The Patterns and Predictors of Physical Activity and its Impact on Cardiovascular Disease in Community Dwelling Older Adults

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of

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Declaration

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Sean Kilroy

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Summary

Background: Physical activity in older adults is extremely important in the prevention of and protection from many non-communicable diseases including cardiovascular disease (CVD) which is the leading cause of death worldwide. However, a large proportion of older adults worldwide fail to meet the current recommended guidelines. Thus, to develop preventive lifestyle strategies and identify targets for intervention it is necessary to have information regarding the factors predicting physical activity levels and physical activity patterns. In addition, although physical activity level is inversely associated with CVD morbidity and mortality, the mechanisms involved are complex and the key mediating role that cardio-metabolic risk factors play in the relationship has yet to be fully elucidated. Understanding the predictors and effects of physical activity in older adults is crucial so participation can be appropriately promoted for the primary and secondary prevention in CVD.

Methods: Utilising 2 waves of data from the Irish Longitudinal Study on Ageing (TILDA), this study aimed to assess the patterns and predictors of physical activity and assess the impact of physical activity on cardio-metabolic risk factors and CVD. Participants were community dwelling older adults aged 65 years and older living in Ireland who completed the International Physical Activity Questionnaire (IPAQ) and who attended a health assessment. Baseline data was collected via three methods: a computer-aided personal interview, a self-completion questionnaire and a health assessment. Two years later participants completed the IPAQ (follow-up data). A series of multivariate binary logistic regression analysis were employed to assess the impact of a wide range of factors (socio-demographic, social engagement, physical and mental health, cognitive and behavioural health factors) on baseline physical activity level and also on change in physical activity levels from baseline to follow up. In addition, adjusted binary logistic regression models were used to assess the impact of physical activity on cardio-metabolic risk factors and CVD. Dichotomous mediation analysis utilising logistic regression models examined the mediating effect of the cardio-metabolic risk factors on the relationship between physical activity and CVD. Statistical analysis was conducted using SPSS version 24.

Results: In total, 2,360 community dwelling Irish older adults (≥65) took part in this study at baseline. Of the 65% reaching the recommended physical activity guidelines, those with a chronic health problem, higher quality of life and higher anxiety were significantly more likely to be active. Being older, female, unemployed, having poor self-rated health, functional limitations, greater sitting time, muscle weakness, diabetes, cognitive impairment and depression were all associated with lower odds of being physically active. Active participants had lower odds of having high blood pressure, diabetes, obesity, abdominal obesity and CVD. The relationship between physical activity and CVD was partially mediated by high blood pressure, obesity and abdominal obesity. Physical activity levels declined longitudinally over the two year period. Four patterns of physical activity were identified: those who remained active (Active maintainer), became inactive (Relapser), remained inactive (Inactive maintainer) and became active (Adopter). For those active at baseline, being older, female, having lower education, a chronic health problem, abdominal obesity, depression, being a smoker and sitting for more than 8 hours per day were all associated with higher odds of relapsing at follow up, whereas participants with better hearing had lower odds of relapsing. Those inactive at baseline, who had better self-rated health, had higher odds of adopting at follow-up. In addition, secondary education, pain and functional mobility impairment was associated with lower odds of adopting.

Conclusion: This study found a longitudinal decline in physical activity over time and identified particular groups of the Irish older adult population who are at risk of becoming physically inactive. Although the relationship between physical activity and CVD was partially explained by some cardio-metabolic risk factors, those reaching the recommended were less likely to have CVD regardless of many of the socio-demographic, behavioural and cardio-metabolic risk factors. Identifying these predictive factors of future activity is helpful in identifying targets for interventions to maintain physical activity over time in older adults. The implications of these associations should be incorporated in the implementation of future health promotion interventions and within community health practice.

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ADL: Activities of Daily Living

BMI: Body Mass Index

CAGE: Cut down, Annoyed, Guilt, Eye Opener

CAPI: Computer-Aided Personal Interview

CASP-19: Control Autonomy Self-Realisation and Pleasure

CES-D: Centre for Epidemiological Studies Depression Scale

CHD: Coronary Heart Disease

CI: Confidence Interval

COPD: Chronic Obstructive Pulmonary Disease

CVA-stroke: Cerebrovascular Accident

CVD: Cardiovascular Disease

DoH: Department of Health

ELSA: English Longitudinal Study of Ageing

HADS-A: Hospital Anxiety Depression Scale – Anxiety

HRS: Health and Retirement Survey

HSE: Health Service Executive

IADL: Instrumental Activities of Daily Living

IPAQ – SF: International Physical Activity Questionnaire – Short Form

MCAR: Missing Completely at Random

MetS: Metabolic Syndrome

MNAR: Missing Not at Random

MET-min/week: Metabolic Equivalent-Minutes per Week

MMSE: Mini-Mental State Examination

MOCA: Montreal Cognitive Assessment

NCD: Non Communicable Diseases

OR: Odds Ratio

QoL: Quality of Life

RCTs: Randomized Controlled Trials

RANSAM: Random Sample

SCQ: Self Completion Questionnaire

SHARE: Survey of Health, Ageing and Retirement in Europe

SNI: Social Network Index

SPSS: Statistical Package for the Social Sciences

TIA: Transient Ischemic Attack

TILDA: The Irish Longitudinal Study on Ageing

TUG: Timed Up and Go

UCLA: University of California-Los Angeles

WC: Waist Circumference

WHO: World Health Organisation

Chapter 1

Introduction

1.0 Overview

Using wave one data from 2010 (Baseline) of the Irish Longitudinal Study of Ageing (TILDA), the purpose of the present study is to investigate the predictors of physical activity and its impact on cardiovascular disease (CVD) and cardio-metabolic risk factors. In addition, this study aims to examine the mediating role of cardio-metabolic risk factors in the relationship between physical activity and CVD. Following this, the study utilises wave two data from 2012 (Follow up) of TILDA and assesses the patterns and predictors of physical activity change from baseline to follow up.

This chapter gives a brief overview of the TILDA study followed by the background of the research in terms of the older adult, physical activity, CVD and cardio-metabolic risk factors. The older adult is discussed in relation to population prevalence and chronic disease. Physical activity is defined and described in terms of the different types of activities and the national guidelines for the general population. Following this, CVD and cardio-metabolic risk factors are briefly discussed. Finally, the structure of this PhD thesis is outlined.

1.1 TILDA

The **I**rish **L**ongitu**D**inal Study on **A**geing (TILDA) is a ground-breaking epidemiological research initiative which is the biggest of its kind and most detailed study on ageing ever undertaken in Ireland looking at the health, wealth, support and lifestyles factors of over 8,500 community dwelling adults aged 50 years and older and how their conditions alter over a 10 year period (http://tilda.tcd.ie/). With such a large data set, researchers utilising the TILDA database may detect patterns that can be generalised to a wider population. TILDA also allows comparison with other longitudinal studies worldwide such the Longitudinal Study of Ageing in England (ELSA), the Health and Retirement Study in America (HRS), and the Survey of Age, Health, Ageing and Retirement in Europe (SHARE). Carried out by Trinity College Dublin, TILDA collected data on a wide range of factors including individual's health, social and economic status, as well as biological and environmental components. These variables can be explored to understand the factors associated with successful ageing and assist in health policies, ultimately to make Ireland a better place in which to grow old (Kenny *et al.* 2010). This study explores a specific aspect of the TILDA study – physical activity, from different perspectives in older adults.

1.2 Background

1.2.1 Older Adults

The majority of countries worldwide consider the chronological age of 65 years or older to define the older adult. In addition, most developed nations have accepted or in fact made retirement compulsory at the age of 65. This transition out of the workforce presents new psychological and behavioural processes including new social roles, expectations, challenges, and opportunities which may impact health (Wang & Shi, 2014). TILDA provides a unique opportunity to examine solely a nationally representative sample of older Irish adults aged 65 and older presented with this major life transition. Older adults represent the fastest growing sector of the population worldwide with figures set to triple over the next 40 years in people aged 65 and over. According to the World Health Organisation (WHO), it was estimated that 524 million older adults represented 8% of the world population in 2010, a figure which is expected to increase to 1.5 billion by the year 2050, representing 16% of the world population (WHO 2011). In Ireland, the Central Statistics Office (2013) has projected that the total population of Irish people aged 65 and over will increase from 12% (n = 540,000) to 22% (n = 1.4m) by the year 2041. More interestingly, TILDA (2014) projected that the number of older adults aged 80 and over will increase by 250% over the same time period. The increased ageing proportion of the population is partly due to a decline in fertility rates and an overall increase in life expectancy (National Institute on Aging & World Health Organization 2011). However, as the population of older adults increase, chronic or non-communicable diseases (NCDs) such as CVD and cancer will become much more prevalent resulting in poor health, disability and mortality (Niccoli & Partridge 2012). NCDs are non-infectious and non-contagious diseases and are considered a key health challenge in today's society. In contrast to previous eras, NCDs represent the main cause of morbidity and mortality worldwide accounting for 70% (n = 39.5m) of all deaths (WHO 2015). With the rapid increase in the number of older adults and the associated morbidity accompanied with NCDs in older adults, the public health sector faces many serious challenges (WHO 2015). Indeed, National Health Services are unlikely to have the capacity to deal with the sheer number of older adults suffering from chronic disease (National Institute on Aging and World Health Organization 2011). Although the prevalence of chronic NCDs such as CVD and cancer rise rapidly with increasing age, engaging in healthy behaviours can avoid or delay the onset of many of these diseases (Stenholm *et al.* 2016). In fact, there is unquestionable evidence recognising that physical activity is one of the most important lifestyle behaviours that contributes to successful primary and secondary prevention of numerous NCDs and is associated with successful healthy ageing and wellbeing (Warburton *et al.* 2006, Lunenfeld & Stratton 2013). Not achieving the recommended physical activity guidelines (physical inactivity) is considered the 4th leading risk factor for mortality worldwide and is believed to cause approximately 3.2 million deaths per year (WHO 2010).

Physical inactivity costs the global economy more than 67.5 billion a year and contributes to between 6-10% of the major NCDs including CVD and cancer (Lee *et al.* 2012, Ding *et al.* 2016).

1.2.2 Physical Activity

Physical activity is a broad complex human behaviour which refers to activity undertaken in a variety of contexts. The terms physical activity and exercise are often used interchangeably and correlated with physical fitness, however, the interchangeable usage of these terms leads to misunderstandings in research as they do not mean the same thing. Although classified as a subcategory of physical activity, exercise is a specific form of physical activity which is "planned, structured, repetitive, and purposive in the sense that improvement or maintenance of one or more components of physical fitness is an objective" (Caspersen *et al.* 1985, p.128). Not to be confused with exercise, physical activity is defined as "any bodily movement produced by skeletal muscles that requires energy expenditure" (Caspersen *et al.* 1985, p.126). Physical activity can be categorised into different domains including transportation, occupational, household and leisure time physical activity (Sun *et al.* 2013). Physical activity related to transportation may include walking or cycling, while occupational physical activity may involve activities in the workplace. Household activities may involve domestic chores, play, games, sports or planned exercise, in the context of daily, family, and community activities. Leisure time physical activity may include walking, dancing, gardening, hiking, swimming and is of greatest interest in relation to health promotion because the potential for changing behaviours is thought to be the highest in this domain (Booth 2000). Leisure time physical is particularly relevant to older adults as they tend to have significantly more time available to them than people in younger age cohorts due to retirement (Robinson & Godbey 1999, Lietner & Lietner 2004). Habitual physical activity can be defined as the level and pattern of energy expenditure of daily life activities during leisure time and work. Total physical activity levels includes physical activity in all different domains and can be further described using frequency, intensity, time and type (Howley 2001, Monotype 2002).

The National Guidelines on Physical Activity for Ireland were documented by the Department of Health (DoH) and the Health Service Executive (HSE) in 2009 (DoH & HSE, 2009). Based on global evidence, the recommendations were adopted from policies from the WHO and the Toronto Charter for Physical Activity (Global Advocacy Council for Physical Activity, 2010). These guidelines recommend adults do at least 150 minutes of moderate-intensity aerobic physical activity or at least 75 minutes of vigorous intensity aerobic or the combination of moderate and vigorous intensity per week. However, 1 in 3 or 31% of adults fail to achieve the recommended levels of physical activity required to induce health benefits (Hallal *et al.* 2012). The research base for physical activity is limited when compared to other health and disease factors as the magnitude of physical activity behaviour as a health consequence is a relatively new field in health science. Physical inactivity is now recognised as one of the major risk factors for NCDs (Marshall *et al.* 2005, Menotti *et al.* 2007, WHO 2007, Bauman *et al.* 2009). According to Loyen *et al*. (2016) population levels of physical activity in adults across Europe is currently unknown, partially due to differences in physical activity measurements. In this review, those reaching the physical activity guidelines ranged from 7 – 96% across studies and countries. The large variation in reported physical activity levels comes as a result of differences in assessment methods which makes it difficult to compare population levels across countries. For example, some studies use subjective self-report measures like questionnaires while others report physical activity levels objectively using accelerometer data. Recall and social desirability bias have been associated with subjective physical activity measures while accelerometers have been criticised for not capturing the whole picture, for example missing upper body movements, the ability to distinguish between sitting and standing or report whether a person is carrying any weight (Lee & Shiroma 2014). The WHO (2006) has stated that there is a need to ensure that physical activity is monitored consistently over time at a population level and that this will allow public health policies and strategies to target and identify specific details in relation to those not reaching the recommended levels of physical activity (Loyen *et al.* 2016). Ireland is recognised as one of the least active countries in Europe (WHO 2010). Recently, Ireland launched its first ever National Physical Activity Plan which hopes to see an additional half a million Irish people physically active according to the national guidelines. Specifically, the 10 year plan aims to increase the proportion of adults achieving the recommended guidelines by 1% per year (DoH 2016).

1.2.3 Cardiovascular Disease

As outlined above, one of the most common NCDs is CVD and the known efficacy of physical activity on this disease is well documented (Lee *et al*. 2012, Marques *et al.* 2017). CVD consists of all the diseases of the heart and circulatory system which includes coronary heart disease (CHD), angina, myocardial infarction (heart attack), congenital heart disease and cerebrovascular accident (CVA – stroke). CVD is the leading cause of mortality and morbidity, killing approximately 17.3 million people worldwide representing nearly 32% of all deaths (Global Burden of Disease 2013). In Europe, more than 4 million deaths are attributable to CVD representing 45% of all deaths (Townsend *et al*. 2016). However, Townsend *et al.* (2016) noted CVD mortality inequalities across Europe calling for further research to examine why some countries show improved CVD outcomes while others don't. The burden of CVD in Ireland is among the lowest in Europe with mortality rates 9% below the EU average which can be explained by favourable trends in major CVD risk factors including smoking, blood pressure and cholesterol (Department of Health (DoH 2016). In fact, Ireland has led the way in CVD disease reduction being to first country in the world to ban smoking in the work place in 2004. Despite the substantial decline in the mortality and morbidity associated with CVD in Ireland over the last decade, it is still the greatest cause of death accounting for approximately one third of all deaths. Similar to the success of Irelands smoking ban, implementing other major policies on modifiable health behaviours in Ireland can again lead the way for CVD reduction in Europe (Bennett *et al*. 2006, DoH 2016). The major modifiable risk factors for CVD include high blood pressure, high cholesterol, cigarette smoking, heavy alcohol intake, physical inactivity, diabetes, obesity and poor diet (WHO 2011).

1.2.4 Cardio-metabolic Risk Factors

The factors associated with CVD can be categorised into lifestyle/behavioural risk factors (smoking, physical activity, diet and alcohol) or metabolic risk factors (high blood pressure, high cholesterol, diabetes, obesity) (Spencer *et al.* 2016). Other known factors including genetic factors, age, gender, education, poverty and psychological factors (e.g. stress, depression) have also been recognised to predict CVD (WHO 2009). Sullivan *et al.* (2007) referred to the co-occurrence of high blood pressure, diabetes, high cholesterol and obesity as cardio-metabolic risk factor clusters. Similarly, the term metabolic syndrome (MetS) has been recognised and defined in the literature as the cluster of factors including insulin resistance, obesity, elevated blood pressure and cholesterol (Alshehri 2010). The main CVD risk factors are also recognised as the top leading predictors of death worldwide. These include high blood pressure, smoking, high blood glucose, physical inactivity and obesity which account for 13%, 9%, 6%, 6% and 5% of deaths worldwide, respectively (WHO 2009).

High blood pressure (hypertension) is a major health problem and is classed as one of the main attributable factors associated with the total burden of disease worldwide. Defined as a persistent blood pressure measurement above 140 mmHg systolic and/or 90 mmHg diastolic, high blood pressure accounts for approximately 4.5% of the global burden of disease and attributable to 7.1 million premature deaths worldwide (Chobanian *et al*. 2003, WHO 2009). High blood pressure is recognised as the main underlying risk factor for the early onset of CVD (WHO 2009). The prevalence of high blood pressure in Ireland as with the majority of Europe is approximately 30%. However, high blood pressure increases with age and reports have documented that up to two thirds of people aged 65 and over has high blood pressure. Other factors are also known to increase the risk of developing high blood pressure which are similar to some of the lifestyle factors associated with CVD, including smoking, diet and physical inactivity (Chobanian *et al.* 2003, Messerli *et al.* 2007, WHO 2009, Lim *et al.* 2012).

High cholesterol is a major factor associated with chronic disease and is responsible for 2.6 million deaths worldwide representing 4.5% of total deaths. High cholesterol is one of the major metabolic risk factors associated with CVD and accounts for 16% of CVD mortality (World Heart Federation 2016). Overall, in 2008, 39% of world's population had raised total cholesterol above the clinical cut off (>5 mmol), however the prevalence is Europe is much higher, with approximately 54% of men and women suffering from the condition (WHO 2016).

Diabetes has also been recognised as a major factor associated with CVD and was responsible for 1.5 million deaths in 2012, the 8th leading cause of death worldwide. According to the American Heart Association (2016) adults with diabetes are two to four time more likely to die from CVD. Diabetes can be defined as a fasting plasma glucose ≥ 7.0mmol/L (WHO 2016).

According to the WHO (2016), overweight and obesity is defined as an abnormal or excessive accumulation of fat that may impair health. Body mass index (BMI) is utilised to assess overweight and obesity in relation to height and weight in adults and can be calculated by dividing a person's weight in kilograms (Kgs) by their height in meters squared (m^2) (kg/m^2). Obesity is defined as a BMI greater than or equal to 30. Additionally, obesity can also be calculated using other indexes including body fat percentage, waist circumference (WC) and waist-to-hip ratio (WHR) (Litwin 2008). Overweight, obesity, abnormal or excessive fat accumulation, are major modifiable risk factors associated with CVD morbidity and mortality in adults and the prevalence is continuing to increase over time in line with the ageing population (WHO 2016).

1.2.5 Physical Activity, CVD and Cardio-metabolic risk factors

The benefits of physical activity have been well documented in the prevention and protection of many NCDs including CVD and the evidence for associations between physical activity and CVD will be discussed further in chapter 2. Physical activity level is inversely associated with cardiovascular morbidity and mortality with physical inactivity contributing to approximately 30% of the CVD burden (Physical Activity Guidelines Committee 2008). Similarly, physical activity has been recognised to play a modifying role in the cardio-metabolic risk factors namely high blood pressure, high cholesterol, diabetes and obesity. Evidence for the association between physical activity and the cardio-metabolic risk factors will be explored in more detail in chapter 2.

Although the major factors associated with CVD have been well researched, there is still a need to examine the predictors of some modifiable health behaviours including physical activity. Understanding the effects and role of physical activity in older adults is crucial so participation can be appropriately promoted for the primary prevention of CVD (Hemingway 2007). In addition, the relationship between physical activity and CVD may not be direct with some cardio-metabolic factors perhaps playing a key mediating role. In other words, the amelioration of CVD by physical activity may be in part explained by the effect of physical activity on the cardio-metabolic risk factors. Physical activity influences CVD and cardio-metabolic risk factors and this thesis seeks to examine this central role of physical activity and explore the underlying mechanisms in explaining the relationship between physical activity and CVD through the cardio-metabolic risk factors in older adults.

1.3 Thesis Structure

This PhD Thesis is divided into five main chapters. Following this introductory chapter (chapter 1), chapter 2 includes the literature review which leads to the justification of the aims and objectives of this thesis. Chapter 3 outlines the aims and objectives of the research followed by details of the methodology utilised for this research. Chapter 4 presents the results of the study and chapter 5 presents the discussion of the results in relation to other studies followed by a conclusion to this thesis.

1.3.1 Chapter 2: Literature Review – This chapter discusses the results of studies that have examined the physical activity levels and patterns of physical activity levels in older adults. In addition, the results of research examining the role of physical activity in cardiovascular disease (CVD) and risk factors are also discussed. Chapter two critically reviews and evaluates the literature on physical activity and CVD in relation to older adults. The strengths and limitations of the current research that lead to the justification of this study are discussed.

1.3.2 Chapter 3: Methodology – This chapter provides information on the study design, participants, measures and data collection methods of the TILDA study. The chapter also presents the aims and research questions of the study followed by the philosophical paradigm and research design. Next, the sample is defined and predictor and outcome variables are described in detail. Finally, the methods of data analyses are discussed.

1.3.3 Chapter 4: Results – This chapter presents the descriptive and inferential statistics of the total sample under socio-demographic and social engagement, physical and mental health and behavioural and cognitive health headings. Baseline physical activity levels and the predictors of baseline physical activity from the logistic regression models are presented. The impact of physical activity on CVD and cardio-metabolic risk factors is also described and models to understand the role of the main cardio-metabolic risk factors in the relationship between physical activity and CVD are presented. Next, the physical activity levels after a 2 year timeframe (at follow-up) are described followed by their categorisation into four patterns of physical activity change. Finally, the logistic regression analysis comparing participants active at baseline and their status at follow up and the participants inactive at baseline and their status at follow up are also presented.

1.3.4 Chapter 5: Discussion and Conclusion - Chapter five provides a detailed discussion of the findings of chapter four from the current research. The findings are discussed in relation to other studies. Finally, the conclusion to the study with implications and suggestions for future research are presented.

Chapter 2

Literature Review

2.0 Introduction

The previous chapter gave a brief overview of the research in terms of the older adult, physical activity, cardiovascular disease (CVD) and cardio-metabolic risk factors. This chapter begins by outlining the guidelines and benefits of physical activity for older adults. Studies that have described population levels and patterns of physical activity in older adults are discussed. Within this chapter, a review of the known predictors of physical activity has been explored and discussed. These include socio-demographic, social engagement and environmental factors, physical and mental health characteristics and cognitive and behavioural health factors. Following this, results of the research examining the role of physical activity in cardiovascular disease (CVD) and cardio-metabolic risk factors in older adults is discussed. The strengths and limitations of current research that lead to the justification of this research are also discussed.

2.1 Physical Activity and Older Adults

The current physical activity guidelines do not differ between adult and older adult populations as the health benefits of being physically active are independent of age. Older adults are recommended to do at least 150 minutes of moderate-intensity aerobic physical activity or at least 75 minutes of vigorous intensity aerobic or the combination of moderate and vigorous intensity activity in bouts of at least 10 minutes duration per week. Older adults are also recommended to do at least 2 days of muscle strengthening exercises involving large muscle groups. In addition, activities enhancing **balance are** encouraged on 3 or more days per week which will prevent falls (U.S. Department of Health and Human Services 2008, Department of Health and Children / Health Service Executive 2009). The current physical activity recommendations are supported by a large body of evidence from prospective cohort studies documenting the inverse association between physical activity and many chronic NCDs (Physical

Activity Guidelines Committee 2008). In fact, older populations may benefit more from physical activity than any other age group. However, participation in physical activity is reported to be considerably less in older adult populations than in any other age group, with rates of participation dropping off sharply in those over the age of 65 with 31% reporting to be physically inactive (Houde & Melillo 2002, Fahey *et al.* 2004, Morgan *et al.* 2008).

Physical activity in older adults is extremely important in the maintenance of independence, improvement in the quality of life experienced and the prevention and protection from many NCDs including CVD, cancer and diabetes (Blair *et al.* 1996, Hu *et al.* 1999, Knowler *et al.* 2002, Manson *et al.* 2002, Slattery & Potter 2002, Thompson *et al.* 2003, Chao *et al.* 2004, Ratnasinghe *et al.* 2010). In addition, physical activity has been recognised to reduce the risk of osteoporosis, obesity, falls and depression in older adults (Vuori 2001a, Vuori 2001b, Wing & Hill 2001, Brosse *et al.* 2002, Ross *et al.* 2004, Mann *et al.* 2007, Mertz *et al.* 2010). The benefits of physical activity extend way beyond these health benefits in society, by also increasing social interaction and community engagement and it is associated with other positive health behaviours including healthy eating and non-smoking (Fahey *et al.* 2004, WHO 2006). According to the WHO (2006, p.2) "promoting physical activity should be seen as a necessity, not a luxury". Surveys to date have suggested that there is still room for improvements in guideline achievement and that understanding the factors associated with physical activity in older adults can more effectively guide policies and practices to increase physical activity participation which ultimately reduce the burden of NCDs including CVD, the most common cause of death (Perk *et al.* 2012, Murtagh *et al.* 2014). Factors associated with physical activity will be further discussed in depth in section 2.5.

2.2 Physical Activity Levels of Older Adults

A review by Sun *et al.* (2013) recognised that the proportion of older adults physically active ranged from 2.4% to 83% across 53 studies with the majority of these studies documenting that 20 – 60% of older adults achieve the recommended guidelines. Within this review, 150 minutes of moderate or vigorous physical activity per week was accepted as the recommended physical activity level however leisure time physical activity was most often assessed. In addition, the majority of physical activities were assessed by self-report measures although few studies which measured physical objectively were included. Self-report measures, may be problematic due recall bias “over the last 7 days” and social desirability where participants can over estimate physical activity levels according to what they believe is socially acceptable (Bauman et al. 2009).

Although data on the global levels of physical activity in older adult populations are limited, few population based surveys have attempted to describe the national physical activity rates of older adults. The majority of this epidemiological research assessing the physical activity levels in older adults have utilised self-report measures. In Brazil, Gobbi *et al*. (2012) reported that 49% of older adults meet the physical activity guidelines of 150 minutes of moderate physical activity per week. A more recent study by Shiraly *et al*. (2017) documented the prevalence of physical activity in Iranian older adults. The study recognised that less than 11% of the sample reached the recommended guidelines. In addition, those aged 60 – 70 years and males were significantly more likely to reach the recommended levels compared to those aged 71-80 years and females, respectively.

Other research has documented the physical activity prevalence rates stratified by age and gender. Marques *et al.* (2015) reported the prevalence of physical activity in European adults with the inclusion of those aged 65 and over (n = 12,274) with compliance of the physical activity guidelines. According to that research, 59% and 58% of male and female older adults achieved the recommended physical activity guidelines, respectively.

In the United Kingdom, Townsend *et al.* (2015) compiled the percentages of older adults achieving the recommended physical activity guidelines in England (n = 2,124), Scotland (n = 1,322) and Northern Ireland (n = 1,156). In England, 58% of men and 52% of women aged between 65 and 74 were sufficiently active. However, only 36% and 18% of men and women aged 75 and over achieved the recommended physical activity levels. Similarly, the proportion of Scottish adults aged 65 - 74 were 56% and 52% for males and females respectively. In those aged 75 and over in

Scotland, 31% of males and 21% of females were sufficiently active. The proportions of older adults aged between 65 and 74 meeting the physical activity guidelines in Northern Ireland were much lower, with only 43% of males and 30% of females reaching the physical activity target. Furthermore, in those aged 75 and over in Northern Ireland, only 19% and 8% of male and females were sufficiently active, respectively.

In the United States, 3 separate surveys attempted to report the prevalence of older adults meeting the physical activity guidelines. Overall the proportion of adults aged 65 and over meeting the physical activity guidelines was 27.3% for NHANES (n = 1,166), 35.8% for NHIS (n = 7,590) and 44.3% for BRFSS (139,724). Specifically, the proportion adults aged 65–74 meeting the physical activity guidelines were 30.7% for NHANES, 41.7% for NHIS and 47.8% for BRFSS. In those aged 75–84, the proportion of older adults meeting the physical activity guidelines were 22.6%, 31.3% and 39.5% for NHANES, NHIS and BRFSS, respectively. NHIS also reported the proportion of those aged 85 and over, with only 18.4% achieving the recommended guidelines. Those 65 – 74 years old and males were significantly more likely to achieve the recommended physical activity guidelines than the older age groups and females, respectively (Keadle *et al.* 2016).

Although the current trends in the physical activity levels of older adults appear consistent in that a lower proportion of those in the older aged groups and females achieve the recommended physical activity guidelines, there appears to be a considerable difference in the physical activity levels of the total older adult population across studies. The differences in physical activity measurements utilised may explain the large variation in physical activity levels thus make it impossible to compare across countries and studies. For example, although the physical activity guidelines recommend all physical activity domains, the report by Keadle *et al.* (2016) only reported leisure time physical activity on the three US surveys. In addition to this, the way leisure time physical activity was assessed also differed in each survey. For the NHANES, the Global Physical Activity Questionnaire was used to assess the frequency and duration of physical activity while the NHIS survey asked participants how often they did vigorous or light/moderate intensity activity per week and their average duration in each category. For BRFSS, participants reported the number of days per week and time per day they engaged in moderate and vigorous physical activity for at least 10 minute bouts. These differences in measures are likely to explain the different prevalence rates across studies.

2.3 Physical Activity Patterns of Older Adults

As mentioned previously, data on the global levels of physical activity in older adult populations are limited, particularly research examining the patterns of physical change over time in older adults. Understanding the physical activity change patterns in older adults is important so intervention and protection policies can be put in place to protect this vulnerable population from chronic disease. According to Hamer *et al.* (2012), physical activity levels in middle age are associated with physical activity in older adults (Hamer *et al*. 2012). Shaw *et al.* (2010) noted that this trend appears to happen early in the life course, although an increasingly steep decline in activity levels can be seen in the older age groups. A 2% decline for each increased year of age in both adult and older adult populations have been reported separately (Weiss *et al*. 2007, Schrack *et al.* 2014). Buchman *et al.* (2014) also documented a similar trend; however, a steeper decline of about 3% per year for each year above 81 years was noted. In a sample of community dwelling English older adults (n = 5022) as part of the ELSA study, Smith *et al*. (2015) carried out a study examining the patterns of physical activity over time. The researchers noted that less than half of older adults were persistently active over a 10 year period however, the authors were unable to classify being active according to the recommended guidelines due to limitations in ELSA. Other research has categorised physical activity behaviours from time points documenting different physical activity trajectories overtime. For example, Barnett *et al*. (2008) assessed leisure time physical activity in adults aged 18- 60 years (n = 884), over a 22 year period identifying 4 main physical activity patterns over time. The authors categorised participants according to their physical behaviour which saw 56% and 12% of adult’s consistently and sufficiently inactive and active, respectively, overtime. In addition, 25% became active or increased their physical activity levels over time and 7% became inactive or decreased their physical activity levels. Since then, more research has replicated Barnett *et al*. (2008) and attempted to categorise physical activity behaviours over time in older populations. Xue *et al.* (2012) recognised physical activity trends over a 12 year period in community dwelling older women aged 70–79 years (n = 433) including always active, fast declining, stable moderate and always sedentary. The authors documented that 17% and 32% were consistently active and moderately active over time while 19% and 32% were fast declining and always sedentary, respectively. In addition, Pan *et al*. (2015) conducted a nationally representative study of Taiwanese older adults aged 50 – 96 years old (n = 4,018). The authors classified respondents according to their physical activity patterns over 4 waves between the years 1996 to 2007. Participants who were consistently inactive represented nearly 48% of the sample while those with an increasing probability of becoming active from being inactive accounted for 23%. Participants consistently active over the 4 waves represented nearly 17% of the sample while those physically active at baseline with a high probability of becoming inactive represented 12% of the sample. Similarly, Jefferis *et al*. (2015) carried out research examining patterns of physical activity in older men aged 70 – 90 years old (n = 1419). The authors documented that 76% of men over 70 years old were consistently inactive over 2 years while only 5% of those inactive at baseline became physically active meeting the recommended physical activity guidelines. In the same study, only 8% of the sample was consistently active while 8% became inactive. Lee *et al.* (2015) utilised data from the Korean Longitudinal Study on Aging (KLoSA) to demonstrate the patterns of physical activity change in a nationally representative sample of community dwelling older adults in Korea (≥65 years). In the total sample of 2605, 1390 (53%) and 419 (16%) were consistently inactive and active over a year period. Of those active at baseline, 433 (17%) became inactive while 363 (14%) inactive at baseline became active. Finally, using data from the English Longitudinal Study of Ageing (ELSA), Hamer *et al*. (2014) noted in a sample of 3454 English community dwelling adults, that 70% remained active and 9% remained inactive over 4 years. In addition, 12% became inactive while 9% became active.

