants had their ABI measured, completed a 6-minute walk test, a walking impairment questionnaire, and a questionnaire to assess levels of physical activity over the previous month. Results revealed that mortality risk was significantly lower in the physically active group compared to the group with little or no activity (hazard ratio=0.51). Patients who performed less than 1 hour of physical activity per week that exceeded light intensity at baseline had a lower risk of mortality indicating that even minimal amounts of physical activity performed at moderate intensity can benefit PAD patients. Using 111 participants from a randomised control trial aimed at examining the effect of a resistance training and supervised walking programme on functional performance, Payvandi et al. (2009) observed that higher levels of objectively measured physical activity during daily life were associated with significantly better brachial artery flow-mediated dilation. Even after adjusting for confounders (age, sex, race, BMI, ABI, hypertension, diabetes mellitus, and history of smoking) results remained statistically significant.

There are a number of exercise programs available for PAD patients. The near-maximal-pain method has been shown to be very effective at increasing pain-free walking distance and maximal walking distance (Gardner & Poehlman, 1995). This involves patients walking until maximal pain forces them to stop. The patient rests until the pain subsides and then they resume walking. This process is repeated until a cumulative total of 30 to 60 minutes has been walked. The program is performed 2-3 times per week for 3-6 months. Although this exercise program has shown to be effective (Gardner, 2002), it has been criticised for placing extra pressure on the cardiovascular system of the patient which can cause exaggerated blood pressure or induce an inflammatory response (Ernst & Martai, 1987; Mika, Spodaryk, Cencora, Unnithan & Mika, 2005). An alternative method is to encourage the patient to engage in a low intensity and pain-free walking exercise program. Here, the point at which the patient begins to feel pain is used as the cut-off point for walking. This type of program has been deemed effective at improving walking distance, walking speed, symptoms, and self-perceived quality of life (Barak, Stopka, Martinez & Carmeli, 2009; Gardner, Montgomery, Flinn & Katzel, 2005). Other alternative forms of exercise programs and training include pole-striding exercise, arm and leg exercises, and resistance exercise training (Brenner et al. 2012).

2.4.6 Measurement of PAD

2.4.6.1 ABI

The ankle brachial index (ABI) is the clinical standard and first-line diagnostic tool used by medical practitioners to screen for and diagnose PAD in individuals that present with lower extremity symptoms (Kim, Wattanakit & Gornik, 2012). This non-invasive tool is also useful in establishing the severity and progression of PAD in patients diagnosed with the condition (Irish Heart Foundation, 2004). The specificity and sensitivity of the ABI is high (Guo et al. 2008) compared with angiography, the medical imaging technique, and it has been shown to be effective at detecting PAD in primary care settings (Hirsh et al. 2001). The ABI is calculated by obtaining the blood pressure in both upper and lower limbs. Following a 5-10 minute rest in the supine position, systolic blood pressure is measured in the dorsalis pedis and posterior tibial arteries using a 5-8 MHz handheld Doppler device and compared with the brachial pressure. The higher of the two ankle systolic blood pressures in each leg is then divided by the higher of the two brachial systolic blood pressures to calculate the ABI (Irish Heart Foundation, 2004). The higher of the two brachial pressures is used as the denominator to account for the possible narrowing of the subclavian artery which can reduce upper extremity blood pressure (Kim et al. 2012). The lower of the two ABI values is used as the patients' overall ABI score.

2.4.6.2 Interpreting ABI

ABI scores were standardised in 2011 by the American College of Cardiology and the American Heart Association. A breakdown of the score ranges and corresponding values is provided in *Table 2*. An ABI score <0.9 is considered abnormal and indicates significant PAD and ABI scores between 0.91 and 0.99 are interpreted as borderline abnormal. Healthy adults have a normal ABI, valued between 1.0 and 1.4. An ABI score greater than 1.4 signifies calcified or non-compressible arteries (Rooke et al. 2011). Individuals that present with a borderline ABI value usually repeat the diagnostic test following an exercise test (treadmill or walking) as exercise increases blood flow across a fixed stenosis and results in a decline in ankle pressure. A fall in ankle pressure or ABI of 20% or more suggests PAD (Kim et al. 2012). Approximately 5% of patients with PAD will have an ABI above 0.9 due to stiff or calcified arteries (Hiatt, 2001). Non-compressible arteries are common in patients of advanced age or those with long standing diabetes mellitus where calcium and phosphate accumulate in the vessel wall (Nitta, 2011; Jeffcoate, Rasmussen, Hofbauer & Game, 2009). Calcified arteries are not indicative of PAD and so a toe-brachial index is normally performed to confirm diagnosis. Blood pressure in the great toe is measured using a small digital blood pressure cuff and a Doppler probe. Blood pressure in the toe is then divided by the higher of the two brachial artery pressures to establish a score. A toe brachial index of 0.7 is suggestive of PAD (Kim et al. 2012).

Table 2: ABI classification

Value	**Interpretation**
1.00 – 1.4	Normal
0.91 – 0.99	Borderline
<0.90	Abnormal
>1.4	Non-compressible vessels (calcification)

Studies have indicated that a low ABI score is significantly associated with an increased risk in all-cause and cardiovascular mortality (Heald, Fowkes, Murray, Price & Ankle Brachial Index Collaboration, 2006; Lee et al. 2004). Results from the Edinburgh Artery Study (Leng et al. 1996) suggested a 5-year relative risk of all-cause and cardiovascular mortality of 1.58 and 1.85, respectively, for individuals with an abnormal ABI score. Low ABI scores are also associated with a greater decline in walking performance. A study by McDermott et al. (2004) found that compared to participants with a normal ABI score, individuals with an ABI <0.5 had almost a 13-fold increased risk of being unable to walk continuously for 6 minutes 2 years later, even after adjusting for co morbidities. High ABI scores are also associated with an increased mortality risk (Everhart, Pettitt, Knowler, Rose & Bennett, 1988). Resnick et al. (2004) reported that the adjusted hazard ratio for all-cause and cardiovascular mortality was 1.77 and 2.09 higher, respectively, for individuals with non-compressible arteries compared to healthy individuals with a normal ABI.

2.4.6.3 Claudication questionnaires

PAD can also be established using subjective measures, namely questionnaires. A wide variety of claudication questionnaires are available to choose from, all with the same purpose of establishing symptom severity or disease progression among patients. The WHO/Rose questionnaire has moderate sensitivity and high specificity but can only detect symptomatic disease (Rose, 1962; Leng & Fowkes, 1992). The Edinburgh Claudication Questionnaire (ECQ) is based on the WHO/Rose questionnaire and has high specificity and sensitivity and is also effective in diagnosing intermittent claudication in epidemiological surveys of PAD (Leng & Fowkes, 1992). The Walking Impairment Questionnaire (WIQ) has been shown to accurately assess the presence of PAD and the perceived impact of the disease on walking limitations such as walking distance or speed, (McDermott et al. 1998; Verspagent et al. 2009). Finally, the Peripheral Artery Questionnaire (PAQ) was designed to quantify patients' health status and quality of life. This self-administered questionnaire contains 20 items relating specifically to the patients' condition over the past 4 weeks and each item is categorised into one of the following domains: physical function, symptom stability, symptom scale, treatment satisfaction scale, quality of life, and social function. Using likert responses, patients rate their level of limitation based on their symptoms. This questionnaire has been shown to comprehensively assess the impact and limitations PAD has on individuals (Hoeks et al. 2009; Smolderen et al. 2008).

2.4.7 Other measures of PAD

PAD severity can also be determined by measuring functional ability. This refers to

> "the actual or potential capacity of an individual to perform the activities and tasks that can be normally expected" (Kirch, 2008, p. 466).

Common tests used to assess the functional ability of individuals with PAD include treadmill tests, the 6-minute walk test and the repeated chair rises test (Amoh-Tonto, Malik, Kondraugunta, Ali & Kullo, 2009; Dolan et al. 2002; McDermott et al. 2004; McDermott et al. 2011). The 6-minute walk test is used to assess aerobic endurance. Individuals are required to walk between two cones that are a set distance apart for a total of 6 minutes. The total distance covered is then recorded (Rickli & Jones, 2001). The test has been shown to correlate positively with time to onset of leg pain during treadmill testing, maximum distance achieved in treadmill testing, physical activity levels, and ABI (Montgomery & Gardner, 1998). The repeated chair rises test measures lower body strength and involves individuals sitting up straight in a chair with arms folded across their chest. Individuals are asked to stand up and sit down as quickly as possible. This is repeated 5 times and the time taken to complete all 5 is recorded (Csuka and McCarthy, 1985). Other function ability tests include the standing balance, 4 metre walking velocity, and the summary performance score which is a global measure of leg functioning (Guralnik, Ferrucci, Simonsick, Salive & Wallace, 1995). Functional assessments are also performed before individuals begin an exercise intervention in order to create a baseline from which any improvements can be determined (Brenner et al. 2012).

2.5 Aim

This study aims to characterise the current sedentary behaviour and physical activity patterns of patients with PAD. The study also examined the relationship between the severity of PAD and current sedentary and physical activity behaviour patterns.

2.6 Research Questions

The following research questions were investigated:

1. What are the activity levels of individuals with Peripheral Arterial Disease in comparison to those without the condition?

2. What are the sedentary behaviour patterns of individuals with Peripheral Arterial Disease in comparison to those without the condition?

3. Is the severity of PAD related to physical activity and sedentary behaviour patterns?

4. What is the relationship between (a) objectively and (b) subjectively measured physical activity and sedentary behaviour?

2.7 Chapter Summary

This chapter has highlighted that low levels of physical activity and high amounts of time spent sedentary independently contribute to ill health and the prevalence of chronic disease worldwide. Due to the nature of PAD, individuals with the condition experience difficulty with ambulatory function which leads to a subsequent decline in daily physical activity. In addition, this population group also engage in sedentary behaviours. In order to capture the habitual patterns of individuals with PAD, assessments of both activity and sedentarism are necessary. This study will also provide contextual information about the PAD population group which is important for identifying intervention targets and public health messages. The following chapter will discuss the methodology implemented for this research study.

Chapter 3 Methodology

3.1 Chapter Overview

This chapter outlines the study design employed and the population sample used in this research. In the instruments section, the different measurement tools used to collect information on the population of interest are described individually. The main outcome measures of each instrument are also outlined. A step by step breakdown of the study's data collection protocol is also given to provide a clear view of the data collection process. A description of how the information gathered was analysed is also provided. Finally, this chapter outlines the research questions that were investigated in this study.

3.2 Study Design

This research involved an observational analysis of a case and control group which set out to identify the current sedentary behaviour and physical activity patterns of PAD patients and controls of the same gender and similar age (within 5 years of each other/an age band of 5 years). Case-control studies involve selecting individuals on the basis of whether individuals do (cases) or do not (controls) have a certain disease or outcome of interest. The degree of exposure to particular risk factors, as well as possible interactions between them, are then determined in each group (dos Santos Silva, 1999). Case-control study designs gained recognition following their use in studies which established a link between smoking and lung cancer (Levin, Goldstein, & Gerhardt, 1950; Schrek, Baker, Ballard, & Dolgoff, 1950; Wynder, & Graham, 1950). These studies are regarded as having set the stage for the modern era of case-control study designs (Paneth, Susser, & Susser, 2002). Case-control studies are considered cheap and quick to carry out. They can be useful when studying rare outcomes as cases are easier to find, or for early investigations when the role of exposure is unclear. They can also be used to examine multiple exposures since the exposure is classified after the outcome (Carneiro et al. 2011). One drawback of using a case-control design is that the true prevalence of the disease cannot be measured, as the proportion of cases and ratio of controls has been artificially created by the investigator (Gordis, 2009). Case-control studies are also subject to selection and information bias, as exposure and outcome have both occurred by the time the patient has been recruited. However, this can be reduced by identifying controls that have the same characteristics as cases i.e. matching (Carneiro et al. 2011). Quantitative methods of data collection were used to gather data for this study. An objective measurement tool (accelerometer) and self-report measures (questionnaire and activity diary) were used to establish an activity and sedentary profile of participants. Vascular health measures, an additional self-report questionnaire, a walking test, and a chair test were used to examine the severity of PAD in cases and the functional capacity of all participants. Body composition was also assessed. Using this research design and method, a thorough description of the habitual behaviour patterns of individuals with PAD was acquired.

3.3 Study Population

A purposive sampling method was used for this research, as it was necessary to locate an appropriate sample for procedure compliance and study completion. This non-probability method of sampling is typically formed by selecting individuals based on a known characteristic (Williams, 2001). Incident (newly diagnosed) as opposed to prevalent (new and old) cases were used in this study. Incident cases are preferred as any risk factors identified using prevalent cases may be linked more with survival rate rather than disease development (Gordis, 2009). Cases were recruited weekly from two separate out-patient clinics at the Department of Vascular Surgery in Waterford Regional Hospital between November 2012 and September 2013. Case patients consisted of males and females from the South-East region of Ireland (Carlow, Kilkenny, Tipperary, Waterford, and Wexford), aged 45 years and over, and diagnosed with Fontaine classification Stage II PAD, also known as intermittent claudication, (Fontaine et al. 1954) by their consultant vascular surgeon. As discussed previously, (p.33) PAD is a chronic arterial occlusive disease of the lower extremities, resulting from systemic arthrosclerosis where the arterial lumen gradually narrows over time (CDC, 2013). Intermittent claudication has long been regarded as the most common presenting symptom of PAD (Rose, 1962), and is characterised by tightness or cramping in the calf, thigh, or buttock, induced by exercise and relieved by rest (Regenstenier, 2004; Beebe, 2001). Eligible incident cases were identified using ABI measurements as this is the clinical standard non-invasive and first-line test for screening for and diagnosing PAD (Kim et al. 2012).

Individuals that presented a history of coronary artery disease including previous myocardial infarction, angina, coronary artery bypass graft or percutaneous coronary angioplasty were excluded from the study as these may have an effect on physical activity capacity and therefore have a confounding effect. Individuals of advanced age or with dementia were also excluded because of their potential inability to answer questions or recall events accurately.

When using hospital based cases it can be difficult to identify a specific reference population from which they emerged. This may be due to reasons such as the exact catchment area of the hospital cannot be defined as people may come from the surrounding area or live farther away or not all PAD patients (cases) in the area were referred to that particular hospital. This makes the selection process for controls difficult. One way to overcome this however is by defining the study population as potential "hospital users" (dos Santos Silva, 1999). Based on this premise, controls were recruited from one Men's Shed group (Waterford) and from two active retirement groups (Kilkenny and Waterford). Men's sheds are a community-driven meeting place for older males. One of the main objectives of this organisation is to enhance or maintain the well-being of members. This is achieved by performing a range of tasks and activities that are mutually agreed. Active retirement groups are an example of one of the many organisations established to support retired people (both males and females) in their pursuit of hobbies, leisure activities and education. An advertisement was also placed in the local newspaper. Controls were selected for inclusion based on similar characteristics to cases. Group matching, where individuals are matched based on similar characteristics, was used to proportionally match controls of the same gender and similar age band (within 5 years) (Gordis, 2009). The same exclusion criteria used for cases was applied to controls.

3.4 Variables

For comprehensive assessment of activity and sedentary behaviour patterns, research instruments must be valid (measure what it intends to measure), reliable (provide the same results when repeated under the same circumstances), practical (acceptable to both the investigator and participant in terms of cost) and non-reactive (refrain from altering the population or behaviour that it measures) (Laporte, Montoye, & Caspersen, 1985). This research incorporated the use of both objective (accelerometer) and subjective (questionnaires and activity diary) measurement tools.

3.4.1 Descriptive Characteristics

Information on gender, age group, employment status, and education level was collected to provide descriptive data on subjects. This was obtained using a questionnaire. Height and weight measurements were also collected to provide information on body composition.

3.4.2 Physical Activity

As previously stated**,** (p.4) physical activity refers to any muscle movement that leads to energy expenditure Caspersen et al. (1985). In this study, dimensions of physical activity were quantified in terms of frequency, intensity, and duration using an accelerometer, questionnaire, and activity diary. Frequency was measured as the number of days per week spent completing physical activity. Intensity was divided into vigorous and moderate and defined as activity performed at 6 or more times the intensity of rest for adults, and activity carried out at 3–5.9 times that of rest intensity, respectively (WHO, 2010). Walking was also included and was defined as having walked for at least 10 minutes. Individuals were categorised as highly or moderately active using the IPAQ short form scoring protocol (IPAQ, 2005). Those that did not meet the criteria for either of these categories were placed into a low activity category. Duration of physical activity was expressed in hours and minutes for each day and for an entire week. Physical activity was also quantified in terms of steps taken per day. It is suggested that healthy individuals should perform 10,000 steps each day to produce health benefits. However, this target may not be achievable for certain groups such as older adults or individuals with a chronic condition, as these individuals may be more limited in daily activities (Tudor-Locke & Bassett, 2004). Therefore, the cut-points for the number of steps taken per day were defined as per the adult graduated step index proposed by Tudor-Locke et al. (2011). This equated to approximately 8,000 steps per day for healthy adults and approximately 5,600 steps per day for individuals with a chronic illness or disability.

3.4.3 Sedentary Behaviour

Sedentary behaviour is regarded as participating in activity that does not significantly increase energy expenditure above the resting level when in a seated or lying position. This study defined sedentary behaviour as a lack of movement or posture allocation in terms of non-upright activity i.e. activities performed while lying or sitting (Chastin & Granat, 2010; Troiano et al. 2012). Standing was not included as it is different physiologically to sedentary behaviour (Hamilton et al. 2007). In this study, sedentary behaviour was quantified in terms of frequency and duration. Frequency referred to the number times per day spent in sedentary periods i.e. a seated/lying position. The duration of these sedentary periods (also referred to as "sedentary bouts") was expressed in hours and minutes. These hours and minutes were then categorised into three groups: sedentary activities lasting less than 5 minutes, between 5 and 20 minutes, and longer than 20 minutes. These three categories were used as they had been pre-defined in the Microsoft® Office 2007 Excel template used to categorise sedentary bouts by specific duration (see section 3.7.3). Interruptions in sedentary periods were referred to as "breaks" and involved changing from a lying/sitting position to an upright posture. These were expressed as total numbers and in minutes.

3.4.4 Vascular Health and Functional Ability

Vascular health refers to the condition of the vessels of the vascular system and is concerned with the level of atherosclerosis within the vessels. Functional ability involves examining the level of motor function individuals possess to complete various activities of everyday life. The total distance walked by participants during the 6-minute walk test and the number of repetitions performed during the 30 second chair stand test were quantified in terms of mean scores.

3.5 Instruments

3.5.1 Accelerometer

Accelerometers are unobtrusive measurement tools that can be used in ambulatory monitoring for continuous long-term measurement of activities. They can accurately distinguish static and dynamic activities in prolonged free-living situations (Godfrey et al. 2007). The ActivPAL accelerometer, which has dimensions of 53 x 35 x 7 mm and weighs approximately 20g, was worn continuously for 7 days by participants except during water based activities. The device is considered a valid and reliable monitor for objectively assessing physical activity (Dahlgren et al. 2010; Grant et al.

2008; Ryan et al. 2006) and for measuring sedentary behaviour (Kozey-Keadle et al. 2011; Grant et al. 2006). The monitor provided a detailed breakdown of many variables including total time and percentage of time spent seated/lying, standing and walking, which allowed the measurement of both activity and sedentary time. It also showed the number of steps per day, the number of transitions between postures, and the cadence of walking periods (Grant et al. 2006). Data were recorded in 15-second time periods know as epochs. Activity was recorded using algorithms which were then downloaded at the end of the study period to a PC via a USB interface. Data were processed and converted to an Excel document and into the Statistical Package for the Social Sciences (SPSS) for further analysis.

3.5.2 Questionnaires

3.5.2.1 Physical Activity and Sedentary Behaviour Questionnaire

Questionnaires are regarded as feasible measurement tools in quantifying energy expenditure through volitional and non-volitional activities. They are the most commonly used instruments for the measurement of population physical activity (Mader et al. 2006). Participants were administered a questionnaire incorporating the short version of the IPAQ and a sedentary behaviour item (see Appendix A). The IPAQ was developed for international monitoring and comparisons of physical activity and was deemed an acceptable instrument for measuring physical activity (Craig et al. 2003). The item relating to sedentary activities has been previously validated on a population of older adults in Australia (Gardiner et al. 2011). The questionnaire provided details about the level of physical activity participation over the previous 7 days in activities of vigorous and moderate intensity, walking, and time spent completing sedentary activities. Energy expenditure was also calculated and expressed in terms of MET.

3.5.2.2 Peripheral Artery Questionnaire

PAD patients (cases) completed a Peripheral Artery Questionnaire (PAQ) developed by Spertus, Jones, Poler, & Rocha-Singh (2004) and designed to quantify the health status and quality of life of patients with PAD (see Appendix B). This self-administered questionnaire contains 20 items relating specifically to the patients' condition over the past 4 weeks. Using likert responses, patients rated their level of limitation due to the symptoms experienced. The first question asked by the PAQ ascertains the most symptomatic leg. Each remaining item in the questionnaire is then matched to an individual domain based on the area the question referrers to. The first domain is labelled “physical functioning” and involves ascertaining the level of limitation patients experience when completing routine activities ranging from light to heavy exertion. The second domain is referred to as “symptom scale” and is concerned with any improvement or deterioration in individuals’ symptoms. The third domain is titled “symptom scale” and obtains a description of the frequency and degree of pain or discomfort experienced. The next domain is known as “treatment satisfaction scale” and is interested in how positively or negatively patients perceive the particular treatment they are receiving. The following domain is called “quality of life” and asks about patients’ current level of limitation and its effect on their desired level of functioning and their mental health status. The final domain is “social functioning” and poses questions relating to patients’ capacity to fulfil social roles. Total scores for each domain are ranked on a scale of 0-100, with higher score indicating better health status and quality of life. This questionnaire has been shown to comprehensively assess the impact and limitations PAD has on individuals (Hoeks et al. 2009; Smolderen et al. 2008).

3.5.3 Activity Diary

Activity diaries are a common method used to depict information on how people use their time throughout the day (Crosbie et al. 2006). They can prove a valid method in data collection when used in a small sample for a short length of time (Bowling, 2002). Furthermore, they allow participants to respond and return the diary within a number of days which is critical to ensure accurate data collection (Dillman, 2000). Activity diaries provide detailed information about the duration and types of activities engaged in, which can facilitate subsequent data processing (Bringolf-Isler et al. 2009; Welk, 2002). In this study, the activity diary was divided into 30 minute time slots. Participants were asked to complete the diary at regular intervals each day; morning, afternoon, evening, and at night, and to be as specific as possible when writing down details of activities. Participants also indicated the intensity level of each activity recorded by writing “light”, “moderate” or “vigorous” in a separate column (see Appendix C). The activity diary was used in conjunction with wearing the activPAL accelerometer to comprehensively characterise sedentary activities engaged in by participants.

3.5.4 Ankle Brachial Index

Ankle Brachial Index (ABI) is a non-invasive, highly sensitive instrument used to measure the level of obstruction of the lower extremity arterial system (Hirsh et al. 2001). It is useful in determining the progression of PAD in patients and their associated cardiovascular risk (Lee et al. 2004; Thatipelli et al. 2007). As part of their assessment at the vascular outpatient clinic at WRH, ankle and brachial systolic blood pressures were measured in PAD patients (cases) by a trained nurse using a 5-8MHz handheld Doppler device with the patient in a supine position. Both the posterior tibial and dorsalis pedis artery systolic pressures were measured and compared with the brachial pressures. This process was repeated and the average of the two pressures for each artery was taken. The ABI value for each patient was then calculated by dividing the higher of the ankle artery pressures by the higher of the two brachial pressures (Irish Heart Foundation, 2004). The lower of the two ABI values was used as the patients' overall ABI score.

3.5.5 Functional Ability Tests

3.5.5.1 Walking Test

The 6-minute walk test is a sub maximal test that evaluates the aerobic endurance of individuals i.e. individuals' ability to perform large-muscle activity over an extended length of time (Rikli & Jones, 2001). To improve scoring effectiveness, this test uses a distance-based scoring system as opposed to a time-based scoring system. This allows scores to be recorded for all participants regardless of their level of ability. The 6-minute walk test has shown strong test-retest reliability among healthy older adults (Steffen, Hacker, & Mollinger, 2002) and is considered a valid measure of functional status of patients with specific conditions such as heart failure (Pollentier et al. 2010), pulmonary disease (Morales-Blanhir et al. 2011; Pinto-Plata, Cote, Cabral, Taylor & Celli, 2004), and Alzheimer disease (Ries, Echternach, Nof & Gagnon Blodgett, 2009). Criterion validity of this test is considered strong as it can detect declines in performance that are anticipated across age groups. Scores are also consistent as those with higher levels of physical activity perform better and achieve a higher score than individuals with lower levels of activity (Rikli & Jones, 1998). Participants walked between 2 cones 20 meters apart with markers placed every 5 meters for 6 minutes under instruction to cover as much distance as possible. No warm up was allowed and participants were asked to sit for 10 minutes before the test began. Remaining time was communicated to participants and they were given encouragement every minute. If participants needed to stop they were given a chair to rest until they were ready to continue but remained where they stopped. The time and distance to initial cessation and the distance achieved in 6 minutes was recorded.

3.5.5.2 Chair Stand Test

The chair stand test is performed to assess lower body strength which is essential for completing everyday tasks such as climbing stairs or getting up from a chair (Rikli & Jones, 2001). This is an adapted version of the timed-stands test devised by Csuka and McCarthy (1985), where individuals completed the test for a specific amount of time (30 seconds) instead of recording the amount of time taken to complete a specified number of chair-stand repetitions. This means that each individual achieves a score despite their level of ability. The chair stand test has been shown to correlate well with laboratory measures of lower-body strength (Bohannon, 1995) and has shown good criterion validity (Jones, Rikli & Beam, 1999). Similar to the 6-minute walk test, this test can also identify predicted performance declines across decade years, as well as higher scores among more physically active older adults and lower scores among less active individuals. Participants were asked to sit on a chair with their legs uncrossed and arms folded across their chest. Participants were then asked to stand upright and sit down repeatedly for 30 seconds. The total number of repetitions was then recorded.

3.5.5.3 Body Mass Index

Body mass index (BMI) is an anthropometric measure used as a marker of obesity among populations. Although it does not measure body fatness directly, BMI has been shown to correlate well with other direct measures of body fat (Mei et al. 2002). As its calculation requires only height and weight measurements, it is inexpensive, easy to perform, and functions adequately in identifying and monitoring trends in obesity levels (Prentice & Jebb, 2001). A stadiometer was used to measure height (m). Participants stood up straight with heels and shoulders against the backboard, looking straight ahead. Weight (kg) was assessed using a digital scale. Participants removed their shoes for both measurements. BMI was computed from these two measures using the formula: weight (kg) / $[\text{height (m)}]^2$.

3.6 Data Treatment

All quantitative data (demographic, accelerometer, questionnaire, ABI, walk test, chair test) were entered into a SPSS for windows v19.0 (SPSS Inc, Chicago, IL) database and stored on a secure network drive. All questionnaire data were double-entered and checked by a member of the research team.

3.6.1 Demographic Data

Age and BMI were both re-categorised into three groups (45-54, 55-64, 65+ years; normal18.5-24.9, overweight 25-29.9, obese 30+). These categories were selected as they were the main age and BMI ranges of the study sample. Employment status and education level were dichotomised into employed or not employed and primary/secondary or third level, respectively.

3.6.2 ActivPAL

Following the completion of the study, all accelerometer data was downloaded to a personal computer. Each data set produced by the activPAL was examined to ensure that a sufficient number of valid days were recorded. Only participants with a minimum of 4 full days (3 weekdays and 1 weekend day) of accelerometer recording were processed for analysis as this number of days is within the acceptable range for achieving sufficiently reliable estimates of outcome variables of interest (Trost et al. 2005).

3.6.3 Physical Activity and Sedentary Behaviour Questionnaire

As noted above, all questionnaire data were coded and entered into an SPSS file. For standardisation and comparability of results, data were cleaned, processed, and truncated using the rules outlined in the IPAQ scoring protocol guidelines (IPAQ, 2005). Questionnaire responses given in hours and minutes were converted to hours. To normalise the distribution of activity levels, each vigorous, moderate, and walking time that exceeded 180 minutes was re-coded as a new variable to be equal to 180 minutes.

3.6.4 Peripheral Arterial Questionnaire

Responses from the 20 item questionnaire were organised as per guidelines developed by Spertus et al. (2004). Each item was categorised into one of the following domains based on the area each question was referencing: physical function, symptom stability, symptom scale, treatment satisfaction scale, quality of life, and social function.

3.6.5 Activity Diary

Data from the activity diary was coded in conjunction with activPAL data. The duration and types of sedentary behaviours were examined for the hours following rise time and preceding bedtime, which was obtained from the activPAL analysis. In addition, sedentary bouts lasting longer than 20 minutes during the remainder of the day and the types of sedentary activities performed were explored. The second weekday and first weekend day completed by each participant was coded. The second weekday was chosen to remain consistent with activPAL data as accelerometer data analysis began on the second day of recording.

3.7 Data Analysis

3.7.1 Statistics

Data were analysed using the Statistical Package for the Social Sciences (SPSS). Analysis indicated that data were normally distributed. Descriptive statistics and cross-tabulations were used to initially summarise and characterise the activity patterns of PAD patients (cases) and controls. This included the generation of mean time spent sitting, standing, and in various physical activities (of different intensity), the average number of sedentary bouts and length of time spent in each sedentary category, and finally, the number and duration of breaks from sedentary activities. These scores were compared across cases and controls. Inferential statistics (primarily independent t-tests) were used to investigate any significant difference in these scores between the two study groups. For all analyses and calculations, an alpha level of 0.05 was used to indicate statistical significance. All values were reported as mean ± standard deviations. Correlations were used to investigate relationships, if any, between the severity of PAD, walking capacity and vascular health, and time spent in various activities. To classify correlations, guidelines proposed by Cohen (1988) were used i.e. $r<0.3$, small; $r=0.31-0.5$, moderate; $r>0.5$, large. The Bland-Altman method was used to examine the systematic and random error between the objective and subjective measures of sedentary and activity time (Bland & Altman, 1986).

3.7.2 Physical activity

The activPAL proprietary software (activPAL™ Professional V6.4.1) was used to examine the objectively recorded data. Epoch data for the entire period of recording was exported to a Microsoft® Office 2007 Excel spreadsheet provided by PAL Technologies. This showed the number of seconds that each participant spent upright and stepping, the number of step counts and posture transitions performed, and a MET score per 15s epoch. The totals for each were calculated using a custom developed Microsoft® Office 2007 Excel template. This template was copied into the original activPAL data file at 6:59:45 on day 2 of the study period. This time point was chosen as per instructions from the template developer (Dowd et al. 2012) i.e. omission of Day 1 data and inclusion of subsequent recorded days. This created a profile of the time spent sedentary over the study period for each participant. Data were summed over each 24 hour day and averaged to get the mean time spent in each posture, as well as the amount of steps taken and posture transitions made during the monitoring timeframe. The mean number and duration (minutes) of breaks in sedentary time were also calculated. In addition, sleep time was removed from both the standing and walking totals generated by the activPAL using a custom developed Microsoft® Office 2007 Excel template. The daily rise time, bed time, and non-wear time (if present) were entered into the template and the daily sleep time for each participant was calculated. Totals of standing and walking time (hours) based on an average waking day for each individual were then provided by the template.

Self-reported frequency of physical activity was calculated as number of days per week and self-reported time spent in activities of different intensity and walking was summed and expressed as mean hours per day. To determine the associated energy cost of vigorous and moderate intensity activity, and walking, the number of hours per week spent in each activity was multiplied by the MET score for that particular activity (8 METS for vigorous intensity, 4 METS for moderate intensity, and 3.3 METS for walking). Using MET totals and following the IPAQ scoring guidelines (2005), individuals were classified as either low, moderately, or highly active.

3.7.3 Sedentary behaviour

In addition to providing details on activity time, the epoch file generated by the activPAL software also showed the number of seconds that each participant spent sedentary for each 15s epoch. Similar to the activity data, totals were computed using a custom developed Microsoft® Office 2007 Excel template, where the template was copied into the original activPAL data file at 6:59:45 on the day 2 of the study period, and a profile for each participant was created. The original activPAL data file was further processed for each participant using the custom software MATLAB® program (Dowd, Harrington, Bourke, Nelson, & Donnelly, 2012) to determine the amount of daily time spent sedentary. To improve accuracy in calculating sedentary time, non-wear time (if present) of the monitor was manually removed. This was defined as 60 minutes or more of consecutive zero accelerometer counts between the hours of 7am and 12am. The amount of time spent sedentary after waking time and before bedtime on each recorded day was identified to obtain the total number of and time spent in sedentary bouts.

A sedentary analysis Microsoft® Office 2007 Excel template was used to categorise sedentary bouts by specific duration. These categories were <5, 5-10, 11-20, >20, >30, >40, and >60 minutes. To aid analysis, these categories were redefined as <5, 5-20, and >20 minutes. The amount of time spent sedentary after waking time and before bedtime on each recorded day was exported to the sedentary analysis template. The mean number of sedentary bouts was computed by summing the average number of bouts spent in each sedentary category and then calculating the mean for both PAD patients (cases) and controls. Similarly, the total amount of time (hours) spent in each category was determined by summing the amount of time spent in each sedentary category for both groups and then obtaining the mean time.

As sleeping is recognised as a necessary sedentary activity, sleep time was removed from the sitting/lying totals generated by the activPAL accelerometer using another custom developed Microsoft® Office 2007 Excel template. The rise time, bedtime, non-wear time (if present), and total sedentary hours for each recorded day were entered into the template, and from this, daily sleep time was determined. Daily sleep time was totalled and averaged over the number of recorded days to calculate the mean sleep time for each participant.

Both the number and duration of breaks in sedentary time i.e. changing from a sitting/lying position to an upright posture were identified using an additional custom developed Microsoft® Office 2007 Excel template. Similar to the sedentary analysis template, the amount of time spent sedentary after waking time and before bedtime on each recorded day was copied into the sedentary breaks template. Here, the average number of sedentary breaks per day for PAD patients (cases) and controls were calculated. In addition, the duration (minutes) of these breaks were computed into the following categories: <5, 5-10, 11-20, and >20 minutes. The average numbers of breaks per day for each participant were summed to determine the mean number of breaks completed by each group. Similarly, the duration of breaks were calculated by summing the amount of time in each break category and calculating the mean time.

Self-reported sedentary time from the IPAQ was calculated as the sum of time in each sedentary activity (TV, computer, reading, socialising, driving, hobbies, and other activities) and expressed as hours per waking day (Gardiner *et al.* 2011). Self-reported sedentary time from the activity diary was analysed using the custom software MATLAB® program (Dowd et al. 2012). From this, all sedentary bouts performed 1 hour after rise time and 1 hour before bed time were noted. All sedentary bouts lasting greater than 20 minutes during the day were also ascertained. The activity diary was then used to identify the main type of sedentary activity performed. The types of sedentary activities were categorised using the same activities listed in the IPAQ sedentary item question i.e. TV, computer, reading, socialising, driving or public transport, doing hobbies, and doing any other sedentary activities. The duration of sedentary activities in the morning and before bed time were classified as short, moderate, or long based on the sedentary bout categories used to analyse activPAL data i.e. <5 minutes; short, 5-20 minutes; moderate, and >20 minutes; long. Activities that varied between short and moderate, short and long, or moderate and long were collectively labelled as mixed. The types and duration of activities were compared across morning, day, and before bedtime between cases and controls. Comparisons between weekday and weekend days were also carried out.

3.7.4 Vascular Health

Data from the PAQ were entered into SPSS and scored by allocating 1 point to responses suggesting the most limited function and an additional point for each higher response in the item. All items within each domain were summed. The lowest possible score for that domain was subtracted and then divided by the range of that domain and multiplied by 100. A summary score for each case was then achieved by summing the physical function, symptom scale, treatment satisfaction, quality of life, and social function domain scores. The ABI scores of PAD patients (cases) were classified into 1 of 4 groups using the Rooke et al. (2011) classification system, as outlined previously on p.42. Using ABI scores, cases were then dichotomised into groups labelled “abnormal” and “normal/borderline” to examine the impact of varying ABI levels on functional ability and activity and sedentary patterns.

3.7.5 Functional Ability

Physical performance and potential functional decline was assessed using two senior fitness tests developed by Rikli and Jones (2001): the 6-minute walk test and 30-second chair stand test. Mean scores for each test were calculated and compared between groups.

3.8 Ethical Considerations

Ethical approval was obtained in March 2012 from the Waterford Institute of Technology Research Ethics Committee. Prior to data collection, each participant was informed of the purpose and content of the research. All data collected was treated as confidential and anonymous, and participants were assured of this. In addition, participants were informed that only individuals directly involved in the research project would have access to the information supplied by them. Furthermore, it was highlighted to each participant that they had the freedom and right to withdraw from the study at any point before data collection had been completed. Informed consent was obtained from all participants prior to any data collection and a disclosure agreement was established between the researcher and primary investigator to protect the information provided by participants.

3.9 Aim

The aim of this study was to characterise the current sedentary behaviour and physical activity patterns of patients with PAD. The study also examined the relationship between the severity of PAD and current sedentary and physical activity behaviour patterns.

3.10 Research Questions

The methods described were used to examine the following research questions:

1. What are the activity levels of individuals with Peripheral Arterial Disease in comparison to those without the condition?

2. What are the sedentary behaviour patterns of individuals with Peripheral Arterial Disease in comparison to those without the condition?