Although the overall trends documented in both cross sectional studies reporting physical activity prevalence and longitudinal studies reporting physical activity change over time recognised low levels and unfavourable physical activity behaviours in adults and older adults, contrasting physical activity assessments, make it difficult to compare these levels and trajectories across studies. For example, most of the reported studies assessed leisure time physical activity or physical activity in terms of sport or exercise. This criterion generally excludes physical activities in the household, at work or physical activity attained through transportation. It has been well established that older adults are less likely to meet the recommended guidelines compared to younger age cohorts, particularly leisure time physical activity. However, research documents the importance of domestic and work related physical activity for older adults and females (Hallal *et al.* 2003). In fact, domestic activities including gardening have been identified as the most common type of physical activity achieved by older adults. Research by Murphy *et al.* (2013) recognised that domestic physical activity makes up a high proportion (36%) of self-reported physical activity particularly among females and older adults. Interestingly, research by Mooney *et al*. (2015) documented that domestic activities including gardening represent higher physical activity scores than athletes among older adults in New York. Indeed, domestic activities have been associated with a reduction in all-cause mortality among older adults in the UK (Besson *et al*. 2008).

It is evident that some physical activity is better than none and more is better than some, however even low levels of physical activity at approximately half the recommended guidelines which can be achieved through 15 minutes walking a day, can reduce all-cause mortality in older adults by 22% according to recent research by Edouard *et al.* (2017). Thus, the inclusion of moderate and not just high levels of physical activity should be included when assessing the physical activity levels of older adults. The recommended physical activity guidelines also recognised the importance of these physical activity types. Thus, when assessing the physical activity levels and patterns the inclusion of all types or total physical activity should be assessed.

2.4 Predictors of Physical Activity

The majority of research on the predictors of physical activity in older adults has come from cross sectional research documenting that age, gender, socioeconomic status and marital status are associated with physical activity behaviour (Kaplan *et al*. 2001; Browning *et al*. 2009). Similarly, Bauman *et al.* (2012) also reported that age, gender, education level, ethnicity and social support were associated with physical activity, however causal inference should not be assumed. According to Bauman *et al*. (2002), simple statistical associations should be referred to as factors associated with physical activity rather than determinants. Some authors however use the term determinants to describe the factors associated with physical activity which is erroneous, as a determinant of physical activity implies causal inference. Research examining determinants of physical activity are extremely limited with some reviews revealing unconvincing evidence (Bauman *et al.* 2012). A systematic review of 59 longitudinal studies in older adults reported few determinants of physical activity behaviour from 80 potential factors (van Stralen *et al.* 2009). Health status or perceived fitness, stress, physical and psychological outcome realisations, activity history during adulthood, recreational facilities and locations, transport environment, social environment, intention to exercise and action planning were documented as determinants of physical activity behaviour. All other variables including demographic factors (i.e. age, gender, socioeconomic status, marital status) were deemed as inconclusive, not a determinant or was not reported in the review (van Stralen *et al*. 2009). In addition, a more recent review of longitudinal studies by Koeneman *et al.* (2011) reported no significant determinants of physical activity or exercise in older adults. Although some studies have examined the factors associated with physical activity, the research has predominantly come from cross sectional studies with limited research documenting predictors or factors associated with physical activity over-time, particularly in community dwelling older adults and older adults aged 75 and over. Although van Stralen *et al.* (2009) reviewed the literature on physical activity change in older adults; the review mainly consisted of randomized controlled trials (RCTs) and intervention studies which included older adults with specific chronic conditions. Similarly, few longitudinal studies have identified some factors associated with physical activity change in older adults including age and gender. However, much of the evidence is inconclusive (Koeneman *et al.* 2011, Bauman *et al.* 2012). The following section discusses the factors which have been documented in the literature as predictors of cross sectional and longitudinal physical activity in older adults. These factors are discussed in more detail under the following headings; socio-demographic, social engagement, physical and mental health and behavioural health and environmental factors. The main factor will be discussed section by section.

2.4.1 Socio-demographic and Social Engagement

Socio-demographic and social engagement factors including age, gender, education, employment, marital status and social connectedness have been commonly documented as factors associated with physical activity in older adults.

The majority of cross sectional literature to date has recognised a decline in physical activity levels with increasing age (Lim & Taylor 2005, Harris *et al.* 2009, Knuth *et al*. 2009, Davis *et al*. 2011, Hamrik *et al.* 2014). In fact, the decline in physical activity with increasing age has been recognised as one of the most prominent findings in physical activity research (Trost *et al*. 2002, Sun *et al.* 2013). Sun *et al.* (2013) conducted a systematic review on the physical activity levels of older adults in which twenty studies assessed physical activity across the age groups of older adults. The authors documented that the prevalence of physical activity in older adults ranged from 2.4% to 83% with the majority of these studies reporting that between 20–60% meet the recommended guidelines. In this review, physical activity levels consistently declined with increasing age between the youngest and oldest older adults.

Desrosiers *et al*. (1998) argues that cross sectional research may underestimate the age-related decline in physical activity. Although longitudinal research on the physical activity levels in older adults is limited, few studies have established older age as an independent predictor of physical activity decline over time (Burton *et al*. 1999, Cohen - Mansfield *et al*. 2010, Ferreira *et al.* 2010, Hamer *et al.* 2012). Overall, findings across several cross sectional and longitudinal studies show that physical activity levels decline with age and that age is in an independent predictor of current physical activity levels and reduced physical activity over time.

The chronological nature of age does not reflect the difference in the health of older adults. Essential physiological functions needed to take part in physical activity including aerobic capacity and pulmonary function decline with increasing age. Similarly, decreased muscle mass and strength, agility, flexibility also show an accelerated decline in older adults. The decline in functional fitness, aerobic capacity and pulmonary function may partially explain the underlining cause of a rapid decline in the physical activity levels of older adults particularly in very old adults (Dontas *et al*. 1984, Rabbitt *et al.* 2011, Milanović *et al*. 2013).

Regarding gender, current cross sectional research has consistently documented that male older adults are physically more active and more likely to reach the recommended physical activity levels than their female counterparts (Trost *et al*. 2002, Lim & Taylor 2005, Steffen *et al*. 2006, Lin *et al.* 2010). Although 3 studies in a recent review by Sun et al (2013) showed that females were more active than males, 22 studies in the review recognised that males were more active than females. According to Murtagh *et al.* (2014), females are on average 75% less likely to be sufficiently active than males. Although Bauman *et al*. (2012) supported a positive association between male gender and physical activity, the authors emphasize that there is insufficient evidence to advocate the relationship.

Longitudinal studies on older adult populations have documented that female gender is an independent predictor of reduced physical activity over time (Burton *et al*. 1999, Shimada *et al* 2007, Yasunaga *et al.* 2008, Cohen Mansfield et al 2010, Ferreira *et al*. 2010, Koeneman *et al*. 2011). Separately, Bijnen *et al.* (1998) documented a 33% decline in males and Xue *et al*. (2012) documented a 19% decline in physical activity levels in females over 10 and 12 year follow up, respectively. Comparing these studies would suggest that the decline in physical activity is greater in males which support the contrasting 3 studies in Sun *et al's*. (2013) review (Hallal *et al*. 2003, Ready *et al.* 2009, Xue 2010). However, the difference here may be explained by past gender roles that have assimilated through the years, which may still apply in older females. For example, the converse findings may reflect the inclusion of household related physical activity or non-leisure activity which is considered an important form of physical activity in older females. Traditionally, females have relied on household chores and non-leisure types of activity as their total physical activity levels. Moschny *et al*. (2011) also documented that older males were more likely to take part in sporting activities while female older adults took part in domestic activities.

Although the majority of literature has recognised male gender as a positive factor associated with physical activity in older adults, inconsistent measurements of self-report physical activity and the exclusion of domestic activities and non-leisure types of physical activity in some surveys may underestimate the physical activity levels of older females (Weller & Corey 1998). More recently, Notthoff *et al.* (2017) showed conflicting results regarding gender and physical activity levels. Although the majority (27) of studies reported that males were more likely to be physically active than females, 19 studies documented no association and 7 showed reverse findings that females were more likely to be physically active than males. The authors concluded that the difference in physical activity levels may be depending on specific physical activity domain. Further longitudinal research using improved measures of total physical activity is warranted in older adults to determine a more realistic view of the gender differences in physical activity overtime.

A considerable amount of cross sectional literature has recognised the positive association between education and physical activity in older adults (Kaplan *et al.* 2001, Chad *et al*. 2005, Browning *et al.* 2009, Haley *et al*. 2010, Koeneman *et al*. 2011). Longitudinal research in the area has also confirmed that higher education is associated with greater physical activity levels over time (Burton *et al*. 1999, Gallant & Dorn 2001). Droomers *et al*. (2001) and Hamer *et al*. (2012) documented that less educated middle-aged and older adults are more likely to reduce their physical activity levels over time. Although age is a major predictor of reduced physical activity, Buchman *et al.* (2014) recently recognized that older adults with a higher level of education have a slower rate of physical activity decline which supports previous work by Shaw & Spokane (2008). These findings suggest that better health knowledge attained through higher education may influence older adults to remain active over time. However, Walsh *et al.* (2001) notes that less educated individuals may have fewer opportunities to engage in physical activity due to strenuous work commitments. Shaw & Spokane (2008) suggested that individuals with low education heavily rely on employment as their main form of physical activity. In support of this, Chung *et al*. (2009) documented that people who work in physically demanding jobs are more likely to report regular physical activity. Similarly, men at manual work had higher levels of physical activity than non-manual workers (Golubic *et al*. 2014). Studies investigating employment and the physical activity levels of older adults are complex due to different measurements of employment status and physical activity domains. Previous cross sectional research have documented the positive impact of employment on physical activity (Golubic *et al*. 2014, Schrack *et al*. 2014). It has been suggested that consistent employment throughout middle-age and older adulthood is an important factor in maintaining daily activities (van Domelen *et al*. 2011, Schrack *et al*. 2014). For example, Shaw & Spokane (2008) recognised that workers were more likely to participate in regular physical activity compared to non-workers. Similarly, Chung *et al*. (2009) showed that employed people were more likely to participate in regular physical activity than the retired. Although, Golubic *et al*. (2014) documented similar results, the association was only significant in males. In contrast to the above findings, research has shown that retirement is in fact associated with higher levels of physical activity (Godfrey *et al*. 2013). Several longitudinal studies have also confirmed the positive impact of retirement on leisure time physical activity (Touvier *et al*. 2010, Lahti *et al*. 2012). In addition, Koeneman *et al*. (2012) showed that both moderate and vigorous levels of physical activity increases in older adults who retired compared to those who continued working. Although a systematic review by Barnett *et al*. (2012) confirmed that both exercise and leisure-time physical activity increases after retirement, the findings on total physical activity levels were inconsistent. It has also been suggested that this increase in sport, exercise and leisure physical activity associated with transition into retirement may not last for too long. In fact, the inconsistencies in the research may be due to difference in age cohorts and follow-up times (Engberg *et al.* 2012). With the majority of research only focusing on leisure time physical activity, Menai *et al*. (2014) suggests that the association between retirement and physical activity needs to be better defined.

Although Hamer *et al*. (2012) and Schrack *et al.* (2014) found no association between type of employment and physical activity; other studies have recognised that the relationship between employment status and physical activity may depend on education, wealth or occupational class or type. For example, Shaw & Spokane (2008) recognised that not working and job losses were associated with reduced physical activity for lower educated older adults. In contrast, not working and job losses were associated with higher levels of physical activity in higher educated older adults. Barnett *et al*. (2012) argues that physical activity level and transition into retirement is dependent on socioeconomic status. For example, older adults with a low socioeconomic status who retire are more likely to decrease their physical activity levels while those with a high socio-economic status are more likely to increase their physical activity. Changing conditions at work, moving upwards in occupational status and occupational physical activity have also been linked with higher levels of physical activity (Brown *et al* 2009, Borodulin *et al*. 2012).

It has been well documented that marital status and spousal physical activity levels are important factors associated with physical activity levels in older adults (Mensink *et al*. 1997, Pettee *et al*. 2006, Janke *et al.* 2006, Barnett *et al.* 2013, Li *et al*. 2013). Similarly, longitudinal research has recognised that older adults who are married are more likely to maintain physically active lifestyle overtime (Burton *et al*. 1999, Cohen-Mansfield *et al*. 2010). However, these associations were only established in the bivariate analysis losing significance in the multivariate model suggesting that there are more important predictors of physical activity. Change in marital status has also been documented as a predictor of physical activity overtime; however the literature in older adult populations is limited. It has been reported that both divorce and widowhood have been associated with worse health outcomes and that marital transitions such as widowhood are more common among older adults (Hughes & Waite 2009). In a sample of middle-aged and older adults combined, Lee *et al*. (2004) recognised that women who divorced increased their physical activity.

However, Koeneman *et al*. (2012) showed that widowhood was not associated with physical activity change in older adults. In support of this, Brown *et al*. (2009) documented similar results in older women. Research suggests that social connectedness may be an important determinant of factor associated with healthy behaviours. A previous systematic review has documented several social factors that influence physical activity behaviour in adults. Social cohesion, physicians influence and social support from friends and family have been shown to have a positive impact on physical activity (Trost *et al.* 2002). Social support is a multidimensional concept that is simply defined as resources provided by others and is often categorised into 4 domains including emotional, instrumental, appraisal, and information support. The social network of older adults is important for physical activity behaviour and may in turn also provide them with the social needs to help overcome the feelings of social isolation and loneliness, a common scenario often seen in older adult populations. Although, Harris *et al*. (2012) showed that living alone and loneliness were not related to physical activity levels in older adults, the majority of research has documented that lack of social support, social isolation, loneliness, living alone and rural residency has been consistently associated with lower levels of physical activity (Booth *et al.* 2000, Brownson *et al.* 2000, Crombie *et al*. 2004, Chad *et al*. 2005, Lim *et al*. 2005, Vance *et al*. 2007, Park & Park 2010, Baert *et al*. 2011, Cotter & Lachman 2011, Moschny et al 2011, van Cauwenberg *et al.* 2011, Stathi *et al.* 2012).

A socially supportive environment, a physically active spousal partner and having a high proportion of friends and family who exercise themselves is associated with higher levels of physical activity (De Bourdeaudhuij & Sallis 2002, Plotnikoff *et al*. 2004, Pettee *et al*. 2006, Mudrák *et al.* 2014). Eyler *et al.* (1999) suggests that social support specific to physical activity may provide the initial motivation to increase physical activity level. However, it has been suggested that adults intentionally look for people who are less physically active than themselves, in order to feel reassured about their own behaviour (Wood 1996).

Burton *et al.* (1999) showed that older adults not having a close friend were less likely to maintain physical activity levels overtime. However, when entered into the logistic model, it was not significant suggesting that more important variables are attributable to the maintenance of physical activity in older adults. More interestingly, there was a negative association between physical activity maintenance and social support from a health care physician. In addition, Li *et al.* (2005) recognised that social cohesion was associated with physical activity. However it was not associated with change in physical activity overtime. In a study of older men, Janney *et al*. (2011) recognised that living alone was associated with greater declines in physical activity over time. Shankar *et al.* (2011) also recognised that loneliness and social isolation were associated with reduced physical activity. More recently, Newall *et al.* (2013) documented that loneliness was associated with reduced physical activity among older adults, supporting previous work in middle-aged and older adults (Hawkley *et al*. 2009).

Although social support has been recognised as a factor associated physical activity in older adults, the majority of the research has come from cross sectional studies with limited and inconsistent prospective evidence advocating the effect social support has on physical activity over time, especially in older adults. Also, older adults with low social support are more likely to misperceive their adherence to the recommended physical activity levels, which may reflect the longitudinal results relying on self-report physical activity (Visser *et al*. 2014).

2.4.2 Physical Health

Chronic disease and poor health is common and widespread in older adult populations. As a result older adults may find it difficult to achieve the recommended physical activity levels. In fact, findings from population based, cross sectional research have recognised the negative impact of poor health and disease on the physical activity levels of older adults (Kaplan *et al.* 2001, Lim &

Taylor 2005). Symptoms of cardiovascular disease (CVD) and respiratory conditions including shortness of breath and fatigue may inhibit older adults from taking part in physical activities (Melillo *et al.* 1996). Similarly, pain and muscle weakness from old age conditions like arthritis, osteoporosis and sarcopenia may also be an underlying reason why older adults fail to meet the physical activity guidelines. Although longitudinal research on the physical activity levels of older adults is limited, previous prospective research has demonstrated the negative impact of poor health and disease on the physical activity levels of adults (Weiss *et al.* 2007, Zimmerman *et al*. 2008, Picavet *et al*. 2011). Similarly in older adults, few longitudinal studies have recognised that poor health is associated with a reduction in physical activity over time (Burton *et al*. 1999, Janney *et al*. 2010, Hamer *et al.* 2012). Cohen-Mansfield *et al.* (2010) documented several factors associated with physical health that influence physical activity in older adult's overtime. Non institutionalised, lower co-morbidity, fewer doctors' and nurses' visits, fewer medications and better self-rated health were all associated with better adherence to physical activity over time (Cohen-Mansfield *et al.* 2010). In fact, many of the chronic health conditions that can actually be benefited from physical activity may also be associated with reduced physical activity overtime which in turn may further exacerbate their health complications, leading to inactivity (Cohen-Mansfield *et al*. 2010, Janney *et al*. 2010, Egan & Mentes 2010). van Gool *et al.* (2007) reported increased odds of inactivity after diagnosis of chronic conditions. In fact, respiratory disease, heart disease, diabetes, high blood pressure and breast cancer have been associated with a reduction in physical activity overtime (van Gool *et al*. 2007, Janney *et al*. 2010, Kwan *et al*. 2012, Newsom *et al*. 2012, Xue *et al*. 2012). In contrast, other prospective research has shown quite the opposite with an increase in physical activity after diagnosis of hypertension and diabetes (Neutel *et al.* 2008, Newsom *et al*. 2012). Similarly, Dai *et al.* (2014) showed that women who developed a chronic disease and men who remained with a chronic disease were in fact, less likely to reduce their physical activity levels overtime. Additionally, Li *et al*. (2013) recognised that recently diagnosed married women with a chronic disease were more likely to increase their physical activity levels. The authors suggest that people with chronic diseases may use physical activity to protect themselves and improve their condition or health status. However, Dai *et al.* (2014) revealed that women who became healthy were also more likely to reduce their physical activity levels. This result was puzzling for the authors. The research examining physical activity change after the diagnosis of a chronic disease is unclear and inconsistent and warrants further research.

The effects of physical activity on BMI have been well documented. A recent systematic review of longitudinal studies in adults and older adults combined recognised that greater physical activity leads to less weight gain after several years of follow-up (Reiner *et al*. 2013). More interestingly, several studies have also suggested that the relationship between physical activity and BMI is bidirectional with some authors implying that a high BMI is associated with reduced physical activity over time (King *et al*. 1997, Schmitz *et al*. 1997, Peterson *et al*. 2004, Ekelund *et al.* 2008, Hansen *et al*. 2013). In fact, body weight, BMI, fat mass (FM) and abdominal obesity have all been documented as independent predictors of reduced physical activity over time (Ekelund *et al.* 2008, Lakerveld *et al*. 2011). Although the current cross-sectional literature in older adults has shown similar results, it's impossible to establish the direction of their relationship due to the cross sectional designs (Harris *et al*. 2009, Haley & Andel 2010, Davis *et al*. 2012). In addition, according to van Stralen *et al*. (2009), there is relatively weak evidence to suggest that BMI is an independent predictor of physical activity with limited and inconsistent results found in the literature (Kirjonen *et al.* 2006, Barnett *et al*. 2008, Ferreira *et al.* 2010 Koeneman *et al.* 2011).

Nevertheless, a longitudinal study by Mortensen *et al*. (2006) recognised that a high BMI was associated with an increased risk of reduced physical activity in middle-aged men and women. In fact, BMI in middle-aged adults is associated with physical activity behaviour in old age (Hamer *et al.* 2012). In support of this, Borodulin *et al.* (2012) reported that adults who remain in a healthy weight range over a 22 year follow up period are likely to be physically active. Similarly in older adults, Schrack *et al.* (2014) recently highlighted that higher BMI was an independent predictor of reduced physical activity. Moreover, change in weight has also been associated with change in physical activity levels. Golubic *et al.* (2013), demonstrated that a large increase in weight (>2 kg/year) over a 10 year follow up period was significantly associated with reduced physical activity. In fact, even moderate weight gain was associated with 30.5% greater odds of being physically inactive 10 years later. Other studies found the association of BMI and physical activity differed by gender. For example, Xue *et al*. (2012) revealed that obesity in older women was associated with a fast decline in physical activity levels over time. Similarly, Dai *et al*. (2014) established that females who became or remained overweight or obese were more likely to reduce their physical activity but no association was found in males. In contrast, Zimmerman *et al.* (2008) recognised the association in men were obese men had an increased risk of reduced physical activity compared to overweight men. However, although females did follow a similar trend, the result was insignificant.

2.4.3 Mental Health

The protective effects of physical activity on the mental health of older adults have been well documented (Lautenschlager *et al.* 2004). According to Lee *et al.* (2014) physical activity can protect against depression in older adults. Cross sectional research has consistently publicised the benefits of physical activity in older adults with depression, anxiety, stress and mood disorders. Walking, domestic/gardening and sporting type activity has been documented to protect against depression and those with higher levels of physical activity at even lower risk (Joshi *et al* 2016). However, this relationship between physical activity and mental health has been also shown to be bidirectional with mental health having been shown to impact the physical activity levels of older adults. Elfrey & Ziegelstein (2009) referred to this relationship as the “inactivity trap” and recent research has confirmed its significance recognising the bidirectional association of depression and anxiety on physical activity (Azevedo Da Silva *et al*. 2012, Steinmo *et al.* 2014). Other research has just documented the association one way and that depression is an independent predictor of reduced physical activity over time in older adults (Perrino *et al*. 2010, Julien *et al.* 2013). Nevertheless, other prospective studies just examining the predictors of physical activity change have also confirmed that baseline depression and anxiety is associated with reduced physical activity overtime (Panagiotakos *et al.* 2008, Roshanaei-Moghaddam *et al*. 2009, Cohen-Mansfield *et al*. 2010, Xue *et al*. 2012). In addition, although Ku *et al*. 2012) and Lindwall *et al.* (2011) showed no association between baseline depression and physical activity, change in depressive symptoms was associated with change in physical activity overtime. Similarly, Van Gool *et al*. (2003) also found no association with baseline depressive symptoms and physical activity, however, emerging depressive symptoms was associated a reduction in physical activity. While van Stralen *et al's.* (2009) review highlighted that there is relatively weak evidence to imply mental health impacts physical activity in older adults, more recent research in the area would suggest otherwise. It has been argued that depression may result in a lack of motivation and low energy which may result in this decline in physical activity. In addition, age and gender maybe potential moderators in the bidirectional relationship between physical activity and depression. Although Lindwall *et al*. (2011) found no significant gender differences, the authors call for more research in the area given the substantial gender differences noted in physical activity and depression separately. Other mental health factors have not been well documented, however negative mood and stress (emotional distress) have been acknowledged as potential predictors of reduced physical activity (Burton *et al*. 1999, Sallis & Owen 1999, Trost *et al.* 2002, Van Stralen *et al*. 2009, Mouchacca *et al.* 2013).

Falls and fear of falling are a common serious problem in older adults leaving them susceptible to injuries. It has been reported that between 30 to 60% of community-dwelling older adults fall every year with approximately half of them falling more than once (Rubenstein 2006). In addition, falls have been associated with fear of falling and avoidance of activities (Delbaere *et al*. 2004, Jorstad *et al*. 2005). In fact, according to Friedman *et al*. (2002) falls and fear of falling are related with each other in which falls predict fear of falling and vice versa. In addition, falls and fear of falling have been considered a major risk factor for the decrease in physical activity in older adults (Zijlstra *et al.* 2007). A longitudinal study by Shimada *et al*. (2007) recognised that older adults who reported a fear of falling were significantly more likely to stop physical activities over a 2 year follow up period. In support of this, Ferreira *et al*. (2010) noted that falls with a negative consequence was the most important factor associated with reduced physical activity over time.

2.4.4 Behavioural Health Factors

Previous cross sectional research suggests that smoking status is negatively associated with physical activity levels in adults (Trost *et al.* 2002, *Kaczynski et al.* 2008). Few longitudinal studies have confirmed this association in adults, recognising that smokers are more likely to reduce their physical activity levels over time (Laaksonen *et al.* 2002, Zimmerman *et al*. 2008, Picavet *et al.* 2011). In addition, even former smokers who quit have progressively higher levels of physical activity in the years after quitting compared with continuing smokers (Auer *et al*. 2014). Borodulin *et al*. (2012) also acknowledged the positive impact of not smoking on physical activity in adults aged 30-80 years. Although prospective research in the older adult populations is limited, few longitudinal studies have recognised smoking as an independent predictor of reduced physical activity over time supporting the research in adult populations (Droomers *et al*. 2001, Janney *et al*. 2011, Dai *et al*. 2014). In fact, Shimada *et al*. (2007) revealed that smoking was a significant independent predictor of stopping physical activity after two years. Smoking is a major risk factor for many chronic diseases including CVD, respiratory disease and cancer. It has been suggested previously that the symptoms of some of these chronic conditions may interfere with the physical activity levels of older adults. Consequently, a potential explanation as to why we see a steeper decline in the physical activity levels of older adults who smoke. In addition, sedentary behaviours like sitting time, high levels of TV viewing and insufficiently active at baseline have been associated with physical inactivity maintenance and reduced physical activity over time (Lakerveld *et al*. 2011, Picavet *et al.* 2011). Sedentary behaviours have also been associated with functional limitations, chronic disease and mortality (García-Esquinas *et al*. 2017). Physical inactivity, sedentary behaviours and smoking are 3 major modifiable risk factors linked to death. It has been recognised that healthy behaviours generally cluster together in older adults (Schneider *et al*.

2009). Remaining physically active, reduce sedentary behaviours like TV viewing time and not smoking may be a typical healthy combination in healthy older adults.

2.4.5 Environmental & Other Factors

A safe neighbourhood, neighbourhoods with more green space, a more accessible neighbourhood design, safety from traffic, the presence of hills, walking/hiking/biking trails, footpaths, public parks, recreational facilities (golf courses, skating rinks, swimming pools & tennis courts) and owning a pet have been associated with higher levels of physical activity in older adults (Booth *et al*. 2000, Fisher *et al*. 2004, Chad *et al*. 2005, Lim & Taylor 2005, Michael *et al*. 2006, Tucker-Seeley *et al*. 2009, Hall & McAuley 2010, Strath *et al*. 2012, Gong *et al*. 2014). However, a systematic review by Van Cauwenberg *et al.* (2011) revealed that there are inconstant results in the literature advocating that some of these environmental factors are not associated with physical activity in older adults. Fisher *et al.* (2004) and Michaels *et al*. (2006) also revealed that Neighbourhood problems were not associated with physical activity in older adults. Although some cross sectional research has documented mixed results regarding environmental and neighbourhood characteristics and their association with physical activity in older adults, Moran *et al.* (2014) suggests that the physical environment should be safe, accessible to recreational facilities, daily destinations and rest area and be aesthetically appealing in order to promote physical activity in older adult populations. In the longitudinal literature, Ranchod *et al*. (2014) recognised that recreational density was associated with change in physical activity in older adults; the majority of other longitudinal studies in the area have only focused on physical activity in the form of walking. Nevertheless, close proximity to parks/ trails, and gyms, perceived access to physical activity facilities and neighbourhood safety for walking were associated with smaller declines in walking over time (Li *et al*. 2005). Although Michael *et al*. (2010) showed a similar association in older men, the results where only significant in men in a high socioeconomic status. Brown *et al.* (2011) documented that higher levels of perceived neighbourhood climate (i.e. perceptions of a more positive and supportive neighbourhood social environment) were related to a greater number of blocks walked at follow-up. Further research is warranted to investigate the factors and impact of recreational facilities and neighbourhood satisfaction on physical activity in older adults (Morris *et al* 2008, Ranchod *et al 2013*).

Shibata *et al*. (2012) documented that dog ownership was associated with higher levels of physical activity compared to non-dog walkers and non-dog owners in Japanese older adults. In addition, a review by Christian *et al*. (2013) documented similar results. These findings suggest that dog ownership may be a potential factor to promoting overall physical activity in older adults. However the authors call for more longitudinal and interventional studies to provide stronger evidence.