3. Is the severity of PAD related to physical activity and sedentary behaviour patterns?

4. What is the relationship between (a) objectively and (b) subjectively measured physical activity and sedentary behaviour?

3.11 Chapter Summary

This chapter has outlined the study population and research methods used in this study. This chapter has also provided details about the statistical analysis performed to examine the proposed research questions. The next chapter will present the results obtained from the studied population group.

Chapter 4 Results

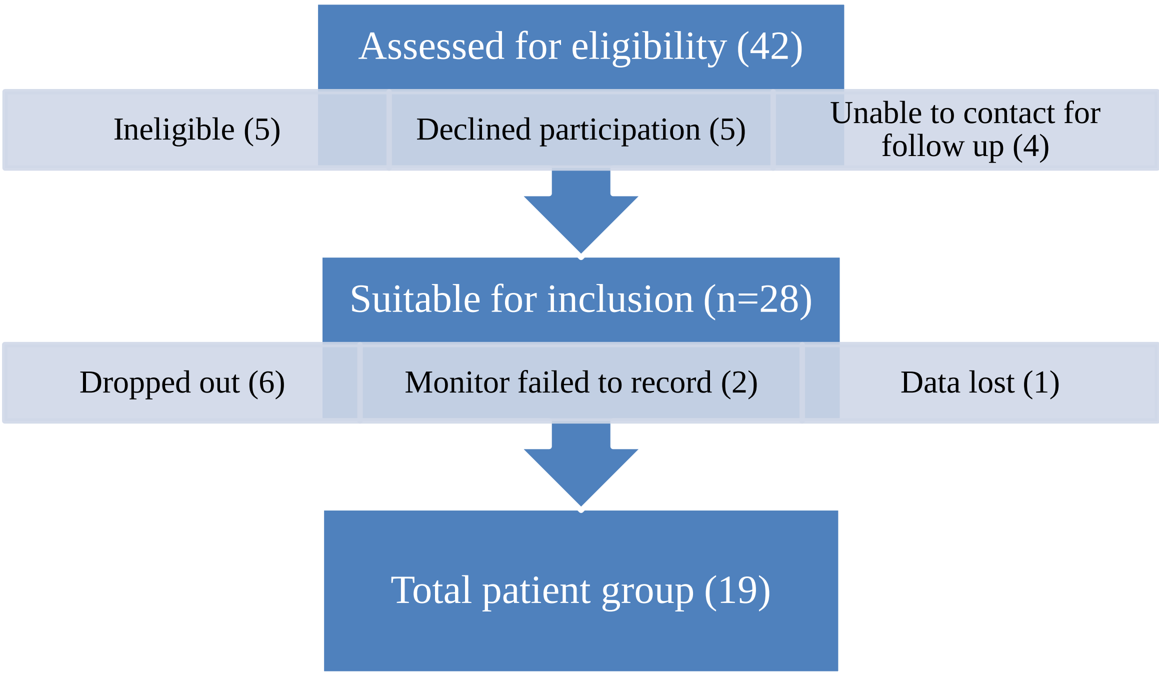
4.1 Chapter Overview

This chapter presents the main findings of the research. An overview of the participant recruitment process and a description of the characteristics of the study sample are provided. The results are subsequently presented in a format which systematically answers the research questions for this study as described on (p.62). Firstly, the physical activity patterns of participants are outlined. ActivPAL (objective) data is presented first, followed by IPAQ and activity diary (subjective) data. This format is repeated when discussing the sedentary behaviour patterns of the study sample. Vascular health and functional ability data are used to address the third research question which is concerned with the effect of PAD severity on activity and sedentary patterns. ABI and PAQ data are described first, followed by results from the walk and chair tests. Finally, Pearson correlations and Bland-Altman analysis are presented to address the final research question interested in the relationships and differences between both objective and subjective measures of physical activity and sedentary behaviour.

4.2 Recruitment of participants

Forty-two PAD patients (cases) and 31 controls were recruited between November 2012 and September 2013. As indicated in *Figure 2,* a total of 14 cases were excluded due to failure to meet the inclusion criteria and refusal to participate in the research. The remaining 28 cases were scheduled to complete the study but a further nine were subsequently excluded due to drop out and incomplete data collection. This resulted in 19 PAD patients completing the study, giving a final participation rate of 45% for the case group. Similar to patient recruitment, a number of control data were lost due to participants dropping out (5), malfunctioning of activity monitors (3), and data lost during return via postage (1). From the remaining 22 participants, 5 females and 17 males of similar age (within 5 years of one another) were used for data analysis. The overall participation rate for the control group was 71%.

Figure 2: Recruitment and progression of cases



4.3 Characteristics of participants

Table 3 provides a profile of participants in both groups. The original breakdown of demographic data prior to the re-categorising of data can be viewed in appendix D. The study sample (n=41) consisted predominantly of male subjects: 84.2% of cases and 77.3% of controls were men. The mean age of participants was similar between groups, with PAD patients (cases) aged 62.9±8.8 years and controls aged 62.3±9.3 years. A greater percentage of the case group were classified as overweight/obese (83.3%) as opposed to having a normal BMI (16.7%). Similarly, more participants in the control group were classified as overweight/obese (68.2%), with the remainder recording a normal BMI level (31.8%). However, mean BMI was significantly different between groups (p=0.006), with cases recording a higher mean BMI (28.38±5.17) than controls (26.5±3.7). There was a significant difference in employment between cases and controls (p=0.032), with only 2 (11.1%) cases in employment compared to 10 (45.5%) controls. A greater proportion of cases than controls were not in employment due to sickness/disability, retirement/performing home duties, or currently seeking employment (88.9% vs. 54.5%). Education levels were also significantly different between the groups (p=0.001). Most cases (88.9%)

had completed either primary or secondary level education, and only 11.1% had acquired third level education. In contrast, in the control group, 40.9% had finished either primary or secondary schooling, and 59.1% reported a third level education. BMI, employment, and education data were not recorded for one case.

Table 3: Profile of participants

	Case (n=19) **% (n)**	**Control (n=22)** **% (n)**
Gender		
Male	84.2 (16)	77.3 (17)
Female	15.8 (3)	22.7 (5)
Age Group		
45-54	15.8 (3)	22.7 (5)
55-64	21.1 (4)	40.9 (9)
65+	63.2 (12)	36.4 (8)
BMI Classification		
Normal	16.7 (3)	31.8 (7)
Overweight	44.4 (8)	50 (11)
Obese	38.9 (7)	18.2 (4)
Employment		
Employed	11.1 (2)	45.5 (10)
Not employed	88.9 (16)	54.5 (12)*
Education		
Primary/Secondary	88.9 (16)	40.9 (9)
Third level	11.1 (2)	59.1 (13)*

*p<0.05 Cases v Controls

4.4 Activity patterns of participants

4.4.1 Objectively measured activity patterns

Table 4 shows the average daily time (hours) spent in different accelerometer postures during a waking day i.e. with sleep time taken out. With sleep time removed, this equated to an average of 16.07 and 16.32 daily waking hours for PAD patients (cases) and controls, respectively. Mean daily activity time was significantly lower among PAD patients (cases) than controls (p=0.007). Cases spent 1.46±.43 hours per day being active compared to 1.92±1.59 hours among controls. Mean daily sedentary time and mean daily standing time were both similar across cases and controls.

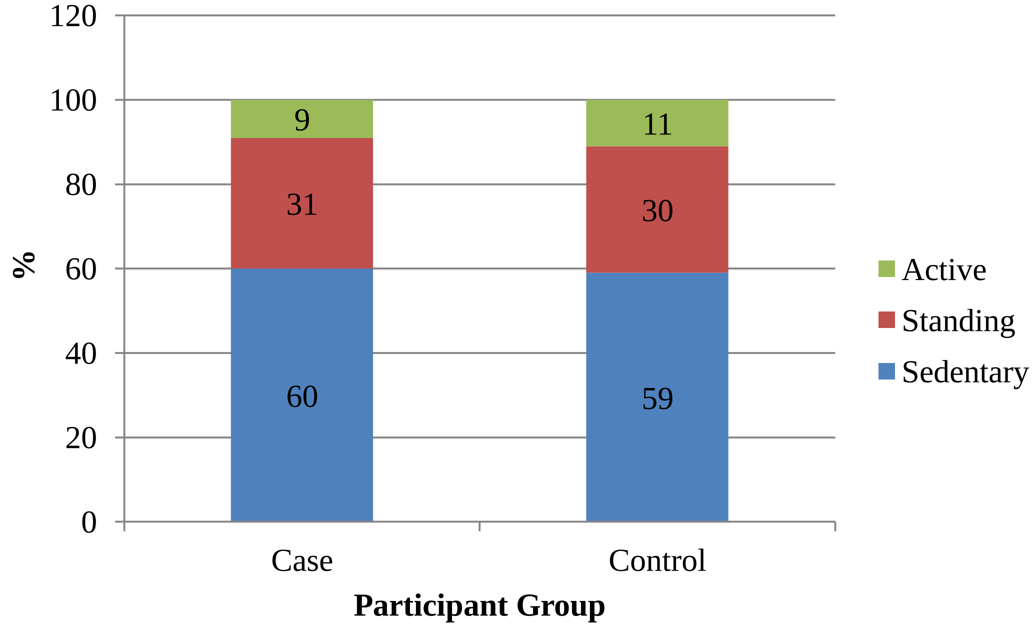
Table 4: Objectively measured mean time (hours per day) spent in different postures

	Case (n=18) (M,SD)	**Control (n=22) (M, SD)**
Sedentary	9.59 (1.74)	9.51 (1.77)
Standing	5.02 (1.88)	4.89 (1.76)
Active	1.46 (.43)	1.92 (1.59)*

*p<0.05 Cases v Controls

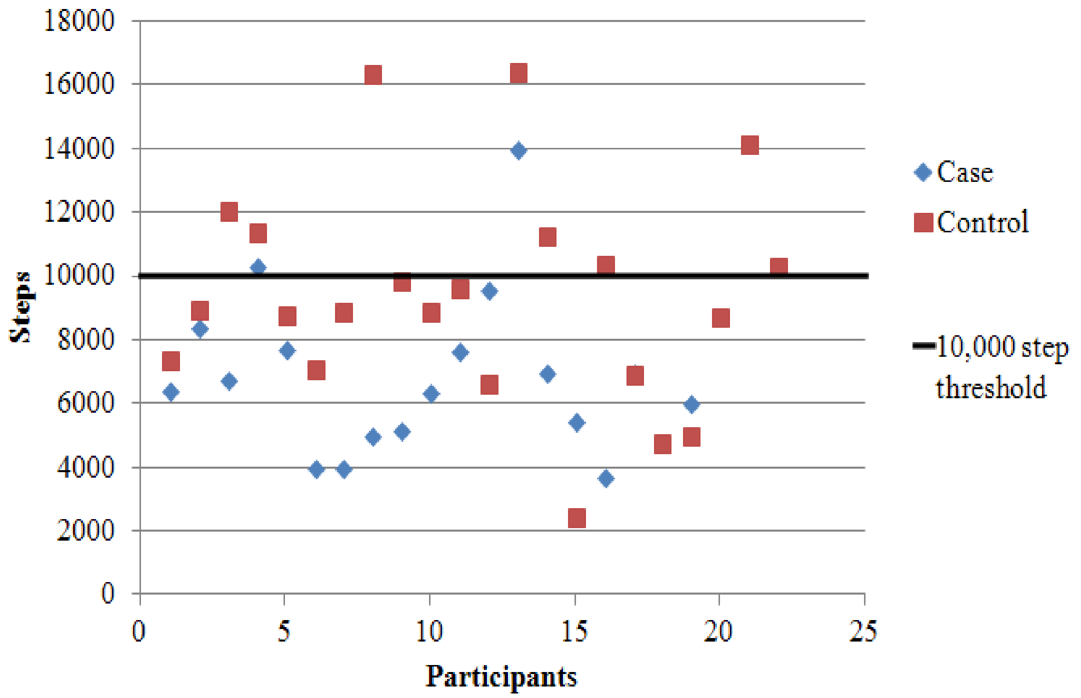
Figure 3 displays the percentage breakdown of time spent in different activities based on a waking day using accelerometer data.

Figure 3: Objectively measured distribution of activity in a waking day



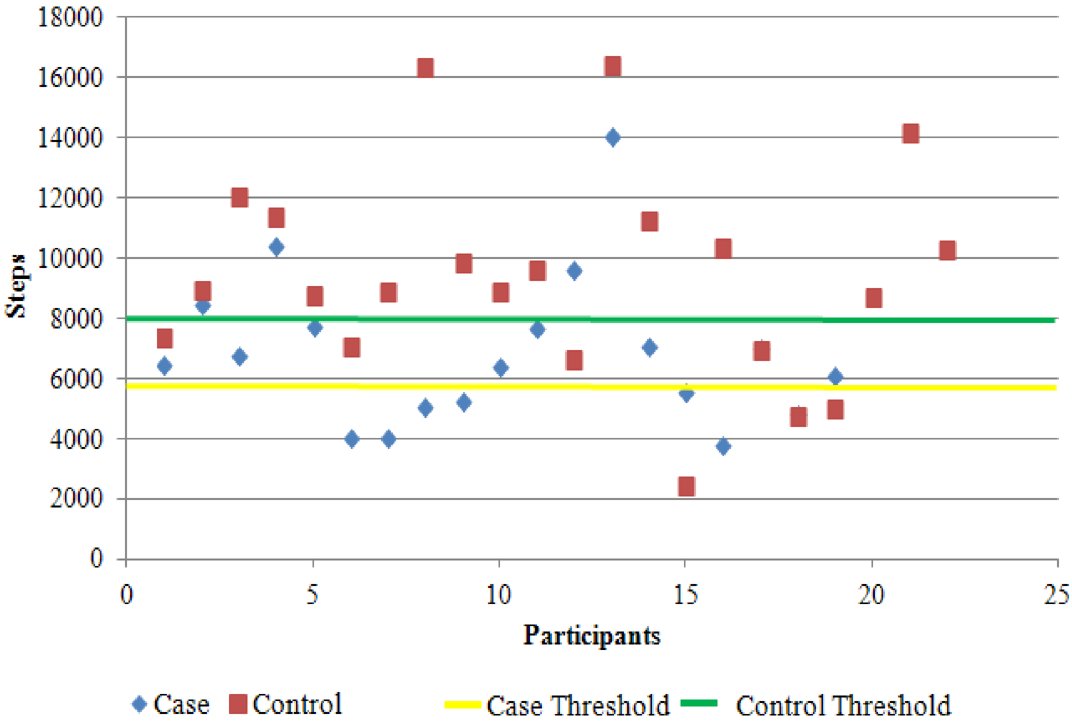
In a further assessment of activity, accelerometers also provided data on the number of steps taken per day. Overall, PAD patients (cases) performed significantly fewer steps than controls (6801±2518 vs. 9357±3452; p=0.009). *Figure 4* shows individual variation in achievement of the 10,000 steps per day threshold which is recommended to achieve health benefits. Two cases and 8 controls achieved this guideline.

Figure 4: Objectively measured mean number of steps taken per day



Adjustment of step threshold values for specific populations using the graduated step index proposed by Tudor-Locke et al. (2011) i.e. 8,000 steps p/d for healthy older adults and 5,600 steps p/d for individuals with a chronic illness/disability, revealed that 12 cases and 15 controls attained these adjusted step thresholds (see *Figure 5)*.

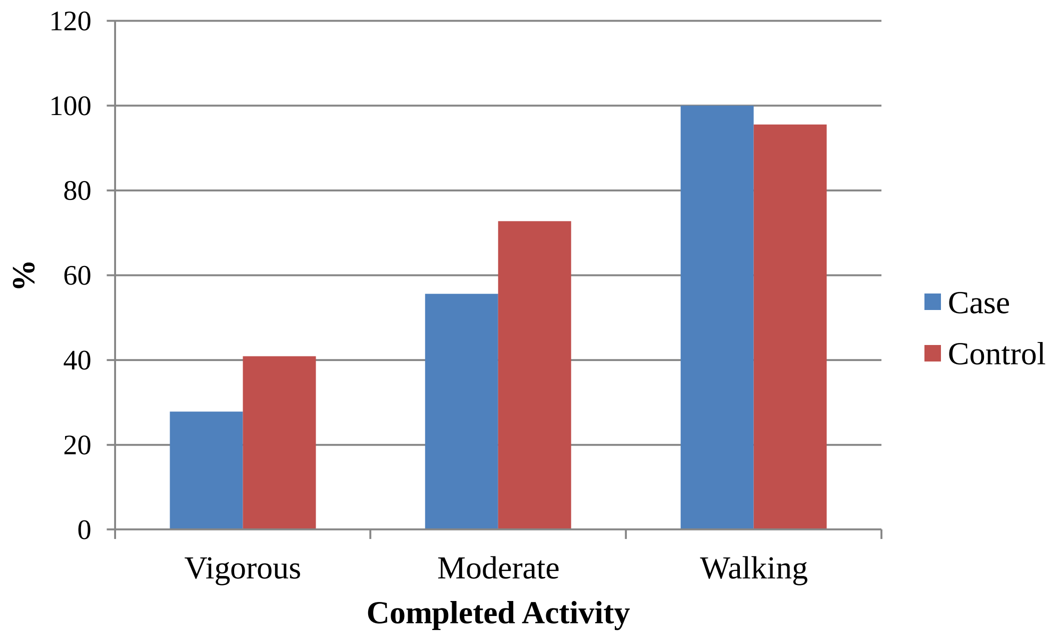
Figure 5: Objectively measured mean number of steps taken per day, adjusted for specific population groups



4.4.2 Subjectively measured activity patterns

Questionnaire data highlighted that fewer PAD patients (cases) (27.8%) than controls (40.9%) reported engaging in vigorous intensity activities over the previous 7 days. With regard to activities of moderate intensity, cases also completed a lower amount than controls (55.6% and 72.7% respectively). Walking was the most common activity performed, with almost all participants stating that they completed this activity over the previous 7 days (see *Figure 6*). A chi-square test revealed no statistically significant difference between groups with respect to completing vigorous activity (p=0.386), moderate activity (p=0.257), or walking (p=0.36).

Figure 6: Self-report percentage of participants that completed vigorous and moderate activity, and walking



In relation to the frequency of participation in physical activity over the previous week, results indicated that both groups reported spending a similar number of days participating in vigorous intensity activity and walking. On average, cases spent fewer days per week in moderate intensity activities than controls. However, results were not statistically significant (2.71±2.85 vs. 3.36±2.84; p=0.478) (see *Table 5*).

Table 5: Self-reported frequency of vigorous and moderate activity, and walking over the previous 7 days

	Case (n=18) (M, SD)	**Control (n=22) (M, SD)**
Vigorous activity (days/week)	1.1 (2.3)	0.95 (1.4)
Moderate activity (days/week)	2.71 (2.85)	3.36 (2.84)
Walking (days/week)	6.11 (.1.5)	6.05 (1.91)

*p<0.05 Cases v Controls

Self-reported time (hours) spent in vigorous activity on one day over the previous week was lower among cases than controls (0.35±0.79 vs. 0.83±1.21 h). Self-reported time spent in moderate activity on one of the previous 7 days was significantly lower among cases than controls (0.36±0.46 vs. 1.15±1.07 h; p=0.005). Walking time was similar for both groups, with cases spending slightly less time walking than controls (approximately 14 minutes) (see *Table 6*).

Table 6: Self-reported time (hours per day) spent in vigorous and moderate intensity activity, and walking over the previous 7 days.

	Case (n=18) (M, SD)	**Control (n=22) (M, SD)**
Vigorous activity (hrs/day)	0.35 (.79)	0.83 (1.21)
Moderate activity (hrs/day)	0.36 (.46)	1.15 (1.07)*
Walking (hrs/day)	0.90 (.87)	1.13 (.85)

*p<0.05 Cases v Controls

Self-reported mean weekly time (hours) for all activities was lower among cases than controls (see *Table 7*). PAD patients (cases) reported significantly lower mean time in moderate intensity activity compared to controls (1.98±2.83 vs. 5.7±7.01 h; p=0.036). Results indicated that total weekly self-reported physical activity approached significance between cases and controls (8.44±8.86 vs. 14.63±10.69; p=0.052).

Table 7: Self-reported time (hours per week) spent in vigorous and moderate intensity activity, and walking over the previous 7 days.

	Case (n=18) (M, SD)	**Control (n=22) (M, SD)**
Vigorous activity (hrs/week)	0.91 (1.72)	1.85 (3.24)
Moderate activity (hrs/week)	1.98 (2.83)	5.7 (7.01)*
Walking (hrs/week)	6.11 (6.22)	7.34 (6.13)
Total activity (hrs/week)	8.44 (8.86)	14.63 (10.69)

*p<0.05 Cases v Controls

Mean MET time (hours) was lower among cases than controls for all activities, and was significantly lower for mean MET time spent in moderate intensity activity ($p=0.005$). Cases completed 7.92±11.33 MET-hours of moderate activity over the previous 7 days while controls totalled 22.79±28.04 hours of moderate intensity activity. Total MET-hours were also significantly lower among cases than controls ($p=0.003$), with cases achieving a total of 17.11±20.25 MET-hours and controls totalling 40.28±33.97 MET-hours over the previous 7 days (see *Table 8*).

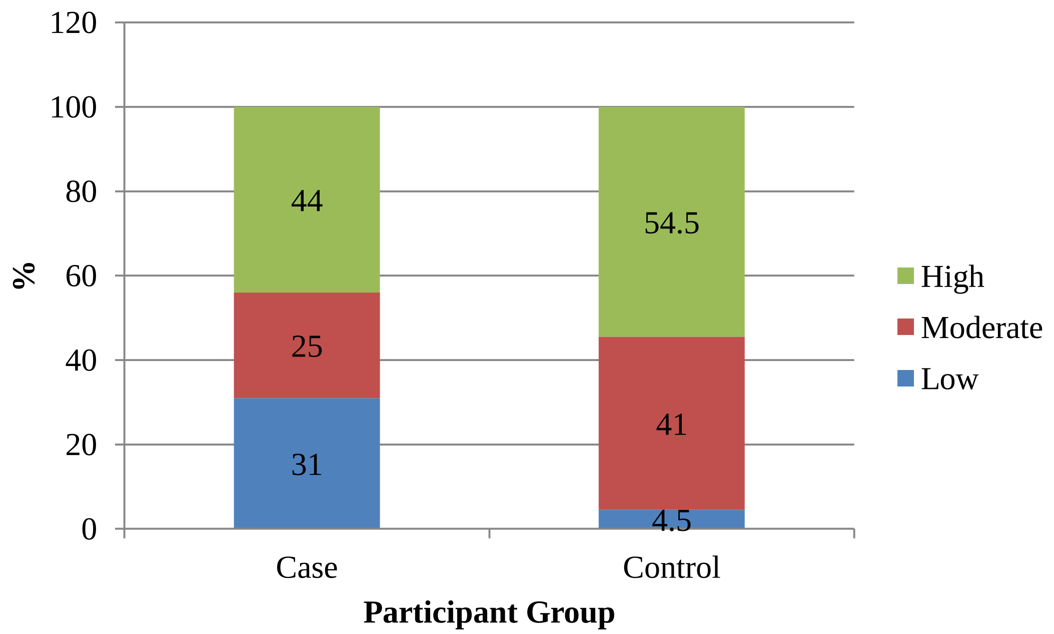
Table 8: Metabolic equivalent (MET) time (hours) spent in vigorous and moderate intensity activity, and walking over the previous 7 days.

	Case (M, SD)	**Control (M, SD)**
Vigorous activity (hrs/week)	7.26 (13.74)	14.79 (25.92)
Moderate activity (hrs/week)	7.92 (11.33)	22.79 (28.04)*
Walking (hrs/week)	2.98 (2.87)	3.74 (2.79)
Total (hrs/week)	17.11 (20.25)	40.28 (33.97)*

*p<0.05 Cases v Controls

Based on the information described above i.e. frequency and duration of activity, and MET time, and using the guidelines outlined in the IPAQ scoring protocol (IPAQ, 2005), individuals were categorised into a low, moderate, or high physical activity category. More cases than controls were classified as low active (31.3% vs. 4.5%) while more controls than cases were deemed moderate or highly active (*Figure 7*).

Figure 7: Distribution of self-reported activity category

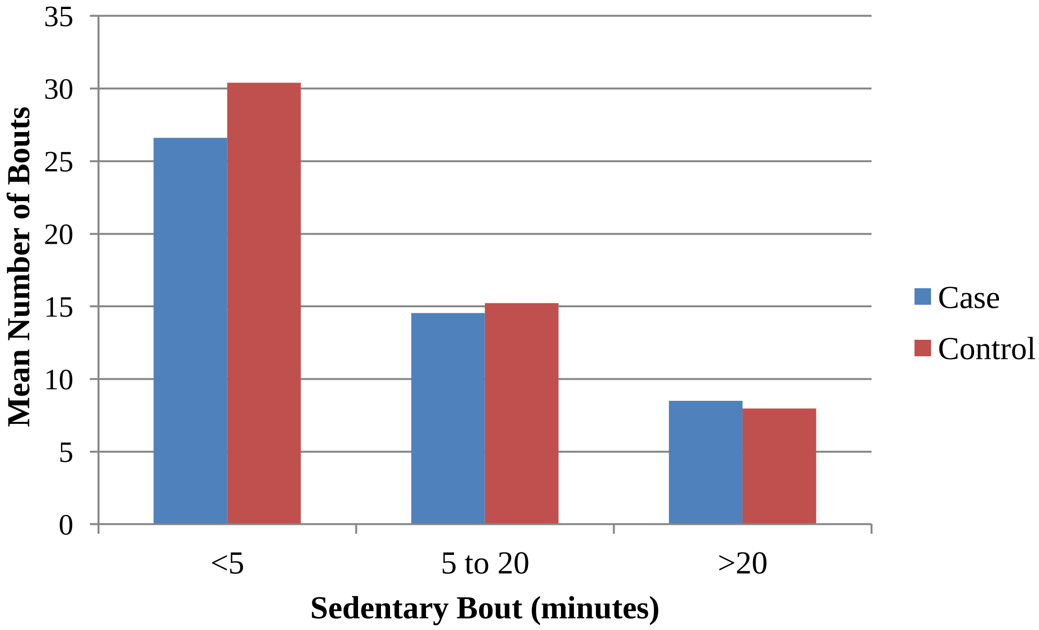


4.5 Sedentary behaviour patterns of participants

4.5.1 Objectively measured sedentary behaviour

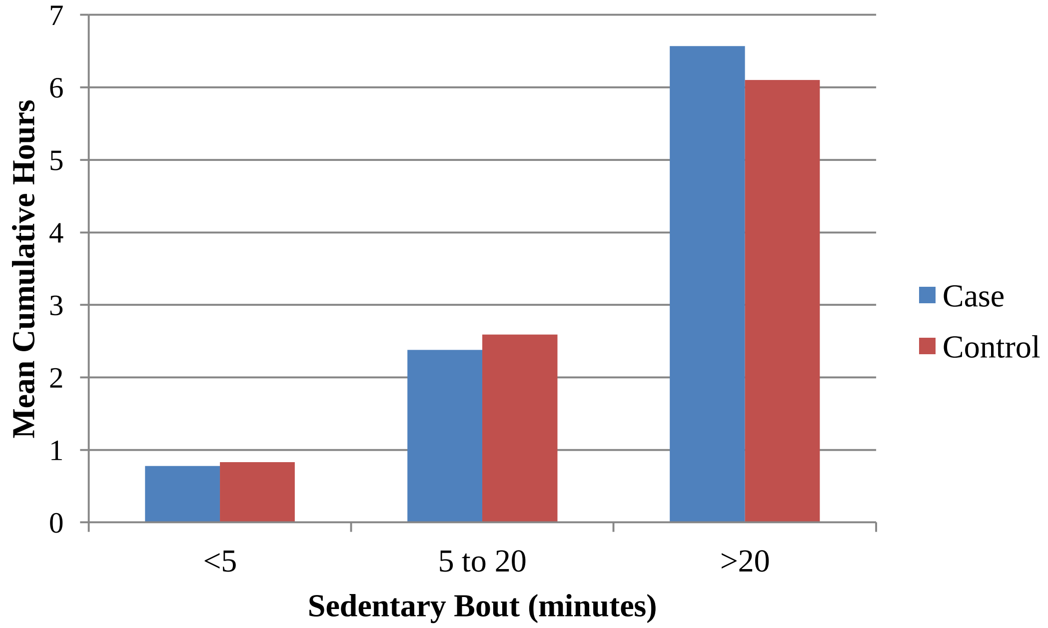
Analysis of activPAL data revealed that mean daily sedentary time was 17.52±1.91 hours for PAD patients (cases) and 17.19±1.92 hours for controls. The removal of sleep time revealed that both groups recorded a similar mean daily sedentary time, with cases spending 9.59±1.74 hours of their waking day sedentary and controls accumulating 9.51±1.77 hours of sedentary time per waking day. As indicated in the data analysis section on page 57, sedentary time was examined further using the MATLAB® computer program (Dowd et al. 2012). *Figures 7 and 8* show the mean number of sedentary bouts and the mean time (hours) spent in each sedentary bout category (<5 minutes, 5-20 minutes, and >20 minutes). *Figure 8* shows that sedentary bouts lasting <5 minutes were the most frequent bout in both groups, and higher among controls (26.61±11.36 for cases and 30.4±12.91 for controls). The average number of sedentary bouts recorded in the 5-20 minutes category (15.23±4.91 vs. 14.55±3.73) and in the >20 minute category (8.5±2.15 vs. 7.96±2.09) were similar among cases and controls. The mean number of sedentary bouts did not differ significantly between both groups in any of the sedentary bout categories.

Figure 8: Objectively measured mean number of sedentary bouts



Accelerometer data also indicated that for both groups the greatest amount of sedentary time was spent in bouts lasting longer than 20 minutes (*Figure 9)*. PAD patients (cases) spent a higher average time in this sedentary category, recording 6.57±1.74 hours compared to 6.1±1.88 hours for controls. The average time spent in the <5 minutes and 5-20 minutes sedentary categories was comparable between both groups, with controls spending slightly more time than cases in both of these sedentary categories (0.83±0.32 vs. 0.78±0.26 h and 2.6±0.73 vs. 2.37±0.53 h, respectively). The mean time (hours) spent in sedentary bouts did not differ significantly between both groups in any of the sedentary bout categories.

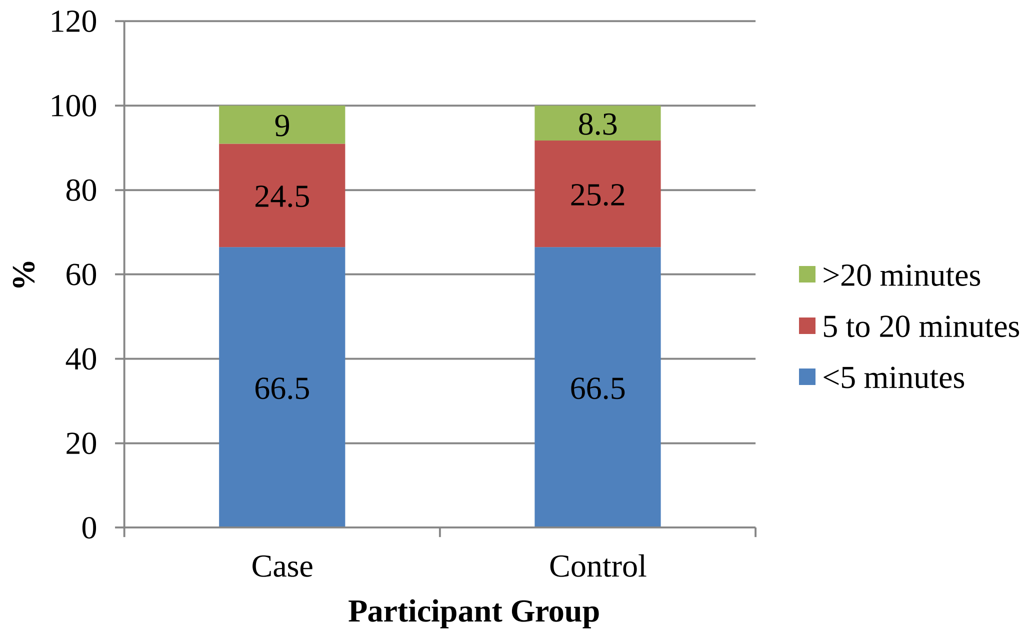
Figure 9: Objectively measured mean time (hours) spent in sedentary bouts



4.5.2 Breaks in sedentary time

In a further assessment of sedentary patterns using activPAL data, breaks in sedentary time were examined i.e. when an individual changed from a lying/sitting position to an upright posture. The mean number of breaks in sedentary time per day was 51.7±12.56 for PAD patients (cases) and 54.6±15 for controls, where p=0.505. On average, the duration of these breaks were shorter among cases (7.83±2.86 minutes) than controls (8.32±4.35 minutes), where p=0.671. *Figure 10* shows the distribution of sedentary breaks per day. The durations of sedentary breaks were largely similar among cases and controls.

Figure 10: Objectively measured distribution of breaks in sedentary time



4.5.3 Subjectively measured sedentary behaviour via questionnaire

IPAQ data indicated that PAD patients (cases) reported significantly lower mean daily sedentary time than controls ($p=0.029$). Cases estimated that they spent 5.01±2.62 hours per day in sedentary activities while controls approximated that 8.78±4.28 hours of their day comprised of activities of a sedentary nature. *Table 9* provides an overview of self-reported participation in different sedentary activities. Participation in all activities was higher among the control group but significance was only apparent for computer use. The latter was significantly lower among cases than controls (0.23 vs. 1.78 hours per day; $p=0.000$). Overall, the most prevalent sedentary activity was TV viewing, which represented 11.48% and 16.51% of total sedentary behaviour for cases and controls respectively (1.84 vs. 2.64 hours per day). Socialising was a common activity among both participant groups, representing approximately one hour of total sedentary activity per day.

Table 9: Self-reported mean time (hours per day) spent in sedentary activities

	Case (n=18) (M,SD)	**Control (n=22) (M, SD)**
Television (TV)	1.84 (1.59)	2.64 (1.35)
Computer	0.23 (.47)	1.78 (2.21)*
Reading	0.61 (.54)	1.00 (1.03)
Socialising	0.86 (.85)	1.22 (.92)
Driving	0.68 (.50)	1.04 (.75)
Hobbies	0.20 (.29)	0.50 (.96)
Other	0.59 (1.07)	0.60 (.95)

*p<0.05 Cases v Controls

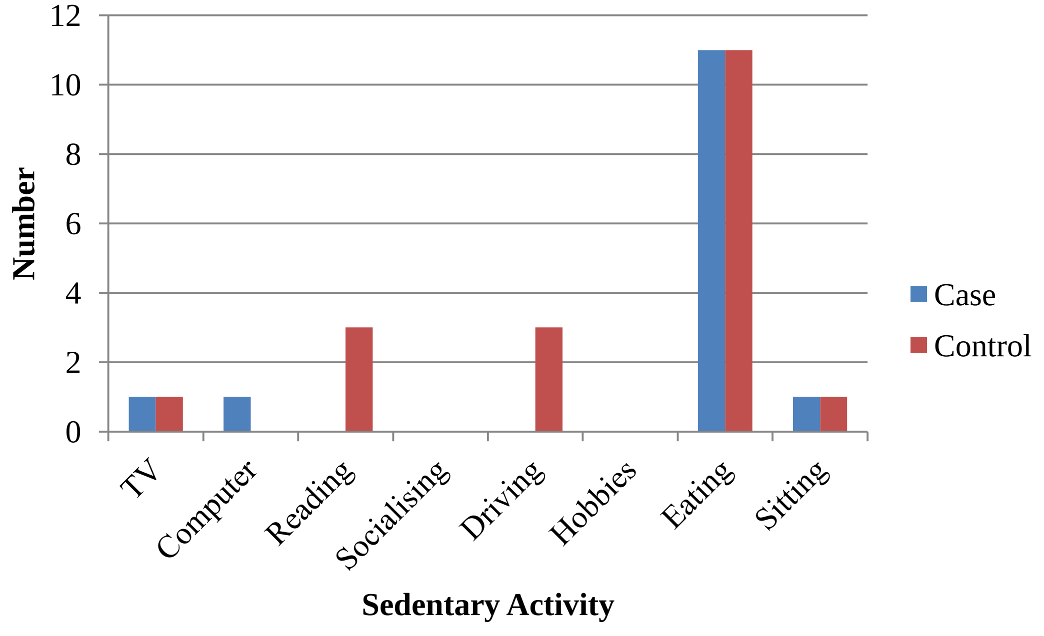
4.5.4 Subjectively measured sedentary behaviour via activity diary

Seventy-nine percent of PAD patients (cases) and 95% of controls completed the activity diary, giving a high compliance rate for both groups. Details about activities were written by participants during most 30 minute time slots, but not all. As previously discussed, (p.57) interpretation of activity diary data was carried out in conjunction with information recorded by the activPAL. All sedentary bouts performed 1 hour after rise time, 1 hour prior to bed time, and all sedentary bouts lasting >20 minutes during the day were examined.