2.5 Physical activity and Cardiovascular Disease in Older Adults

A journal article by Taylor (2014), entitled "Physical activity is medicine for older adults", is a clear and obvious statement stressing the benefits of physical activity in older adults. This is supported by an abundance of research documenting the benefits of physical activity in the prevention and protection of many NCDs (Lee *et al*. 2012, Marques *et al*. 2017). In fact, no medical treatment can protect against as many chronic diseases as physical activity (Naci *et al*. 2013). The current physical activity recommendations for older adults of 150 minutes of moderate intensity physical activity per week or 75 min of vigorous-intensity physical activity per week, or an equivalent combination of moderate and vigorous physical activity is supported by a large body of evidence from 30 prospective cohort studies documenting the inverse association between physical activity and CVD (Physical Activity Guidelines Committee 2008). Physical inactivity or not reaching the current recommended guidelines is said to contribute to approximately 30% of the CVD burden

(Physical Activity Guidelines Committee 2008). Building on this evidence, Shiroma & Lee (2010) documented CVD risk reductions of 30-40% among the highly active when compared to the least active. The rate of CVD rapidly increases with age with more than 90% of events occurring in middle-aged and older adult populations. In addition, mortality due to CVD is apparent in four out of every five adults over the age of 65 years. This is worrying considering the distinct obstacles to maintaining a physically active lifestyle for older adults. Older adults may actually benefit more from physical activity than any other age cohort which is unfortunate considering very few older adults achieve the recommended amounts of physical activity (Jefferis *et al* 2014, Taylor 2014). According to Endes (2016) the health benefits of physical activity in older adult populations are limited and understudied. The majority of the evidence to date has been derived from studies with middle-aged and older adults combined and although evidence from epidemiologic studies indicate that the same factors associated with CVD in middle-aged adults are relevant in older adults, few studies have focused exclusively on older adults (≥65) especially among the oldest old (≥80) (Shiroma & Lee 2010, Cheng *et al.* 2013). However, recent, studies have emerged which highlight the benefits of walking, leisure time and total physical activity levels in older adult populations. Barengo *et al.* (2017) documented the benefits of leisure time physical activity in a population-based cohort study in Finland with a sample of older adults aged 65-74 years (n = 2,456). The authors noted that moderate and high levels of leisure time physical activity was associated with lowers rates of CVD mortality and the incidence of CVD. In addition, Brown *et al*. (2014) documented the benefits of walking in community dwelling adults aged 60 years and older (n = 5,000) with a 21 % reduction in the risk of CVD mortality. This is supported by a large prospective study of 4,207 older adults by Soares-Miranda *et al.* (2016) who recognised the benefits of walking in reducing CVD including CHD and stroke in those aged 75 and older. Specifically, those who walked briskly (>3mph) had 50%, 53% and 50% lower risk of CHD, stroke, and CVD respectively. In addition, those who walked at least 49 blocks per week had 36%, 54% and 47% lower risk of CHD, stroke and CVD, respectively. Separately, the authors conducted analysis on the types of physical activity and their association with CVD. Indeed, walking remained an independent predictor for reduced CVD, however, leisure time physical activity did not. This finding is interesting as most of the evidence documenting the benefits of physical activity in CVD risk reduction has focused on leisure time physical activity (Sattelmair *et al*. 2011, Koolhaas *et al*. 2016). However, the literature has been dominated by studies using middle aged and older adults combine. The findings here may be explained by the different types of physical activities undertaken by middle aged and older adults. For example, middle aged adults may be more active in leisure time while older adults may be physically active through domestic type activities. However, very few studies particularly in older adults have assessed the benefits of total physical activity in older adults. In a national survey, Kim *et al.* (2017) assessed the total physical activity levels of Korean community dwelling adults aged 20 years and older (n = 26,294). The authors showed fully adjusted (≥ 65 years, hypertension, diabetes mellitus, sex, and smoking) risk reductions of 18% and 34% for moderate and high levels of physical activity groups, respectively (Kim *et al* 2017). Similarly, Kubota *et al*. (2017) investigated the association between total physical activity and CVD in a prospective study of middle-aged and elderly Japanese adults (n = 74,913). The authors documented maximum risk reductions for CVD in adults who achieved moderate levels of total physical activity. Recently, Lear *et al.* (2017) recognised that recreational and non-recreational physical activity was associated with a lower risk of mortality and CVD events in a study from 17 countries utilising a large sample of 130,843 adults aged between 30 – 80 years old. This is supported by representative sample (n = 4232) of 60 year old Swedish adults who were followed over 12.5 years (Ekblom-Bak *et al.* 2014). Regardless of exercise behaviour, the authors noted that those who were physically active had approximately 30% lower risk of CVD and all-cause mortality.

Understanding the predictors of physical activity change patterns in older adults for CVD prevention is extremely important given the rapidly aging population and expected increased prevalence of cardiovascular events. For example, studies tracking the maintenance and initiation of physical activities in middle aged and older adults have documented positive results (Rothenbacher *et al.* 2006). Hamer *et al.* (2013) recognised that older adults who remained physically active overtime or became physically active were less likely to develop major chronic disease. These findings may also be true for cardiovascular mortality and morbidity. In fact, research by Wannamethee *et al.* (1998) also recognised that maintaining or increasing physical activity reduced mortality risk including deaths from CVD in older men. Also, in older women, Gregg *et al.* (2003) documented that becoming physically active reduced CVD mortality by nearly 40%. More interestingly, becoming physically active had a similar mortality rate as those who remained active while those becoming inactive had a mortality risk similar to those inactive at baseline advocating that current physical activity level in old age is much more important that past physical activity behaviour. Research by Jefferis *et al.* (2014) extended prior knowledge gained from middle aged adults into older populations. The authors documented that older men who maintained or became physically active had lower CVD risk, particularly CVD mortality.

Understanding the effects and role of modifiable risk factors such as physical activity in older adults is crucial so participation can be appropriately promoted for the primary prevention of CVD (Hemingway 2007). According to Perk *et al.* 2012 (2012) surveys to date have recognised that there is still scope for improvements in guideline achievement.

2.6 Literature Review Summary

With the global burden of NCDs and the general decline of physical activity levels seen with the ageing population, understanding the factors associated with physical activity and the decline in physical activity over time is important to develop public health policies targeting specific vulnerable older adults. So far, few intervention strategies have been put in place aiming to increase physical activity in older adult populations and positive outcomes are generally limited and short lived (van der Bij *et al.* 2002). Indeed, this literature review revealed many independent factors associated with the physical activity levels of older adults. It also, identified factors associated with physical activity change patterns in older adults. These predictive factors included socio-demographic, social engagement, physical, mental and behavioural health and environmental factors. The findings from the literature review support Li *et al.* (2005) who recognised that the factors associated with physical activity in older adults are complex, interacting and wide-reaching involving individual, social, physical and environmental factors. Although identifying these factors are important for health promotion policies in a bid to increase physical activity in older populations, further research should examine many of the factors found in the literature collectively in multivariate models to identify the most parsimonious predictive factors associated with physical activity in older adults. In support of this, Shiraly *et al.* (2017) recently suggested that research should identify the most important factors associated with physical activity in older adults so interventions to increase participation can be prioritised. According to Burton *et al.* (2009) focusing on only one type of influence may over-estimate the amount of unique variance accounted for, leading to inaccurate inferences of the strength of an association (Burton *et al.* 2009). Also, different factors associated with physical activity may differentiate across countries due to socio-cultural differences, thus it may be necessary to identify predictive factors in every society (Shiraly *et al* 2017).

Chapter 3

Methodology

3.0 Introduction

The previous chapter described and identified the current gaps in the literature which provides justification for this research. This chapter describes the research methodology and methods adopted for this study utilising data from TILDA. The chapter begins by presenting the research aims, objectives and specific research questions followed by details of the philosophical paradigm underpinning the research. The study design, ethical considerations, sample and recruitment, data collection methods and measures are described next. Finally, the statistical procedures and data analysis procedures are discussed in detail in the context of each research question.

3.1 Aims and Objectives

Utilising data from the TILDA study, this research aims to:

Assess the patterns of physical activity and physical activity change in community dwelling older adults.

- Assess factors associated with physical activity and physical activity change in community dwelling older adults.
- Assess the impact physical activity has on cardiovascular disease (CVD) and cardio-metabolic risk factors
- Examine the mediating effect of the cardio-metabolic risk factors (blood pressure, cholesterol, diabetes, obesity (body mass index (BMI)) and abdominal obesity (waist circumference (WC)) in the relationships between physical activity and CVD.

The first data collection point will be termed baseline. Using the baseline data, this research examines a wide range of known factors associated with physical activity collectively and identifies the main predictors of baseline physical activity. Next, the study examines the impact of physical activity on CVD in the older adults and the cardio-metabolic risk factors, namely blood pressure, cholesterol, diabetes, obesity (BMI) and abdominal obesity (WC). Through this analysis this research aims to identify and explain potential pathways or the process that underlies the relationship between physical activity and CVD through the cardio-metabolic risk factors (mediating effect). In addition, utilising baseline and two year follow up data, this research explores the patterns of physical activity change. Finally, this research assesses a wide range of known factors associated with physical activity collectively and identifies the main predictors of physical activity change in the older adult.

3.2 Overarching Research Question

What are patterns and factors associated with physical activity and what impact does physical activity have on CVD in community dwelling older adults?

Specific Research Question

1: What proportion of community dwelling older adults in Ireland are physically active according to the recommended guidelines?

2: What are the main predictors of baseline physical activity among community dwelling older adults?

3: What is the impact of physical activity on the cardio-metabolic risk factors?

3a: What is the impact of physical activity on high blood pressure?

3b: What is the impact of physical activity on high cholesterol?

3c: What is the impact of physical activity on diabetes?

3d: What is the impact of physical activity on obesity (BMI)?

3e: What is the impact of physical activity on abdominal obesity (WC)?

4: What is the impact of physical activity on cardiovascular disease?

5: Do the cardio-metabolic risk factors mediate the relationship between physical activity and cardiovascular disease?

5a: Does high blood pressure mediate the relationship between physical activity and cardiovascular disease?

5b: Does high cholesterol mediate the relationship between physical activity and cardiovascular disease?

5c: Does diabetes mediate the relationship between physical activity and cardiovascular disease?

5d: Does obesity (BMI) mediate the relationship between physical activity and cardiovascular disease?

5e: Does abdominal obesity (WC) mediate the relationship between physical activity and cardiovascular disease?

6: What are the patterns of physical activity change from baseline to follow up?

7: What are the predictors of physical activity change?

7a: What are the predictors of physical activity change for older adults active at baseline?

7b: What are the predictors of physical activity change for older adults inactive at baseline?

3.3 Philosophical Paradigm

Methodology refers to the procedure used to get knowledge and can be defined as "the strategy, plan of action, process or design lying behind the choice and use of particular methods and linking the choice and use of the methods to the desired outcomes" (Crotty 2003, p. 3). A research paradigm can be described as a worldview or a way of thinking and understanding the world. Kuhn (1962, p. 45) defines a research paradigm as "the set of common beliefs and agreements shared between scientists about how problems should be understood and addressed". A research paradigm involves a pattern, structure and framework of scientific and academic information, values and assumptions and is characterised by three main dimensions which make up the philosophical framework (Guba 1990). The ontological, epistemological and methodological assumptions make up the philosophical framework. Ontology can be defined as "the study of being" (Crotty 2003, p. 3) while epistemology is 'a way of understanding and explaining how we know what we know' (Crotty 2003, p. 10). Medical, behavioural and social science research is generally categorised by two main research approaches namely qualitative and quantitative methods. Quantitative research stems from a positivist paradigm which is characterised on the understanding that there is a true and objective reality independent of the researcher and that this knowledge can be revealed through the use of scientific methods (Krauss 2005). "Positivism is an epistemological position that advocates the application of the methods of the natural sciences to the study of social reality and beyond" (Bryman & Bell 2007, p.3). Positivists believe that research is objective and value free thus this approach seeks to explain and predict outcomes were aspects of life are measured, assigned numerical codes and subjected to statistical analysis to draw up conclusions and findings that can be generalised. However, more recent quantitative research is guided by the post-positivist paradigm, an alternative philosophy or after thought of positivism which challenges the positivist's perspective of absolute reality (Creswell 2008, Tashakkori & Teddie, 1998). Similar to positivists, post-positivists are independent and believe research is objective and consistent with current knowledge (Carson *et al.* 2001, Doucet et al, 2010). However, the post-positivist acknowledges that all observation is fallible and has error and that all theory is revisable. The current study adopted the post-positivism paradigm. While retaining the notion of a single objective reality through prediction and explanation, it also acknowledges that reality can never be fully uncovered as a result of unobservable concepts and researcher biases. By recognising these unobservable elements the post-positivists provide a more realistic and precise knowledge of science and the environment (Clark 1998). The variables selected by the researcher are guided by the literature and the research methods adopted will ensure that the researcher is independent of the data limiting research bias and personal values (Carson *et al.* 2001).

3.4 Study Design

The current research adopted a prospective, longitudinal, observational cohort design. Phase 1 of this thesis is a cross-sectional analysis of the baseline of the cohort to establish the prevalence of active and inactive community dwelling older adults in Ireland. This also allowed the researcher to determine the main predictors associated with baseline physical activity levels and also assess the impact of physical activity on CVD and cardio-metabolic risk factors. Following this, a prospective, longitudinal, analysis of the cohort with a two year follow up period was adopted for phase 2 of this thesis which facilitated the analysis of the main predictors associated with physical activity change over time in community dwelling older adults.

3.5 Ethical Considerations

Ethical approval was granted to TILDA by the Faculty of Health Sciences in Trinity College Dublin for both baseline and follow up data collection. Important ethical principles were adhered to with the purpose of ensuring protection of participant's anonymity and confidentiality particularly with information of a sensitive nature, including financial, health and social circumstances. Respect for autonomy is demonstrated by regarding the participant as an independent person who makes their own decisions with regards to participation (Rogero-Anaya *et al*. 1994, Holloway & Wheeler 2010, Burns & Grove 2011). All participants provided signed informed consent before participating in the interviews at both baseline and follow up and again at the health assessment at baseline (Kenny *et al.* 2010). Participants who were uncomfortable answering certain questions could skip them and any participants had the right to withdraw from the study at any time. Strict measures to protect confidentiality were adhered to as each participant was assigned their own personal unique identification number. Participant's name, address and date of birth were removed from the data and stored separately ensuring that no information can identify participants through the data. Access to the TILDA data was provided through a request form to the Irish Social Sciences Data Archive at University College Dublin (http://www.ucd.ie/issda/data/tilda/) were an anonymised version of baseline and follow up data sets were released to maintain confidentiality and data protection. This public release dataset was anonymised in collaboration with the Central Statistics Office where no sensitive data was to be released and some variables were top-coded, grouped or dropped to eliminate self-identification. Ethical approval was granted for secondary analysis of TILDA data set by the Faculty of Health Sciences in Trinity College Dublin.

3.6 Sample and Recruitment

The data used in this study was collected as part of the TILDA study and collected information on the health, economic and social circumstances of community dwelling adults aged 50 years and over living in the Republic of Ireland. Baseline data collection was carried out between October 2009 and July 2011 and follow up data was collected between February 2012 and March 2013. Selection of participants was carefully designed to ensure that the sample population was representative of the community dwelling adult population aged 50 and over in the Republic of Ireland and representative of the socio-demographic and geographical cohorts across the country. Based on the Irish Geodirectory developed by the Economic and Social Research Institute of Ireland (Whelan 1979), the RANSAM sampling procedure was utilised. RANSAM is a computer based system which has complete and up-to-date listings and mapping of homes in Ireland compiled by the Ordnance Survey Ireland. RANSAM groups the addresses into clusters so that the final clusters selected were stratified to represent the socio-demographic profile and geographic distribution (Kenny *et al*. 2010). Each home in the Republic of Ireland had an equal probability of selection from the sample list of addresses. Interviewers visited each of the selected homes to establish if participants were eligible to take part in the study i.e. aged 50 and over. From the clustered random sample of all households in the Republic of Ireland, a total of 8,175 community dwelling adults aged 50 and older participated in the study at baseline (response rate 62%). Of the 8,175 original baseline participants, 6995 participated at follow up (86% response rate) (Kenny *et al.* 2010, Barrett *et al.* 2011, Kearney *et al.* 2011, Whelan & Savva 2013). Full details of the selection procedures have been published previously in The Design of the Irish Longitudinal Study on Ageing (Kenny *et al.* 2010).

For the current study further inclusion criteria were applied. Participants at baseline who were i) aged 65 and over, ii) completed the International Physical Activity Questionnaire short form (IPAQ-SF) and iii) had a health assessment at home or at a TILDA health centre were included for phase 1 baseline analysis. For phase 2 analysis, all participants from baseline analysis who completed the IPAQ at follow up were included.

3.7 Data Collection

TILDA collected information on the health, economic and social circumstances of community dwelling adults aged 50 years and over living in the Republic of Ireland. TILDA data is strongly harmonised with large scale longitudinal research including the English Longitudinal Study of Ageing (ELSA, https://www.elsa-project.ac.uk/), the Survey of Health, Ageing and Retirement in Europe (SHARE, http://www.share-project.org/) and the Health and Retirement Survey (HRS, http://hrsonline.isr.umich.edu/) in America. TILDA data was collected via three methods including a Computer-Aided Personal Interview (CAPI), a Self-Completion Questionnaire (SCQ) and a health assessment in the participant's home or at a TILDA health Centre (Appendix 1 - 4). The CAPI was conducted face to face in the participant's home with a trained interviewer. Interviews took on average 90 minutes and data was inputted directly into a portable computer. The CAPI captured questions on socio-demographic variables such as age, gender, education, employment and marital status and information on social circumstances such as social connectedness. Health variables relating to physical, cognitive, mental and behavioural health were included in addition to variables on medication and healthcare utilisation.

Participants who completed the CAPI questionnaire were invited to complete the SCQ, a paper questionnaire which complements the CAPI and includes various questions of a sensitive nature, including questions on quality of life, emotional well-being and health behaviours. Topics in the SCQ included social connectedness, loneliness, perceived stress, stressful life events, anxiety, worry, quality of life and alcohol intake. Social participation, relationship quality and loneliness were assessed which add to the social connectedness section in the CAPI, while the assessment of anxiety and worry in the SCQ add to the mental health section in the CAPI. In addition, the assessment of quality of life and alcohol intake add to the health and behavioural health sections respectively. The SCQ took approximately 20 minutes to complete and participants had the option to fill in the SCQ directly after the CAPI while the interviewer was present or at a later date and return the questionnaire by post. Both the CAPI and the SCQ contained one off questions as well as embedded validated questionnaires. Details of the scales/questions are discussed below.

Participants who completed the CAPI were also invited to take part in a health assessment at a designated TILDA health centre in Dublin or Cork or a modified health assessment at the participant's home when travel was impractical. Of the 3,499 participants who completed the CAPI and SCQ and were ≤65, 2,372 (67%) underwent a health assessment. Trained research nurses carried out the health assessments which took 3 hours and 1.5 hours at the health centre and participants home, respectively. The health assessment included anthropometric and clinical measurements including height, weight and waist and hip circumference. Physical performance parameters including grip strength and mobility were also recorded. In addition, depression, cognition, attention, memory, speed of processing and executive function was also assessed.

All living participants were invited back two years later (follow up) to complete the CAPI and SCQ. There was no health assessment at follow up. Participants lost at follow up were more likely to be older, have a lower education level, be less physically active, have CVD and rate their physical health as fair or poor.

3.8 Measures

Further information about the variables collected by the different data collation methods are detailed below and include socio-demographic (3.8.1) factors, social engagement (3.8.2), physical (3.8.3) and mental health (3.8.4) characteristics, cognitive (3.8.5) and behavioural health (3.8.6) factors. The operationalisation and coding protocols for all variables used for data analysis are specified below in Tables 3.1 to 3.5.

3.8.1 Socio-demographics

Age, gender, education level, employment and marital status, location and medical cover were assessed by self-report in the CAPI (Appendix 2). Age was obtained by participants reporting their date of birth and the author further classified into three categories including those aged between 65 – 69, 70 – 74 and 75 and over. Male or female gender was documented and education was assessed by participants reporting their highest level of education achieved (Some primary; Primary or equivalent Intermediate/junior/group certificate or equivalent; Leaving certificate or equivalent; Diploma/certificate; Primary degree or Postgraduate/higher degree) which was categorised as primary, secondary or tertiary education by the author. Participants classified their employment status as retired, employed, self-employed, unemployed, permanently sick or disabled, looking after home or family or in education or training which were reduced into three responses by the author including employed, retired or unemployed/other. Participants reported their medical cover as medical card holders, having medical insurance or no cover. Participants documented their marital status as being married, living with a partner as if married, single (never married), separated, divorced or widowed. This researcher further dichotomised this variable as married or not. Participants were asked about their location or their dwelling. Responses included Dublin city or county, a city or town in Ireland or a rural part of Ireland which was dichotomised by the author into urban or rural residents (Table 3.1).

3.8.2 Social Engagement

Social connectedness was assessed in the CAPI using an adapted version of the Berkman-Syme Social Network Index (SNI) (Berkman and Syme 1979) a self-report questionnaire which measures four categories of social connectedness including marital status, friends and relatives, religious activity and memberships in community organisations (Appendix 2). Specifically, the index includes 1) married or not, 2) the presence of at least two children, other relatives or friends, 3) attends religious services at least once per month, 4) participates in any sports or social group or club, a church connected group, a voluntary association, a self-help or charitable body or other community group or a day care centre. Each connection type is scored either zero (No) or one (Yes) and the four scores are summed to create four levels (0-4) of social connectedness or engagement namely socially isolated, moderately isolated, moderately integrated and socially integrated. Categories were further condensed by the author into socially isolated or socially integrated (Table 3.1). The SNI is a well-validated scale and a common instrument used in public health research for use in adults aged 18–64 years old. The SNI has been validated used to predict mortality in general populations and those with cardiovascular disease and cancer (Berkman *et al.* 1979, House *et al.* 1982, Kroenke *et al.* 2006, Kroenke *et al.* 2013, Lubben *et al.* 2015). Sykes (2002) reported the validity and reliability of the scale with a Cronbach's alpha of 0.84.

Table 3.1: Operationalisation and coding protocols for Socio-demographic and Social Engagement Predictors

Measure	Operationalisation
Age group	0 = 65 – 69 1 = 70 – 74 2 = ≥ 75
Sex	0 = Male 1 = Female
Education Level	0 = Primary 1 = Secondary 2 = Tertiary
Employment Status	0 = Retired 1 = Employed 2 = Unemployed/Other
Medical Cover	0 = Not Covered 1 = Medical Insurance 2 = Medical Card
Location	0 = Urban 1 = Rural
Married	0 = No 1 = Yes
Social Connectedness	0 = Socially isolated 1 = Socially integrated

3.8.3 Physical Health

In the CAPI, participants self-rated their physical health, vision and hearing as excellent, very good, good, fair or poor. Responses were further condensed by the author into two categories fair/poor or excellent / very good / good self-rated physical health. In addition, participants were asked if they suffered from a chronic or long term health problem and a life threatening illness or accident with responses classified as yes or no. Similarly responses were categorised as yes or no to questions asking participants if they had fallen in the last year, if they were afraid of falling and if they were often troubled with pain. The presence of a disability or functional limitations in basic tasks of everyday life known as activities of daily living (ADL) was assessed by participants self-reporting difficulties with personal care, such as eating, bathing, dressing, toileting, and moving about due to a health or memory problem. Additionally, presence of a disability or functional limitations in activities performed by a person in order to live independently known as instrumental activities of daily living (IADL) was assessed by participants self-reporting difficulties with household chores, preparing meals, shopping, using the telephone, taking medications correctly and managing money. These questions were adapted from standardised ADL and IADL scales (Katz *et al.* 1970, Lawton & Brody 1970). Responses were categorised by the author as having no disability or having an IADL or ADL.

Some of the cardio-metabolic risk factors (high blood pressure, high cholesterol and diabetes) were also reported in the CAPI. High blood pressure, high cholesterol and diabetes were self-reported based on ever having a doctor's diagnosis of the condition and responses were classified as simply yes or no (Appendix 2).

Obesity was measured objectively during the health assessment in terms of BMI. First, height was measured in centimetres (cm) to one decimal place using a SECA 240 wall mounted measuring rod (Appendix 4). Footwear, heavy clothing and head gear were removed prior the measurement and participants were asked to stand with their back to the measuring rod facing forward and straight ahead, feet together and knees straight. Weight was assessed in kilograms (Kgs) to one decimal place using a SECA electronic floor scales or a SECA seated scales. Footwear and heavy clothing were removed prior measurement. BMI was calculated from measured height and weight as: weight (Kgs) divided by height squared (m^2). Four categories of BMI were established by the author according the WHO (2000) guidelines including underweight, normal weight, overweight and obese. Obesity was defined as a BMI equal to 30 and over.

Abdominal obesity was also measured during the health assessment in terms of waist circumference (Appendix 4). Participants were asked to remove outer layers of clothing, tight garments, belts, unnecessary contents in pockets and to stand evenly on both feet approximately 30 cm apart. Waist circumference was assessed using a SECA measuring tape and waist was defined as halfway between the iliac costal and the costal margin. Abdominal obesity was defined as a waist circumference equal to or greater than 102cm and 88cm for male and females, respectively (WHO 2000). For both BMI and WC responses were categorised by the author as obese or not obese.

Similar to the cardio-metabolic risk factors, angina, myocardial infarction, heart failure, stroke, transient ischaemic attack (TIA), stent/vascular surgery was self-reported based on ever having a doctor's diagnosis of these conditions (Appendix 2). Participants with none of these conditions or having not undergone a stent or vascular surgery were classified by the author as having no CVD while participants with the presence of one or more of these conditions or having undergone a stent or vascular surgery were classified as having CVD.

The timed up and go (TUG) was administered during the health assessment (Appendix 4). The TUG is a well-known and widely used test of functional mobility and often used to recognise frailty among older adults. Participants were required to wear regular footwear and the use of any mobility aids that they would normally require was permitted. Participants were asked to rise from a standard arm chair at an approximate height of 46 cm, walk forward for 3 meters, turn around and return to their starting position in a seated position. A score of less than 12 seconds was used by the author as a cut off to identify normal mobility among the sample (Podsiadlo & Richardson 1991). Savva *et al.* (2013) demonstrated that using a cut off over ≥ 12 seconds has sensitivity and specificity of 72% and 86% and 31% and 96% for identifying frail and pre-frail older adults, respectively. In addition, TUG has high test-retest reliability in community dwelling older adults (Shumway-Cook *et al*. 2000) and correlates well with other functional assessments such as gait speed and the Berg Balance Scale (Ng & Hui-Chan 2005).

Grip strength was measured objectively during the TILDA home or health assessment using a Baseline hydraulic hand dynamometer (Appendix 4). Hand jewellery was removed prior the test and the handle was set making sure that the four fingers rested comfortably on the grip. Participants were instructed to squeeze the device with maximum force ensuring that the forearm was at a right angle to their upper arm. This test was carried out standing however, if necessary, participants were allowed to sit down, upright. Also, if the dynamometer was too heavy to hold, the participant was allowed to rest the instrument on their free hand or obtain help from the nurse on site. Four measurements were recorded (2 on each hand) to the nearest whole number in kilograms. Mean grip strength on the dominant hand was used. Grip strength lower than 32.45 Kg and 18.20 Kg were used by the author to determine muscle weakness in older men and women, respectively (Dong *et al.* 2014).

Quality of life (QoL) was assessed in the SCQ by the CASP-19 (Appendix 3). This instrument is widely used in older adult populations and is a quick and multidimensional scale with good psychometric properties. The instrument is made up of four domains including control, autonomy, self-realization and pleasure. These domains are represented by 19 items and participants are asked to indicate how often (often, sometimes, not often, or never) each statement applies to them. Each item in the scale is scored on a 4-point Likert scale (0 – 3) and a total mean score is calculated with a range of 0 – 57 with higher scores representing better quality of life. CASP-19 has been shown to be a valid and reliable instrument to assess QoL and has been used in over 20 countries worldwide (Hyde *et al*. 2015).

Table 3.2: Operationalisation and Coding Protocols for Physical Health Predictors

Measure	Operationalisation
Chronic Health Problem	0 = No 1 = Yes
Self-rated Physical Health	0 = Fair/poor 1 = Excellent/ V.good /good
Self-rated Vision	0 = Fair/poor 1 = Excellent/ V.good /good
Self-rated Hearing	0 = Fair/poor 1 = Excellent/ V.good /good
Functional Limitations	0 = Not Disabled 1 = IADL/ADL Disability
Obesity (BMI)	0 = Not Obese 1 = Obese
Abdominal Obesity (WC)	0 = Not Obese 1 = Obese
High Blood Pressure	0 = No 1 = Yes
High Cholesterol	0 = No 1 = Yes
Diabetes	0 = No 1 = Yes
Falls in the Last Year	0 = No 1 = Yes
Fear of Falling	0 = No 1 = Yes
Troubled with Pain	0 = No 1 = Yes
Life Threatening Illness or Accident	0 = No 1 = Yes
Timed up & go	0 = Normal Mobility (< 12 secs) 1 = Functional Decline (≥ secs)
Grip Strength	0 = No Muscle Weakness (Female ≥32.45kg; Male ≥18.20kg) 1 = Muscle Weakness (Female < 32.45kg; Male < 18.20kg)
Quality of Life (QoL) (CASP)	Range: 0 – 57

ADL = Activities of daily living; IADL = Instrumental activities of daily living; BMI = Body Mass Index; WC = Waist Circumference; QoL = Quality of Life; CASP = Control, Autonomy, Self-realisation and Pleasure.

3.8.4 Mental Health

Participants self-rated their mental health as excellent, very good, good, fair or poor, in the CAPI. Responses were further condensed by the author into two categories fair/poor or excellent / very good / good self-rated mental health. Depression was assessed in the CAPI by the Centre for Epidemiological Studies Depression Scale (CES-D) (Radloff, 1977), a measure which has been widely used in epidemiological studies to measures symptoms of depression in general populations over the age of 18 (Appendix 2). The self-report scale measures major components of depressive symptoms over the past 7 days including feelings of depressive mood, guilt, worthlessness as well as loss of appetite and sleep trouble. This 20-item measure is scored on a 4-point Likert scale (0 – 3) for frequency of symptoms to each of the items on the scale (rarely / none of the time, some of the time, most of the time or all of the time). A total score ranged from 0 – 60, the higher the score the greater the depression and the author used a score of > 16 which indicated clinically significant depressive symptoms. Studies have supported the sensitivity, specificity, reliability and validity of the CES-D among and community dwelling and ethnically diverse older adults (Radloff 1977; Beekman *et al.* 1997; Mui *et al.* 2001; van de Rest *et al.* 2010).

Anxiety was assessed in the SCQ by with the Hospital Anxiety Depression Scale anxiety subscale (HADS-A) (Zigmond & Snaith 1983) (Appendix 3). The widely used self-report scale which excludes somatic symptoms measures current anxiety symptoms in non-psychiatric patients. This 7-item subscale requires participants to specify how well particular statements currently describe their feelings. Each item in the scale is scored on a 4-point Likert scale (0 – 3) with scores ranging from 0 – 21. Higher scores indicate higher levels of anxiety and the author used a score of ≥8 was to classify participants with anxiety (Bjelland *et al.* 2002, Croon *et al.* 2005, *Olssøn et al.* 2005, Hinz & Brähler 2011). Psychometric properties were assessed in the older population and the internal consistency was satisfactory ranging from 0.71 to 0.90 (Spinhoven *et a*l. 1997).

Loneliness was assessed in the SCQ by a modified 5 item version of the University of California-Los Angeles (UCLA) Loneliness scale (Russell *et al.* 1978) (Appendix 3). The scale is widely used to assess subjective feelings of loneliness. For example, participants were asked "how often do you feel left out?" and "how often do you feel lonely?" with total scores ranging from 0-10 with higher scores indicating greater feelings of loneliness. McCrory *et al* (2016) showed that the 5-item scale was reliable with a satisfactory Cronbach alpha of 0.79.

Table 3.3: Operationalisation and Coding protocols for Mental Health Predictors

Measure	**Operationalisation**
Self-rated Mental Health	0 = Fair/poor 1 = Excellent/V.good /good
Depression (CESD)	Range: 0 – 60
Anxiety (HADS – A)	Range: 0 – 21
Loneliness (UCLA)	Range: 0 – 10

CESD = Center for Epidemiological Studies-Depression; HADS-A = Hospital Anxiety and Depression Scale; UCLA = University of California Los Angeles

3.8.5 Cognitive Health

Cognitive health was assessed during the health assessment using the Mini-Mental State Examination (MMSE) (Folstein *et al.* 1975) and the Montreal Cognitive Assessment (MOCA) (Nasreddine *et al.* 2005) (Appendix 4). The MMSE is widely used in clinical and research settings to screen and assess cognitive impairment. The questionnaire contains nineteen items on orientation, recall and recent memory, abstract thinking, attention and calculation, recall, language, and object identification which is scored from 0 – 30 with a single point given for each correct answer. Previous research has demonstrated that the assessment has good reliability with inter correlations of 0.89 (Folstein *et al.* 1975) and an internal consistency with an alpha coefficient of 0.78 (McDowell *et al.* 1997). The conventional cut-off score of < 24 shows a sensitivity and specificity of 63% and 96% however Kukull *et al.* (1994) recommends using a higher cut of 26 or 27. Nasreddine *et al.* (2005) recognised a cut-off score of 26, had a sensitivity and specificity of 78% and 100%, respectively. This study used the cut off score of 26 to detect cognitive impairment.