4.5.5 Types of sedentary activities in the morning

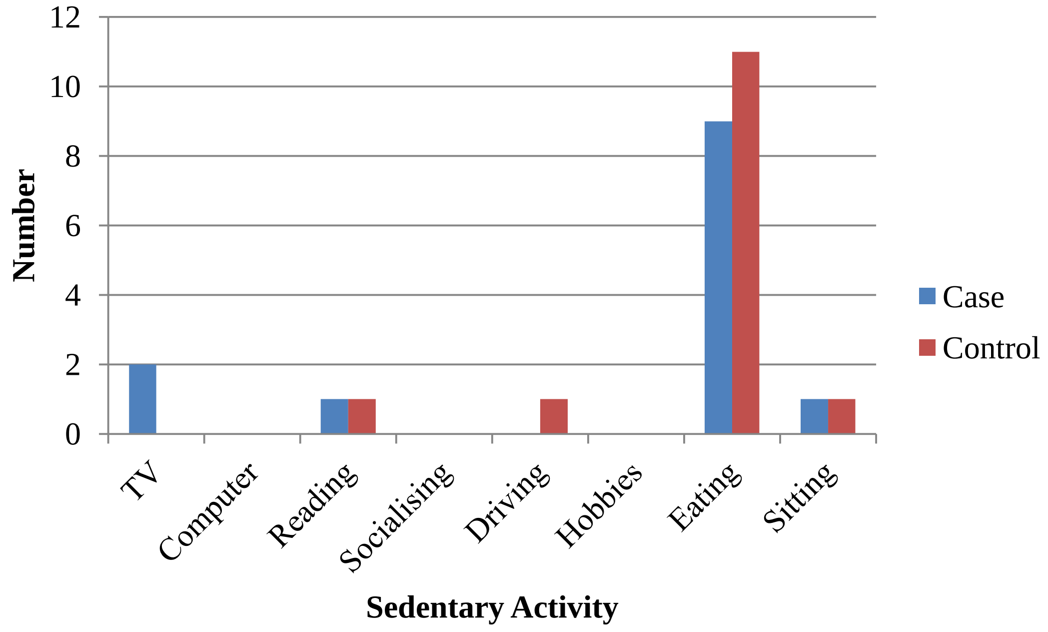
Figure 11 shows that eating was the predominant sedentary activity performed by PAD patients (cases) (n=15) on weekday mornings. Eleven cases (73.3%) reported eating breakfast, while watching TV, using the computer, and sitting were all reported by one case each (6.7%). Eleven controls (n=21) also stated eating as their main sedentary activity on weekday mornings, representing 52.4% of the group. Other sedentary activities reportedly engaged in by controls on weekdays were reading and driving (both 20%), and watching TV and sitting (both 4.7%)

Figure 11: Distribution of types of sedentary activities performed on weekday mornings



Weekday trends remained the same for cases' weekend mornings with 9 (64.3%) stating eating as their main sedentary activity, while 2 (14.3%) reported watching TV and 1 reported sitting (7.1%). Eating also remained as the leading sedentary behaviour on weekend mornings for controls, reported by 59.9% of the group. Weekend data on the types of activities performed were not available for one case and two controls (see *Figure 12).*

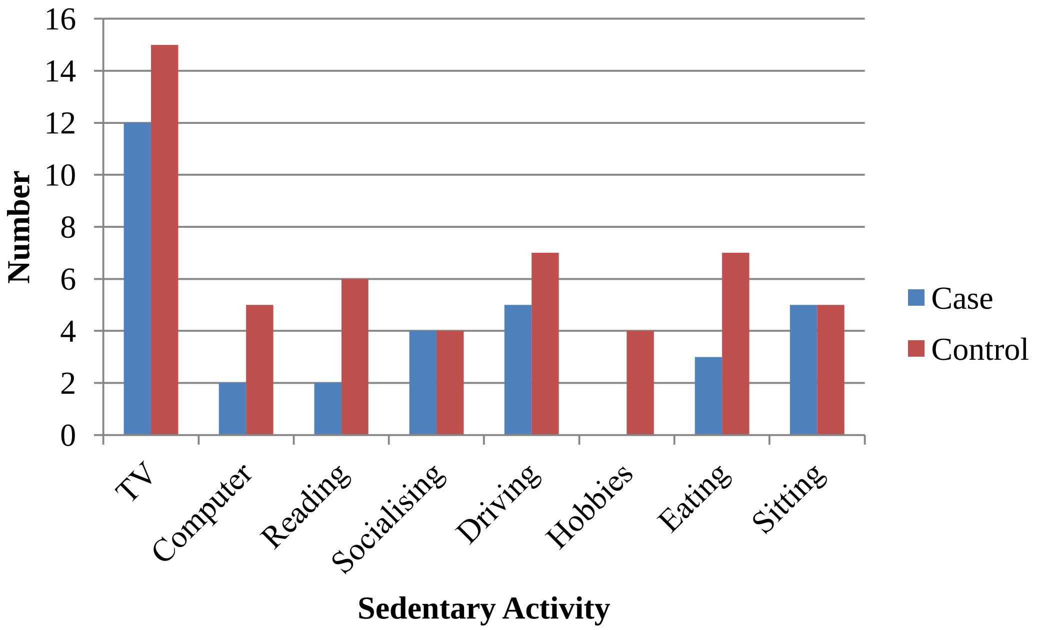
Figure 12: Distribution of types of sedentary activities performed on weekend mornings



4.5.6 Types of sedentary activities during the day

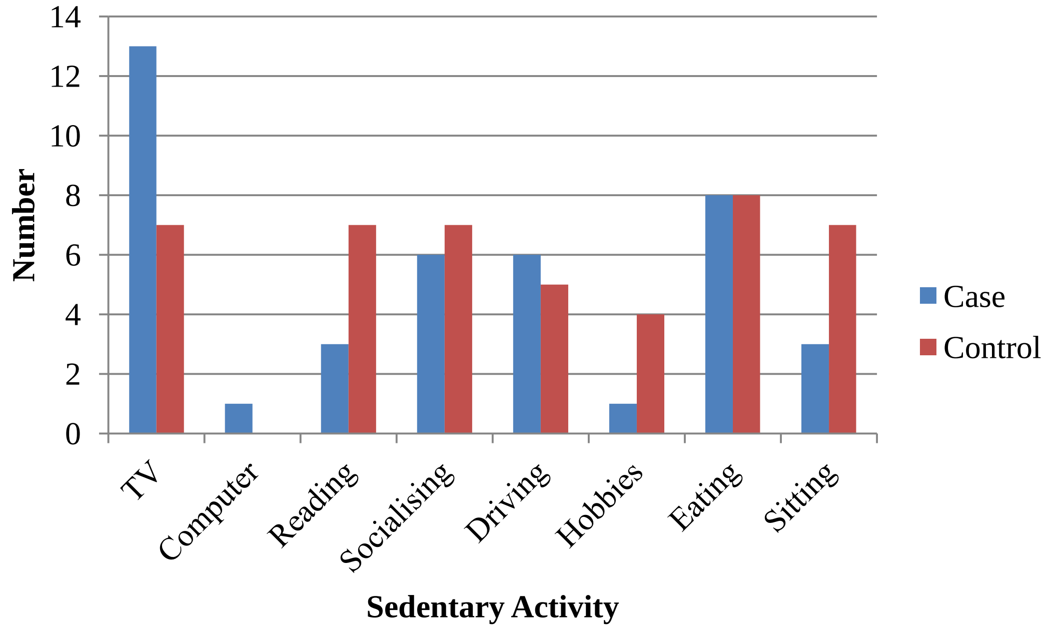
Figure 13 illustrates that the most commonly reported sedentary activity carried out by PAD patients (cases) during the day was watching TV, with 12 (80%) of cases engaging in TV viewing at one point during the day. The second most popular sedentary activities were eating and driving (both 33.3%). For controls, TV viewing was also the most prevalent sedentary activity performed during the day (71.4%). Five controls (23.8%) reported sitting with 2 (40%) of those reporting sitting at work. This was closely followed by driving and eating which were both reported by a third of controls. Four controls reported performing hobbies during the day but were not reported by any cases.

Figure 13: Distribution of types of sedentary activities performed during the day on weekdays



Data for cases remained unchanged during weekends, with TV viewing and eating the most common sedentary activities stated by 13 (87%) and 8 (53.3%) of cases respectively. Eating was the most prominent sedentary activity on weekends, reported by 8 (44.4%) of controls. The second most common sedentary activities were reading, socialising, and sitting (all 38.9%). One control did not record any sedentary bouts lasting longer than 20 minutes, and data were not available for 3 controls (see *Figure 14*).

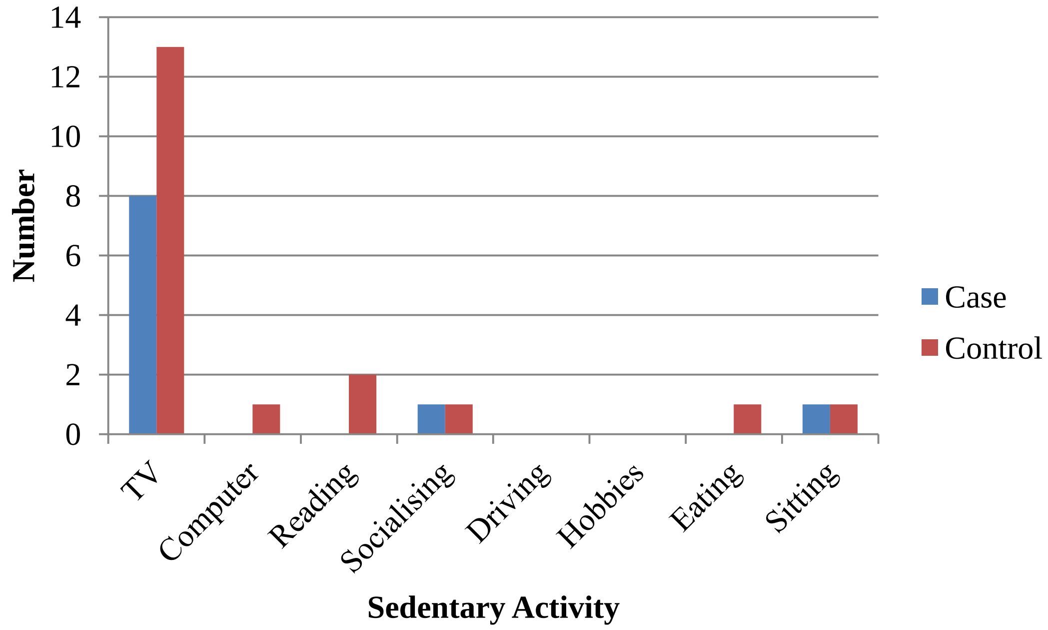
Figure 14: Distribution of types of sedentary activities performed during the day on weekends



4.5.7 Types of sedentary activities before bedtime

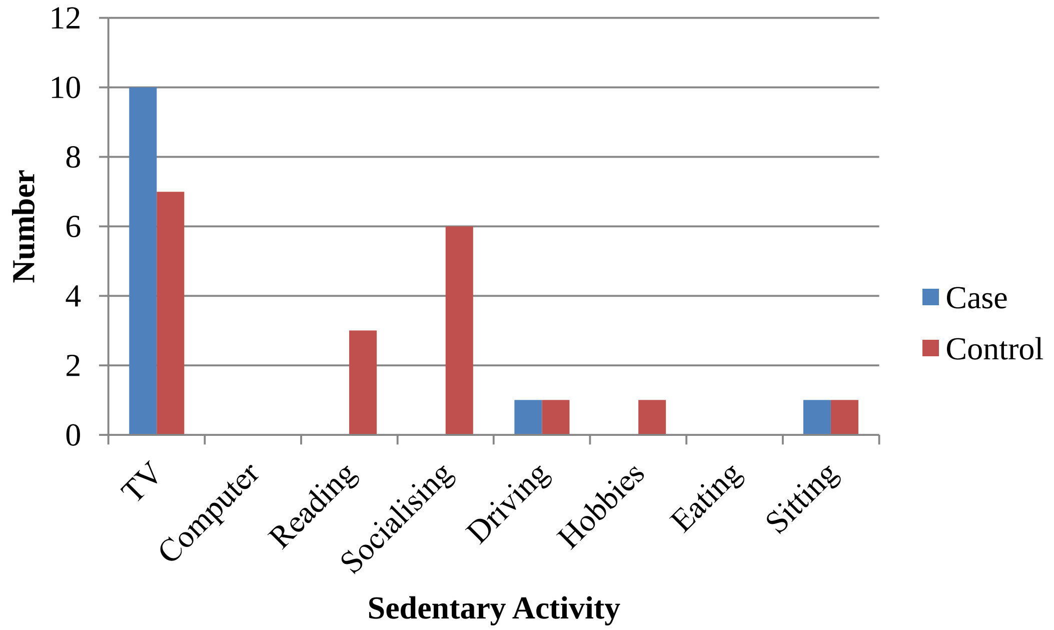
During the hour before bedtime, watching TV was the main sedentary behaviour reported by 8 PAD patients (cases) (80%). Socialising and sitting were also reported by two separate participants. Five cases failed to provide any information about activities performed during this time. TV viewing was also the main sedentary activity engaged in by controls during the hour before bedtime (72%). Other controls reported engaging in reading (11%), socialising, eating, and sitting, (5.6%). No data on sedentary activities performed before bedtimes were available for 3 controls (see *Figure 15*).

Figure 15: Distribution of types of sedentary activities performed before bedtime on weekdays



Watching TV was also the predominant sedentary activity for cases during the weekend, reported by 10 cases (76.9%). Other activities included driving and sitting, both carried out separately by 2 controls. Three participants did not give any details about the activities carried out during this time. Watching TV was also the most common sedentary activity before bedtime on weekends for controls (44%). Socialising, reading, and eating were also reported by 6 (37.5%), 3 (19%) and 3 (19%) controls, respectively. Five controls failed to document any activities in the hour before bedtime (see *Figure 16*).

Figure 16: Distribution of types of sedentary activities performed before bedtime on weekends

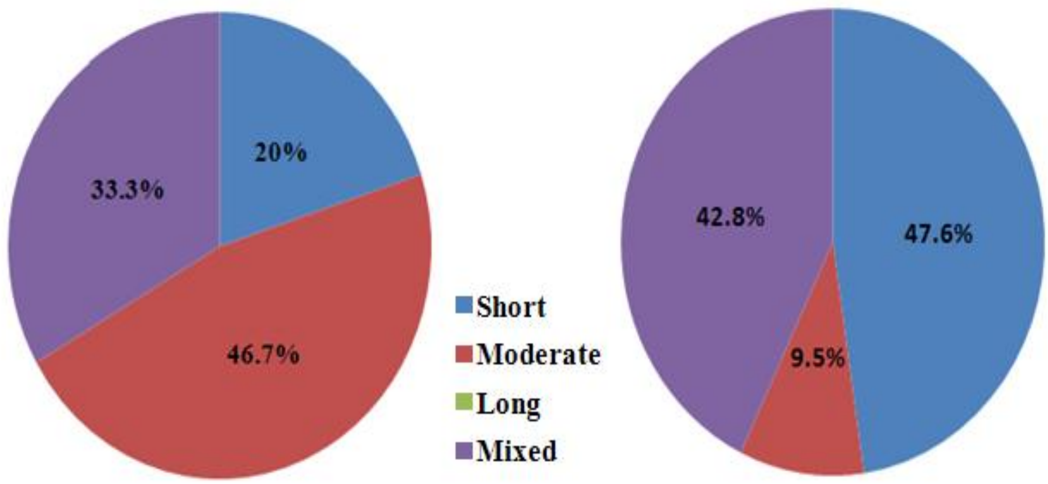


4.5.8 Duration of sedentary activities in the morning

Just under half (46.7%) of the sedentary activities performed by PAD patients (cases) on weekday mornings were moderate in length i.e. lasted between 5 and 20 minutes. Twenty percent of cases performed activities of a sedentary nature that were short in length i.e. <5 minutes. The remainder of the cases (33.3%) carried out a combination of both short and long sedentary activities, with no cases engaging in morning activities that were long in duration i.e. longer than 20 minutes. A larger percentage (47.6%) of controls participated in sedentary activities on weekday mornings that were short in duration (<5 minutes) and just under 10% took part in sedentary activities that lasted between 5 and 20 minutes. The remainder of the controls engaged in activities of a sedentary nature that varied in duration, with a third of controls completing sedentary activities that were of a mixed duration i.e. short and moderate, and 9.5% carrying out sedentary activities that were of both short and long duration (see Figures 17a and 17b).

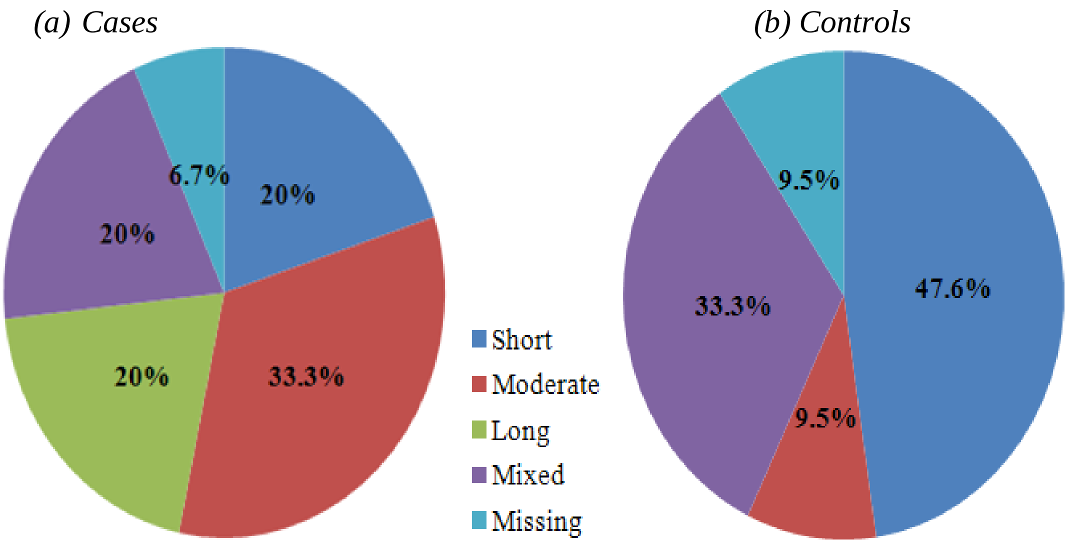
Figure 17: Distribution of sedentary bouts during weekday mornings

(a) Cases *(b) Controls*



Figures 18a and *18b* highlight that the duration of PAD patients' (cases) sedentary behaviours varied slightly during the weekend. The number of cases that performed sedentary activities in short bouts remained the same. However, the percentage of cases that carried out sedentary activities of moderate length decreased to 33.3% and the number of cases that were sedentary for periods longer than 20 minutes on weekend mornings increased from zero to 20%. Controls' morning activity remained unchanged during the weekends. However, weekend data were not reported by 2 controls.