The Montreal Cognitive Assessment (MOCA) was also used to assess cognitive impairment among the sample. The MOCA has been known as a quicker and more sensitive assessment than the MMSE and has been recognised as a better screening tool for measuring mild cognitive impairment among older adults (Nasreddine *et al.* 2005; Smith *et al.* 2007; Hoops *et al*. 2009). The measure assesses many cognitive domains including attention and concentration, executive function, memory, language, visuoconstructional skills, conceptual thinking, calculations, and orientation. The 30 item measure shows good internal consistency with a Cronbach alpha of 0.83 (Nasreddine *et al.* 2005). Although the recommended cut off score of 26 has been recognised, a lower cut-off score of 22 was used in this thesis as it shows better sensitivity (96%) and specificity (95%) in detecting cognitive impairment (Tu *et al.* 2013). In addition, a lower score reduces the false positive rate and shows overall better diagnostic accuracy (Carson *et al.* 2017).

Table 3.4: Operationalisation and Coding Protocols for Cognitive Health Predictors

Measure	Operationalisation
MMSE	0 = Normal (≥26) 1 = Mild/Moderate/Severe (<26)
MOCA	0 = Normal (≥22) 1 = Cognitive impairment (<22)

MMSE = Mini–Mental State Examination; MOCA = Montreal Cognitive Assessment

3.8.6 Behavioural Health

Physical activity levels at baseline and at follow up were assessed in the CAPI using the International Physical Activity Questionnaire short form (IPAQ-SF) (Appendix 1). The IPAQ-SF is a 7 item self-report questionnaire used widely and internationally to assess total physical activity levels (Transport, occupation, household and leisure domains) in four activity domains including vigorous physical activity, moderate physical activity, walking and sitting (Craig *et al.* 2003). Results of these activities excluding sitting time can be converted into metabolic equivalent-minutes per week (MET-min/week) which represents the amount of energy expended carrying out physical activity. Using an average MET score for each domain (walking - 3.3, moderate physical activity - 4.0 and vigorous physical activity - 8.0), total MET minutes per week is calculated as follows:

Total MET minutes/week =

Walking (3.3 METs × minutes × days) + Moderate (4.0 METs x minutes x days) + Vigorous (8.0 METs x minutes x days)

Scores can be further categorised into low (0-599 METs), moderate (600 – 2999 METs) or high (>3000 METS) physical activity levels http://www.ipaq.ki.se/ipaq.htm. The author categorised participants who were classed as moderate or highly active meet the recommended physical activity guidelines (U.S. Department of Health and Human Services, 2008) while those categorised as low, did not meet the guidelines. Physical activity levels were then categorised in line with national and international standards as active (i.e. meeting the recommended guidelines) or inactive (i.e. not meeting the recommended guidelines) (Department of Health and Children / Health Service Executive, 2009). IPAQ has been validated in adults across 12 countries (Craig *et al*. 2003; Bauman *et al.* 2009). In older adults, Tomioka *et al.* (2011) examined the reliability and validity of the IPAQ in an older Japanese sample. The authors documented that while the reliability of IPAQ was not sufficient however; it was a valid and useful instrument for assessing physical activity in older adults. In addition, Tran *et al.* (2013) found that IPAQ-SF was a reliable and valid instrument to assess physical activity in older adults.

Sitting time was also assessed during the CAPI within the IPAQ. Participants were asked how many hours they spent sitting at work, at home, while doing course work or during leisure time in the last 7 days (Appendix 2). This study used a cut off score of ≥8 hours sitting based on literature suggesting harmful effects of sedentary behaviours of more than 8 hours per day (Rosenkranz *et al*. 2013). In addition, smoking status and trouble sleeping was assessed during the CAPI (Appendix 2). Participants self-reported whether they were non-smokers, former or current smokers and responses were categorised by the author as being a current smoker or non-smoker / former smoker. Trouble sleeping was assessed by participants self-reporting how often they had trouble falling asleep. Responses were categorised as most of the time, sometimes or rarely or never have trouble sleeping (Ganguli *et al.* 1996, Bonanni *et al.* 2010). The responses were further condensed by the author into two categories most of the time / sometimes or rarely / never have trouble sleeping.

Assessment of an alcohol problem was measured in the SCQ by the CAGE questionnaire (Mayfield *et al.* 1974). The CAGE questionnaire consists of four items regarding alcohol use (Appendix 3). Participants are asked if they ever felt they should cut down on their drinking, felt annoyed that people criticised their drinking, felt guilty about their drinking and if they had ever had a drink first thing in the morning to steady the nerves or get rid of a hangover. Responses on the questionnaire are scored 0 for no or 1 for yes and a score of 2 or greater is considered an alcohol problem. A review by Dhalla & Kopec (2007) recognised that the CAGE questionnaire has high test-retest reliability (0.80-0.95) and is a suitable screening tool for use in clinical practices.

Table 3.5: Operationalisation and Coding Protocols for Behavioural Health Predictors

Measure	Operationalisation
Alcohol problem (CAGE)	0 = No 1 = Yes
Smoker	0 = Past / Never 1 = Current
Physical Activity (IPAQ)	0 = Inactive (Low) 1 = Active (Moderate / High)
Trouble Sleeping	0 = Most / Sometimes 1 = Rarely or Never
Sitting Time (IPAQ)	0 = < 8 1 = ≥ 8

CAGE = **C**ut down, **A**nnoyed, **G**uilt, **E**ye opener; IPAQ = International Physical Activity Questionnaire.

3.9 Statistical Procedures and Data Analysis

All analyses were conducted in SPSS version 24 (IBM 2016).

High reliability and validity of research instruments are necessary for quality quantitative research (Polit & Beck 2003). All the scales used in this study have been deemed reliable and valid by other researchers in previous studies. Nevertheless, internal reliability for each instrument used in this study was again tested by the researcher using SPSS and resultant data is presented in Appendix 6. Internal consistency which measures stability within the instrument is the most commonly used reliability method in nursing research. According to Lacobucci & Duhachek (2003 p. 486) "researchers should report the standardized alpha for the philosophical reason that the scales of our measurements tend to be arbitrary". Internal consistency is regarded as satisfactory with values between 0.70 and 0.90 (Nunnally & Bernstein 1994, Bresciani *et al.* 2009), however a Cronbach's alpha of 0.60 is acceptable and sufficient in exploratory research (Loewenthal 2004 & Hair *et al.* 2006). The instruments were deemed valid because they measure what they intend to measure (Keele 2011).

Descriptive statistics of the sample characteristics are illustrated using numbers, percentages, means and standard deviations as appropriate, under the following headings; socio-demographics, social engagement, physical health, mental health, cognitive health and behavioural health. Following descriptive analysis of the physical activity data from the IPAQ, all participants were divided into two groups on the basis of meeting the recommended physical activity guidelines or not and physical activity level was recorded as a dichotomous variable, "active" or "inactive". Descriptive statistics using numbers, percentages, means and standard deviations were used to present the sample characteristics based on their physical activity level. Comparison of the differences in the proportions/means of the predictor variables between the two groups (active vs inactive) was done by chi-square analyses for the categorical predictor variables and univariate logistic regression for the continuous predictor variables.

As the outcome variable – physical activity was dichotomous, multivariate logistic regression analysis using manual backward elimination was the chosen technique to identify significant predictors of physical activity. This method of analysis is an efficient and powerful technique to assess predictor variables contributions to a dichotomous outcome. However, accuracy may depend on some critical factors and assumptions including variable selection, sample size, linearity of the logit, independence of errors and multicollinearity. These critical factors and assumptions of multivariate logistic regression were first tested prior final data analysis.

All potential factors associated with physical activity in this thesis were selected based on previous research guided by the literature from both cross sectional and longitudinal studies. Comparison of the differences in the proportions/means of the predictor variables between those physically active or physically inactive was done by chi-square analyses for categorical variables and univariate logistic regression for continuous variables. Any variable with a p value of less than 0.25 was considered for the final model and variables with p values greater than this were manually excluded from the models. This cut off value is supported in the literature (Bendal & Afifi 1977, Mickey *et al* 1989, Zhang *et al* 2016). Using a less rigorous p-value than the conventional levels of p value (0.05) used for significance has the advantage of including more variables in the analysis and also precludes against the exclusion of potentially important predictors (Hosmer & Lemeshow 2000, Tabachnick & Fidell 2007, Bursac *et al.* 2008). To test the assumption of multicollinearity, correlation analysis was utilised to test the relationship between the independent variables. According to Tabachnick & Fidell (2012), correlation coefficients less than 0.90 avoid multicollinearity issues. Linearity of the logit was tested by looking at the interaction term of the continuous independent variables with their natural log. Significance of greater than 0.05 indicated that the assumption of linearity of logit was met (Field 2009, p. 296).

After testing for assumptions and selecting appropriate variables, a multivariate logistic regression analysis was conducted using manual backward elimination in SPSS to determine what are the main predictors of baseline physical activity among community dwelling older adults (3.2: Research question 2). Backward elimination method starts with the full model which includes all predictor variables and removes insignificant variables from the model (Sarkar *et al.* 2010). Data was presented as adjusted odds ratios (OR) and 95% confidence intervals (CI) of the likelihood of being physically active. Alpha was set at significance 0.05.

Logistic regression models were also used to determine the impact of physical activity on the cardio-metabolic risk factors (3.2: Research questions 3a-e) and CVD (3.2: Research question 4). Five separate unadjusted logistic regression models were utilised to provide significance of effect, odds ratios (ORs) and 95% confidence intervals (CIs) for the associations between physical activity and each of the cardio-metabolic risk factors (high blood pressure, high cholesterol, diabetes, obesity (BMI) and abdominal obesity (WC). Additionally, separate models were adjusted for potential confounding covariates based on the literature including demographics factors (age, gender and education) and adding behavioural risk factors (smoking and alcohol) in the final model.

Similarly, an unadjusted logistic regression model was utilised to provide significance of effect, odds ratios (ORs) and 95% confidence intervals (CIs) for the association between physical activity and cardiovascular disease. Separate models were also adjusted for potential confounding covariates including demographics factors (age, gender and education) in model 2, adding behavioural risk factors (smoking and alcohol) in model 3 and adding the cardio-metabolic risk factors in the final model 4.

To assess research questions 5 a – e (3.2), namely, the mediating effect of cardio-metabolic risk factors in the relationship between physical activity and cardiovascular disease, procedures outlined by Baron & Kenny (1986) and Judd & Kenny (1981) were initially employed. For these models, the outcome (CVD) and mediator variables were dichotomous and therefore logistic regression analysis was utilised. The coefficients obtained from logistic regression were standardized to make them comparable before the Sobel test (Sobel 1982) was applied for the mediation analysis. Specifically, each coefficient was multiplied by the standard deviation of the predictor variable and divided by the standard deviation of the response variable in the corresponding equation. Herr (2016) utilised equations from MacKinnon & Dwyer (1993) to conduct such a mediation analysis technique with dichotomous outcomes (http://www.nrhpsych.com/mediation/logmed.html) (Appendix 7 & 8). The coefficients were then entered into the Sobel test calculator obtained electronically from http://www.quantpsy.org/sobel/sobel.htm. This was utilised in this study to test whether cardio-metabolic risk factors mediated the relationship between physical activity and CVD. Mediation was assumed if (a) physical activity significantly predicted the cardio-metabolic risk factors, (b) physical activity significantly predicted CVD without the cardiovascular risk factors in the model, (c) cardio-metabolic risk factors predicted CVD, and (d) the effect of physical activity on CVD was significantly reduced when cardio-metabolic risk factors were added to the model. The Sobel test was used to test this mediation through assessing whether a critical ratio from the predictor variable on the response variable through the mediator was significantly different from zero.

Next the patterns of physical activity change from baseline to follow up were assessed (3.2: Research question 6). Similar to baseline categorisation of physical activity levels, participants were categorised as inactive and active using the follow up data. Active participants at both time points were categorised as active maintainers, while those inactive at both time points were classed as inactive maintainers. Participants active at baseline but who were inactive at follow up were categorised as relapsers while those inactive at baseline and were active at follow up were classed as adopters. The patterns of physical activity change are presented as numbers and percentages. In addition, the characteristics of the sample according to their physical activity behaviour are described in numbers, percentages, means and standard deviations where appropriate.

Finally the predictors of physical activity change were determined (3.2: Research questions 7a and b). Similar to baseline analysis and using the same procedure to analyse predictors of baseline physical activity, two separate multivariate logistic regression models were utilised to assess predictors of the different physical activity change patterns. The first multivariate logistical model compared the groups active at baseline and their physical activity status at follow up (Active Maintainers vs Relapsers) and the second multivariate logistical model compared the groups inactive at baseline (Inactive Maintainers vs Adopters) and their physical activity status at follow up.

Sample size estimation for the multivariate logistic regression models was calculated based on the guidelines of Peduzzi *et al*. (1996) for a minimum sample size (N) required for sufficient power for the research. A general rule of thumb for determination of sample size for multiple logistic regressions is a minimum of 10 events per predictor variable (EPV).

$$N = 10\,k / p$$

Where p is the smallest proportion of cases in the population

Where k is the number of predictors

Based on 35 independent variables (Tables 3.1 – 3.5) and the proportion of inactive participants (35%) at baseline, the maximum number of participants needed to conduct a powered multivariate logistic regression model was 1000.

$$1000 = 10\,(35) / 0.35$$

Missing data diagnosis was conducted on the dataset to understand the patterns and randomness of the missing data. Missing data analysis showed that the missing data for some of the independent variables was not missing completely at random (MCAR). Multiple imputation techniques cannot handle data missing not at random ((MNAR) (de Goeij et al (2013). As a result, listwise deletion was the chosen technique for dealing with such data. Listwise deletion is the most common and frequently used method in dealing with missing data (Kang 2013). Although, the advantages of listwise deletion include its straightforwardness and use of a complete data set, the procedure may cause bias in the estimates of the parameters (Donner 1982) and the total sample size can be substantially reduced resulting in a loss of statistical power (Allison 2001). However, due to the large sample size and using the methods described above, listwise deletion did not adversely affect statistical power in our analysis. Of all variables examined, only 6 variables had missing data greater than 2% (Appendix 5). According to Schafer (1999) missing data of less than 5% is unlikely to be biased while greater than 10% is likely to have consequential issues with bias estimates (Bennett 2001).

CHAPTER 4

RESULTS

4.0 Introduction

This study utilised the data collected in The Irish Longitudinal Study on Ageing (TILDA) (http://www.tcd.ie/tilda/). TILDA is a groundbreaking epidemiological study on community dwelling adults aged 50 and over who are living in Ireland. This research is a component of the TILDA study which aimed to (i) assess the patterns and predictors associated with physical activity and (ii) assess the impact of physical activity on cardiovascular disease (CVD) and cardio-metabolic risk factors in adults aged 65 and over. This chapter will present the findings of this research. First, the sample population and percentage response rate will be described with the inclusion criteria for baseline and follow up analysis.

Phase 1: Baseline Data – The descriptive characteristics of the sample and all variables will be described under the following headings; Socio-demographic, social engagement, physical health, mental health, cognitive health and behavioural health. Next, the physical activity levels (4.3) and predictors of baseline physical activity are presented (4.4 and 4.5). Following this, the results examining the impact of physical activity on CVD and the cardio-metabolic risk factors are presented (4.6 and 4.7). Finally, results of the mediation analysis examining the role of cardio-metabolic risk factors in the relationship between physical activity and CVD are presented (4.8).

Phase 2: Follow up Data – For phase 2 of the results, the physical activity levels at follow-up are described followed by their categorisation into four patterns of PA change (4.9 and 4.10). Analysis comparing participants active at baseline and their status at follow up (Active maintainers vs Relapsers) and the participants inactive at baseline and their status at follow up (Inactive Maintainers vs Adopters) are presented separately (4.11 to 4.13).

4.1 Sample

Figure 4.1 describes the sample utilised for this research. As previously mentioned (3.6), a total of 8,175 community dwelling adults aged 50 and older participated in the TILDA study at baseline (response rate 62%). Of the 8,175 original wave 1 participants, 6995 completed wave 2 (86% response rate) (Kearney *et al*. 2011, Kenny *et al.* 2010). The total sample utilised for this research included 2360 community dwelling older adults who were; i) aged 65 and over ii) completed the International Physical Activity Questionnaire (IPAQ) and iii) attended a health assessment at home or at a TILDA health centre at wave 1 (Baseline). In total, 2360 (29% of original TILDA sample at baseline) participants were included in all baseline analysis (Phase 1). Of the 2360 participants at baseline, 2076 (88%) completed the IPAQ at wave 2 (Follow up) and were included in follow up analysis (Phase 2).

Based on the work of Peduzzi *et al.* (1996) the following procedure was adopted to establish the minimum number of participants required for the analysis.

N = 10 k / p

Where p is the smallest proportion of cases in the population

Where k is the number of predictors

In the baseline analysis of physical activity, 828 or 35% participants did not meet the physical activity guidelines. In total, 16 predictor variables were considered for the final multivariate logistic model suggesting that 457 participants were needed for the baseline logistic regression analysis.

N = 10 x 16 / 0.35 = 457 (minimum sample size)

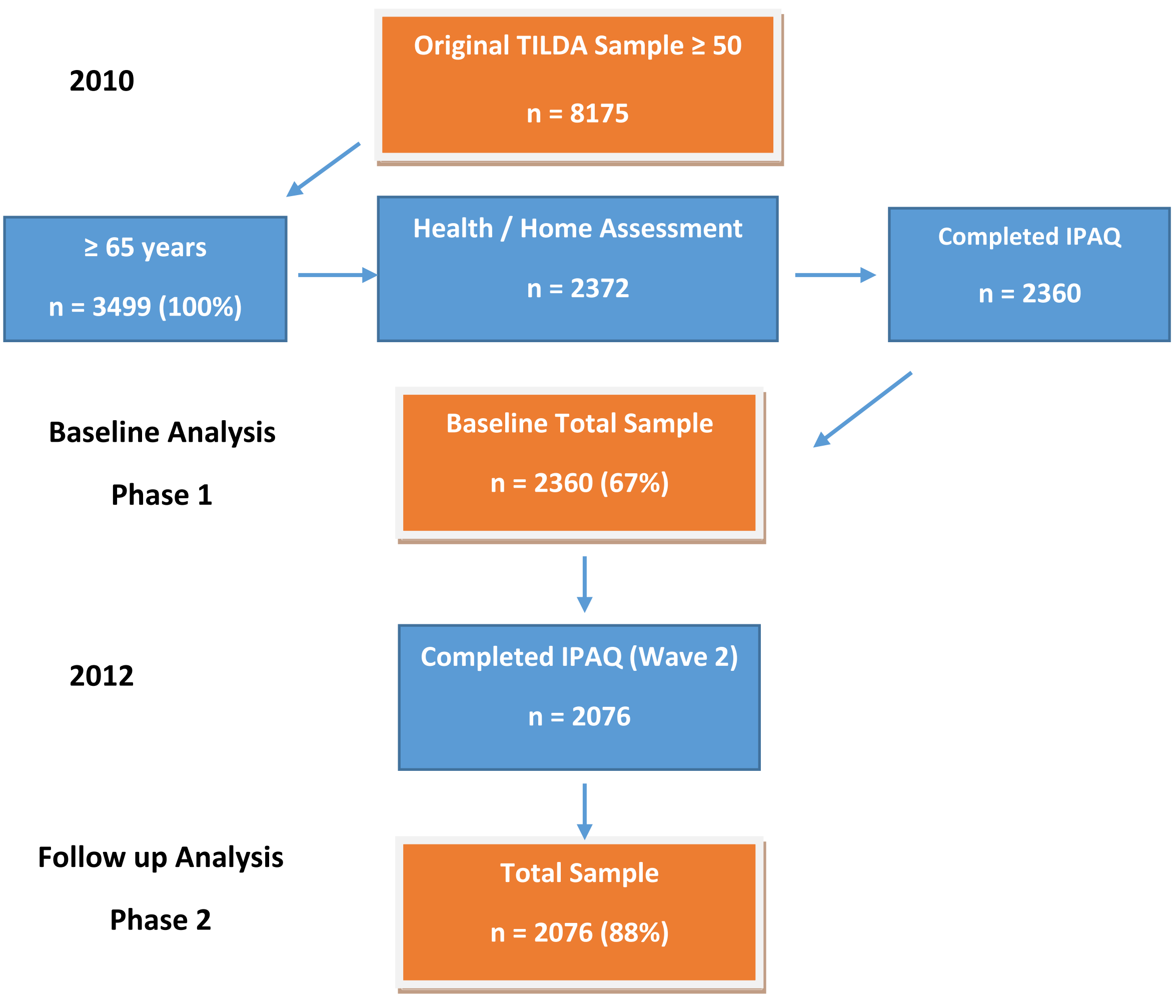
In the follow up analysis of physical activity change, 359 (26%) and 256 (37%) participants adopted and relapsed, respectively. In total, 10 predictors were included in the active maintainers vs relapsers final model and 7 predictors were included in the inactive maintainers vs adopters final model suggesting that 385 and 189 participants were needed for the follow up logistic regression analysis, respectively.

N = 10 x 10 / 0.26 = 385 (minimum sample size)

N = 10 x 7 / 0.37 = 189 (minimum sample size)

Figure 4.1: Sample utilised from TILDA for baseline and follow up analysis

Phase 1: Baseline Data



4.2 Characteristics of the Sample

4.2.1 Socio-demographics and Social Engagement

As indicated in Table 4.1, the largest of the sample was aged 65 – 69 (38%), 52% were female and 63% were married / partnered. Of the sample, 27% had a third level education and over 70% were retired.

Table 4.1: Socio-Demographic and Social Engagement Characteristics
(n = 2360 unless otherwise indicated)

Variable	Category	N (%)
Age	65 – 69 70 – 74 ≥ 75	897 (38) 660 (28) 803 (34)
Gender	Male Female	1131 (47.9) 1229 (52.1)
Education (n = 2357)	Primary Secondary Tertiary	910 (38.6) 812 (34.5) 635 (26.9)
Employment Status	Retired Employed Unemployed/Other	1685 (71.4) 222 (9.4) 453 (19.2)
Medical Cover (n = 2359)	Not Covered Medical Insurance Medical Card	86 (3.6) 616 (26.1) 1657 (70.2)
Location (n = 2358)	Urban Rural	1303 (55.3) 1055 (44.7)
Marital Status	Not Partnered Married / Partnered	877 (37.2) 1483 (62.8)
Social Connectedness (n = 2178)	Socially Isolated Socially Integrated	595 (27.3) 1583 (72.7)

4.2.2 Physical Health

Table 4.2 presents the physical health characteristics of the sample. As indicated in table 4.2, 45% had a chronic or long-term health problem while 74%, 89% and 80% of participants self-rated their physical health, vision and hearing as excellent, very good or good, respectively. Using the WHO (2009) cut offs to classify obesity as measured by BMI (≥ 30 kg/m^2) and abdominal obesity by waist circumference (≥ 102 cm - Male; ≥ 88 cm - Female), 35% and 55% of the sample were classified as obese and abdominally obese, respectively.

Of the sample, 23% experienced a fall in the last year and 38% of participants were often troubled with pain. Furthermore, using cut off points to assess muscle weakness as measured by grip strength (< 32.45 kg – Males; < 18.20 kg - Females) (Dong *et al*. 2014) and mobility impairment by the timed up and go functional assessment (> 12 secs) (Bischoff *et al.* 2003), 59% and 19% had muscle weakness and a functional mobility impairment, respectively. Nearly a quarter (24.7%) of the participants reported having a life-threatening illness or accident. Finally, quality of life scores assessed by the CASP-19 ranged from 10 to 57 (M = 45.01; SD = 7.08) with higher scores indicating better quality of life.

Table 4.2: Physical Health Characteristics
(n = 2360 unless otherwise indicated)

Variable	Category	N (%)
Chronic Health Problem (n = 2358)	No Yes	1300 (55.1) 1058 (44.9)
Self-Rated Physical Health	Fair/Poor Excellent/V.good/Good	623 (26.4) 1737 (73.6)
Self-Rated Vision	Fair/Poor Excellent/V.good/Good	264 (11.2) 2096 (88.8)
Self-Rated Hearing	Fair/Poor Excellent/V.good /Good	478 (20.3) 1882 (79.7)
Functional Limitations	Not Disabled IADL/ADL Disability	1944 (82.4) 416 (17.6)
Obesity (BMI) (n = 2341)	No Yes	1516 (64.8) 825 (35.2)
Abdominal Obesity (WC)	No Yes	1069 (45.3) 1291 (54.7)
High Cholesterol	No Yes	1338 (56.7) 1022 (43.3)
Diabetes	No Yes	2113 (89.5) 247 (10.5)
High Blood Pressure	No Yes	1244 (52.7) 1116 (47.3)
Falls in the last year (n = 2359)	No Yes	1808 (76.6) 551 (23.4)
Fear of Falling (n = 2357)	No Yes	1640 (69.6) 717 (30.4)
Troubled with Pain (n = 2358)	No Yes	1466 (62.2) 892 (37.8)
Life Threatening Illness / Accident (n = 2094)	No Yes	1576 (75.3) 518 (24.7)
Timed Up & Go (n = 2316)	Normal mobility Functional mobility impairment	1872 (80.8) 444 (19.2)
Grip Strength (n = 2319)	No muscle weakness Muscle weakness	968 (41) 1392 (59)
Quality of Life (n = 1768)	Mean (SD) (Range 10-57)	45.01 (7.1)

BMI = Body mass index; WC = Waist circumference; ADL = Activities of daily living; IADL = Instrumental activities of daily living.

4.2.3 Mental Health

As indicated in Table 4.3, 91% of participant's self-rated their mental health as excellent, very good or good. Overall, depression scores ranged from 0 – 53 (M = 5.45, SD = 6.4). These figures on further examination reflect that 75% of participants had no or mild depressive symptoms while nearly 8% had severe depressive symptoms. In addition, anxiety scores ranged from 0 – 21 (M = 4.72, SD = 3.41) with 19% reaching clinical anxiety levels (≥8) (Bjelland *et al.* (2002). Finally, loneliness scores ranged from 0 – 10 (M = 1.93, SD = 2.13) with higher score indicating feelings of loneliness.

Table 4.3: Mental Health Characteristics
(n = 2360 unless otherwise indicated)

Variable	Category	N (%)
Self-Rated Mental Health (n = 2359)	Fair/Poor Excellent/V.good/Good	210 (8.9) 2149 (91.1)
Depression (n = 2318)	Mean (SD) (Range 0 – 53)	5.45 (6.4)
Anxiety (n = 2060)	Mean (SD) (Range 0 – 21)	4.72 (3.41)
Loneliness (n = 2084)	Mean (SD) (Range 0 – 10)	1.93 (2.13)

4.2.4 Cognitive Health

Using previously established cutoff points of ≥ 26 and ≥ 22 by Djuradin *et al.* (2010) and Freitas *et al*. (2013) for the MMSE and the MOCA tests for normal cognitive function, nearly 85% and 73% of the sample had normal cognitive function, respectively (Table 4.4).

Table 4.4: Cognitive Health Characteristics

(n = 2360 unless otherwise indicated)

Variable	Category	N (%)
MMSE	Normal Cognitive Function Mild/Moderate/Severe	1989 (84.6) 362 (15.4)
MOCA	Normal Cognitive Function Cognitive Impairment	1709 (73.2) 625 (26.8)

MMSE = Mini–Mental State Examination; MOCA = Montreal Cognitive Assessment

4.2.5 Behavioural Health

As indicated in table 4.5, 12% of participants were current smokers, 37% had trouble falling asleep and less than 8% were classed as problem drinkers. Using cut off points established by van der Ploeg *et al.* (2012), 14% of participants spent 8 or more hours sitting per day.

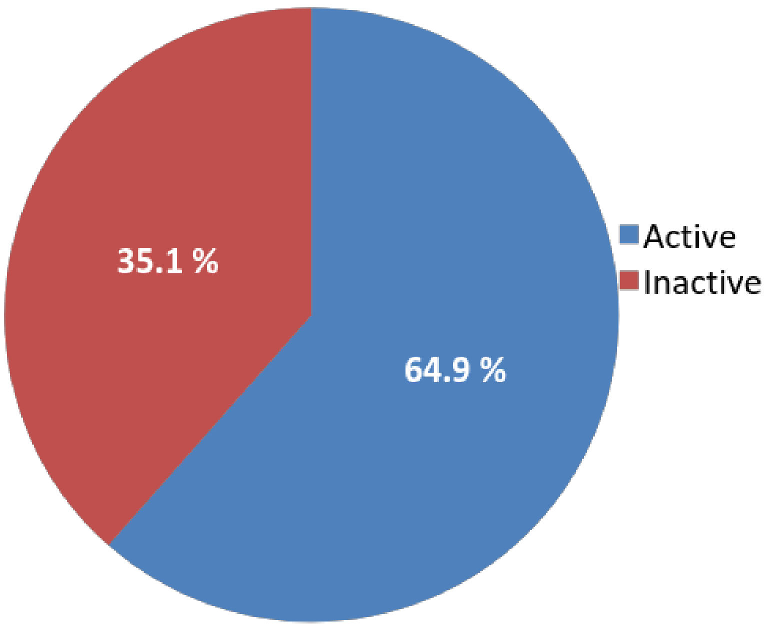
Table 4.5: Behavioural Health Characteristics
(n = 2360 unless otherwise indicated)

Variable	Category	N (%)
Smoking	Never / Past Current	2080 (88.1) 280 (11.9)
Trouble Falling Asleep	Rarely/never Sometimes/Always	1494 (63.3) 866 (36.7)
Alcohol Problem (n = 2115)	No Yes	1952 (92.3) 163 (7.7)
Time Spent Sitting (n = 2341)	< 8 ≥8	2015 (86.1) 326 (13.9)

4.3 Physical Activity Levels at Baseline

The distribution of participants Active and Inactive at Baseline is presented in Figure 4.2. At baseline, 1532 (65%) were sufficiently active according to the national physical activity guidelines while 828 (35%) did not meet the recommended criteria (U.S. Department of Health and Human Services, 2008; Department of Health and Children, 2009).

Figure 4.2: Distribution of the Sample Active and Inactive at Baseline



4.4 Bivariate Factors Associated with Baseline Physical Activity

4.4.1 Socio-demographic and Social Engagement Factors Associated with Baseline Physical Activity

The association between the socio-demographic and social engagement variables with physical activity levels at baseline are presented in Table 4.6. In this sample of community dwelling older adults aged 65 and over, the lowest proportion of participants meeting the physical activity guidelines was among the oldest age groups (70 -74 and ≥75). Those in the oldest age group (75 years and older), had the lowest proportion of active participants with 54% compared to the youngest group (65 – 69) which had had the highest with 73% ($p < 0.05$). A greater proportion of males (72%) than females (59%) reported being physically active ($p < 0.05$). In addition, those with the highest level of education (third level) had the greatest proportion of physically active participants with 74% while those with a primary education had the lowest with 62% ($p < 0.05$). A higher proportion of employed participants (79%) met the physical activity guidelines compared to those retired or unemployed with 67% and 50%, respectively ($p < 0.05$). Participants with a medical card had the lowest proportion of participants physically active with 60% and those with no medical cover had the highest proportion (79%) of people physically active ($p < 0.05$). A higher proportion of married (68%) participants were physical active compared to those not married (60%) ($p < 0.05$).

Finally, a higher proportion of participants who were socially integrated (68%) were physically active compared to those participants socially isolated (59%) ($p < 0.05$).

Table 4.6: Socio-Demographic and Social Engagement Factors Associated with Baseline Physical Activity (n = 2360 unless otherwise indicated)

Variable	Category	Inactive N (%)	Active N (%)	p - value[a]
Age	65 – 69 70 – 74 75 or over	239 (26.6) 217 (32.9) 372 (46.3)	658 (73.4) 443 (67.1) 431 (53.7)	≤0.001**
Gender	Male Female	318 (28.1) 510 (41.5)	813 (71.9) 719 (58.5)	≤0.001**
Education (2357)	Primary Secondary Tertiary	349 (38.4) 313 (38.5) 166 (26.1)	561(61.6) 499 (61.5) 469 (73.9)	≤0.001**
Employment	Retired Employed Unemployed/Other	557 (33.1) 46 (20.7) 225 (49.7)	1128 (66.9) 176 (79.3) 228 (50.3)	≤0.001**
Medical Cover (2359)	Not Covered Medical Insurance Medical Card	18 (20.9) 153 (24.8) 657 (39.6)	68 (79.1) 463 (75.2) 1000 (60.4)	≤0.001**
Location (2358)	Urban Rural	442 (33.9) 386 (36.6)	861 (66.1) 669 (63.4)	.177[+]
Marital Status	Not married Married	349 (39.8) 479 (32.3)	528 (60.2) 1004 (67.7)	≤0.001**
Social Connectedness (2178)	Socially Isolated Socially Integrated	242 (40.7) 506 (32%)	353 (59.3) 1077 (68%)	≤0.001**

[a] The p-values were obtained by Pearson chi-square test

[+] < 0.25; ** < 0.01

4.4.2 Physical Health Factors Associated with Baseline Physical Activity

The association between the physical heath variables with physical activity level at baseline are presented in Table 4.7. A greater proportion of participants with no chronic health problem (70%) were physically active compared to those with a chronic health problem (59%) ($p < 0.05$). A higher proportion of participants who self-reported their physical health (71% vs 48%), vision (67% vs 47%) and hearing (66% vs 60%) as excellent, very good or good compared to fair or poor were physical active ($p < 0.05$), respectively.

Participants reporting an IADL or ADL disability had the lowest proportion (40%) of participants meeting the guidelines while 70% of those with no disability had the highest proportion of participants physically active.

Obese and abdominally obese participants had the lowest proportion of people physically active with 59% and 61%, respectively, while those not obese or abdominally obese had the highest proportions of people physically active with 69% and 70%, respectively ($p<0.05$). Those who self-reported having high blood pressure and diabetes had a lower proportion of people physically active with 60% and 50%, respectively while those with no self-report high blood pressure and diabetes had the highest proportion with 69% and 67%, respectively ($p<0.05$). A greater proportion of participants with no fear of falling (72%) were physically active compared to those with a fear of falling (50%) ($p < 0.05$). A lower proportion of participants with functional mobility impairment (42%) and muscle weakness (59%) were physically active compared to those with normal mobility (71%) and no muscle weakness (73%) ($p < 0.05$). Participants who were troubled with pain had the lowest proportion (56%) of participants meeting the guidelines while 70% of those who were not troubled with pain had the highest proportion of participants physically active. Finally, those with a higher quality of life score were more likely to be physically active than inactive ($p < 0.05$).

Table 4.7: Physical Health Factors Associated with Baseline Physical Activity
(n = 2360 unless otherwise indicated)

Variables	Category	Inactive N (%)	Active N (%)	p - value[a]
Chronic Health Problem (2358)	No Yes	394 (30.3) 433 (40.9)	906 (69.7) 625 (59.1)	≤0.001**
Self-Rated Physical Health	Fair/Poor Excellent/V. good/Good	325 (52.2) 503 (29)	298 (47.8) 1234 (71)	≤0.001**
Self-Rated Vision	Fair/Poor Excellent/V.good/Good	141 (53.4) 687 (32.8)	123 (46.6) 1409 (67.2)	≤0.001**
Self-Rated Hearing	Fair/Poor Excellent/V. good/Good	190 (39.7) 638 (33.9)	288 (60.3) 1244 (66.1)	.017*
Functional limitations	Not Disabled IADL/ADL Disability	578 (29.7) 250 (60.1)	1366 (70.3) 166 (39.9)	≤0.001**
Obesity (BMI) (2341)	No Yes	474 (31.3) 342 (41.5)	1042 (68.7) 483 (58.5)	≤0.001**
Abdominal Obesity (WC)	No Yes	320 (29.9) 508 (39.3)	749 (70.1) 783 (60.7)	≤0.001**
High Cholesterol	No Yes	449 (33.6) 379 (37.1)	889 (66.4) 643 (62.9)	.075[+]
Diabetes	No Yes	705 (33.4) 123 (49.8)	1408 (66.6) 124 (50.2)	≤0.001**
High Blood Pressure	No Yes	384 (30.9) 444 (39.8)	860 (69.1) 672 (60.2)	≤0.001**
Falls in the last year (2359)	No Yes	617 (34.1) 210 (38.1)	1191 (65.9) 341 (61.9)	.086[+]
Fear of Falling (2357)	No Yes	468 (28.5) 358 (49.9)	1172 (71.5) 359 (50.1)	≤0.001**
Troubled with Pain (2358)	No Yes	437 (29.8) 390 (43.7)	1029 (70.2) 502 (56.3)	≤0.001**
Life Threatening Illness / Accident	No Yes	526 (33.4) 186 (35.9)	1050 (66.6) 332 (64.1)	.291
Quality of Life (1768)	Mean (SD)	42.7 (7.85)	46.14 (6.38)	≤0.001**
Timed Up & Go (2316)	Normal mobility Functional mobility impair.	539 (28.8) 258 (58.1)	1333 (71.2) 186 (41.9)	≤0.001**
Grip Strength (2319)	No muscle weakness Muscle weakness	260 (26.9) 568 (40.8)	708 (73.1) 824 (59.2)	≤0.001**

BMI = Body mass index; WC = Waist circumference; ADL = Activities of daily living; IADL = Instrumental activities of daily living

[a] The p-values were obtained by Pearson chi-square test for categorical variables or univariate logistic regression for continuous variables.

[+] < 0.25; * < 0.05; ** < 0.01

4.4.3 Mental Health Factors Associated with Baseline Physical Activity

The association between the mental health variables with physical activity level at baseline are presented in Table 4.8. A higher proportion of participants who self-reported their mental health as excellent, very good or good (66%) compared to fair or poor (50%) were physical active ($p < 0.05$). In addition, those with lower depression, anxiety and loneliness score were significantly more likely to be physical active compared to those with lower scores ($p < 0.05$).

Table 4.8: Mental Health Factors Associated with Baseline Physical Activity
(n = 2360 unless otherwise indicated)

Variable	Category	Inactive N (%)	Active N (%)	p - value[a]
Self-Rated Mental Health (2359)	Fair/Poor Excellent/V.good/Good	105 (50) 722 (33.6)	105 (50) 1427 (66.4)	≤0.001**
Depression (2318)	Mean (SD)	7.12 (7.53)	4.56 (5.48)	≤0.001**
Anxiety (2060)	Mean (SD)	4.97 (3.66)	4.59 (3.27)	.016*
Loneliness (2084)	Mean (SD)	2.27 (2.25)	1.76 (2.04)	≤0.001**

[a] The p-values were obtained by Pearson chi-square test for categorical variables or univariate logistic regression for continuous variables.
* < 0.05; ** < 0.01

4.4.4 Cognitive Health Factors Associated with Baseline Physical Activity

The association between the cognitive health variables with physical activity level at baseline are presented in Table 4.9. A higher proportion of participants with normal cognitive function (MMSE – 68%, MOCA - 71%) were physically active while participants with mild, moderate or severe cognitive impairment (MMSE - 48%, MOCA – 50%) had the lowest proportion of those physically active ($p < 0.05$).

Table 4.9: Cognitive Health Factors Associated with Baseline Physical Activity
(n = 2360 unless otherwise indicated)

Variable	Category	Inactive N (%)	Active N (%)	p-Value [a]
MMSE (2351)	Normal Cognitive Function Mild/Moderate/Severe	633 (31.8) 189 (52.2)	1356 (68.2) 173 (47.8)	≤0.001**
MOCA (2334)	Normal Cognitive Function Cognitive Impairment	501 (29.3) 313 (50.1)	1208 (70.7) 312 (49.9)	≤0.001**

MMSE = Mini–Mental State Examination; MOCA = Montreal Cognitive Assessment
[a] The p-values were obtained by Pearson chi-square test for categorical variables or univariate logistic regression for continuous variables.
** < 0.01

4.4.5 Behavioural Health Factors Associated with Baseline Physical Activity

The association between the behavioural health variables with physical activity level at baseline are presented in Table 4.10. A greater proportion of participants with an alcohol problem (74%) compared to not having an alcohol problem (65%) were physically active ($p < 0.05$). In addition, a higher proportion of participants who rarely or never had trouble falling asleep (68%) were physically active compared to those who sometimes or always had trouble falling asleep (60%) ($p < 0.05$). Finally, a lower proportion of participants who spent 8 or more hours sitting per day (37%) were physically active compared to those who spent less than 8 hours sitting per day (70%) ($p < 0.05$).

Table 4.10: Behavioural Health Factors Associated with Baseline Physical Activity
(n = 2360 unless otherwise indicated)

Variable	Category	Inactive N (%)	Active N (%)	p – Value [a]
Alcohol Problem	No Yes	680 (34.8) 43 (26.4)	1172 (65.2) 120 (73.6)	.029*
Smoking	Never / Past Current	717 (34.5) 111 (39.6)	1363 (65.5) 169 (60.4)	.089[+]
Trouble Falling Asleep	Rarely/Never Sometimes/Always	484 (32.4) 344 (39.7)	1010 (67.6) 522 (60.3)	≤0.001**
Time Spent Sitting	<8 hours ≥8 hours	614 (30.5) 205 (62.9)	1401 (69.5) 121 (37.1)	≤0.001**

[a] The p-values were obtained by Pearson chi-square test for categorical variables or univariate logistic regression for continuous variables.
[+] < 0.25; * < 0.05; ** < 0.01

4.5 Final Multivariate Analysis of the Factors Associated with Baseline Physical Activity

Main Findings – Research question 2 – Include Question

No variables violated the assumption of multicollinearity based on the correlational analysis of the independent variables for the final multivariate logic model. Logistic regression was applied to identify the variables independently associated with physical activity among the sample. Thirty (30) variables (Age, gender, education, employment, medical cover, marital status, social connectedness, chronic health problem, self-rated physical health, self-rated vision, self-rated hearing, functional limitations, obesity (BMI), abdominal obesity (WC), diabetes, high blood pressure, fear of falling, troubled with pain, quality of life, timed up & go, grip strength, self-rated mental health, depression, anxiety, loneliness, cognitive health (MMSE & MOCA), alcohol problem, trouble falling asleep and time spent sitting) that showed significant association (p < 0.05) after bivariate and univariate analysis were considered together in multivariate analysis. In addition, 4 variables (Location, high cholesterol, falls in the last year and smoking) with a p value of < 0.25 were also considered.

The initial model included all the variables from Tables 4.6 – 4.10 that were associated with physical activity with a p-value < 0.25. Life threatening illness or accident was removed from the initial model because it was not associated with physical activity based on the bivariate analysis.

Results from the initial logistic regression model with a total of 34 variables can be seen in appendix 9. To generate the most parsimonious model, backward elimination procedure was adopted in which final estimates for each variable yielded an adjusted OR and 95% CI for each factor retained in the model.

Overall, 16 variables were retained in the final logistic model (Age, gender, employment, chronic health problem, self-rated health, functional limitations, fear of falling, troubled with pain, trouble falling asleep, sitting time, cognitive health (MOCA), grip strength, diabetes, depression, anxiety and quality of life). The Omnibus test of model coefficients and the Hosmer and Lemeshow goodness of fit test were used to evaluate the model fit for a logistic regression and give an indication of how well the model performed. The logistic regression model was statistically significant, $\chi2$ (18) = 253.278, $p < .0005$. The model explained between 15% (Cox & Snell R^2) and 21% (Nagelkerke R^2) of the variance in physical activity levels and correctly classified 72.3% of cases. Of the 16 variables retained in the final model, 13 variables remained independently associated with physical activity. The number of cases in the final model was 1573 which was sufficient to meet the power needs of a logistic regression model with 16 variables.

Findings based on the backward elimination final multivariate logistic regression model (Table 4.11) showed that older age, female gender, unemployment, fair or poor self-rated health, functional limitations, greater sitting time, muscle weakness assessed by grip strength, diabetes, cognitive impairment and depression was associated with lower odds of being physically active. In addition, having a chronic health problem, higher quality of life and anxiety were associated with higher odds of being physically active. The adjusted odds and 95% CIs of being physically active are presented in table 4.11. Specifically, those aged 75 and over were 35% (OR: .652; CI: .485 – 878; $p < 0.05$) less likely to be physically active compared to those aged between 65 and 69. Females were 44% (OR: .556, 95% CI: .422 - .732, $p < 0.05$) less likely to be active compared to males and those unemployed were 31% (OR: .686, 95% CI: .496 - .949, $p < 0.05$) less likely to be active compared to those retired. Those with a self-reported chronic health problem were 32% (OR: 1.319, 95% CI: 1.010 – 1.724, $p < 0.05$) more likely to be physical active compared to older adults with no reported chronic health problem. Those with an ADL or IADL functional limitation were 39% (OR: .612, 95% CI: .435 - .861, $p < 0.05$) less likely to be physically active. Those who reported sitting for 8 hours per day or more were 61% (OR: .386, 95% CI: .273 - .547, $p < 0.05$) less likely to be physically active and participants with cognitive impairment (MOCA), diabetes and muscle weakness as assessed by grip strength was associated with 37% (OR: .629, 95% CI: .470 - .842, $p < 0.05$), 43% (OR: .568, 95% CI: .384 - .841, $p < 0.05$) and 23% (OR: .774, 95% CI: .604 - .992, $p< 0.05$) lower odds of being physically active, respectively. Finally, a unit increase in depression score was associated with 3% (OR: .974, 95% CI: .952 - .997, $p < 0.05$) lower odds of being physically active while a unit increase in anxiety and quality of life was associated with 5% (OR: 1.054, 95% CI: 1.011 – 1.099, $p < 0.05$) and 4% (OR: 1.041, 95% CI: 1.019 - 1.064, $p < 0.05$) higher odds of being physically active, respectively.

Table 4.11: Final Multivariate Logistic Regression Model of Factors Associated with Baseline Physical Activity

Variable	Category	B	Odds Ratio	95 % CI for OR Lower	Upper	p - value
Age	65-69	1				
	70-74	-.255	.775	.579	1.038	088
	75 or over	-.427	.652	.485	.878	.005**
Gender	Male	1				≤0.001**
	Female	-.587	.556	.422	.732	
Employment	Retired	1				
	Employed	.249	1.283	.815	2.021	.282
	Unemployed/Other	-.377	.686	.496	.949	.023*
Chronic Health Problem	No	1				
	Yes	.277	1.319	1.010	1.724	.042*
Self-Rated Health	Fair / Poor	1				
	Excellent/Vgood/good	.308	1.361	1.005	1.843	.046*
Functional limitations	Not Disabled	1				
	IADL / ADL Disability	-.491	.612	.435	.861	.005**
Fear of falling	No	1				
	Yes	-.254	.776	.592	1.018	.067
Troubled with Pain	No	1				
	Yes	-.242	.785	.606	1.017	.067
Trouble Falling Asleep	Rarely/never	1				
	Sometimes/Always	.222	1.249	.961	1.623	.096
Sitting time	<8	1				≤0.001**
	≥8	-.952	.386	.273	.547	
MOCA	Normal Cog. Function	1				
	Cognitive impairment	-.463	.629	.470	.842	.002**
Grip Strength	No muscle weakness	1				
	Muscle weakness	-.256	.774	.604	.992	.043*
Diabetes	No	1				
	Yes	-.565	.568	.384	.841	.005**
Depression		-.026	.974	.952	.997	.027*
Anxiety		.053	1.054	1.011	1.099	.013*
Quality of life		.040	1.041	1.019	1.064	≤0.001**

MOCA = Montreal Cognitive Assessment; ADL = Activities of daily living; IADL = Instrumental activities of daily living

* $p < 0.05$; ** $p < 0.01$

4.6 Cardio-metabolic Risk Factors

Table 4.12 presents the distribution of cardio-metabolic risk factors for the total sample. Of the sample, 47%, 43% and 11% had high blood pressure, high cholesterol and diabetes, respectively. In addition, 35% of participants were obese (BMI ≥ 30 kg/m^2) and 55% abdominally obese (WC ≥ 102 cm - Male; ≥ 88 cm - Female).

Table 4.12: Baseline Cardio-Metabolic Risk Factors (n = 2360 unless otherwise indicated)

Variable	Category	N (%)
High Blood Pressure	No Yes	1244 (52.7) 1116 (47.3)
High Cholesterol	No Yes	1338 (56.7) 1022 (43.3)
Diabetes	No Yes	2113 (89.5) 247 (10.5)
Obesity (BMI) (2341)	No Yes	1516 (64.8) 825 (35.2)
Abdominal Obesity (WC)	No Yes	1069 (45.3) 1291 (54.7)

BMI = Body mass index; WC = Waist circumference

4.6.1 Physical Activity and Cardio-Metabolic Risk Factors

Main Findings – Research Question 3

Physical activity levels were directly associated with 4 of the 5 cardio-metabolic risk factors examined in the logistic regression model (Table 4.13). Model 1 shows the unadjusted odds ratios while model 2 adjusted for age, gender and education. Model 3 adjusted for the same set of variables as in model 2 plus smoking and alcohol (Table 4.13). Physical activity was not associated with increased odds of having high cholesterol in any of the models.

The unadjusted ORs from the logistic regression model showed that those meeting the recommended physical activity guidelines had 32%, 50%, 36% and 34% lower odds of having high blood pressure (OR: .676, 95% CI - .570 - .801, $p < 0.05$), diabetes (OR: .505, 95% CI - .387 - .658, $p < 0.05$), obesity (BMI) (OR: .642, 95% CI - .539 - .766, $p < 0.05$) and abdominal obesity (WC) (OR: .659, 95% CI - .554 - .782, $p < 0.05$), respectively (Model 1). After adjusting for age, gender and education (Model 2), the relationship between physical activity level and blood pressure, diabetes, obesity and abdominal obesity all remained statistically significant. Specifically, active participants had 25%, 53%, 39% and 31% lower odds of having high blood pressure (OR: .748, 95% CI - .627 - .892, $p < 0.05$), diabetes (OR: .469, 95% CI - .355 - .619, $p < 0.05$), obesity (BMI) (OR: .611, 95% CI - .508 - .733, $p<0.05$) and abdominal obesity (OR: .693, 95% CI - .580 -. 828, $p < 0.05$), respectively. Finally, in the fully adjusted multivariate model with the addition of smoking and alcohol (Model 3), between physical activity level and blood pressure, diabetes, obesity and abdominal obesity all remained statistically significant. Physically active participants had 29%, 49%, 39% and 30% lower odds of having high blood pressure (OR: .713, 95% CI - .591 - .860, $p < 0.05$), diabetes (OR: .506, 95% CI - .376 - .681, $p < 0.05$), obesity (BMI) (OR: .611, 95% CI - .503 - .744, $p < 0.05$) and abdominal obesity (OR: .699, 95% CI - .578 -.845, $p < 0.05$).

Table 4.13: Logistic Regression Models Predicting Cardio-Metabolic Risk Factors from Physical Activity Levels Meeting the Recommended Guidelines

	Model 1			Model 2			Model 3		
	OR	**95% CI**	**p-value**	**OR**	**95% CI**	**p-value**	**OR**	**95% CI**	**p-value**
High Blood Pressure	.676	.570 - .801	≤0.001**	.748	.627 - .892	.001**	.713	.591 - .860	≤0.001**
High Cholesterol	.857	.723 – 1.016	.075	.862	.722 – 1.029	.100	.866	.718 - 1.046	.135
Diabetes	.505	.387 - .658	≤0.001**	.469	.355 - .619	≤0.001**	.506	.376 - .681	≤0.001**
Obesity (BMI)	.642	.539 - .766	≤0.001**	.611	.508 - .733	≤0.001**	.611	.503 - .744	≤0.001**
Abdominal Obesity (WC)	.659	.554 - .782	≤0.001**	.693	.580 -. 828	≤0.001**	.699	.578 - .845	≤0.001**

OR – Odds ratio; CI – Confidence Intervals; BMI – Body mass index; WC – Waist circumference; **p < 0.01; ORs (with 95% CIs) for older adults with a cardio-metabolic risk factor who participated in physical activity at recommended levels compared with subjects without cardio-metabolic risk-factors. Model 1: unadjusted; Model 2: adjusted for age, gender, education; Model 3: adjusted for the same set of variables as in model 2 plus smoking and alcohol.

4.7 Baseline Cardiovascular Disease

Table 4.14 presents the numbers and percentages of participants with a specific CVD or CVD surgery. Of the sample, 10% had angina, 8% had a heart attack, 3% had a stroke, 4% a TIA and less than 2% had heart failure (Table 10). Nearly 5% of the sample had a stent or vascular surgery.

Table 4.14: Numbers and percentages of participants with a specific CVD or CVD surgery (n = 2360 unless otherwise indicated)

Variable	Category	N (%)
Angina	No Yes	2122 (89.9) 238 (10.1)
Heart Attack	No Yes	2172 (92) 188 (8)
Heart Failure	No Yes	2323 (98.4) 37 (1.6)
Stroke	No Yes	2292 (97.1) 68 (2.9)
TIA	No Yes	2268 (96.1) 92 (3.9)
Stent or Vascular Surgery	No Yes	106 (2172) 82 (4.5)

TIA = Transient Ischemic Attack

Table 4.15 presents the numbers and percentages of participants with no CVD or CVD surgery and those with at least one CVD or CVD surgery from table 4.14. CVD was defined as yes to one or more of the above conditions or CVD procedure. Of the sample, 80.2 % of the sample had no CVD.

Table 4.15: Classification of CVD among the sample (n = 2360)

Cardiovascular Disease	
None **N (%)**	**At least 1** N (%)
1893 (80.2)	467 (19.8)

4.7.1 Physical Activity and Cardiovascular Disease

Main Findings – Research Question 4

From the logistic regression model for older adults with CVD who met the physical activity recommendations, the unadjusted ORs were 0.663 (95% CI 0.539 to 0.815, p <0.05) compared with those without CVD (table 4.16). Specifically, participants meeting the physical activity guidelines were 34% less likely to have a CVD. These ORs were attenuated slightly in the multivariate models but remained statistically significant (p < 0.05) after adjustment for the demographic variables age, gender and education (Model 2 – OR: .684; 95% CI: .549 - .851, p<0.05) and further adjustments for the behavioural CVD risk factors, smoking and alcohol (Model 3 – OR: .687, 95% CI: .543 - .870; p<0.05) and the cardio-metabolic risk factors, blood pressure, diabetes, cholesterol, BMI and WC (Model 4 – OR: .764, 95% CI: .598 - .976). After adjusting for age, gender, education, alcohol, smoking, high blood pressure, high cholesterol, diabetes, obesity (BMI) and abdominal obesity (WC), those physically active were 24% less likely to have a CVD (OR: .764, 95% CI:.598 - .976, p < 0.05) (Table 4.16).

Table 4.16: Logistic regression models predicting CVD from Physical Activity Levels Meeting the Recommended Guidelines

Cardiovascular Disease	OR (95% CI)	p - value
Model 1	.663 (.539 -.815)	≤0.001**
Model 2	.684 (.549 - .851)	.001**
Model 3	.687 (.543 - .870)	.002**
Model 4	.764 (.598 - .976)	.031*

OR – Odds ratio; CI – Confidence Intervals; *p<0.05; **p<0.01
ORs (with 95% CIs) for older adults with CVD who participated in physical activity at recommended levels compared with subjects without CVD. Model 1: unadjusted; model 2: adjusted for age, gender, education; Model 3: adjusted for the same set of variables as in model 2 plus smoking and alcohol; Model 4: adjusted for the same set of variables as in model 3 plus high blood pressure, diabetes, high cholesterol, obesity (Body mass index), abdominal obesity (Waist circumference).

4.8 Mediation of Physical Activity and CVD through Cardio-Metabolic Risk Factors

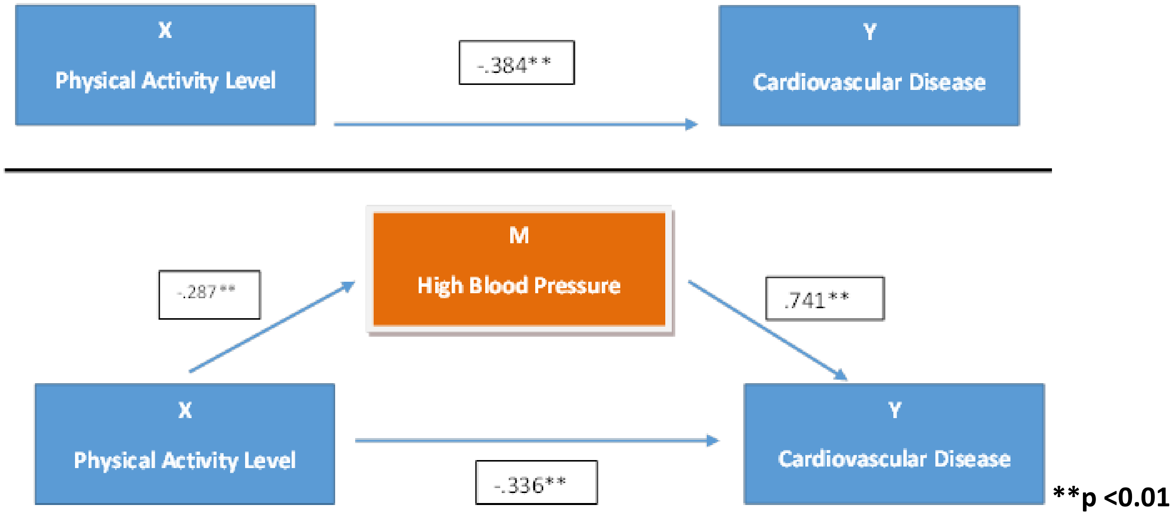
Main Findings – Research question 5

Physical activity was not associated with high cholesterol in the separate logistic regression models on the cardio-metabolic risk factors; therefore mediation analyses were conducted with high blood pressure, diabetes, obesity as measured by BMI and abdominal obesity as measured by waist circumference as mediator. Four different models were carried out: (i) the mediating effect of high blood pressure on the relationship between physical activity and CVD; (ii) the mediating effect of diabetes on the relationship between physical activity and CVD; (iii) the mediating effect of obesity (BMI) on the relationship between physical activity and CVD; and (iv) the mediating effect of abdominal obesity (WC) on the relationship between physical activity and CVD. In this hypothesised model, the effect of baseline physical activity (IPAQ) on CVD occurs via the known cardio-metabolic risk factors namely the expectation that physical activity reduces blood pressure, diabetes BMI and WC. All analyses were adjusted for age, gender and education. Mediation was assumed if (a) physical activity significantly predicted the cardio-metabolic risk factors, (b) physical activity significantly predicted CVD without the cardiovascular risk factors in the model, (c) cardio-metabolic risk factors predicted CVD, and (d) the effect of physical activity on CVD was significantly reduced when cardio-metabolic risk factors were added to the model. The Sobel test was used to test this mediation through assessing whether a critical ratio from the predictor variable on the response variable through the mediator was significantly different from zero.

4.8.1 Mediation of Physical Activity and CVD through High Blood Pressure

In the first model, the independent variable is physical activity, the outcome variable is CVD and the mediator variable is high blood pressure. The total effect of the physical activity on CVD was statistically significant ($c = -0.384$, $SE = .112$, $Z = 11.8$, $p = 0.001$). Both the effects of the physical activity on high blood pressure and of high blood pressure on CVD were also statistically significant (a = -.287, SE = 0.090, Z = 10.3, p = 0.001; b = 0.741, SE = 0.110, Z = 45.5, p < 0.0001) (Figure 4.3). Therefore, the first three steps for mediation analysis as described by Baron and Kenny (1986) were satisfied. Results show that the standardised regression analysis with regard to high blood pressure yielded the following results: a = -.287, Sa =.09, b= .741, and Sb = .11 and these values were then entered into the Sobel test (Sobel 1982) calculator obtained electronically from http://www.quantpsy.org/sobel/sobel.htm. The observed p value as shown in table 4.17 shows that high blood pressure (z = -2.88, p < .01) mediated the relationship between physical activity and cardiovascular disease. The direct effect of physical activity on CVD (c' = -0.336, SE = 0.113) controlling for blood pressure reduced and remained statistically significant (Z = 8.8, p < 0.01) suggesting that high blood pressure only partially explains the effect of the physical activity on CVD. We can estimate that (ab/(ab+c') = 15%.

Figure 4.3: Mediation of Physical Activity and CVD through High Blood Pressure



4.8.2 Mediation of Physical Activity and CVD through Diabetes

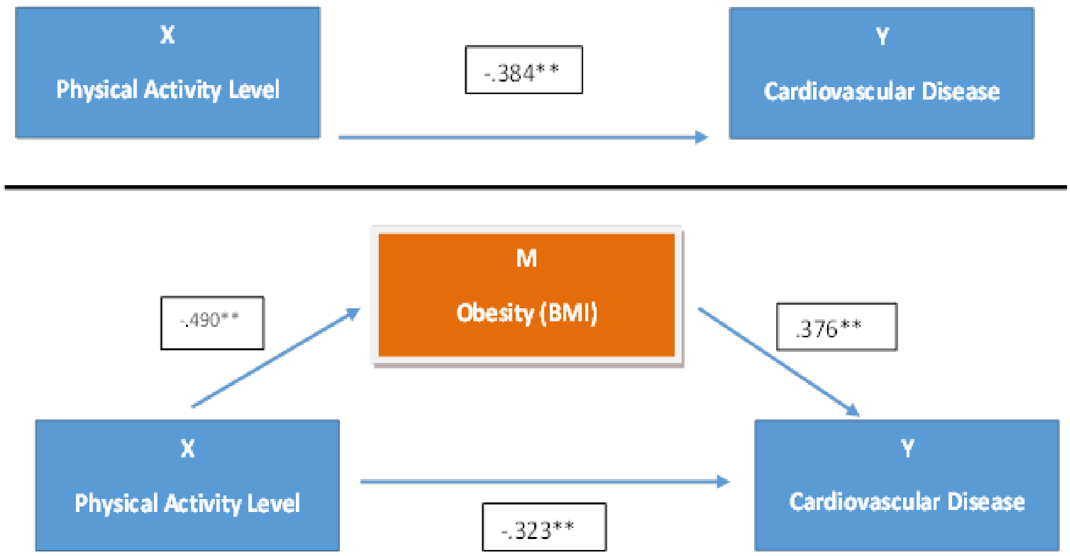
In the second model, the independent variable is physical activity, the outcome variable is CVD and the mediator variable is diabetes. The total effect of the physical activity on CVD was statistically significant (c = -0.384, SE = .112, Z = 11.8, p = 0.001). The effects of the physical activity on diabetes also statistically significant (a = -.764, SE = 0.141, Z = 29.3, p = 0.000)

However, the effects of diabetes on CVD when controlling for physical activity is insignificant (b =.275, SE = .159, Z = 2.97, p = 0.085). Therefore, the first three steps for mediation analysis as described by Baron and Kenny (1986) were not satisfied. With regards to diabetes, the standardised regression analysis showed the following results: a = -.764, Sa = .141, b = .275, and Sb = .159. The Sobel test revealed that Diabetes (Z = -1.65, p > .05) did not mediate the relationship between physical activity and cardiovascular disease (Table 4.17). The direct effect of the PA on CVD (c' = -0.361, SE = 0.113) controlling for diabetes (Z = 10.3, p < 0.01) suggests that diabetes does not explain the effect of physical activity on CVD.