Figure 18: Distribution of sedentary bouts during weekend mornings

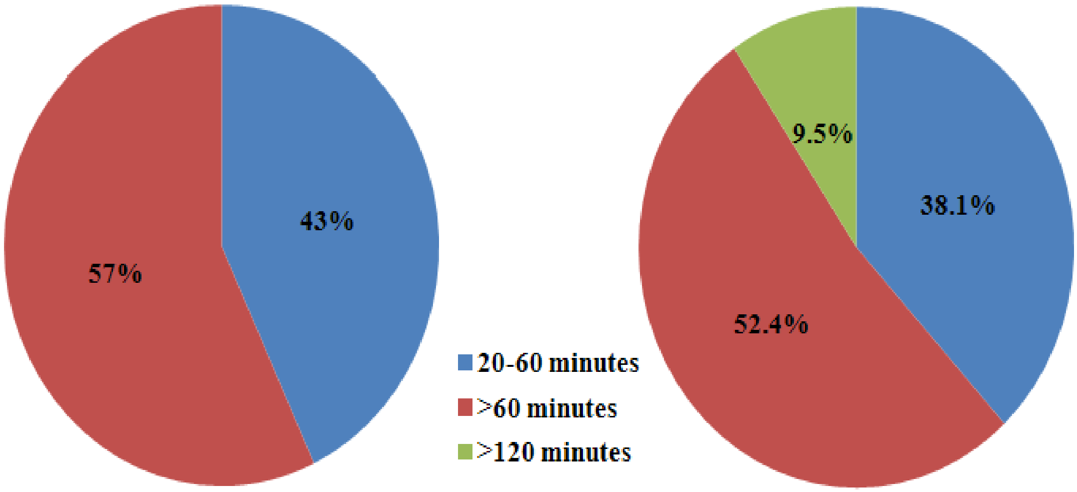


4.5.9 Duration of sedentary activities during the day

All PAD patients (cases) recorded sedentary bouts >20 minutes during the daytime, with 57% of cases recording at least one sedentary bout lasting longer than 1 hour. Similarly, all controls recorded sedentary periods throughout the daytime on weekdays that lasted longer than 20 minutes. Over half of controls (52.4%) recorded sedentary bouts lasting longer than 1 hour and 9.5% recorded engaging in sedentary activities lasting over 2 hours (see *Figures 19a* and *19b*).

Figure 19: Distribution of sedentary bouts during the daytime on weekdays

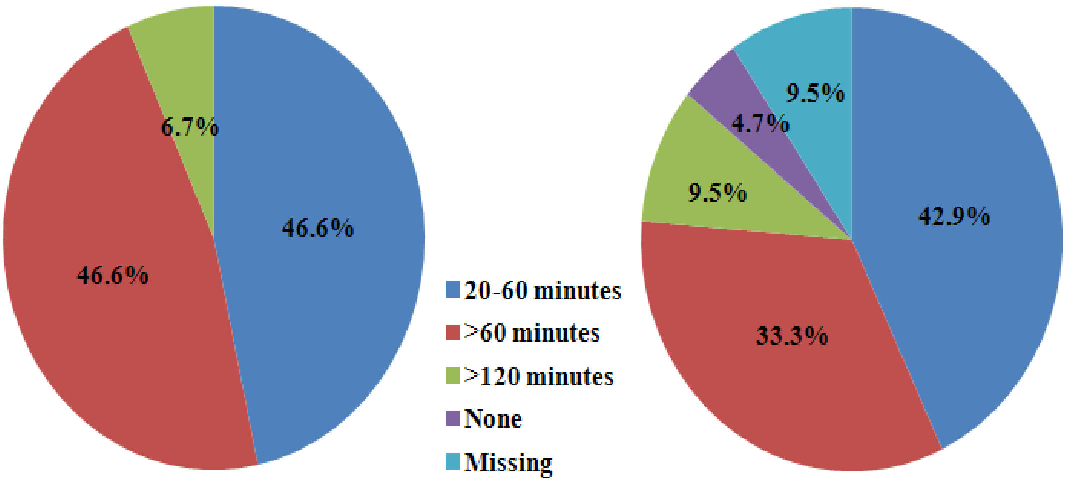
(a) Cases *(b) Controls*



Trends differed slightly for cases' weekend data as an equal amount of cases (46.6%) recorded in sedentary bouts lasting less than 1 hour and over an hour (see *Figures 20a* and *20b*). In addition, one case (6.7%) accumulated a sedentary bout that lasted over 2 hours. Weekend data for controls' daytime sedentary activity also changed. More controls took part in sedentary activities that lasted between 20 and 60 minutes (43%), while only a third performed sedentary activities that lasted longer than 1 hour. One control (4.7%) did not record any sedentary bouts lasting longer than 20 minutes during the day on the weekend. Data were missing for 2 participants.

Figure 20: Distribution of sedentary bouts during the daytime on weekends

(a) Cases *(b) Controls*

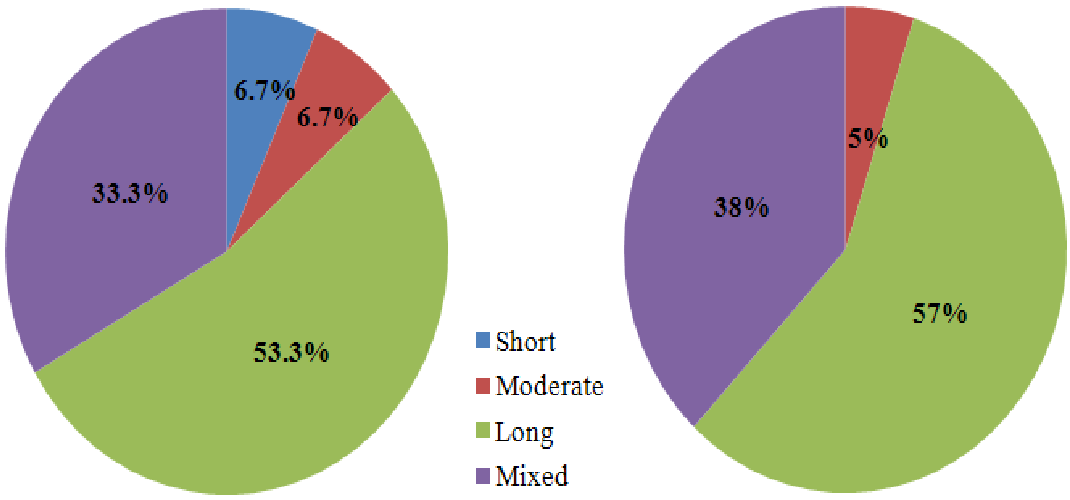


4.5.10 Duration of sedentary activities before bedtime

Over half the sedentary activities carried out by cases during the hour before bedtime were long in duration i.e. >20 minutes (53.3%). A third of cases engaged in sedentary activities that were both mixed in duration (short and moderate). Most of the sedentary activities participated in by controls during the hour before bedtime lasted longer than 20 minutes (57%). No sedentary activities lasted less than 5 minutes and only 5% lasted 5-20 minutes. The rest of the sedentary activities reported were of mixed duration i.e. short and moderate, and short and long (see *Figures 21a* and *21b*).

Figure 21: Distribution of sedentary bouts before bedtime on weekdays

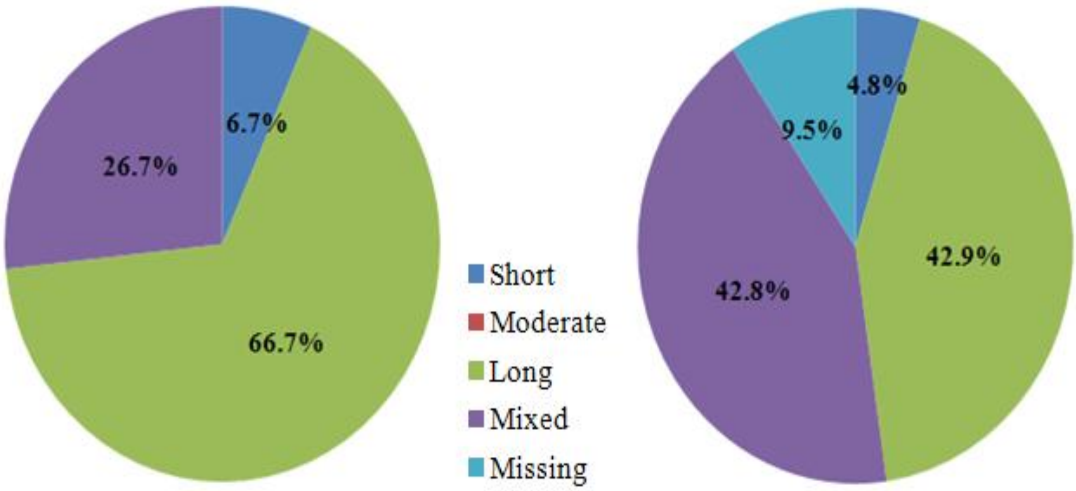
(a) Cases *(b) Controls*



During the weekend, the percentage of cases that engaged in sedentary bouts >20 minutes increased to 66.7%, while the percentage of cases that recorded activities of mixed in length (short and moderate) decreased slightly to 26.7%. The lengths of sedentary activities during the weekend for controls were predominantly long, with just under half of them (47%) spending more than 20 minutes sedentary. Almost a third of controls (32%) recorded sedentary activities that were of mixed duration (short and moderate), while a further 16% recorded sedentary behaviours that were both short and long (>20 minutes) in length (see *Figures 22a* and *22b*).

Figure 22: Distribution of sedentary bouts before bedtime on weekdays

(a) Cases *(b) Controls*

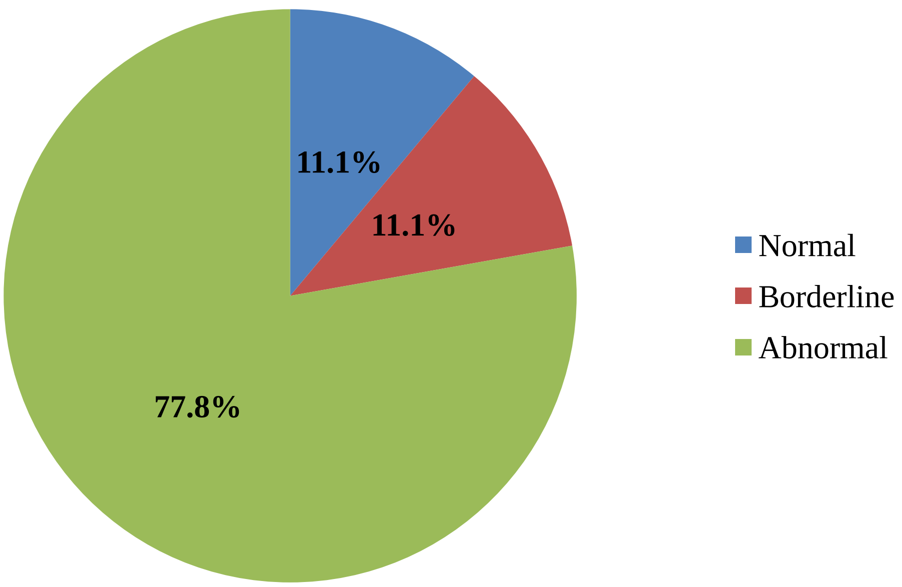


4.6 Severity of Peripheral Arterial Disease

4.6.1 Vascular health measures

The severity and progression of PAD in patients (cases) was determined using an Ankle Brachial Index (ABI) score. As noted previously (p.42), this was obtained by measuring posterior tibial and dorsalis pedis artery systolic pressures which were then compared against brachial pressures. The mean ABI score for cases was 0.78±0.24. Using the Rooke et al. (2011) classification system (as described on page 42), the majority of cases were categorised as having an abnormal ABI level (77.8%). The 4 remaining cases had an ABI level that was classified as borderline (2) and normal but close to having non-compressible arteries (2) (see *Figure 23*). ABI data were missing for one case.

Figure 23: Distribution of ABI classification



The severity of PAD was also established using the Peripheral Artery Questionnaire (PAQ). As previously mentioned (p.42) this questionnaire collects information on the extent as to which the patients' condition has impacted their quality of life and general health status. Each question was placed into 1 of 6 domains based on what the question was referencing i.e. physical function, symptom stability, symptom scale, treatment satisfaction scale, quality of life, and social function. Total scores for each domain are ranked on a scale of 0-100, with higher score indicating better health status and quality of life. Reliability analysis obtained a Cronbach's alpha score of 0.403 for the different domains within the PAQ, giving a poor level of internal consistency. However, as noted in Table 10, the exclusion of the treatment satisfaction domain increased the score to 0.714 and therefore yielded a good level of internal consistency.

Table 10: Cronbach's alpha score for peripheral artery questionnaire domains

	Cronbach's Alpha if item deleted
Physical function	0.394
Symptom stability	0.357
Symptom scale	0.141
Treatment satisfaction	0.714
Quality of life	0.030
Social functioning	0.183

Overall, 15 PAD patients (cases) completed the PAQ. A summary of the mean questionnaire scores for each domain is provided in *Table 11*. Mean scores for four domains (physical function, symptom scale, quality of life, social functioning) and the summary score were similar, ranging from 35.7 to 38.73. The treatment satisfaction domain attained the highest mean score, but as previously noted, due to its impact on the Cronbach's alpha score this domain was removed from further analysis. Three quarters of cases reported that their PAD symptoms had not changed over the previous 4 weeks, while the remaining 25% felt that their condition had worsened.

Table 11: Mean scores of peripheral artery questionnaire

	M, (SD)
Physical function	36.52 (23.92)
Symptom stability	41.18 (15.16)
Symptom scale	35.7 (22.86)
Treatment Satisfaction	58.01 (31.95)
Quality of life	36.77 (25.86)
Social functioning	38.73 (32.93)
Summary score	36.11 (21.03)

4.6.2 Functional ability measures

The functional ability of both groups was also assessed to investigate whether or not the severity of PAD had an effect on the aerobic endurance and lower body strength of PAD patients (cases). *Table 12* shows the average distance (meters) walked during the 6-minute walk test and the average number of chair repetitions performed during the 30 second chair test. Mean distance walked and number of repetitions were both significantly different between groups, with controls walking 186m more (p=0.000) and completing approximately 3 repetitions more (p=0.003) than cases. Over one third (36.8%) of PAD patients (cases) were symptomatic during the 6 minute walk test. Three cases had to stop and rest on one occasion, one patient experienced leg pain 3 times, another was symptomatic on 4 occasions, and another patient had to stop and rest a total of 7 times.

Table 12: Functional ability mean scores

	Case (15) (M, SD)	**Control (15) (M, SD)**
Chair repetitions	9.87 (2.1)	12.67 (2.53)*
Distance walked (meters)	329.4 (109.32)	515.4 (76.33)*

*p<0.05 Cases v Controls

As discussed in the data analysis section (p.57), PAD patients (cases) were separated into two groups (abnormal and normal/borderline) based on their ABI value to examine the impact (if any) of PAD severity on functional ability, and both activity and sedentary patterns. Results indicated that mean scores for the distance walked (metres) during the 6-minute walk test, and both objectively recorded sedentary and activity times were similar between the two PAD severity groups. However, PAD patients (cases) classified with an abnormal ABI score performed significantly fewer chair repetitions than cases grouped as normal/borderline (9.36±2.25 vs. 11.33±0.58; p=0.023). Cases in the abnormal ABI category self-reported a higher weekly mean time spent active and time spent sedentary than those in the normal/borderline ABI category (see *Table 13*).

Table 13: Mean scores for functional ability tests, objective and self-report sedentary and activity patterns

	Abnormal			**Normal/Borderline**		
	M	**SD**	**n**	**M**	**SD**	**n**
Distance walked (meters)	331.91	124.42	11	330	76.08	3
Chair repetitions	9.36	2.25*	11	11.33	0.58	3
ActivPAL activity time (hrs/day)	1.44	0.4	14	1.44	0.6	4
ActivPAL sedentary time (hrs/day)	9.38	1.87	14	10.06	1.47	4
IPAQ activity time (hrs/week)	4.82	5.46	13	16.42	10.42	4
IPAQ activity time (hrs/day)	0.69	0.78	13	2.35	1.49	4
IPAQ sedentary time (hrs/week)	33.7	5.53	13	40.36	16.48	4
IPAQ sedentary time (hrs/day)	4.81	2.85	13	5.77	2.35	4

*p<0.05 Case sub-group 1 v Case sub-group 2
M=mean; SD=standard deviation; n=number

4.7 Correlations between PAD severity and both activity and sedentary patterns

Possible relationships between measures of severity (ABI, PAQ, walk test, and chair test) and objectively and subjectively recorded activity and sedentary time were examined using Pearson correlations. Moderate positive correlations were observed between the distance walked during the 6-minute walk test and the overall PAQ score ($r=0.564$, $n=11$, $p=0.071$), accelerometer recorded activity time ($r=0.505$, $n=11$, $p=0.113$), self-reported activity time ($r=.525$, $n=11$, $p=0.097$). A moderate negative correlation was observed between the chair test and objectively recorded sedentary time ($r=-0.484$, $n=11$, $p=0.131$). In addition, strong positive correlations were found between the chair test and both objectively measured activity time ($r=0.592$, $n=11$, $p=0.055$) and number of steps taken per day ($r=0.527$, $n=11$, $p=0.066$).