4.8.3 Mediation of Physical Activity and CVD through Obesity (BMI)

In the third model, the independent variable is physical activity, the outcome variable is CVD and the mediator variable is obesity measured by BMI. The total effect of the physical activity on CVD was statistically significant (c = -0.384, SE = .112, Z = 11.8, p = 0.001). Both the effects of the physical activity on obesity (BMI) and of obesity (BMI) on CVD were also statistically significant (a = -.490, SE = 0.093, Z = 27.6, p < 0.01; b = 0.376, SE = 0.110, Z = 11.8, p < 0.01). Therefore, the first three steps for mediation analysis as described by Baron and Kenny (1986) were satisfied. Results show that the standardised regression analysis with regards to obesity yielded the following results: a = -.490, Sa =.093, b= .376, and Sb = .110 and these values were then entered into the Sobel test calculator. The observed p value as shown in table 4.18 shows that obesity (BMI) (z = -2.9, p < .01) mediated the relationship between physical activity and cardiovascular disease. The direct effect of the physical activity on CVD (c' = -0.323, SE = 0.113) controlling obesity reduced and remained statistically significant (Z = 8.3, p < 0.01) suggesting that obesity (BMI) only partially explains the effect of physical activity on CVD. We can estimate that (ab/(ab+c') = 9%.

Figure 4.4: Mediation of Physical Activity and CVD through Obesity (BMI)



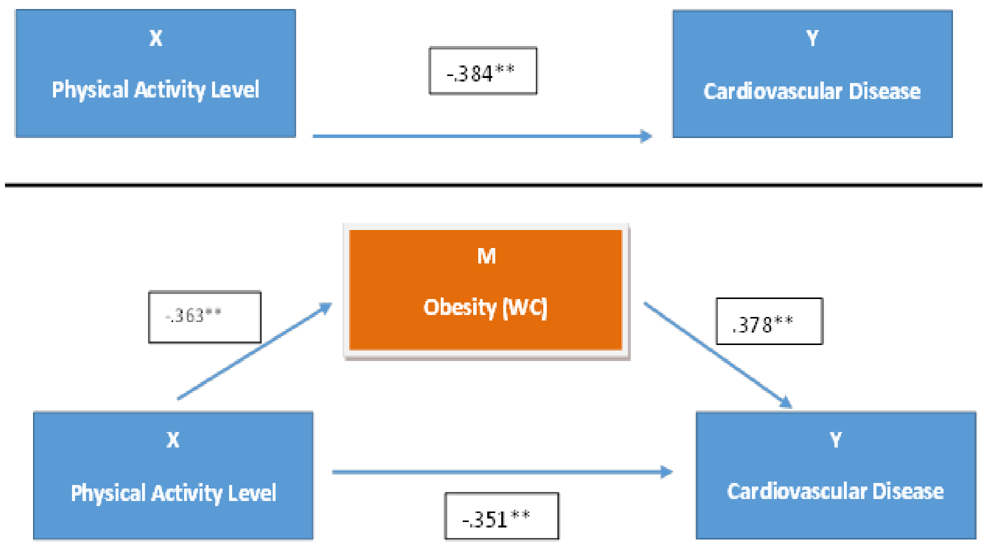
BMI – Body Mass Index. All results were adjusted for age, gender and education;

**p <0.01

4.8.4 Mediation of Physical Activity and CVD through Abdominal Obesity (WC)

In the fourth and final model, the independent variable is physical activity, the outcome variable is CVD, and the mediator variable is obesity measured by waist circumference (WC). The total effect of the physical activity on CVD was statistically significant (c = -0.384, SE = .112, Z = 11.8, p = 0.001). Both the effects of the physical activity on abdominal obesity (WC) and of abdominal obesity (WC) on CVD were also statistically significant (a = -.363, SE = 0.091, Z = 16, p < 0.01; b = 0.378, SE = 0.110, Z = 11.8, p < 0.01). Therefore, the first three steps for mediation analysis as described by Baron and Kenny (1986) were satisfied. Results show that the standardised regression analysis with regard to obesity (WC) yielded the following results: a = -.363, Sa =.091, b= .378, and Sb = .110 and these values were then entered into the Sobel test calculator. The observed p value as shown in table 4.18 shows that obesity (WC) ($z = -2.6$, $p < .01$) mediated the relationship between physical activity and cardiovascular disease. The direct effect of the physical activity on CVD ($c' = -0.351$, SE = 0.112) controlling obesity (WC) reduced and remained statistically significant ($Z = 9.7$, $p < 0.01$) suggesting that abdominal obesity (WC) only partially explains the effect of physical activity on CVD. We can estimate that (ab/(ab+c') = 11%.

Figure 4.5: Mediation of Physical Activity and CVD through Abdominal Obesity (WC)



WC – Waist circumference. All results were adjusted for age, gender and education; **p <0.01.

Table 4.17: Mediation of Physical Activity and CVD through High Blood Pressure and Diabetes

Model	Effect	Estimate	SE	Z	P
Independent Variable: Physical activity **Mediator: High blood pressure** **Outcome: CVD**	Total: Physical activity on CVD (c)	-0.384	.112	11.8	.001**
	Physical activity on high blood pressure (a)	-.287	.090	10.3	.001**
	High blood pressure on CVD given physical activity (b)	.741	.110	45.5	.000**
	Indirect: Physical activity on CVD (ab)	-.213	.074	-2.88	.004**
	Direct: Physical activity on CVD given high blood pressure (c')	-.336	.113	8.8	.003**
Independent Varable: Physical activity **Mediator: Diabetes** **Outcome: CVD**	Total: Physical activity on CVD (c)	-0.384	.112	11.8	.001**
	Physical activity on diabetes pressure (a)	-.764	.141	29.3	≤0.001**
	Diabetes on CVD given physical activity (b)	.275	.159	2.97	.085
	Indirect: Physical activity on CVD (ab)	-.210	.128	-1.65	.099
	Direct: Physical activity on CVD given diabetes (c')	-.361	.113	10.3	.001**

SE Indicates standard error; CVD – Cardiovascular disease; All results were adjusted for age, gender and education; **p <0.01

Table 4.18: Mediation of Physical Activity and CVD through Obesity (BMI & WC)

Model	Effect	Estimate	SE	Z	P
Independent Variable: Physical activity **Mediator: Obesity (BMI)** **Outcome: CVD**	Total: Physical activity on CVD (c)	-0.384	.112	11.8	.001**
	Physical activity on obesity (BMI) (a)	-.490	.093	27.6	≤0.001**
	Obesity (BMI) on CVD given physical activity (b)	.376	.110	11.8	.001**
	Indirect: Physical activity on CVD (ab)	-.184	0.06	-2.9	.004**
	Direct: Physical activity on CVD given Obesity (BMI) (c')	-.323	.113	8.3	.004**
Independent Variable: Physical activity **Mediator: Obesity (WC)** **Outcome: CVD**	Total: Physical activity on CVD (c)	-0.384	.112	11.8	.001**
	Physical activity on obesity (WC) (a)	-.363	.091	16.0	≤0.001**
	Obesity (WC) on CVD given physical activity (b)	.378	.110	11.8	.001**
	Indirect: Physical activity on CVD (ab)	-.137	.053	-2.6	.009**
	Direct: Physical activity on CVD given Obesity (WC) (c')	-.351	.112	9.7	.002**

BMI – Body Mass Index, WC – Waist circumference, CVD – Cardiovascular disease; **$p < 0.05$

Phase 2: Follow up Data

4.9 Physical Activity Levels of Older Adults at Follow Up

Of the 2360 participants at baseline, 2076 completed the IPAQ at follow up. Analysis on the 2076 participants showed that 1379 (66.4%) were sufficiently active while 697 (33.6%) did not meet the recommended physical activity guidelines at baseline.

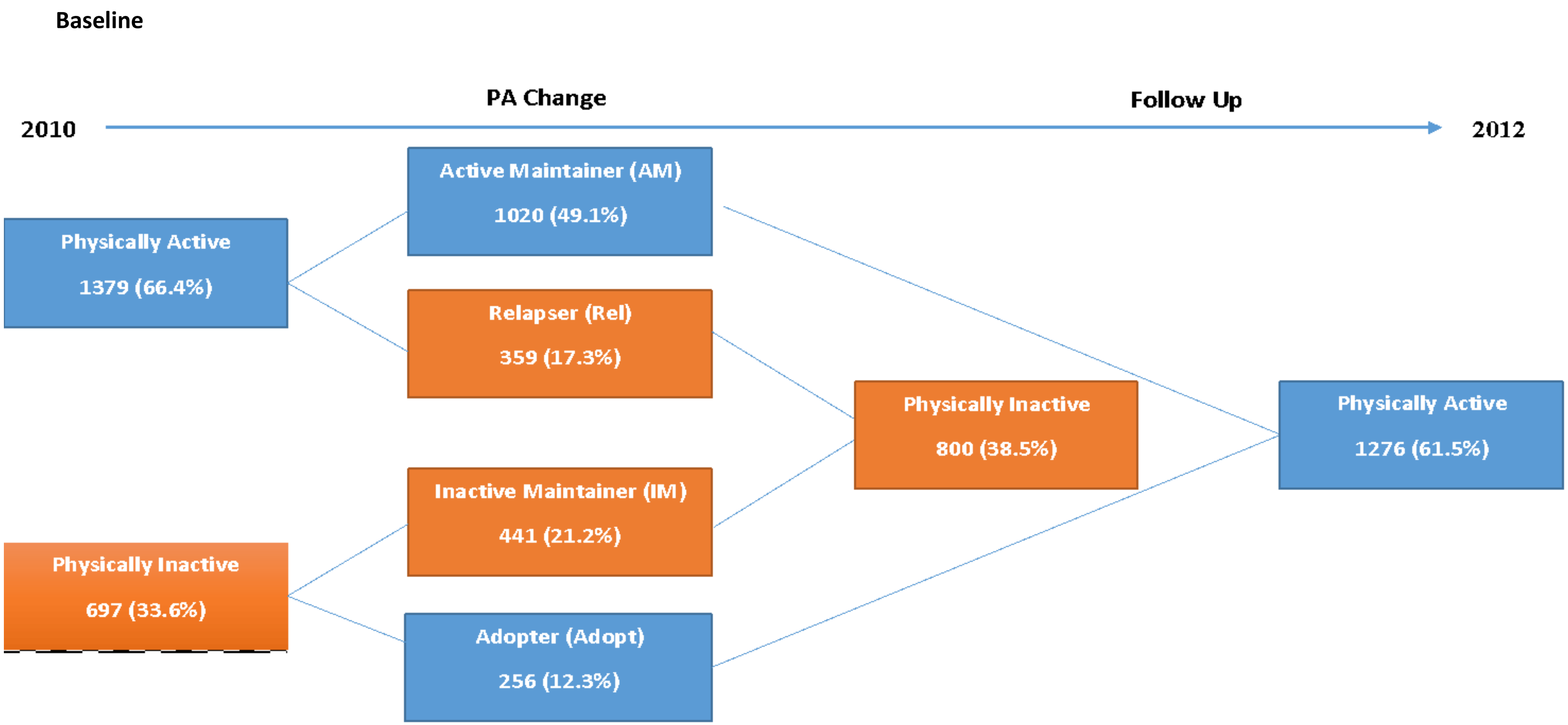
At follow up, (61.5%) were sufficiently active while (38.5%) did not meet the recommended guidelines. The distribution of Active and Inactive at Baseline and Follow-up is presented in Figure 3.

4.10 Patterns of Physical Activity

Main Findings – Research Question 6

Four patterns of physical activity were identified and presented in Figure 4.6. Those who were active at both baseline and follow up were classified as active maintainers (49.1%), while those who had been physically active at baseline and became inactive at follow up were classified as relapsers (17.3%). Those who were inactive at baseline and became active at follow up were classed as adopters (12.3%), while those who remained physically inactive at both baseline and follow up were classed as inactive maintainers (21.2%). Of the 1379 active at baseline, 74% remained sufficiently active while 26% relapsed. Of the 697 physically inactive at baseline, 63% remained physically inactive while 37% became physically active.

Figure 4.6: The patterns of physical activity change from baseline to follow up.



4.11 Bivariate Factors Associated with Physical Activity Change: Active Maintainers vs Relapsers

4.11.1 Socio-Demographic and Social Engagement Factors Associated with Physical Activity Change: Active Maintainer vs Relapser

The association between the socio-demographic and social engagement variables with physical activity change (Active Maintainers vs Relapsers) are presented in Table 4.19. Participants in the oldest age group (75 years and older) had the lowest proportion of active maintainers (67%) and the highest proportion of relapsers (33%) compared to the youngest age group (65 – 69) which had the highest proportion of active maintainers (79%) and the lowest proportion of relapsers (21%) ($p < 0.05$). The highest proportion of relapsers was seen among female participants (31% compared with 22%), while male participants had the highest proportion of active maintainers (78% compared with 69%) ($p < 0.05$). In addition, those with the highest level of education (3RD level) and the employed had the greatest proportion of active maintainers (78% and 81%) and the lowest proportion of relapsers (22% and 19%), respectively ($p < 0.05$). Those with a medical card had the lowest proportion of active maintainers with 71% and the highest proportion of relapsers with 29% compared to participants with medical insurance who had the highest proportion of active maintainers with 80% and lowest proportion of relapsers with (20%) ($p < 0.05$).

Table 4.19: Socio-Demographic and Social Engagement Factors Associated with Physical Activity Change: Active Maintainer vs Relapser (n = 1379 unless otherwise indicated)

Variable	Category	Active Maintainers	Relapsers	p-value [a]
		N (%)	N (%)	
Age	65 – 69 70 – 74 75 or over	471 (78.6) 296 (73.6) 253 (66.9)	128 (21.4) 106 (26.4) 125 (33.1)	≤0.001**
Gender	Male Female	581 (78.3) 439 (68.9)	161 (21.7) 198 (31.1)	≤0.001**
Education (1377)	Primary Secondary Tertiary	348 (70.3) 338 (74.1) 333 (78.2)	157 (29.7) 118 (25.9) 93 (21.8)	.025*
Employment Status	Retired Employed Unemployed/Other	746 (74) 132 (81) 142 (68.3)	262 (26) 31 (19) 66 (31.7)	.022*
Medical Cover (1378)	Not Covered Medical Insurance Medical Card	43 (74.1) 338 (80.3) 638 (71)	15 (25.9) 83 (19.7) 261 (29)	.002**
Marital Status	Not married Married	353 (74.5) 667 (73.7)	121 (25.5) 238 (26.3)	.757
Location (1377)	Urban Rural	564 (73.2) 454 (74.8)	206 (26.8) 153 (25.2)	.516
Social Connectedness (1304)	Socially isolated Socially Integrated	236 (74.9) 737 (74.5)	79 (25.1) 252 (25.2)	.887

[a] The p-values were obtained by Pearson chi-square test

* < 0.05; ** < 0.01

4.11.2 Physical Health Factors Associated with Physical Activity Change: Active Maintainer vs Relapser

The association between the physical health variables with physical activity change (Active Maintainers vs Relapsers) are presented in Table 4.20.

Participants with no chronic health problems had the highest proportion of active maintainers (78% vs 68%) and the lowest proportion of relapsers (22% vs 32%) compared to those with a chronic health problem ($p < 0.05$). A higher proportion of participants who self-reported their physical health (76% vs 64%), vision (75% vs 59%) and hearing (76% vs 68%) as excellent, very good or good compared to fair or poor were active maintainers. In line with this, those with fair or poor self-rated physical health (36% vs 24%), vision (41% vs 25%) or hearing (33% vs 25%) had the highest proportion of relapsers ($p < 0.05$). Participants reporting an IADL or ADL disability had the lowest proportion of active maintainers (59% vs 76%) and the highest proportion of relapsers (41% vs 24%) compared to participants with no disability ($p < 0.05$). Participants with abdominal obesity had the lowest proportion of active maintainers (71% vs 77%) and the highest proportion of relapsers (29% vs 23%) compared to those who were not abdominally obese ($p < 0.05$). Those with self-reported high blood pressure had a lower proportion of active maintainers with 71% while those with no self-report high blood pressure had the lowest proportion of relapsers with 24% ($p<0.05$). A greater proportion of participants with no fear of falling (77%) or not troubled with pain (77%) were active maintainers compared to those with a fear of falling (65%) or troubled with pain (68%). Those with a fear of falling and those who were troubled with pain had a higher percentage of relapsers (35% & 32%) compared to those with no fear of falling (23%) and those who were not troubled with pain (23%) ($p < 0.05$). A lower proportion of participants with a functional mobility impairment (60%) were active maintainers compared to those with normal mobility (76%) while those with no functional mobility impairment had the lowest proportion of relapsers (24% vs 40%) ($p < 0.05$). Participants with lower quality of life scores were significantly more likely to be relapsers than remain physically active ($p < 0.05$).

Table 4.20: Physical Health Factors Associated with Physical Activity Change: Active Maintainer vs Relapser (n = 1379 unless otherwise indicated)

Variable	Category	Active Maintainers	Relapsers	p-value[a]
		N (%)	N (%)	
Chronic Health Problem (1378)	No Yes	635 (78.1) 384 (68)	178 (21.9) 181 (32)	≤0.001**
Self-Rated Physical Health	Fair/Poor Excellent/V.good/Good	167 (63.7) 853 (76.4)	95 (36.3) 264 (23.6)	≤0.001**
Self-Rated Vision	Fair/Poor Excellent/ V.good/Good	60 (59.4) 960 (75.1)	41 (40.6) 318 (24.9)	.001**
Self-Rated Hearing	Fair/Poor Excellent/ V.good /Good	179 (67.5) 841 (75.5)	86(32.5) 273(24.5)	.008**
Functional Limitations	Not Disabled IADL / ADL Disability	933 (75.8) 87 (58.8)	298 (24.2) 61 (41.2)	≤0.001**
Obesity (BMI) (1372)	No Yes	703 (75) 313 (72)	234 (25) 122 (28)	.227+
Abdominal Obesity (WC)	No Yes	522 (77.4) 498 (70.6)	152 (22.6) 207 (29.4)	.004**
High Cholesterol	No Yes	597 (74.5) 423 (73.2)	204 (25.5) 155 (26.8)	.573
Diabetes	No Yes	943 (74.4) 77 (68.8)	324 (25.6) 35 (31.3)	.189+
High Blood Pressure	No Yes	593 (76.5) 427 (70.7)	182 (23.5) 177 (29.3)	.015*
Falls in the last year	No Yes	805 (75.1) 215 (70)	267 (24.9) 92 (30)	.075+
Fear of falling (1378)	No Yes	809 (76.7) 211 (65.3)	246 (23.3) 112 (34.7	≤0.001**
Troubled with pain	No Yes	710 (77) 310 (68)	212 (23) 146 (32)	≤0.001**
Life threatening illness or accident	No Yes	714 (74.7) 232 (75.6)	242 (25.3) 75 (24.4)	.756
Quality of life	Mean (SD)	46.7 (6.2)	44.7 (6.5)	≤0.001**
Timed up and go	Normal mobility Functional mobility impair.	925 (76.1) 91 (59.9)	291 (23.9) 61 (40.1)	≤0.001**
Grip Strength	No muscle weakness Muscle weakness	493 (76.3) 527 (71.9)	153 (23.7) 206 (28.1)	.062+

BMI = Body mass index; WC = Waist circumference; ADL = Activities of daily living; IADL = Instrumental activities of daily living

[a] The p-values were obtained by Pearson chi-square test for categorical variables or univariate logistic regression for continuous variables.

+ < 0.25; * < 0.05; ** < 0.01

4.11.3 Mental Health Factors Associated with Physical Activity Change: Active Maintainers vs Relapsers

The association between the mental health variables with physical activity change (Active Maintainer vs Relapser) are presented in Table 4.21. A higher proportion of participants who self-reported their mental health as excellent, very good or good (75%) compared to fair or poor (62%) were active maintainers while those with fair or poor self-rated mental health were more likely to be relapsers (38.4% vs 25%) ($p < 0.05$). In addition, those with higher depression, anxiety and loneliness score were significantly more likely to be relapsers compared to active maintainers ($p < 0.05$).

Table 4.21: Mental Health Factors Associated with Physical Activity Change: Active Maintainer vs Relapser (n = 1379 unless otherwise indicated)

Variable	Category	Active Maintainers	Relapsers	p-value [a]
		N (%)	N (%)	
Self-Rated Mental Health	Fair/Poor Excellent/ V.good /Good	53 (61.6) 976 (74.8)	33 (38.4) 326 (25.2)	.007**
Depression	Mean (SD)	4.19 (5.29)	5.52 (5.86)	≤0.001**
Anxiety	Mean (SD)	4.46 (3.2)	5.03 (3.37)	.007**
Loneliness	Mean (SD)	1.65 (2)	2.07 (2.2)	.002**

[a] The p-values were obtained by Pearson chi-square test for categorical variables or univariate logistic regression for continuous variables.
** < 0.01

4.11.4 Cognitive Health Factors Associated with Physical Activity Change: Active Maintainer vs Relapser

The association between the cognitive health variables with physical activity change (Active Maintainer vs Relapser) are presented in Table 4.22. A higher proportion of participants with normal cognitive function (MMSE – 75%, MOCA - 76%) were active maintainers compared to participants with mild, moderate or severe cognitive impairment and cognitive impairment (MMSE – 66%, MOCA - 66%). Participants with cognitive impairment were more likely to be relapsers (MMSE: 34, MOCA: 34%) ($p < 0.05$).

Table 4.22: Cognitive Health Factors Associated with Physical Activity Change: Active Maintainer vs Relapser (n = 1379 unless otherwise indicated)

Variable	Category	Active Maintainers	Relapsers	p-value [a]
		N (%)	N (%)	p
MMSE (1376)	Normal Cognitive Function Cognitive Impairment	929 (75) 90 (65.7)	310 (25) 47 (34.3)	.019*
MOCA (1371)	Normal Cognitive Function Mild/Moderate/Severe	845 (75.7) 169 (66.3)	271 (24.3) 86 (33.7)	.002**

MMSE = Mini–Mental State Examination; MOCA = Montreal Cognitive Assessment
[a] The p-values were obtained by Pearson chi-square test for categorical variables or univariate logistic regression for continuous variables.
* < 0.05; ** < 0.01

4.11.5 Behavioural Health Factors Associated with Physical Activity Change: Active Maintainer vs Relapser

The association between behavioural health variables with physical activity change (Active Maintainer vs Relapser) are presented in Table 4.23. A lower proportion of participants who were current smokers compared to non-smokers were active maintainers with (65% vs 75%) while a lower proportion of participants who were past or never smokers were relapsers compared to current smokers (25% vs 35%) ($p < 0.05$). A higher proportion of participants who rarely or never had trouble falling asleep were active maintainers compared to those who sometimes or always had trouble falling asleep (76% vs 70%) ($p < 0.05$). Finally, a lower proportion of participants who spent 8 or more hours sitting per day (61%) were active maintainers compared to those who spent less than 8 hours sitting per day (75%). Those who spent less than 8 hours per day sitting were less likely to relapse compared to those who spent less than 8 hours a day sitting (25% vs 39%) ($p < 0.05$).

Table 4.23: Behavioural Health Factors Associated with Physical Activity Change: Active Maintainer vs Relapser (n = 1379 unless otherwise indicated)

Variable	Category	Active Maintainer	Relapser	p-value[a]
Smoking	Past / Never Current	926 (75) 94 (65.3)	309 (25) 50 (34.7)	.012*
Alcohol Problem (1272)	No Yes	870 (74.9) 82 (74.5)	292 (25.1) 28 (25.5)	.940
Time Spent Sitting	<8 ≥8	947 (75.2) 67 (60.9)	313 (24.8) 43 (39.1)	.001**
Trouble Falling Asleep	Rarely/never Sometimes/Always	691 (76.1) 329 (69.9)	217 (23.9) 142 (30.1)	.012*

[a] The p-values were obtained by Pearson chi-square test * < 0.05; ** < 0.01

4.12 Multivariate Factors Associated with Physical Activity Change: Active Maintainer vs Relapsers

Main Findings - Research Question 7a

No variables violated the assumption of multicollinearity based on the correlational analysis of the independent variables for the final multivariate logic model. Logistic regression was applied to identify the variables independently associated with physical activity change (Active Maintainers vs Relapsers) among the sample. Twenty five (25) variables (Age, gender, education, employment, medical cover, chronic health problem, self-rated physical health, self-rated vision, self-rated hearing, functional limitations, abdominal obesity (WC), high blood pressure, fear of falling, troubled with pain, quality of life, timed up & go, self-rated mental health, depression, anxiety, loneliness, cognitive health (MMSE & MOCA), smoking, trouble falling asleep and time spent sitting) that showed significant association ($p < 0.05$) after bivariate and univariate analysis were considered together in multivariate analysis. In addition, 4 variables (Obesity (BMI), diabetes, falls in the last year and grip strength) with a p value of < 0.25 were also considered.

The initial model included all the variables from Tables 4.19 – 4.23 that were associated with physical activity with a p-value <0.25. The initial model therefore included 29 variables. Marital Status, location, social connectedness, high cholesterol, life threatening illness or accident and alcohol problem were removed from the initial model because they were not associated with physical activity based on the bivariate analysis. Results from the initial logistic regression model with a total of 29 variables can be seen in appendix 9. To generate the most parsimonious model, backward elimination procedure was adopted in which final estimates for each variable yielded an adjusted OR and 95% CI for each factor retained in the model.

Overall, 10 variables were retained in the final logistic model. The Omnibus test of model coefficients and the Hosmer and Lemeshow goodness of fit test were used to evaluate the model fit for a logistic regression and give an indication of how well the model performed. The logistic regression model was statistically significant, χ^2 (12) = 77.129, $p < .0005$. The model explained between 7% (Cox & Snell R^2) and 11% (Nagelkerke R^2) of the variance in physical activity change and correctly classified 76.1% of cases. The number of cases in the final model was 1011 which was sufficient to meet the power needs of a logistic regression model with 10 variables. Findings based on the backward elimination final multivariate logistic regression model (Table 4.24) showed that older age, female gender, not having a third level education, chronic health problem, abdominal obesity, higher depression, current smoker and more than 8 hours sitting per day were associated with higher odd of relapsing. In addition, excellent, very good or good hearing had lower odd of relapsing. The adjusted odds and 95% CIs of being physically active are presented in table 4.24. Specifically, those aged 75 and over were 66% (OR: 1.66, 95% CI: 1.15 – 2.4) more likely to relapse than those aged 65–69. Similarly, females were 66% (OR: 1.66, 95% CI: 1.2 – 2.3) more likely to relapse compared to males. Participants with a chronic health problem had 42% (OR: 1.4, 95% CI: 1.04 – 1.95) higher odds of relapsing compared to those with no chronic health problem. Those with abdominal obesity and smokers were 38% (OR: 1.4, 95% CI: 1.02 – 1.88) and 69% (OR: 1.69, 95% CI: 1.04 – 2.74) more likely to relapse, respectively. Participants had 4% higher odds of relapsing for each unit increase in depression score (OR: 1.04, 95% CI: 1.01 -1.07). Those with third level education had 36% (OR:.64, 95% CI: .44 - .94) lower odds of relapsing compared to those with primary education and participants who self-rated their hearing as excellent / very good or good had 32% (OR: .68, 95% CI: .47 - .99) lower odds of relapsing. Finally, participants who reported sitting for 8 hours or more per day were two times more likely to relapse (OR: 2.03, 95% CI: 1.22 – 3.38).

Table 4.24: Results from the Multivariate logistic model on Physical Activity Change: Active Maintainers vs Relapsers

Variables	Category	B	Odds Ratio	95% CI for OR		p - value
				Lower	Upper	
Age	65-69	1				
	70-74	.290	1.337	.929	1.923	.118
	75 or over	.506	1.659	1.147	2.400	.007**
Gender	Male	1				
	Female	.509	1.664	1.220	2.269	.001**
Education	Primary	1				
	Secondary	-.243	.785	.545	1.129	.191
	Tertiary	-.443	.642	.440	.939	.022*
Chronic Health Problem	No	1				
	Yes	.351	1.421	1.035	1.951	.030*
Self-Rated Health	Fair / Poor	1				
	Excellent / Very good / Good	-.362	.696	.470	1.031	.071
Self-Rated hearing	Fair / Poor	1				
	Excellent / Very good / Good	-.386	.680	.467	.989	.044*
Obesity (WC)	No	1				
	Yes	.324	1.383	1.016	1.882	.039*
Smoker	Past / Never	1				
	Current	.525	1.691	1.042	2.743	.033*
Sitting time	<8	1				
	≥8	.709	2.032	1.221	3.381	.006**
Depression		.040	1.041	1.012	1.071	.005**

* < 0.05; ** < 0.01

4.13 Bivariate Factors Associated with Physical Activity Change: Inactive Maintainers vs Adopters

4.13.1 Socio-demographic and Social Engagement Factors Associated with Physical Activity Change: Inactive Maintainers vs Adopters

The association between the socio-demographic and social engagement variables with physical activity change (Inactive Maintainers vs Adopters) are presented in Table 4.25. Participants in the oldest age group (75 years and older) had the highest proportion of inactive maintainers (70%) and the lowest proportion of adopters (30%) compared to the youngest age group (65 – 69) which had the lowest proportion of inactive maintainers (57%) and the highest proportion of adopters (43%) ($p < 0.05$). The highest proportion of adopters was seen among male participants compared to females (42% compared with 34%), while female participants had the highest proportion of inactive maintainers compared to males (66% compared with 58%) ($p < 0.05$). Those with a medical card had the highest proportion of inactive maintainers with 66% compared to participants with medical insurance (52%) and those not covered (62%) while those with medical insurance were more likely to adopt with 48% compared to 39% and 34% of those not covered and those with a medical card, respectively ($p < 0.05$). In addition, married participants had the lowest proportion of inactive maintainers with 60% while not being married had the highest with 68% ($p<0.05$).

Participants socially isolated had the highest proportion of inactive maintainers (70%) compared to those socially integrated (59%) while those socially integrated had a higher proportion of adopters (41%) compared to those socially isolated (30%) ($p < 0.05$).

Table 4.25: Socio-demographic and Social Engagement Factors Associated with Physical Activity Change: Inactive Maintainers vs Adopters (n = 697 unless otherwise indicated)

Variable	Category	Inactive Maintainers	Adopters	p-value[a]
		N (%)	N (%)	
Age	65 – 69 70 – 74 75 or over	123 (56.9) 116 (59.8) 202 (70.4)	93 (43.1) 78 (40.2) 85 (29.6)	.004**
Gender	Male Female	152 (58.2) 289 (66.3)	109 (41.8) 147 (33.7)	.033*
Education	Primary Secondary Tertiary	180 (66.2) 174 (64) 87 (56.9)	92 (33.8) 98 (36) 66 (43.1)	.153⁺
Employment Status	Retired Employed Unemployed/Other	286 (61.5) 25 (59.5) 130 (68.4)	179 (38.5) 17 (40.5) 60 (31.6)	.218⁺
Medical Cover	Not Covered Medical Insurance Medical Card	8 (61.5) 75 (52.4) 358 (66.2)	5 (38.5) 68 (47.6) 183 (33.8)	.010*
Marital Status	Not Married Married	188 (67.9) 253 (60.2)	89 (32.1) 167 (39.8)	.041*
Location	Urban Rural	234 (62.4) 207 (64.3)	141 (37.6) 115 (35.7)	.607
Social Connectedness	Socially Isolated Socially Integrated	135 (70.3) 266 (58.8)	57 (29.7) 186 (41.2)	.006**

[a] The p-values were obtained by Pearson chi-square test ⁺ < 0.25, * < 0.05; ** < 0.01

4.13.2 Physical Health Factors Associated with Physical Activity Change: Inactive maintainer vs Adopter

The association between the physical health variables with physical activity change (Inactive Maintainers vs Adopter) are presented in Table 4.26. A lower proportion of participants with no chronic health problem (58% vs 69%) were inactive maintainers compared to those with a chronic health problem while those with no chronic health problems were more likely to adopt (42% vs 32%) (p < 0.05). A lower proportion of participants who self-reported their physical health (55% vs 77%) and vision (61% vs 78%) as excellent, very good or good compared to fair or poor were inactive maintainers (p < 0.05), respectively. Participants reporting an IADL or ADL disability had the highest proportion of inactive maintainers (75%) compared those with no disability (59%) while those with no disability were likely to adopt (41% vs 25%) (p < 0.05). Participants with abdominal obesity had the highest proportion of inactive maintainers (68%) compared to those who were not abdominally obese (55%) while participants not abdominally obese were more likely to adopt 45% ($p < 0.05$). Those with self-reported high blood pressure had a highest proportion of inactive maintainers with 69% while those with no high blood pressure had the lowest proportion with 57% ($p < 0.05$). A greater proportion of participants with a fear of falling (71%) were inactive maintainers compared to those with no fear of falling (58%) ($p < 0.05$). A higher proportion of participants troubled with pain (71%) were inactive maintainers compared to those who were not troubled with pain (57%) ($p < 0.05$). A higher proportion of participants with a functional mobility impairment (77%) were inactive maintainers compared to those with normal mobility (57%) while participants with normal mobility were more likely to adopt (43%) compared to those with a functional impairment (23%) ($p < 0.05$). Participants with lower quality of life score were significantly more likely to be inactive maintainers than adopters ($p < 0.05$).

Table 4.26: Physical Health Factors Associated with Physical Activity Change: Inactive Maintainers vs Adopters (n = 697 unless otherwise indicated)

Variable	Category	Inactive Maintainers	Adopters	p-value[a]
		N (%)	N (%)	
Chronic Health Problem (696)	No Yes	203 (58) 237 (68.5)	147 (42) 109 (31.5)	.004**
Self-Rated Physical Health	Fair/Poor Excellent/V. good/Good	202 (76.8) 239 (55.1)	61 (23.2) 195 (44.9)	≤0.001**
Self-Rated Vision	Excellent/V.good/Good Fair/Poor	83 (77.6) 358 (60.7)	24 (22.4) 232 (39.3)	.001**
Self-Rated Hearing	Fair/Poor Excellent/V. good/Good	102 (65.4) 339 (62.7)	54 (34.6) 202 (37.3)	.534
Functional Limitations	Not Disabled IADL / ADL Disability	300 (59.1) 141 (74.6)	208 (40.9) 48 (25.4)	≤0.001**
Obesity (BMI) (688)	No Yes	245 (61.4) 189 (65.4)	154 (38.6) 100 (34.6)	.284
Abdominal Obesity (WC)	No Yes	146 (54.9) 295 (68.4)	120 (45.1) 136 (31.6)	.000**
High Cholesterol	No Yes	234 (62.4) 207 (64.3)	141 (37.6) 115 (35.7)	.607
Diabetes	No Yes	379 (62.6) 62 (67.4)	226 (37.4) 30 (32.6)	.379
High Blood Pressure	No Yes	186 (57.1) 255 (68.7)	140 (42.9) 116 (31.3)	.001**
Falls in the last year (696)	No Yes	332 (63.5) 108 (62.4)	191 (36.5) 65 (37.6)	.804
Fear of falling (695)	No Yes	233 (57.8) 206 (70.5)	170 (42.2) 86 (29.5)	.001**
Troubled with pain (696)	No Yes	210 (56.8) 230 (70.6)	160 (43.2) 96 (29.4)	.000**
Life threatening Illness or Accident	No Yes	278 (61) 104 (65)	178 (39) 56 (35)	.366
Quality of life (511)	Mean (SD)	41.99 (8.1)	44.6 (6.7)	≤0.001**
Timed Up & Go	Normal Mobility Functional mobility Impair.	275 (56.7) 149 (76.8)	210 (43.3) 45 (23.2)	≤0.001**
Grip Strength	No Muscle weakness Muscle Weakness	137 (59.1) 304 (65.4)	95 (40.9) 161 (34.6)	.103[+]

BMI = Body mass index; WC = Waist circumference; ADL = Activities of daily living; IADL = Instrumental activities of daily living

[a] The p-values were obtained by Pearson chi-square test or univariate logistic regression for continuous variables.

[+] < 0.25, ** < 0.01

4.13.3 Mental Health Factors Associated with Physical Activity Change: Inactive maintainer's vs Adopters

The association between the mental health variables with physical activity level at baseline are presented in Table 4.27. A lower proportion of participants who self-reported their mental health as excellent, very good or good (62%) compared to fair or poor (70%) were inactive maintainers (p>0.05). In addition, those with higher depression and loneliness scores were significantly more likely to be inactive maintainers (p < 0.05).

Table 4.27: Mental Health Factors Associated with Physical Activity Change: Inactive Maintainers vs Adopters (n = 697 unless otherwise indicated)

Variable	Category	Inactive Maintainers	Adopters	p-value[a]
		N (%)	N (%)	
Self-Rated Mental Health (696)	Fair/Poor Excellent/V.good/Good	58 (69.9) 382 (62.3)	25 (30.1) 231 (37.7)	.180[+]
Depression (682)	Mean (SD)	7.4 (7.8)	6.15 (7.5)	.039*
Anxiety (593)	Mean (SD)	4.93 (3.57)	4.83 (3.5)	.727
Loneliness (616)	Mean (SD)	2.3 (2.3)	1.95(1.97)	.039*

[a] The p-values were obtained by Pearson chi-square test or univariate logistic regression for continuous variables.
[+] < 0.25, * < 0.05

4.13.4 Cognitive Health Factors Associated with Physical Activity Change: Inactive Maintainer's vs Adopters

The association between the cognitive health variables with physical activity change (Inactive Maintainer vs Adopter) are presented in Table 4.28. A lower proportion of participants with normal cognitive function (MMSE – 60%, MOCA - 59%) were inactive maintainers while participants with mild, moderate or severe cognitive impairment (MMSE - 78%) and cognitive impairment (MOCA – 72%) had the highest proportion of inactive maintainers. Participants with normal cognitive function (MMSE – 40%, MOCA – 41%) were more likely to be adopters compared to those with cognitive impairment (MMSE – 23%, MOCA – 28%) (p < 0.05).

Table 4.28: Cognitive Health Factors Associated with Physical Activity Change: Inactive Maintainer's vs Adopters (n = 697 unless otherwise indicated)

Variable	Category	Inactive Maintainers	Adopters	p-value[a]
		N (%)	N (%)	
MMSE	Normal Cognitive Function Mild/Moderate/Severe	334 (59.9) 107 (77.5)	224 (40.1) 31 (22.5)	≤0.001**
MOCA	Normal Cognitive Function Cognitive impairment	269 (59) 168 (71.8)	187 (41) 66 (28.2)	.001**

MOCA = Montreal Cognitive Assessment
[a] The p-values were obtained by Pearson chi-square test
** < 0.01

4.13.5 Behavioural Health Factors Associated with Physical Activity Change: Inactive Maintainer's vs Adopters

The association between the behavioural health variables and physical activity level at baseline are presented in Table 4.29. A higher proportion of participants who were current smokers were inactive maintainers with 73% while a lower proportion of participants who were past or never smokers were inactive maintainers with 62% ($p < 0.05$). Finally, a higher proportion of participants who spent 8 or more hours sitting per day (75%) were inactive maintainers compared to those who spent less than 8 hours sitting per day (60%) ($p < 0.05$).

Table 4.29: Behavioural Health Factors Associated with Physical Activity Change: Inactive Maintainer's vs Adopters (n = 697 unless otherwise indicated)

Variable	Category	Inactive Maintainers	Adopters	p-value[a]
		N (%)	N (%)	
Smoking	Past / Never Current	379 (61.9) 62 (72.9)	233 (38.1) 23 (27.1)	.048*
Alcohol Problem (625)	No Yes	363 (61.9) 23 (59)	223 (38.1) 16 (41)	.712
Time Spent Sitting (591)	<8 ≥8	318 (59.9) 120 (75)	213 (40.1) 40 (25)	.001**
Trouble Falling Asleep	Rarely/never Sometime/Always	249 (61.5) 192 (65.8)	156 (38.5) 100 (34.2)	.248[+]

[a] The p-values were obtained by Pearson chi-square test

[+] < 0.25, * < 0.05; ** < 0.01

4.14 Multivariate logistic Model with Factors Associated with Physical Activity Change: Inactive Maintainers vs Adopters

Main Findings – Research Question 7b

No variables violated the assumption of multicollinearity based on the correlational analysis of the independent variables for the final multivariate logic model. Logistic regression was applied to identify the variables independently associated with physical activity change (Inactive Maintainers vs Adopters) among the sample. Twenty one (21) variables (Age, gender, medical cover, marital status, social connectedness, chronic health problem, self-rated physical health, self-rated vision, functional limitations, abdominal obesity, high blood pressure, fear of falling, troubled with pain, quality of life, timed up and go, depression, loneliness, cognitive function (MMSE & MOCA), smoking, and time spent sitting) that showed significant association ($p<0.05$) after bivariate and univariate analysis were considered together in multivariate analysis.

In addition, 5 variables (Education, employment, grip strength, self-rated mental health and trouble falling asleep) with a p value of <0.25 were also considered. The initial model all the variables from Tables 4.25 – 4.29 that were associated with physical activity with a p-value <0.25. The initial model therefore included 26 variables. Location, self-rated hearing, obesity (BMI), high cholesterol, diabetes, falls in the last year, life threatening illness or accident, anxiety and alcohol problem were removed from the initial model because they were not associated with physical activity change (Inactive Maintainers vs Adopters). Results from the initial logistic regression model with a total of 26 variables can be seen in appendix 9. To generate the most parsimonious model, backward elimination procedure was adopted in which final estimates for each variable yielded an adjusted OR and 95% CI for each predictor retained in the model. Overall, 7 variables were retained in the final logistic model. The Omnibus test of model coefficients and the Hosmer and Lemeshow goodness of fit test were used to evaluate the model fit for a logistic regression and give an indication of how well the model performed. The logistic regression model was statistically significant, $\chi2$ (8) = 63.491, $p < .0005$. The model explained between 13% (Cox & Snell R^2) and 17% (Nagelkerke R^2) of the variance in physical activity change (Inactive maintainer vs Adopter) and correctly classified 67.4% of cases. The number of cases in the final model was 470, which was sufficient to meet the power needs of a logistic regression model with 7 variables. Findings based on the backward elimination final multivariate logistic regression model (Table 4.30) showed that better self-rated physical health had higher odds of adopting physical activity. In addition, secondary education, troubled with pain and functional mobility impairment were associated with lower odds of adopting physical activity. The adjusted odds and 95% CIs of being physically active are presented in table 4.30. Specifically, those with excellent, very good or good self-rated physical health were over two time more likely to adopt physical activity compared to participants who self–rated their physical health as fair or poor (OR: 2.28, 95% CI: 1.40 – 3.70). Those who were troubled with pain had 37% lower odds to adopt physical activity compared to those who were not troubled with pain (OR: .629, 95% CI: .416 - .950) and those with mobility impairment measured by the timed up and go test had 55% lower odd of adopting physical activity (OR: .448, 95% CI: .265 - .757).

Table 4.30: Results from the Multivariate logistic model on Physical Activity Change (Inactive Maintainers vs Adopters)

Variables	Category	B	Odds Ratio	95% CI for OR		P value
				Lower	Upper	
Education	Primary	1				
	Secondary	-.729	.482	.292	.796	.004**
	Tertiary	-.308	.735	.429	1.261	.264
Social connectedness	Socially Isolated	1				
	Socially Integrated	.438	1.550	.963	2.495	.071
Self-rated physical health	Fair / poor	1				
	Excellent / Very good / Good	.823	2.277	1.403	3.696	.001**
High blood pressure	No	1				
	Yes	-.352	.703	.465	1.063	.095
Troubled with pain	No	1				
	Yes	-.464	.629	.416	.950	.028*
Timed up & Go	Normal Mobility	1				
	Functional mobility impairment	-.803	.448	.265	.757	.003**
MMSE	Normal Cognitive Function	1				
	Mild/Moderate/Severe	-.596	.551	.293	1.036	.064

MMSE = Mini–Mental State Examination

*< 0.05; ** < 0.01

4.15 Summary of Main Findings

This chapter presented the main findings of the study. In total, 2,360 community dwelling Irish older adults (≥65) took part in this study at baseline. The results demonstrated that 65% of community dwelling Irish older adults were physically active at baseline according to the recommended guidelines (3.2: Research question 1). Older age, female gender, unemployment, fair or poor self-rated health, functional limitations, greater sitting time, muscle weakness, diabetes, cognitive impairment and higher depression was associated with lower odds of being physically active in the final multivariate logistic regression model. In addition, having a chronic health problem, higher quality of life and higher anxiety was associated with higher odds of being physically active (3.2: Research question 2).

Regardless of age, gender and education, older adults meeting the recommended physical activity guidelines was associated with lower odds of having high blood pressure and diabetes and were significantly less likely to be obese and abdominally obese. Physical activity level was not associated with high cholesterol (3.2: Research question 3a-e). Regardless of age, gender, education, smoking status, having an alcohol problem, high blood pressure and high cholesterol, diabetes and being obese and abdominally obese, older adults who met the physical activity guidelines were significantly less likely to have cardiovascular disease (3.2: Research question 4).

The mediation analysis revealed that the relationship between physical activity and cardiovascular disease is partially explained by blood pressure, obesity and abdominal obesity. The relationship between physical activity and cardiovascular disease was not explained by diabetes and cholesterol (3.2: research question 5a-e).

Of those who participated at both baseline and follow up, the proportion of older adults meeting the physical activity guidelines declined from 66% to 62%. Of the total sample, 49% were active at both baseline and follow up (Active maintainer) while 17% became inactive at follow up (Relapser). In addition, 21% of the sample was physically inactive at both baseline and follow

(Inactive Maintainers) while 12% became physically active at follow (Adopters) (3.2: Research question 6).

Older age, female gender, third level education, chronic health problem, abdominal obesity, higher depression, current smoker and more than 8 hours sitting per day was associated with higher odd of relapsing in the final multivariate logistic regression model. In addition, excellent, very good or good hearing had lower odd of relapsing (3.2: Research question 7a).

Better self-rated physical health had higher odds of adopting physical activity. In addition, secondary education, troubled with pain and having functional mobility impairment were associated with lower odds of adopting physical activity in the final multivariate logistic regression model (3.2: Research question 7b).

Chapter 5

Discussion and Conclusion

5.0 Introduction

This chapter provides a discussion of the main findings of the study in relation to previous research. This is followed by the strengths and limitations of the study, and a conclusion of the overall research with implications and suggestions for future research.

This study set out to describe the physical activity levels and patterns of physical activity change in a large sample of community dwelling older adults (≥65 years) living in the Republic of Ireland. In doing so, the study sought to gain a better understanding of the baseline factors predicting current physical activity levels and future physical activity levels or physical activity change patterns. In particular, the cross-sectional design investigated the current levels of physical activity at baseline and the main factors associated with physical activity (Phase 1) using a wide range of factors including socio-demographic, social engagement, physical and mental health, cognitive and behavioural health factors. The longitudinal design aspect of the study investigated the patterns of physical activity change from baseline to follow up and the main factors associated with these physical activity behaviours using the same factors as above (Phase 2). Another main objective of this study was to examine the impact of baseline physical activity on current cardiovascular disease (CVD) and cardio-metabolic risk factors. In addition, the study examined the role of these cardio-metabolic risk factors in the relationship between physical activity and CVD.

5.1 Main Findings

5.1.1 Physical Activity Levels

In this study, physically active participants were identified as those reporting moderate and/or high levels of physical activity according to the International Physical Activity Questionnaire (Craig *et al*. 2003) which is in line with international standards and represents meeting the latest recommended physical activity guidelines of 150 minutes of moderate intensity activity weekly (U.S. Department of Health and Human Services 2008, Department of Health and Children 2009). Of the 2360 participants included at baseline, this study revealed that about 65% of community dwelling older adults (≥ 65 years) in Ireland meet the recommendations for physical activity. This is slightly higher than most previous studies reporting the prevalence of physical activity in older adults (Sun *et al*. 2013). A review by Sun *et al.* (2013) reported that the majority of studies report that between 20-60% of older adults meet the current physical activity guidelines. In addition, the findings of the present study are also higher compared to recent studies carried out in Europe (Marquez *et al*. 2015), the United Kingdom (Townsend *et al*. 2015), the United States (Keadle *et al*. 2016), Iran (Shiraly *et al*. 2017) and in Brazil (Gobbi *et al*. 2012). Although these studies also assessed physical activity subjectively, the differences in proportions of older adults meeting the guidelines may be due to different self-reports methods, exclusion of some physical activity domains, differences in country-specific interpretations of the recommended guidelines, different age ranges and socio-cultural differences (Sun *et al.* 2013, Bauman *et al.* 2016). This current study utilised IPAQ-SF which has been deemed a reliable and valid tool to measure physical activity at a population level because it is brief, feasible and ease of use compared to the long form. IPAQ-SF assesses physical activity in all domains including walking, moderate-intensity, and vigorous-intensity activity and has been recognised as a preferable method to assess physical activity prevalence which is comparable at national and international level (Craig *et al*. 2003, Bauman *et al*. 2009b). While Gobbi *et al*. (2012) also used IPAQ to assess the prevalence of physical activity in older adults in Brazil, the IPAQ long form was utilised. In comparison to the short form version, the IPAQ long form has been recommended for research requiring a more detailed assessment of physical activity (Craig *et al.* 2003). Elsewhere and in contrast to this research, the 3 national surveys in the United States reported earlier, only included the assessment of leisure time physical activity (Keadle *et al*. 2016). The threshold employed in these surveys is likely to under represent those reaching moderate levels of physical activity through domestic and work related activity which may explain the lower proportion of older adults achieving the recommended guidelines compared to this study. In addition, other research on the TILDA data set used an alternative criteria to establish a more realistic proportion of older adults (≥60 years) achieving the recommended physical activity guidelines. Murtagh *et al*. (2015) categorised sufficiently active participants as those who only reported high levels of physical activity which eliminates many older adults reaching the moderate levels of activity which can be achieved through domestic and work related activity. The physical activity guidelines recognises the importance of domestic and work related activity in total physical activity levels, particularly for older adults. Indeed, middle aged adults are more likely to achieve the recommended guidelines through leisure time physical activities while older adults are more likely to achieve the guidelines through domestic and work related activities (Hallal *et al.* 2003, Murphy *et al.* 2013, Mooney *et al.* 2015). However, the majority of research often excludes these types of activities when assessing physical activity in older adults. The present study assessed total levels of physical activity which may reflect the higher proportion of Irish older adults achieving the recommended guidelines compared to other countries. However these findings give a better indication of the true prevalence of physical activity in community dwelling older adults in Ireland. According to Moschny *et al.* (2011), a national agreement on a standardized tool that measures physical activity in older adults is required to increase comparability of physical activity research.

5.1.2 Factors Associated with Current Physical Activity Levels

The cross-sectional design of phase 1 allowed this research to examine factors associated with the current physical activity levels of older adults. In line with existing cross sectional literature, this study also recognises multiple factors associated with physical activity levels in older adults. Despite many significant bivariate relationships of socio-demographic, physical and mental health, cognitive and behavioural health factors, the multivariate analysis allowed this study to recognise the most parsimonious factors associated with reaching the recommended physical activity guidelines. This study demonstrates that the socio-demographic factors (age, gender and employment), physical (self-rated health, chronic health problem, diabetes, timed up and go, grip strength, quality of life) and mental health (depression and anxiety) characteristics, cognitive and behavioural (sitting time) health factors were independently associated with physical activity levels at baseline in the multivariate logistic regression model. Some of these findings are consistent with previous cross-sectional research utilising a wide range of factors, including the associations of age, gender, physical function, mental well-being and diabetes (Lim & Taylor 2005). Despite the notable differences in the prevalence of those reaching the physical activity guidelines between studies previously discussed, the factors influencing physical activity across studies are similar. Regarding age, this study is in line with previous research reporting the proportions of those physically active by age categories. As expected, the proportion of older adults achieving the recommended levels declined consistently with increasing age (Gobbi *et al*. 2012, Marquez *et al*. 2015, Townsend *et al.* 2015, Keadle *et al.* 2016). In those aged 65 – 69 years, nearly three quarters of participants reported meeting the guidelines compared to just over half in those aged 75 and over. In fact, the observed decline in physical activity with increasing age has been recognised as one of the most consistent findings in physical activity research (Trost *et al*. 2002, Sun *et al*. 2013). It has been suggested that part of the physical activity decline with increasing age may be due to decreased functional fitness, decreased muscle strength and chronic disease. In fact, chronologically, age is often a useful measure which is highly correlated with of health status, disease burden and disability. Clark *et al.* (2017) suggested that unmeasured physiological factors including muscle weakness and fatigue are likely to explain the association between age and physical activity as the chronological nature of age is unlikely to impact physical activity levels (Milanović *et al*. 2013, McPhee *et al.,* 2016). However, this study adjusted for many physical health variables which are highly correlated with age including chronic health problems, disability, functional mobility, muscle weakness and pain. Regardless of these factors, older age still remained a significant independent factor of not reaching the physical activity guidelines (Lim & Taylor 2005, Browning *et al.* 2009).

Regarding gender differences in physical activity levels the majority of research to date has recognised males to be considerably more active than their female counterparts (Trost *et al*. 2002, Sun *et al*. 2013). Sun *et al.* (2013) reported that males were more active than females with gender differences ranging between 0.2% and 1.5% for objective measures to 0.8% and 21.4% for self-report measures in comparison to this study where the difference was 13%. Although Notthoff *et al.* (2017) showed conflicting results regarding gender and physical activity levels; a range of studies included in the review reported physical activity in different domains. Particularly in the older generation, past gender roles may still exist where females generally report more physical activity through domestic and gardening while males tend to spend more time in the vigorous physical activity domain including work and leisure time related activity. Thus measuring specific physical activity domains is likely to give contrasting results (Hallal *et al*. 2003, Moschny *et al*. 2011). As previously mentioned, all physical activity domains are important in achieving the recommended guidelines, particularly for older adults. This study measured total physical activity levels which assesses both male and female dominant activities including household activities and other non-leisure, non-sporting activities. With the inclusion of all domains, this study still revealed that males were significantly and independently more likely to achieve the recommended physical activity guidelines compared to females.

In contrast to some studies (Chad *et al.* 2005, Browning *et al.* 2009), education was not associated with physical activity levels at baseline. Previous research has documented that higher education is associated physical activity in the domains of walking, domestic and vigorous activities (Nortoff *et al*. 2017). In contrast, Shaw & Spokane (2008) suggests that individuals with low education heavily rely on employment as their main form of physical activity. In fact, regarding employment status, this study revealed that unemployment was associated with lower odds of achieving the recommended physical activity levels. This may reflect the work related physical activity domain captured in the IPAQ measuring total physical activity. For example, a recent review by Notthoff *et al.* (2017) recognised a limited association between physical activity and employment status. However, with regards total physical activity level, one study showed a positive association between employment and physical activity (Berger *et al*. 2005). Taken together, these findings regarding education and employment with total physical activity are interesting. Although, Schrack *et al.* (2014) also showed that being employed was associated with higher levels of physical activity; type of employment (active vs sedentary job) was not associated with physical activity. This may be a result of the considerable wider age range (32–93 years) used in the aforementioned study in comparison to the current research which only included older adults aged 65 and over.

Surprisingly, this research documented that a chronic health problem was positively associated with current physical activity levels. Intuitively, it's fair to assume that older adults with a chronic health problem are less likely to be physically active. However, health has been documented as both a motivator and a barrier to physical activity (Belza *et al.* 2004). Participants with a chronic health problem may have been previously prescribed physical activity or felt more assured that they were able to participate in physical activities after consultation with their doctors. Education on the benefits of physical activity for chronic disease upon diagnosis may have enticed participants to engage in physical activities as a protection mechanism to improve their condition or health status (Li *et al*. 2013). Elsewhere, Chad *et al*. (2005) showed no association between chronic disease and physical activity levels. However, the author's recognised specific chronic diseases (musculoskeletal, breathing, heart and circulation, diabetes and digestive conditions) and number of chronic diseases were associated with lower levels of physical activity suggesting that chronic conditions impact physical activity levels differently. In support of this, the current findings recognised diabetes as an independent factor of not being sufficiently active (Chad *et al*.

2205, Lim & Taylor 2005, Harris *et al.* 2009, Murtagh *et al*. 2015). Moreover, it has been suggested that it may not be the chronic condition or illness itself that is associated with physical activity but rather the severity of and detrimental impact of some chronic conditions including functional limitations and muscle weakness (McKee *et al*. 2015). The present study recognised that functional limitations and muscle weakness were both independently associated with current physical activity levels which may be the result of a chronic health problem. However, due the self-report and dichotomous nature of the variable in question, it is impossible to determine the stage or impact of the chronic disease or illness. In addition, it is impossible to draw conclusions regarding the direction of the relationship from the cross-sectional design.

Better self-rated health and higher quality of life was also found to be significant independent factor associated with physical activity. It seems fair to assume that chronic health is associated with self-rated and quality of life which seems contradictory to the findings of this research. However, the specific chronic conditions affecting quality of life and self-rated health have rarely been explored (McDaid *et al*. 2013). In fact, Molarius & Janson (2002) documented that tiredness, weakness, depression and musculoskeletal pains contribute to the largest part of poor self-rated health than chronic disease and may explain the difference in this study's findings. Irrespective, the findings of this study regarding the association between better self-rated health and higher quality of life with higher physical activity levels is consistent with other cross-sectional research examining factors associated with physical activity in middle aged and older male and female populations (Norman *et al.* 2002, Bergman *et al*. 2008, Giuli *et al*. 2012, Rosenkranz *et al*. 2013, Vagetti *et al.* 2013, Murtagh *et al*. 2015). Although Browning *et al.* (2009) showed no association between self-rated health and physical activity, the authors recognised that attitudes and beliefs towards health may be a better factors associated with physical activity. However, these factors were not included in the models in this study. Previous research has documented that self-rated health is associated with adherence to preventive health service check-ups and medical recommendations which may explain the association with reaching the recommended physical activity guidelines (Alves & Rodrigues 2005, Silva & Menezes 2007, Brunner-Ziegle *et al.* 2013).

Regarding mental and cognitive health characteristics, this study documented mixed findings. Although the positive benefits of physical activity on mental (Depression and anxiety) and cognitive (Dementia) health have been widely published, studies examining the reverse relationship are less often published. In fact, the relationship between physical activity and these factors may be bidirectional. For example, research has shown a bidirectional relationship where physical activity impacts depression and depression impacts physical activity (Elfrey & Ziegelstein 2009, Azevedo Da Silva *et al*. 2012, Steinmo *et al*. 2014). In addition, it is impossible to draw conclusions at this stage regarding the direction of the relationship between physical activity and these factors due to the cross-sectional design. Nevertheless, the current study showed that those with higher depression scores were less likely to achieve the recommended physical activity guidelines which support previous findings (Perrino *et al.* 2010, Julien *et al.* 2013). Surprisingly, the findings in this study regarding anxiety and physical activity contradict the majority of research which show an inverse association. Interestingly, this study found that participants with higher levels of anxiety where more likely to be physically active. However, Stults-Kolehmainen & Sinha *et al*. (2014) suggest that such finding should not be considered happenstance. For example, contradictory evidence regarding stress and physical activity has documented both a decrease and increase in physical activity with the latter explained through higher physical activity acting as a coping mechanism for stress. In addition, previous research has shown similar findings in patients with severe chronic obstructive pulmonary disease (COPD) with regards to anxiety. The authors suggested that the findings could be down to restlessness which is often associated with anxiety, or as a coping mechanism (Nguyen *et al*. 2013).

Finally, the current study documented that sitting for more than 8 hours per day was independently associated with lower levels of physical activity supporting previous research by McKee *et al*. (2015). These findings are worrying from a health prespective as both physical activity level and sedentary behaviours are both and independently associated with increased risk of mortality and chronic health problems (Martinez-Gomez *et al.* 2016). Habits of watching television have been reported as common sedentary behaviour in older adults during leisure time which in itself is considered a major risk factor for mortality. Although older adults have considerably more leisure time available than younger age groups, they are reluctant to be active during this time (Salmon *et al.* 2003). Ekelund *et al.* (2016) recognised that although high levels of moderate physical activity attenuates the risk of mortality associated with long periods of watching TV, it eliminates the risk of mortality associated with high levels of sitting time. Promoting physical activity in those with higher total sitting time is necessary.

5.1.3 Physical Activity Change Patterns

This research observed a decrease in the proportion of older adults meeting the physical activity guidelines from baseline (66%) to follow up (62%). The overall decreasing trend in physical activity from baseline to follow-up shown in this study is in line with previous studies which also showed a decrease in physical activity longitudinally (Bijnen *et al.* 1998, Burton *et al*. 1999, Weiss *et al* 2007, Cohen-Mansfield *et al.* 2010, Buchman *et al*. 2014, Schrack *et al.* 2014). However, this study identified 4 distinct physical activity patterns over time which has rarely been described in other research examining physical activity change in older adults (Barnett *et al.* 2008, Xue *et al*. 2012). During the 2-year follow-up, this research recognised that 21% of participants remained inactive (Inactive maintainer), 17% became inactive (Relapser), 12% became active (Adopter) and 49% remained active (Active maintainer). Although research utilising other longitudinal studies including the Women's Health and Aging Study I & II (WHAS) (Xue *et al.* 2012), The British Regional Heart Study (Jefferis *et al.* 2015), the Korean Longitudinal Study of Ageing (KLoSA) (Lee *et al*. 2015), the Taiwan Longitudinal Study on Aging (TLSA) (Pan *et al*. 2015), The English Longitudinal Study of Ageing (ELSA) (Hamer *et al*. 2013) and the Cross-sectional and Longitudinal Aging Study (CALAS) (Cohen-Mansfield *et al*. 2010) have identified similar patterns of physical activity over time, the proportions associated with patterns are not comparable across studies. As mentioned previously, contrasting physical activity assessments, the exclusion of some physical activity domains, differences in reference guidelines, age ranges and different follow up periods or a change in physical activity assessment at follow-up may explain the diversity.