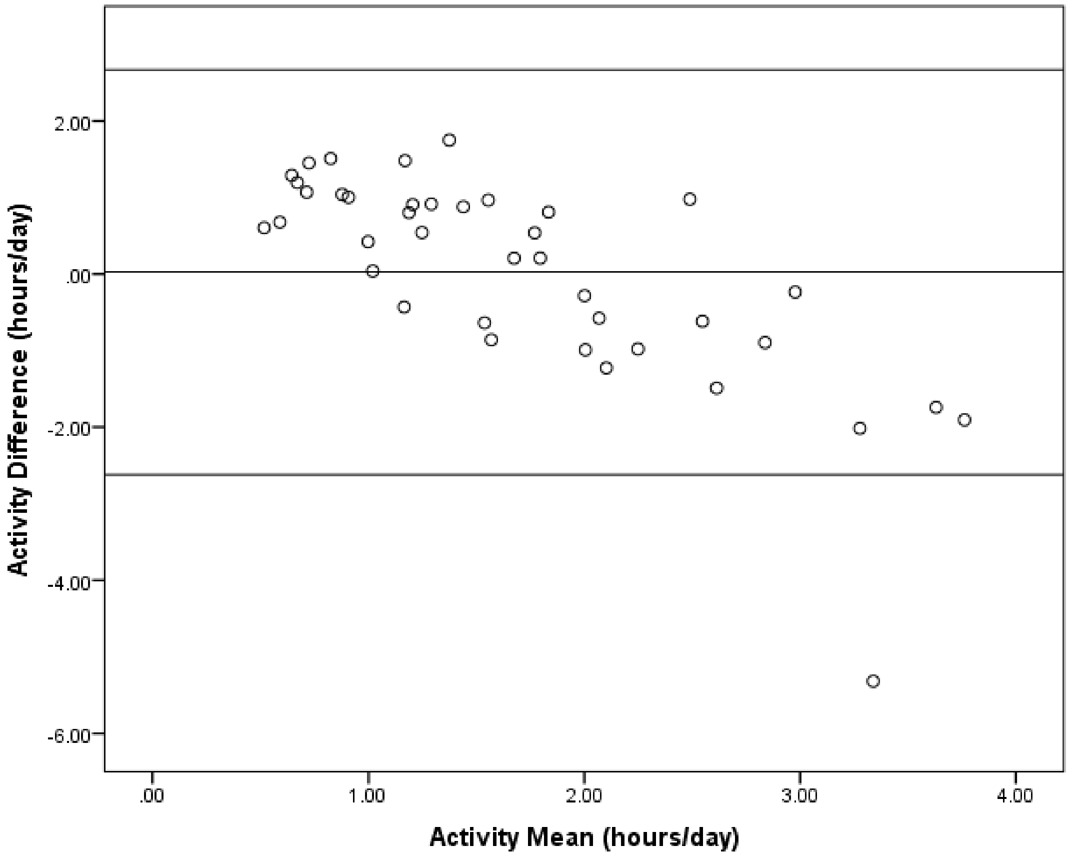
4.8 Correlations between objective and subjective measures of physical activity patterns

Potential relationships between activPAL accelerometer and IPAQ measures of physical activity patterns were also investigated using Pearson correlation coefficient. The number of steps per day recorded by the activPAL were moderately correlated with self-reported weekly ($r=0.395$, $n=40$, $p=0.012$) physical activity time (hours). The number of steps taken per day were also positively correlated with total MET hours per week ($r=0.375$, $n=40$, $p=0.017$). Finally, a positive relationship was found between objectively recorded activity time and self-reported physical activity time per week ($r=0.394$, $n=40$, $p=0.012$) and per day ($r=0.396$, $n=40$, $p=0.011$). Activity time measured by the activPAL accelerometer was also moderately correlated with total MET-hours ($r=0.391$, $n=40$, $p=0.013$).

4.9 Agreement between measures of physical activity patterns

Agreement between activPAL accelerometer and IPAQ measures of physical activity patterns was investigated using the Bland-Altman method. The difference between the two activity time variables was calculated by subtracting subjectively recorded activity time from objectively recorded activity time. The mean of the two variables was also calculated. Differences in measured activity time were plotted against the averages of the objective and subjective measures (see *Figure 24*). Mean activity time (hours per day) between accelerometer and questionnaire data showed a mean difference of 0.03±1.35 hours per day, with the limits of agreement ranging from 2.67 to -2.62 hours. Although the mean difference was very small, and not significantly different from 0 ($p=0.896$) the Bland–Altman plot actually showed poor agreement between the two methods of measurement for activity time as the data followed a downward trend as opposed to a more horizontal scatter pattern. The plot suggests that individuals with a higher mean activity time over-reported the amount of activity performed, and individuals with a lower mean activity time under-reported their daily activity time when compared with objectively recorded activity time. A Pearson correlation indicated a strong negative relationship ($r=-0.767$, $n=40$, $p=0.000$) between Bland-Altman differences and Bland-Altman mean activity time suggesting a greater overestimation by the questionnaire with greater average activities.

Figure 24: Scatter plot showing actual and estimated difference in activity time (hours per day)



Further investigation into the outlier in Figure 24 was performed. ActivPAL data revealed that the participant (control 27) accumulated 2428 steps/day (the lowest amount of steps recorded among the entire sample). In addition, data from the activity monitor illustrated that this participant was active for 0.68 hours/day. However, questionnaire data showed that the participant self-reported engaging in moderate intensity activity on 7 days over the previous week (accumulating a total of 300 minutes) and reported walking on 7 days over the previous week (accumulating a total of 210 minutes). This equated to approximately 6 hours of physical activity per day. This discrepancy between objectively recorded and self-reported activity time may explain the high difference in activity time (5.32 hours/day).

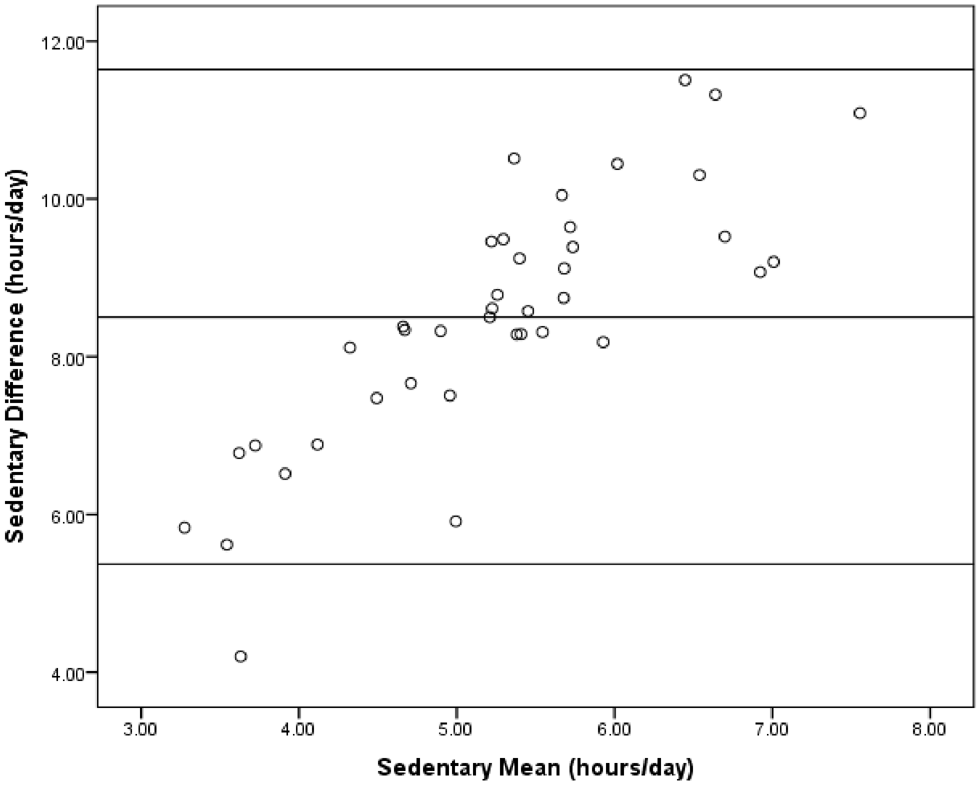
4.10 Correlations between objective and subjective measures of sedentary patterns

Possible relationships between activPAL (objective) and IPAQ (subjective) measures of sedentary patterns were examined using Pearson correlation coefficient. A moderate positive correlation was found between self-reported sedentary time and both objectively recorded sedentary time ($r=0.4$, $n=40$, $p=0.011$) and time spent in sedentary periods lasting 5 to 20 minutes ($r=0.38$, $n=40$, $p=0.015$).

4.11 Agreement between measures of sedentary patterns

The Bland-Altman method was also used to examine the level of agreement between the accelerometer (objective) and questionnaire (subjective) instruments in recording sedentary time. The difference between the two sedentary time variables was calculated by subtracting subjectively recorded sedentary time from objectively recorded sedentary time. The mean of the two variables was also calculated. Differences in measured sedentary time were plotted against the averages of the objective and subjective measures (see *Figure 25*). In this case, the agreement was poor on two counts. Firstly, the mean sedentary time difference was significantly different from zero (8.5±1.6 hours, $p=0.000$). In fact, all participants under-estimated the amount of time spent in sedentary behaviour, as there were no negative readings. The limits of agreement ranged from 11.64 to 5.37 hours, indicating that 95% of respondents in general underestimated sedentary time by more than 5 hours. Secondly, there was a definite upward pattern in the plot, indicating that those with the highest sedentary times per day were the most likely to underestimate their sedentary times. A Pearson correlation between Bland-Altman differences and Bland-Altman average sedentary time showed a strong positive relationship between the two variables ($r=0.825$, $n=40$, $p=0.000$), suggesting a greater underestimation or overestimation as the average sedentary time increases.

Figure 25: Scatter plot showing actual and estimated difference in sedentary time (hours per day)



4.12 Chapter Summary

This chapter has presented the main findings of the study. The characteristics of the sample were similar with the exception of mean BMI, employment status, and education level. Significant differences in objectively measured activity time were observed between PAD patients (cases) and controls. In addition, self-reported time spent in moderate intensity activity was significantly lower among cases than controls. Objectively recorded sedentary time was similar between both groups. Subjective data revealed that cases reported significantly lower mean daily sedentary time compared to controls. Finally, the functional ability of cases was poorer compared to controls. The next chapter will interpret and deliberate the significance and meaning of the main findings.

Chapter 5 Discussion

5.1 Chapter overview

This chapter will consider the overall meaning of the findings obtained from the accelerometer, questionnaire, activity diary, and vascular health and functional ability measures. A recap of the most prominent results is provided, followed by possible explanations for these findings. The limitations of the research are also discussed and recommendations for future research are offered.

5.2 Main findings

The aim of the current study was to characterise physical activity and sedentary behaviour patterns of patients with PAD relative to healthy individuals, and to examine the relationship between the severity of the condition and patterns of activity and sedentarism. Observational analysis of a case and control group was performed using both objective (accelerometer) and subjective (questionnaire and activity diary) measurement tools to determine habitual physical activity and sedentary behaviour patterns. The demographic characteristics of both groups were similar with the exception of a significant difference in employment status, education level, and mean BMI. Significantly fewer cases than controls were employed (11.1% vs. 45.5%; p=0.032) and had completed third level education (11.1% vs. 59.1%; p=0.001), and mean BMI was significantly higher among cases (28.38±5.17 vs. 26.5±3.7; p=0.006).

Regardless of the method used, activity levels were lower among cases. Findings from the study revealed that objectively measured daily activity time was significantly lower among PAD patients (cases) than controls (1.92±1.59 vs.1.46±0.43 hours per day; p=0.007). In addition, cases recorded significantly fewer steps per day compared to controls (6801±2518 vs. 9357±3452; p=0.009). In terms of self-reported amounts of physical activity, cases completed lower amounts of total weekly physical activity than controls (8.43±8.86 vs. 14.63±10.69 hours per week; p=0.052). Cases reported lower amounts of vigorous intensity activity and walking, and significantly lower levels of moderate intensity activity than controls (1.98±2.83

vs. 5.7±7.01 hours per day; p=0.036). Walking was the most frequent activity performed by both groups.

Results from functional ability tests revealed that cases had poorer leg function as walking test (329.4±109.32 vs. 515.4±76.33 metres; p=0.000) and chair test (9.87±2.1 vs. 12.67±2.53; p=0.003) scores were significantly lower than control scores. In addition, cases classified as severe i.e. an ABI score <0.9 performed significantly fewer chair repetitions than cases classified as less severe i.e. with an ABI score >0.9 (9.36±2.25 vs. 11.33±0.58; p=0.023).

Objectively recorded sedentary time was similar between cases and controls (9.59±1.74 vs. 9.51±1.77 hours per day). Objectively measured sedentary patterns were also similar between cases and controls. For both groups, the highest number of sedentary bouts occurred in the <5 minute sedentary category. In addition, the greatest amount of sedentary time was spent in bouts lasting longer than 20 minutes. Self-reported sedentary time was significantly lower among cases than controls (5.01±2.62 vs. 8.78±4.28 hours per day; p=0.029). Evidently, unlike for physical activity, there was a lack of agreement between the modes of data collection. It is important to note that this study considered objectively recorded data as the gold standard measure of activity and inactivity, and therefore the interpretation of results presented in this chapter are based mainly on objective data.

In terms of the types of sedentary activities performed, TV viewing was the most common sedentary activity reported by both groups (1.84±1.59 and 2.64±1.35 hours per day for cases and controls, respectively) and daily computer use was significantly higher among controls than cases (1.78±2.21 vs. 0.23±0.47 hours per day; p=0.000). Sedentary time was lowest in the morning time and increased during the day, with the highest amount of sedentary time occurring in the evening time.

Studies have reported lower amounts of daily physical activity among individuals limited by PAD compared to healthy controls (McDermott et al. 2000). However, to fully capture the habitual patterns of individuals with PAD, measures of both activity and sedentarism are necessary. As well as providing contextual information about the PAD population group which is vital for identifying intervention targets and public health messages, this study builds on the limitations of previous research by examining both physical activity time and sedentary patterns of this particular population group.

5.3 Interpretation of findings

5.3.1 Differences in activity time between cases and controls

ActivPAL data showed that PAD patients (cases) were less active than controls by almost 30 minutes each day. Other studies have also illustrated that individuals with PAD have lower physical activity levels compared to individuals without the condition. For example, a study by Sieminski and Gardner (1997) using objective measures of physical activity observed that individuals with PAD recorded lower levels of daily energy expenditure compared to individuals without the condition (357±238 vs. 616±363 kcal/day; $p<0.001$). McDermott et al. (2000) also found lower weekly physical activity levels among individuals with PAD in comparison to those without the condition using data collected from an accelerometer (803±364 kcal/week vs. 1750±1296 kcal/week).

Lower activity levels among PAD patients (cases) may be attributed to the existence of, and severity of their condition. Results from the functional ability tests indicated that the aerobic endurance and lower body strength of cases were significantly poorer than controls. In addition, cases with severe PAD performed fewer chair repetitions than individuals with a higher ABI score, suggesting that they were even more limited in terms of lower body strength. The nature of PAD, in particular intermittent claudication, means that individuals with the condition have poorer leg strength and function than those without the condition. In addition, the onset of pain in the lower extremities, which is the main symptom of stage II PAD, results in patients needing to frequently stop and rest until the pain subsides (Crowther et al. 2007; Gardner et al. 2001b; McDermott et al. 2001; McDermott et al. 2003b). This loss of functional ability and deterioration in walking performance can cause further reductions in individuals' capacity to perform physical activity. Indeed, individuals with a chronic condition are likely to become less physically active which in turn leads to a cycle of de-conditioning (Durstine et al. 2013). Furthermore, mean physical functioning scores and overall scores in the PAQ were also low, indicating perceived poor functional ability and health status among cases. Therefore, it may be that individuals with PAD in this study were unable to complete high amounts of activity due to actual and perceived constraints of their condition.

The higher proportion of controls employed and with a higher education level compared to cases may have also contributed to the observed difference in activity levels. Controls displayed a better level of physical functioning compared to PAD patients (cases), and so if they are healthy enough to engage in the work environment and have greater functional ability, then they are also likely to be more active than individuals with PAD. Philippaerts and Lefevre (1998) noted activity differences among males of varying professional status. Managers worked significantly more hours per week compared to clerks and workmen (52.1 vs. 42.2 vs. 44.9 hours/week; $p<0.005$, respectively), however workmen had a higher energy expenditure and work index (MET value divided by time working) and activity index (MET value divided by time spent on active leisure activities) than clerks and managers. In a study by Sallis et al. (1985), levels of moderate and vigorous activity were highest for men and women in the high education category (12 or more years of school), with total expenditure the highest for medium educated men. Other than age, the personal characteristic most strongly related to physical activity participation was education. The significant difference in mean BMI may have also played a role in the differences in activity time. Levine et al. (2005) observed that lean individuals were upright for 152 minutes longer per day than obese individuals. In addition, total body movement was negatively correlated with fat mass.

While the severity of PAD may have contributed to the low amount of activity performed by cases, accelerometer and questionnaire data suggests that individuals with PAD in the present study may not have been the most severe sample when compared to research performed among other PAD patients. After taking into consideration the health status of participants and adjusting the step threshold as proposed by Tudor-Locke et al. (2011), over half of cases (63.2%) achieved the tailored step threshold of 5,600 steps per day. Also, a study by Gardner et al. (2007) reported that a sample of PAD patients recorded 3149±1557 steps per day while another study by Clarke et al. (2013) found that individuals with PAD performed 6524±2710 steps per day. PAD patients (cases) in the present study accumulated an average of 6801±2518 steps each day. The daily step count recorded by individuals with PAD in the present study is remarkably similar to those observed by Clarke et al. (2013). Not only does this provide confidence in the data collected in this study but also suggests that cases were not as limited in their walking ability compared to other groups of PAD patients, as they performed similar amounts and in some incidences more steps per day than other PAD samples. This was also apparent during the 6-minute walk test as only a third of cases experienced leg pain and had to stop and rest on at least one occasion during the test.

5.3.2 Nature of sedentary behaviour

Accelerometer-recorded sedentary time was similar between PAD patients (cases) and controls, with both groups spending approximately 9.5 hours per day in sedentary activities. Previous research has also found high sedentary time among individuals with PAD. A recent study by Lauret et al. (2014) reported that intermittent claudication patients with a mean age of 69.6±8.8 years recorded over 8 hours of daily sitting time.

The similarity between cases and controls was not anticipated but research by Chastin & Granat (2010) concluded that occupation and/or the presence of disease does not notably effect total sedentary time. Unlike the previous discussion on physical activity and level of functioning among PAD patients, the implications of the condition do not appear to influence time spent sedentary. Patterns and types of sedentary behaviours were largely similar between both groups, with the exception of sedentary patterns in the morning time, and types of sedentary activities performed during the day. Cases were sedentary for long periods in the morning (between 5 and 20 minutes) whereas controls' morning sedentary bouts were largely short in duration (<5 minutes). Chastin & Granat (2010) studied the patterns of individuals with chronic lower back pain (n=5) and chronic fatigue syndrome (n=14). Using the GINI index (G) they found that these individuals accumulated sedentary time in a boom-bust pattern comprised of mainly long sedentary periods compared to two healthy groups whose patterns of sedentary time were broken into a larger number of periods of different length. While Chastin & Granat (2010) found that occupation did not impact total sedentary time, they did note that occupation played a role in the pattern of sedentary behaviour. Therefore, the higher proportion of controls that were in employment compared to cases may have contributed to the differences in morning time sedentary patterns in the present study.

Apart from morning time sedentary behaviour, in this study, both groups accumulated their sedentary time in long uninterrupted periods and the number of breaks in sedentary time and average duration of these breaks were similar between PAD patients (cases) and controls. As the day progressed, subjective data indicated that TV viewing was the most common sedentary activity performed by both groups and mostly occurred in the evening time. Apart from watching TV, the types of sedentary activities performed during the day varied slightly between cases and controls. Daytime sedentary activities for cases consisted predominantly of watching TV, followed by driving, socialising, and sitting. For controls, sedentary activities also included mainly TV viewing, followed by driving, eating, reading, and computer use. This difference may also be due to the proportion of controls that worked during the day. Although our study did not record the specific types of employment that controls were engaged in, activity diary data indicated that many were involved in office-based employment as they reported activities such as "working at desk", and "sitting at computer". Questionnaire data also suggests that office-based occupations were common among controls, as significantly more controls than cases reported using the computer/internet (1.56 hours more per day). The types of day time activities described by controls are suggestive of office-based employment, in particular reading and computer use.

TV viewing was also the main sedentary activity in the evening time. The high amount of overall TV time is consistent with other research findings such as Gardner et al. (2011) where TV viewing was the largest component of sedentary time. Healy et al. (2011) also reported high amounts of TV viewing time among adults. Just under 80% of men and women aged 60-69 years reported >2 hours of TV viewing per day, increasing to over 80% among men and women aged ≥70 years. Clark et al. (2008) offered a possible rationale for the occurrence of high amounts of TV, suggesting that because many TV programmes regularly occur weekly, even daily, and in regular blocks, TV time is likely to be carried out in long uninterrupted periods of sedentarism, which was the case in the present study. The large volume of sedentary activities performed by participants highlights how sedentary behaviours are becoming innate in individuals' lives and also, indicate that many sedentary activities e.g. eating, sitting at a desk when working, having to drive for transportation, as well as TV viewing require specific intervention strategies.

5.3.3 Overall sedentary behaviour

Previous studies with individuals of a similar age to the overall sample in the present study have also observed high levels of sedentary time. Stamatakis, Davis, Stathi, and Hamer, (2012) reported that 67% of adults aged 60 years and over spent more than 8.5 hours sitting or in low energy expenditure. Matthews et al. (2008) objectively quantified the overall amount of time U.S children, adolescents, and adults spent in sedentary behaviours. Data indicated that adults aged 70-85 years were the most sedentary group, spending 9.5 hours per day in sedentary behaviours. In our study, individuals aged 55-64 years had the highest sedentary time, accumulating 10.7±1.41 hours of sedentary time per day.

5.3.4 Agreement between objective and subjective methods

Although the mean difference between accelerometer and questionnaire data was very small, and not significantly different from 0 ($p=0.896$) the Bland–Altman plot actually showed poor agreement between the two methods of measurement for activity time as the data followed a downward trend as opposed to a more horizontal scatter pattern. The plot suggests that individuals with a higher mean activity time over-reported the amount of activity performed, and individuals with a lower mean activity time under-reported their daily activity time when compared with objectively recorded activity time.

Agreement between the accelerometer and questionnaire instruments in recording sedentary time was also poor on two counts. Firstly, the mean sedentary time difference was significantly different from zero (8.5±1.6 hours, $p=0.000$) - in fact, all participants under-estimated the amount of time spent in sedentary behaviour, as there were no negative readings. The limits of agreement ranged from 11.64 to 5.37 hours, indicating that 95% of respondents in general underestimated sedentary time by more than 5 hours. Secondly, there was a definite upward pattern in the plot, indicating that those with the highest sedentary times per day were the most likely to underestimate their sedentary times. This disparity in relation to perception of sedentary behaviour suggests that cases are quite ill informed about sedentarism and do not understand the practice or implications of prolonged periods of sitting. Although our study did not record the specific types of employment that controls were engaged in, activity diary data indicated that many were involved in office-based employment as they reported activities such as “working at desk”, and “sitting at computer”. Questionnaire data also suggested that office-based occupations were common among controls, as significantly more controls than cases reported using the computer/internet (1.56 hours more per day). Therefore, controls with sedentary occupations may be more conscious of the amount of time they spend being sedentary, possibly because they sit a lot a work and can accurately acknowledge that as sedentary time.

The lack of agreement between methods of data collection could also be due to measurement error of accelerometers or questionnaires or both. Activity diary data showed that a small number of participants performed cycling, and as noted previously (p.16) the activPAL may sometimes misclassify this activity and record it as a sedentary activity. Additionally, the discrepancy between total sedentary time recorded by the activity monitor and the questionnaire may be explained by “eating” not being incorporating as a sedentary item in the questionnaire. Based on activity diary data, eating was a prominent and reoccurring sedentary activity.

5.4 Limitations

There are a number of limitations to this study that warrant acknowledgement. Firstly, the low response rate and small sample size will impact the generalisability of the findings. Therefore, the results obtained in the study must be treated with caution. In addition, there were a low proportion of females in the study which precluded the ability to evaluate sex differences. However, PAD is more common in men which may explain why a higher proportion of our study sample comprised of men. Despite the small sample size, statistical significance was found for a number of variables including objectively measured activity time, suggesting that the study had adequate statistical power. The small sample size may have increased the risk of a type II statistical error; however, the large p-values did not suggest any relevant trends that might have been statistically significant with a larger sample.

Secondly, case-control studies are subject to selection and information bias, as exposure and outcome have both occurred by the time the patient has been recruited. Controls were recruited using a purposive sampling method from Men’s Sheds active retirement groups which will also affect the generalisability of results. It was anticipated that both cases and controls would be matched for gender, age, and socio-economic status. However, participants were only matched for gender and age bands.

Results indicated that significantly more controls than PAD patients (cases) were employed. Given the mean age of controls (62.3±9.3) it is not surprising that just under half (45.5%) of them had not yet retired and were still part of the workforce. Given the mean age of cases (62.9±8.8) it was interesting to find that only 11.1% were employed. A higher percentage of cases were not employed due to sickness/disability (16.7% vs. 4.5%) and retirement (66.7% vs. 45.5%) (see appendix D). Research by Marrett et al. (2013) found that individuals with PAD reported higher levels of overall absenteeism from work and overall work impairment than individuals without PAD, even after adjusting for demographic and health characteristics. Therefore, the significant difference in employment found in this study may be due to the cases being unable to engage fully with the work environment due to the severity of their condition. Finally, a greater proportion of cases with severe and less severe PAD were also desired to facilitate comparisons in activity and sedentary time in more detail. ABI was used as an indicator of PAD severity; however, the amount of cases with severe and less severe PAD was small and may not have been sufficient to thoroughly examine the effect of PAD severity on activity and sedentary time.

Finally, as participants had to remove the monitor when engaging in water-based activities, the activPAL was not worn during all waking hours. Therefore, the data collected may have slightly underestimated activity and sedentary times. The removal of the monitor may have also hindered compliance as participants may have forgot to resume wearing the monitor after taking it off during water-based activities. In addition, intensity of physical activity was not obtained from the activPAL as it does not have specific cut point thresholds. Although it is possible to derive intensity activity counts based on previously validated cut points (Hart et al. 2010), as noted previously (p.15), using different cut-points on the same data can alter results (Strath et al. 2003). However, as physical activity declines with age and middle to older aged adults are less likely to perform large amounts of high intensity activity, calculating time spent in moderate-vigorous intensity activity may not be as important compared to other population groups such as children.

5.5 Recommendations

Based on the findings obtained from this study, interventions aimed at increasing levels of activity should incorporate walking as it is a common type of activity among middle aged and older adults. In addition, walking can be performed in short bouts which may be more suitable to PAD patients than sustained periods of activity. Low intensity and pain-free walking exercise programs have been deemed effective at improving walking distance, symptoms, and self-perceived quality of life among individuals with PAD (Barak, Stopka, Martinez & Carmeli, 2009; Gardner, Montgomery, Flinn & Katzel, 2005). Results from the 30 second chair stand test revealed that lower body strength was particularly poor among PAD patients (cases). Therefore, focus should also be placed on resistance-based exercise such as pole-striding exercise or arm and leg exercises as this form of exercise helps improve functional capacity (Brenner et al. 2012). Results also indicated that the population sample in this study recorded the highest amount of sedentary time in the evening. Therefore, interventions targeting reductions in sedentary behaviour should be carried out during this time of the day. Home or community based exercise programs may also be favourable to help improve uptake/response rate as individuals with PAD found travelling to appointments difficult and had to be accompanied by a family member as their condition prohibited them from driving themselves.

Results from the PAQ suggested that PAD patients (cases) perceived their condition to be more severe than apparent from objective measures, as the PAQ scores did not match the level of ability that was apparent from functional ability tests, namely the 6-minute walk test. Other research also suggests that individuals with PAD experience symptoms of depression (Cherr, Wang, Zimmerman & Dosluoglu, 2007; McDermott et al. 2003a). Therefore, in addition to exercise-based interventions, attention should also be given to counselling-based strategies to facilitate individuals in coping with and managing their condition.

Evidence supports developing recommendations on sedentary behaviour. However, as the dose response effect of what amount or type of sitting is deleterious to health is not yet known, specific guidelines are not currently available. Therefore, additional research investigating the dose-response relationships between sitting and different health outcomes is warranted (Owen et al. 2009). Further research in this area is also warranted to establish consistent definitions and standardised methods of measuring sedentary behaviour.

Further research involving individuals with PAD should consider matching for other demographic characteristics such as socio-economic status, occupation, education level, and BMI as these may play a role in activity and sedentary behaviours. Qualitative forms of research should also be considered to investigate patients' perceptions of physical activity and sedentary behaviour. Studies involving a greater proportion of patients with severe and less severe PAD may observe more meaningful results when examining the effect of PAD severity on activity and sedentary time. In terms of measurement of physical activity, specific cut-points should be established for the activPAL accelerometer to facilitate accurate classification of individuals with PAD into the correct activity categories using this device.

Pearson correlations between objectively measured activity and sedentary time found a negative weak relationship between the two variables ($r=-0.274$, $n=41$, $p=0.082$). This finding supports the displacement hypothesis which suggests that physical activity and sedentary behaviour are not opposites of the same continuum, and that both behaviours are independent from one another. Engaging in a high amount of physical activity time does not imply that sedentary time will be low. Similarly, accumulating high amounts of sedentary time does not mean that physical activity levels will be low. Therefore, both behaviours need to be addressed separately. Similar to other countries including the U.K., Canada, Australia, and the U.S that have started to provide generic recommendations for children and adolescents regarding sedentary time, Ireland needs to develop guidelines on sedentary behaviour and encourage individuals to limit the amount of time they spend sitting in different domains, with focus being placed on all population groups and not just younger age groups.

5.6 Conclusion

This study provided an overview of the physical activity and sedentary behaviour patterns of individuals with and without PAD using observational analysis of a case and control group, and both objective and subjective measurement tools. The severity of the condition was also measured and its impact on habitual activity and sedentary patterns was examined. Findings from the study suggested that PAD patients (cases) were less active than healthy middle aged and older adults. This may be attributed to the severity of PAD among cases which limited their functional ability and reduced their capacity to perform physical activity. Regardless of occupation or illness sedentary time was high and varied only in the nature and timing of sedentary activities engaged in. Breaks in sedentary time and patterns of sedentary behaviours and were also similar, with the exception of morning time patterns where controls' sedentary activities were shorter in duration. Low amounts of physical activity and high sedentary time are a prevalent issue among individuals with PAD and healthy middle-aged and older adults. Therefore, focus needs to be placed on encouraging this population group to steadily increase amounts of activity and reduce prolonged periods of time spent sitting.

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Appendices

Appendix A

Physical Activity and Sedentary Behaviour Questionnaire

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

1. **Are you:** Male______ Female______

2. **Please circle your relevant age category:**

45-49 50-54 55-59 60-64 65-69 70-74 75-79 80+

3. **Which of these best describes your usual situation with regard to work? (Please circle your answer)**

Employee Self-Employed Unemployed Long-term sickness/ disability
Home duties/looking after home/family Retired
Other__________________

4. **What is the highest level of education that you have received? Please circle your answer)**

No schooling or primary education	Some secondary education	Complete secondary education	Some or complete third level education

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

5. **During the last 7 days, did you do vigorous physical activities like heavy lifting, digging, aerobics, or fast bicycling?**

Yes No Skip to Q. 8

6. **On how many days did you do vigorous activities in the past 7 days?**

No. of Days ___________________

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

Hours ___________ Minutes _____________

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

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

Yes No Skip to Q. 11

9. **On how many days did you do moderate activities in the past 7 days?**

No. of Days __________________

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

Hours ___________ Minutes _____________

11. **During the last 7 days, did you walk for at least 10 minutes at a time?**

Yes No

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

12. **On how many days did you walk for at least 10 minutes in the past 7 days?**
    No. of Days ___________________

13. **How much time did you usually spend walking on one of those days?**
    Hours ___________ Minutes _____________

14. This question is about activities you did over the ***last week whilst sitting or lying down***. Don't count the time you spent in bed.

For each of the activities only count the time when this was your main activity. For example if you are watching television and doing a crossword, count it as television time or crossword time but not as both.

During the last week, how much time in total did you spend ***sitting or lying down*** *and….*

SEDENTARY ITEM **TIME**

1. Watching television or videos/DVDs Hours_____ Minutes_____
2. Using the computer/Internet Hours_____ Minutes_____
3. Reading Hours_____ Minutes_____
4. Socialising with friends or family Hours_____ Minutes_____
5. Driving or riding in a car, or time on public transport
   Hours_____ Minutes_____
6. Doing hobbies e.g. playing cards, bingo, crosswords
   Hours_____ Minutes_____
7. Doing any other activities Hours_____ Minutes_____

****Thank you for participating****

Peripheral Artery Questionnaire

These questions refer to blockages in the arteries of your body, particularly your legs, and how that might affect your life. Please read and complete the following questions. There are no right or wrong answers. Please circle the answer that best applies to you.

1. Blockages in the arteries, often referred to as **peripheral vascular disease,** affect different people in different ways. Some feel cramping or aching, while others feel fatigue. What leg (or buttock) causes you the <u>most severe</u> **discomfort, fatigue, pain, aching, or cramps?**

the Right leg (buttock) the Left leg (buttock)

Both are the same Neither

2. Please review the list below and indicate how much limitation you have due to your **peripheral vascular disease** (discomfort, fatigue, pain, aching, or cramps in your calves (or buttocks)) <u>over the past 4 weeks.</u> Place an X in one box on each line.

Activity	Extremely Limited	Quite a bit Limited	Moderately Limited	Slightly Limited	Not at all Limited	Limited for other reasons or did not do the activity
Walking around your home						
Walking 100-200 yards on **level ground**						
Walking 100-200 yards **up a hill**						
Walking 200-400 yards on level ground						
Hurrying or jogging (as if to catch a bus)						
Vigorous work or exercise						

3. <u>Compared with 4 weeks ago</u>, have your symptoms of peripheral vascular disease (discomfort, fatigue, pain, aching, or cramps in your calves (or buttocks) changed?

My symptoms have become…

Much worse Slightly worse Not changed

Slightly better Much better No symptoms

4. Over the <u>past 4 weeks</u>, how many times did you have **discomfort, fatigue, pain, aching, or cramps in your calves (or buttocks)?**

All of the time Several times per day

At least once a day 3+ times per week but not every day

1-2 times per week Less than once a week

Never over the past 4 weeks

5. Over the <u>past 4 weeks</u>, how much has **discomfort, fatigue, pain, aching, or cramps in your calves (or buttocks)** bothered you?

Extremely bothersome **Moderately** bothersome **Somewhat** bothersome

Slightly bothersome **Not at all** bothersome I've had **no leg discomfort**

6. Over the <u>past 4 weeks</u>, how often have you awakened with a **pain, aching, or cramps in your legs or feet?**

Every night 3 or more times per week but not every night

1-2 times per week Less than once a week Never over the past 4 weeks

7. How satisfied are you that everything possible is being done to treat your **peripheral vascular disease**?

Not satisfied at all Mostly dissatisfied Somewhat satisfied

Mostly satisfied Completely satisfied

8. How satisfied are you with the explanations your doctor has given you about your **peripheral vascular disease**?

Not satisfied at all Mostly dissatisfied Somewhat satisfied

Mostly satisfied Completely satisfied

9. Overall, how satisfied are you with your current treatment of you **peripheral vascular disease**?

Not satisfied at all Mostly dissatisfied Somewhat satisfied

Mostly satisfied Completely satisfied

10. Over the past 4 weeks, how much has your **peripheral vascular disease** limited your enjoyment of life?

Extremely limited Limited **quite a bit** **Moderately** limited

Slightly limited **Not limited** at all

11. If you had to spend the rest of your life with your **peripheral vascular disease** the way it is right now, how would you feel about this?

Not satisfied at all Mostly dissatisfied Somewhat satisfied

Mostly satisfied Completely satisfied

12. Over the past 4 weeks, how often have you felt discouraged or down in the dumps because of your **peripheral vascular disease**?

I felt that way **all of the time** I felt that way **most of the time**

I **occasionally** felt that way I **rarely** felt that way

I **never** felt that way

13. How much does your **peripheral vascular disease** affect your lifestyle? Please indicate how your **discomfort, fatigue, pain, aching, or cramps in your calves (or buttocks)** may have limited your participation in the following activities over the past 4 weeks. Place an X in one box on each line.

Activity	**Severly Limited**	**Limited quite a bit**	**Moderately Limited**	**Slightly Limited**	**Did not limit at all**	**Does not apply or did not do for other reasons**
Hobbies, recreational activities						
Visiting family/friends out of your home						
Working or doing chores						

Thank you for participating

Appendix C

Activity Diary

Day_____________ **Day Number____**

Time of Activity	**Details of Activities**	**Intensity (L/M/V)**
12.00-8.00a.m		
8.00-8.30		
8.30-9.00		
9.00-9.30		
9.30-10.00		
10.00-10.30		
10.30-11.00		
11.00-11.30		
11.30-12.00p.m.		
12.00-12.30		
12.30-1.00		
1.00-1.30		
1.30-2.00		
2.00-2.30		
2.30-3.00		
3.00-3.30		

3.30-4.00		
4.00-4.30		
4.30-5.00		
5.00-5.30		
5.30-6.00		
6.00-6.30		
6.30-7.00		
7.00-7.30		
7.30-8.00		
8.00-8.30		
8.30-9.00		
9.00-9.30		
9.30-10.00		
10.00-10.30		
10.30-11.00		
11.00-11.30		
11.30-12.00		

(**L**= Low Intensity e.g. slow walking, **M** = Moderate Intensity e.g. fast walking or jogging, **V** = Vigorous Intensity e.g. running)

Description of Participants

Variable	Case (n=19) % (n)	Control (n=22) % (n)
Gender		
Male	84.2 (15)	77.3 (17)
Female	15.8 (3)	22.7% (4)
Age Group		
45-49	10.5 (2)	9.1 (2)
50-54	5.3 (1)	13.6 (3)
55-59	10.5 (2)	13.6 (3)
60-64	10.5 (2)	27.3 (6)
65-69	36.8 (7)	18.2 (4)
70-74	21.1 (4)	9.1 (2)
75-79	5.3 (1)	9.1 (2)
BMI Classification		
Normal	16.7 (3)	31.8 (7)
Overweight	44.4 (8)	50 (11)
Obese	38.9 (7)	18.2 (4)
*Employment		
Employee	5.6 (1)	22.7 (5)
Self-Employed	5.6 (1)	22.7 (5)
Unemployed	5.6 (1)	4.5 (1)
Sickness/Disability	16.7 (3)	4.5 (1)
Home Duties	5.6 (1)	4.5 (1)
Retired	61.1 (11)	40.9 (9)
*Education		
No school/primary	44.4 (8)	4.5 (1)
Some secondary	44.4 (8)	9.1 (2)
Completed secondary	0 (0)	27.3 (6)
Some/completed third level	11.1 (2)	59.1 (13)