Maintaining a physically active lifestyle and even taking up a physically active lifestyle in old age is associated with healthy ageing (absence of disease, freedom from disability, high cognitive and physical functioning and good mental health) (Hamer *et al*. 2013, Lee *et al*. 2015). Thus, to develop preventive lifestyle strategies in older adults it is necessary to have information regarding the factors predicting physical activity change patterns ultimately to promote a more active lifestyle in older adults. The longitudinal design of this research allowed an exploration of the reasons why older adults may maintain, decrease / relapse or increase / adopt their physical activity levels over a period of time. Since physical activity declines with increasing age, particularly among older adults, it is important to focus on older adults becoming physically active (adopting) and understand why older adults become inactive (relapsing) which has rarely been done.

5.1.4 Factors Associated with Physical Activity Change

To the author's knowledge, this is the first study to report on the factors predicting physical activity change in a population-representative sample of community dwelling older adults aged 65 and over in the Republic of Ireland (Murtagh *et al.* 2015). In addition, very few longitudinal cohort studies have focused on categorising physical activity behaviour over time in older adults and exploring the factors associated with such behaviour (Barnett *et al.* 2008, Xue *et al*. 2012). This is one of the novel aspects of this study, thus this research extends these previous reports by exploring factors of different physical activity behaviours which are meaningful according to the recommended physical activity guidelines. Previously, this study reported many factors of current physical activity levels in older adults. However, considerably fewer factors of physical activity change were noted. This may reflect the smaller number of participants included in the longitudinal analysis, the general trend of a decline in physical activity over time and the considerably smaller number of older adults adopting physical activity. Nevertheless, the results from the longitudinal design suggest that at least some of the factors may be important not only in explaining current physical activity levels, but also in predicting future physical activity in terms of relapsing and adopting behaviours. The current study identified particular factors associated with becoming physically inactive over a 2 year period including socio-demographic (age, gender, education) factors, physical (chronic health problem, abdominal obesity and self-rated hearing) and mental (depression) health characteristics and behavioural (current smoking status and sitting time) health factors. In addition, the findings of this study identify specific factors associated with becoming physically active over a 2 year period including socio-demographic (education) and physical health (self-rated health, pain, timed up and go) factors.

5.1.4.1 Factors Associated with Relapsing and Adopting

Of those sufficiently active at baseline, the longitudinal design adopted at phase 2 allowed the present study to identify particular groups of the Irish older adult population who were more likely to reduce their activity levels over time, becoming physically inactive. In addition, this study identified specific groups of older adults who were more likely to become physically active over time including socio-demographic (education) and physical health (self-rated health, pain, timed up and go) factors. Although findings from the cross-sectional design at phase 1 documented that older age and female gender were independent factors of not meeting the recommended physical activity guidelines at baseline, the longitudinal findings of this study recognised that even older age groups and females who did meet the guidelines at baseline, were indeed significantly more likely to relapse over 2 years. These findings are in line with previous longitudinal studies identifying that those aged 75 years and older and females as important targets for physical activity interventions in Ireland (Burton *et al*. 1999, Shimada *et al.* 2007, Yasunaga *et al.* 2008, Cohen Mansfield *et al*. 2010; Ferreira *et al.* 2010, Koeneman *et al*. 2011, Hamer *et al*. 2012).

The longitudinal results regarding education level and employment status showed reverse findings compared to results from the cross-sectional design. As suggested earlier, those with lower levels of education may be more likely to achieve the recommended physical activity guidelines through work related activities compared to those with higher education (Shaw & Spokane 2008). In this sample of adults aged 65 and over, it is likely to see a transition from employment to unemployment or retirement over time. This may explain the reverse findings of our cross sectional and longitudinal analysis. For example, the transition out of work is unlikely to negatively affect the physical activity levels of those with higher levels of education. In fact, transition from the workforce into retirement has been associated with an increase in leisure-time physical activity (Touvier *et al*. 2010, Lahti *et al*. 2012). Shaw *et al.* (2008) suggested that the transition out of employment is likely to affect the physical activity levels of those with lower levels of education. However, the relationship between retirement and total physical activity is unclear (Barnett *et al.* 2012). The findings of the present study recognised that those with higher levels of education where less likely to relapse thus remain sufficiently active over time. The findings documented that only those with better self-rated health were more likely to adopt. Although the previous cross sectional findings of the current study showed that a chronic health problem was associated with reaching the physical activity guidelines, those with a chronic health problem were also more likely to relapse. This supports the previous suggested explanations on the idea that chronic illness is progressive and that it may be impact of chronic disease over a 2 year period that's likely to affect physical activity. Similarly, those with abdominal obesity were also more likely to relapse supporting previous longitudinal findings (Ekelund *et al.* 2008, Lakerveld *et al.* 2011). In line with this, those experiencing pain were less likely to become physically active (adopter), thus remaining physically inactive over 2 years (inactive maintainer). Schofield (2017) stated that pain management particularly in older adults is poor with health care professionals likely to underestimate pain and as a result under prescribe and under medicate the elderly. The result of this study highlight the need to identify those at risk of experiencing pain which supports suggestions by Cohen-Mansfield et al (2010) and Ho et al (2016) to develop strategies in older adults for pain management aiming to relieve pain which may prevent those from engaging in physical activity. Similarly, those with functional mobility impairment were also less likely to become active. Those with better self rated hearing were less likely to relapse and remain sufficiently active over time. This finding supports a previous cross sectional studies which documented that lower levels of physical activity and higher levels of sedentary time were associated with poor hearing in older adults (Loprinzi *et al*. 2013, Gispen *et al*. 2014). Furthermore, the current study recognised that those with higher depression scores at baseline were more likely to become physically inactive over time which also supports previous studies which recognised a decrease physical activity over time associated with depression (Perrino *et al*. 2010, Julien *et al*. 2013, Panagiotakos *et al*. 2008, Xue *et al*. 2012). These results support suggestions by Perrino *et al*. (2010) calling for health policy interventions to address depression among older adults which is turn may increase current levels physical activity and enhance physical activity maintenance which will ultimately improve the overall physical and mental health of older adults.

The findings regarding behavioural characteristics and physical activity are worrying. The current study documented that smokers and those who spent more than 8 hours sitting per day were more likely to reduce their physical activity levels and become physically inactive. Smoking and sedentary time is associated with disability and chronic disease which may explain the decline in activity levels. Nevertheless, the cluster of these unhealthy behaviours is worrying considering the association physical activity which may further impair their condition (Schneider *et al*. 2009, González *et al*. 2017). Identifying these predictive factors of future activity is potentially helpful in identifying targets for intervention to maintain or adopt physical activity in older adults.

5.2 Impact of Physical Activity on CVD and Cardio-metabolic Risk Factors

In this study, CVD was defined as having one or more of the following cardiovascular conditions or procedures including angina, heart failure, a heart attack, stroke, TIA or a stent / vascular surgery. Results documented that 20% of Irish community dwelling adults aged 65 years and over have a CVD.

Sufficiently active older adults had significantly lower odds associated with CVD. This inverse trend and protective effect of physical activity was independent of the known major CVD risk factors including socio-demographic (age, gender, education), behavioural (smoking and alcohol) and cardio-metabolic (high blood pressure, high cholesterol, diabetes, BMI, abdominal obesity) factors which have been consistently documented in the CVD literature (Ignarro *et al.* 2007). In the fully adjusted model, those reaching the recommended physical activity guidelines were 24% less likely to have a CVD. The findings here are not surprising considering the abundance of literature documenting the benefits reaching the current recommendations of 150 minutes of moderate intensity physical activity per week (Physical Activity Guidelines Committee 2008). Similar, studies which also assessed physical activity levels in line with the 2008 guidelines reported CVD risk reductions of between 20 – 35% for moderate and for higher intensity activities. In addition, the findings of this research were recently supported in a national survey of Korean adults which showed fully adjusted (≥ 65 years, hypertension, diabetes mellitus, sex, and smoking) risk reductions of CVD with 18% and 34% for moderate and high levels of physical activity groups, respectively (Kim *et al.* 2017). Although the current study controlled for considerably more covariates and combined moderate and high levels of physical activity which is in line with international standards of reaching the recommended guidelines, the findings are similar to research by Kim *et al*. (2017) who also used the IPAQ-SF to assess physical activity. The current study therefore seems to confirm health enhancing physical activity in which reaching moderate levels can significantly reduce the incidence of CVD in a representative sample of community dwelling older adults in Ireland. The majority of evidence to date has been derived from studies that focussed on leisure time physical activity alone, CVD mortality and populations with middle aged and older adults combined (Shiroma & Lee 2010, Koolhaas *et al.* 2015, Barengo *et al*. 2017). Therefore, the findings of this research extend the literature in a number of ways. Although evidence from epidemiologic studies indicate that the same factors associated CVD in middle-aged adults are relevant in older adults, few studies have focused solely on older adults (≥65) especially among the oldest old (≥80) (Batty *et al*. 2002, Shiroma & Lee 2010, Cheng *et al*. 2013, Lillo *et al.* 2015, Soares-Miranda *et al.* 2016). The findings of the current study focus exclusively on older adults with an even distribution across age groups (65-69, 70 – 74, ≥75). Also, the proportion of those aged 80 years and older is well represented. CVD represents a major challenge to healthy ageing, and the findings of this study support the recommended guidelines of meeting 150 minutes of moderate physical activity in reducing CVD risk in an ageing population of Ireland.

Moreover, in contrast to the mainstream of research which often documents the association of leisure time physical activity and CVD, particularly in epidemiological research (Kubota *et al.* 2017), the current study reported the association with total physical activity levels. In fact, leisure time physical activity may not be as important in the elderly considering older adults often engage in different activity types compared to younger and middle-aged adults (Hallal *et al*. 2003, Murphy *et al.* 2013, Soares-Miranda *et al.* 2016). The evidence provided from the present study shows a considerable inverse association with total physical activity on the incidence of CVD suggesting that the accumulation of minutes from a range of physical activity domains and not just leisure time physical activity may be an important aspect in how older adults can achieve the recommended guidelines thus protecting themselves from CVD. Older adults, who actually achieve the recommended guidelines, do so through moderate activities including domestic chores (Hallal *et al*. 2003, Murphy *et al.* 2013). These findings are in line with more recent research reporting the association of total physical activity levels on CVD events and CVD mortality (Koolhaas *et al*. 2016, Kubota *et al.* 2017, Lear *et al.* 2017). Kubota *et al.* (2017) suggested that moderate levels of total physical activity in middle-aged and elderly Japanese adults may have the highest risk reductions in CVD supporting recent work by Lear *et al.* (2017) and Koolhaas *et al*. (2016) which documented significant CVD risk reductions of both recreational and non-recreational activity including commuting, work-related and domestic activities in large samples of middle aged and older adults combined.

Even after accounting for the well documented cardio-metabolic risk factors such as blood pressure, cholesterol, diabetes, obesity and abdominal obesity, the inverse relationship between physical activity and CVD remained significant which has been previously documented (Mora *et* *al.* 2007). The precise mechanisms through which physical activity lowers CVD risk are not well understood and although it appears that these cardio-metabolic play a role in the relationship between physical activity and CVD, the contribution of these cardio-metabolic risk factors have been less explored particularly in older adults (Mora *et al.* 2007). In the present study, cardio-metabolic risk factors examined included high blood pressure, high cholesterol, diabetes, obesity and abdominal obesity. This study revealed that these risk factors were highly prevalent in Irish community dwelling older adults. Results revealed that 47%, 11% and 43% have high blood pressure, diabetes and high cholesterol, respectively. In addition, 35% and 55% of participants were classified as obese and abdominally obese, respectively.

When examining the impact of physical activity on the cardio-metabolic risk factors, the findings revealed that older adults achieving the recommended physical activity guidelines had significantly lower prevalence rates of high blood pressure, diabetes, obesity and abdominal obesity whereas no significant difference was observed in those with high cholesterol. The inverse trend and protective effect of physical activity was independent of known non-modifiable and modifiable risk factors including age, gender, education, smoking and alcohol. These findings are somewhat consistent with Rosique-Esteban *et al.* (2017) who also showed significant adjusted risk reductions in diabetes, obesity and abdominal obesity for those reaching the recommend physical activity guidelines and no associations with cholesterol. In this study, cholesterol was assessed by participants self reporting whether are not their doctors told them they had high cholesterol. Total cholesterol is the most commonly used measure of cholesterol and includes low-density lipoprotein (LDL) cholesterol and high-density lipoprotein (HDL) cholesterol. However total cholesterol can be an inaccurate measure given the different effects of LDL and HDL on health. High levels of HDL are associated a healthy cardiovascular system and although physical activity can improve total cholesterol levels, regular physical activity has been shown to increase HDL cholesterol while only maintaining, LDL cholesterol and triglycerides (Mann *et al.,* 2014).

In addition and in contrast to this current study, the authors found that blood pressure was not associated with physical activity which may be explained by the considerably younger sample used or due to further adjustments of sedentary time behaviours in their analysis compared to the current study. The current research revealed that active participants were 29% less likely to have high blood pressure which is supported by previous research (Jakes *et al*. 2003, Warburton *et al*. (2010). For example, Warburton *et al*. (2010) revealed hypertension risk reductions of 33% for those active compared to inactive.

The findings from the mediation analysis in the current study documented that the inverse association between total physical activity and CVD can be partially explained by the beneficial effects of physical activity on blood pressure, BMI and abdominal obesity. These associations were maintained regardless of age, gender and education. Although many studies have examined the relationship between physical activity and CVD, few studies have evaluated the mediation role of the different cardio-metabolic risk factors in community dwelling older adults. To the author's knowledge, this is the first study to describe these associations among a large population sample of Irish community dwelling men and women adults aged 65 and over. In a sample of middle aged and older women, Mora *et al.* (2007) documented that inflammatory and haemostatic biomarkers are the most important factors in explaining the relationship between physical activity and CVD followed by blood pressure, lipid profile and obesity which explains 59% of the total physical activity related reduction in CVD. The present study extends the literature by examining the role of traditional cardio-metabolic risk factors including WC in a representative sample of community dwelling older adults.

In the current study, findings revealed that blood pressure was the most important mediating factor followed by waist circumference and BMI. Although, the previous findings revealed that physical activity was a better factors associated with BMI than WC, findings in the mediation analysis recognised that waist circumference is a slightly stronger mediator than BMI in explaining the relationship between the physical activity and CVD (11% versus 9%). This finding is consistent with previous literature and extends the finding in older adult's populations recognising WC as a better predictor of health outcomes than BMI (Lee *et al.* 2008, Czernichow *et al.* 2011).

5.3 Strengths and Limitations

Phase 1 of this thesis sought to investigate the levels and factors associated with physical activity at baseline and assess the impact of physical activity on CVD with the mediating role of cardio-metabolic risk factors. The strengths of the current research (Phase 1) include the large nationally representative sample of community dwelling male and female adults aged 65 and over which allows generalisation of the findings to the non-institutionalised population of older adults living in Ireland. Furthermore, a main strength of this study was the combined multivariate examination of a wide range of potential factors associated with physical activity level using backward stepwise elimination to generate the most parsimonious set of factors. Given the sample size of the current study, all multivariate logistic regression models had sufficient power to examine many predictive factors collectively (Peduzzi *et al.* 1996). In addition, this study measured total physical activity levels, which includes transportation, walking and domestic activities and therefore is more appropriate when assessing the physical activity levels of older adults. Previous research has mainly focused on leisure-time physical activity which may be more fitting in younger and middle aged adults.

When assessing the impact of physical activity on CVD, the effect of confounding was reduced since there were adjustments made for known cardiovascular risk factors including age, gender, education, smoking, alcohol, high blood pressure, high cholesterol, diabetes, BMI and WC.

The strengths of phase 2 of the current study include the longitudinal design and the nationally representative sample of community dwelling older adults. Although the time period between baseline and follow up was short, the same physical activity measurement at two time points allowed this study assess physical activity patterns which are meaningful in terms of maintaining, adopting or relapsing according to the physical activity guidelines. Similarly, the combined multivariate examination of a wide range of potential factors associated with physical activity change patterns.

Despite these strengths, several limitations should be noted in the interpretation of the findings. First, phase 1 of this research used a cross-sectional design therefore the ability to detect causal relationships is severely limited and findings cannot be precisely inferred. Second, this study was based on data obtained using the IPAQ-SF to assess physical activity levels. Although IPAQ-SF has been deemed a reliable and valid tool to measure total physical activity at a population level, the questionnaire was originally designed to assess physical activity levels in adults aged 18–65 years old. In addition, self-report measures, may be problematic due recall bias "over the last 7 days" and social desirability where participants can over estimate physical activity levels according to what they believe is socially acceptable (Bauman *et al.* 2009). A review by Lee *et al.* (2011) documented that the IPAQ-SF can over estimate physical activity levels by between 36 to 173**%.** Although the cardio-metabolic risk factors BMI and WC were assessed objectively during the health assessments, the determination of CVD (angina, myocardial infarction, heart failure, stroke, TIA, stent/vascular surgery) and other cardio-metabolic risk factors (high blood pressure, high cholesterol and diabetes) were limited as they were based upon self-reports of a doctor's diagnosis which may underestimate the true prevalence of these conditions. As a result there is a risk that CVD is poorly represented in the sample.

In addition the factors associated with physical activity change patterns were restricted to baseline factors. It is possible that follow-up factors or the change in factors over time may be better factors than the baseline measures. Finally, generalisability of the findings regarding physical activity change should be noted with caution. Participants lost at follow up were older, had a lower education level, were less physically active, had no CVD and rated their physical health as fair or poor.

5.4 Conclusion

This study investigated the patterns and predictors of physical activity and assessed the impact of physical activity on CVD and cardio-metabolic risk factors in community dwelling older adults living in Ireland. Despite the well known health benefits of physical activity, only 65% of community dwelling older adults in Ireland achieve the recommended physical activity guidelines. CVD represents a major challenge to healthy ageing, and the findings of this study support the recommended guidelines of meeting 150 minutes of moderate intensity physical activity in reducing CVD and cardio-metabolic risk factors in an ageing population of Ireland. Physical activity was inversely related to total CVD, high blood pressure, diabetes and obesity (BMI and WC). The results from this study emphasize the importance of total physical activity (walking, domestic, transportation) and not just leisure time physical activity for the cardiovascular health of older adults regardless of age, gender, education and behavioural health (smoking, alcohol). However it is important to note that assessing the impact of physical activity in each domain was beyond the scope of this study and further research may be warranted.

Also, this study found a longitudinal decline in those reaching the guidelines over time. Of those physically active at baseline, over a quarter became inactive (relapser) after 2 years. The decline in physical activity was higher in those aged 75 and over, females and those with higher depression and a chronic health problem. Moreover, being a smoker, abdominally obese and sitting for more than 8 hours per day was associated with becoming inactive while those with higher education where less likely to reduce their physical activity levels. Of those inactive at baseline, only those with better self-rated health were more likely to become physically active (adopter) while those with a functional mobility problem and those troubled with pain were less likely to become active. The results of this study have several practical implications for promoting physical activity in community dwelling older adults in Ireland. Ireland launched its first ever National Physical Activity Plan in 2016 (NPAP 2016) which hopes to see an increase in the proportion of adults achieving the recommended guidelines by 1% per year. Physical activity levels are currently declining in older adults thus identifying these predictive factors of future activity is helpful in identifying targets for interventions to maintain physical activity over time in older adults particularly for the prevention of CVD. This study provides findings which policymakers can easily understand. In addition, the implications of these associations should be incorporated in the implementation of future health promotion interventions and within community health practice. The findings highlight the need to target older adults particularly females and those over the age of 75 and those who might actually benefit the most, namely those with chronic health problems including obesity, depression and functional mobility impairments. Thus, primary care providers may be in the best position to play a pivotal role in physical activity prescription. Adequate training and support should be provided to health care professionals and in succession educate patients regarding the key modifiable and behavioural factors including increasing "TOTAL" and acceptable levels of physical activity activities and reducing sedentary behaviours. In the UK, the National Institute for Health and Care Excellence (NICE) urge primary health care providers to prescribe brief and tailored physical activity and follow up at subsequent appointments (NICE, 2013). Yet, most general practitioners in England (80%) are unfamiliar with the national physical activity guidelines (Chatterjee *et al.,* 2017). With the right knowledge, skills and support GPs can provide evidence based physical activity to those who need it most ultimately to enhance many aspects of patient's health (Brooks 2016). In Ireland, over the next 3 years the HSE are increasing investments into research and expanding facilities and amenities to increase opportunities to be physically active.

Although the major factors associated with CVD have been well researched, there is still a need to examine health behaviours including physical activity, particularly the role of total physical activity in the prevention and protection in CVD for older adults. Future waves of the TILDA data sets will allow more research to assess the impact of physical activity change patterns on CVD events and CVD mortality in Irish older adults.

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Appendices

Appendix 1: Dependant Variable from CAPI

IPAQ-SF

Exercise section

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

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.

BH101: During the **last 7 days**, on how many days did you do **vigorous** physical activities like heavy lifting, digging, aerobics, or fast bicycling?

1. _____Number of days per week

5. No I have not done any vigorous physical activities

98. DK/ NOT SURE

99. RF

BH102: How much time did you usually spend doing **vigorous** physical activities on one of those days?

_____ hours per day (0 …10)

_____ minutes per day

98. DK/NOT SURE

99. RF

BH103: 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. Think only about those physical activities that you did for at least 10 minutes at a time. During the **last 7 days**, on how many days did you do **moderate** physical activities like carrying light loads, bicycling at a regular pace, or doubles tennis? Do not include walking.

1. _____ days per week

5. No I have not done any moderate physical activities

BH104: How much time did you usually spend doing **moderate** physical activities on one of those days?

_____ hours per day (0 …10)

_____ minutes per day

BH105: Now 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.

During the last 7 days, on how many days did you walk for at least 10 minutes at a time?

1. _____ days per week

5. No I have not done any walking

BH106: How much time did you usually spend **walking** on one of those days?

_____ hours per day (0 …5)

_____ minutes per day

Appendix 2: Independent Variables from CAPI

Socio-demographic & Social Engagement Variables

Age:

CS002: In which month and year were you born?

MONTH: ____YEAR: _______

Gender:

CS004: Is Respondent male or female?

1. MALE

2. FEMALE

Education:

DM001: What is the highest level of education you have completed?

1. Some primary (not complete)

2. Primary or equivalent

3. Intermediate/junior/group certificate or equivalent

4. Leaving certificate or equivalent

5. Diploma/certificate

6. Primary degree

7. Postgraduate/higher degree

Employment Status

Which one of these would you say best describes your current situation?

IWER: CODE THE ONE THAT APPLIES

1 Retired

2 Employed

3 Self-employed

4 Unemployed

5 Permanently sick or disabled

6 Looking after home or family

7 In education or training

Marital Status

CS006: Are you…

1. Married

2. Living with a partner as if married

3. Single (never married)   GO TO DM001

4. Separated

5. Divorced

6. Widowed

Location:

CS027: IS THIS DWELLING LOCATED

1. IN DUBLIN CITY OR COUNTY

2. A CITY OR TOWN IN THE REPUBLIC OF IRELAND OTHER THAN DUBLIN

3. IN A RURAL PART OF THE REPUBLIC OF IRELAND

Medical Insurance:

HU001: Are you covered by

1. Full Medical Card or equivalent

2. GP Visit Card

96. Neither of these

HU002. Do you have private medical insurance cover (VHI etc.) in your own name or through another family member?

1. Yes, in own name GO TO HU003

2. Yes, as the spouse of a subscriber

3. Yes, as the relative of a subscriber

5. No GO TO

Social Connectedness Score

Notes: 1 is added to respondent's score for each instance they meet the following criteria –

- Member of church
- Married / Living with partner as if married
- Member of organisation excluding the church
- Has at least one close relative or friend

Physical Health Variables

Chronic Health Problem

PH003: Some people suffer from chronic or long-term health problems. By long-term we mean it has troubled you over a period of time or is likely to affect you over a period of time. Do you have any long-term health problems, illness, disability or infirmity?

1. Yes

5. No

Self-rated Physical Health

PH001: Would you say your health is.

1. excellent,

2. very good,

3. good,

4. fair,

5. or, poor?

Self-rated Vision:

PH102: Is your eyesight (using glasses or contact lens if you use them)...

1. excellent

2. very good

3. good

4. fair

5. or, poor?

Self-rated Hearing

PH108: Is your hearing (with or without a hearing aid)……..

1. excellent,

2. very good,

3. good,

4. fair,

5. or, poor?

Functional Limitations

Description: Indicator variable for whether the respondent has an IADL or any ADL.

0 = Not disabled

1 = IADL disability only

2 = Any ADL disability

PH201: Has a doctor ever told you that you have any of the conditions on this card?

1. High blood pressure or hypertension

2. Angina

3. A heart attack

4. Congestive heart failure

5. Diabetes or high blood sugar

6. A stroke (cerebral vascular disease)

7. Ministroke or TIA

8. High cholesterol

9. A heart murmur

10. An abnormal heart rhythm

Falls

PH401: Have you fallen in the last year?

1. Yes

5. No

Fear of Falling

PH408: Are you afraid of falling?

1. Yes

5. No

Pain

PH501: Are you often troubled with pain?

1. Yes

5. No

Mental Health Variables

Self-rated Mental Health

PH002: What about your emotional or mental health? Is it …

1. excellent,

2. very good,

3. good,

4. fair,

5. or, poor?

Depression (CES-D)

MH001: I was bothered by things that usually don't bother me

1. Rarely or none of the time (less than 1 day)
2. Some or a little of the time (1-2 days)
3. Occasionally or a moderate amount of time (3-4 days)
4. All of the time (5-7 days)

MH002: I did not feel like eating; my appetite was poor.

1. Rarely or none of the time (less than 1 day)
2. Some or a little of the time (1-2 days)
3. Occasionally or a moderate amount of time (3-4 days)
4. All of the time (5-7 days)

MH003: I felt that I could not shake off the blues even with help from my family or friends.

1. Rarely or none of the time (less than 1 day)
2. Some or a little of the time (1-2 days)
3. Occasionally or a moderate amount of time (3-4 days)
4. All of the time (5-7 days)

MH004: I felt that I was just as good as other people.

1. Rarely or none of the time (less than 1 day)

2. Some or a little of the time (1-2 days)

3. Occasionally or a moderate amount of time (3-4 days)

4. All of the time (5-7 days)

MH005: I had trouble keeping my mind on what I was doing.

1. Rarely or none of the time (less than 1 day)

2. Some or a little of the time (1-2 days)

3. Occasionally or a moderate amount of time (3-4 days)

4. All of the time (5-7 days)

MH006: I felt depressed.

1. Rarely or none of the time (less than 1 day)

2. Some or a little of the time (1-2 days)

3. Occasionally or a moderate amount of time (3-4 days)

4. All of the time (5-7 days)

MH007: I felt that everything I did was an effort.

1. Rarely or none of the time (less than 1 day)

2. Some or a little of the time (1-2 days)

3. Occasionally or a moderate amount of time (3-4 days)

4. All of the time (5-7 days)

MH008: I felt hopeful about the future.

1. Rarely or none of the time (less than 1 day)

2. Some or a little of the time (1-2 days)

3. Occasionally or a moderate amount of time (3-4 days)

4. All of the time (5-7 days)

MH009: I thought my life had been a failure.

1. Rarely or none of the time (less than 1 day)

2. Some or a little of the time (1-2 days)

3. Occasionally or a moderate amount of time (3-4 days)

4. All of the time (5-7 days)

MH010: I felt fearful.

1. Rarely or none of the time (less than 1 day)

2. Some or a little of the time (1-2 days)

3. Occasionally or a moderate amount of time (3-4 days)

4. All of the time (5-7 days)

MH011: My sleep was restless.

1. Rarely or none of the time (less than 1 day)

2. Some or a little of the time (1-2 days)

3. Occasionally or a moderate amount of time (3-4 days)

4. All of the time (5-7 days)

MH012: I was happy.

1. Rarely or none of the time (less than 1 day)

2. Some or a little of the time (1-2 days)

3. Occasionally or a moderate amount of time (3-4 days)

4. All of the time (5-7 days)

MH013: I talked less than usual.

1. Rarely or none of the time (less than 1 day)
2. Some or a little of the time (1-2 days)
3. Occasionally or a moderate amount of time (3-4 days)
4. All of the time (5-7 days)

MH014: I felt lonely.

1. Rarely or none of the time (less than 1 day)
2. Some or a little of the time (1-2 days)
3. Occasionally or a moderate amount of time (3-4 days)
4. All of the time (5-7 days)

MH015: People were unfriendly.

1. Rarely or none of the time (less than 1 day)
2. Some or a little of the time (1-2 days)
3. Occasionally or a moderate amount of time (3-4 days)
4. All of the time (5-7 days)

MH016: I enjoyed life.

1. Rarely or none of the time (less than 1 day)
2. Some or a little of the time (1-2 days)
3. Occasionally or a moderate amount of time (3-4 days)
4. All of the time (5-7 days)

MH017: I had crying spells.

1. Rarely or none of the time (less than 1 day)
2. Some or a little of the time (1-2 days)

3. Occasionally or a moderate amount of time (3-4 days)

4. All of the time (5-7 days)

MH018: I felt sad.

1. Rarely or none of the time (less than 1 day)

2. Some or a little of the time (1-2 days)

3. Occasionally or a moderate amount of time (3-4 days)

4. All of the time (5-7 days)

MH019: I felt that people disliked me.

1. Rarely or none of the time (less than 1 day)

2. Some or a little of the time (1-2 days)

3. Occasionally or a moderate amount of time (3-4 days)

4. All of the time (5-7 days)

MH020: I could not get "going."

1. Rarely or none of the time (less than 1 day)

2. Some or a little of the time (1-2 days)

3. Occasionally or a moderate amount of time (3-4 days)

4. All of the time (5-7 days)

Behavioural Health

Sitting Time (IPAQ)

BH107: The last question is about the time you spent sitting on weekdays during the last 7 days. Include time spent at work, at home, while doing course work and during leisure time. This may include time spent sitting at a desk, visiting friends, reading, or sitting or lying down to watch television. During the last 7 days, how much time (per day) did you spend sitting on a week day?

(This question is looking for the usual number of hours spent sitting on a typical week day. If respondent has difficulty calculating, interviewer may suggest they approximate by subtracting time spent sleeping, walking, standing, exercising etc. from the 24 hours)

_____ hours per day (0 …20)

_____ minutes per day

Trouble Sleeping

BH202: How often do you have trouble falling asleep?

1. Most of the time

2. Sometimes

3. Rarely or never

Smoke

BH002: Do you smoke at the present time?

IWER: IF RESPONDENT SMOKED IN THE PAST 3 MONTHS CODE 1

1. Yes

5. No, I have stopped

Appendix 3: Independent Variables from SCQ

Physical Health

Did you ever have a life-threatening illness or accident?

Yes No

Mental Health

Anxiety (HADS-A)

Please indicate how well the following statements currently describe your feelings. Please choose one response from the four given for each statement. You should give an immediate response and not think too long about your answer.

I feel tense or “wound up”.

1. Most of the time.

2. A lot of the time.

3. From time to time, occasionally.

4. Not at all.

I get a sort of frightened feeling as if something awful is about to happen.

1. Very definitely and quite badly.

2. Yes but not too badly.

3. A little but it doesn’t worry me.

4. Not at all.

Worrying thoughts go through my mind.

1. A great deal of the time.

2. A lot of the time.

3. From time to time but not too often.

4. Only occasionally.

I can sit at ease and feel relaxed.

1. Definitely.

2. Usually.

3. Not often.

4. Not at all.

I get a sort of frightened feeling like "butterflies" in the stomach.

1. Not at all.

2. Occasionally.

3. Quite often.

4. Very often.

I feel restless as if I have to be on the move.

1. Very much indeed.

2. Quite a lot.

3. Not very much.

4. Not at all.

I get sudden feelings of panic.

1. Very often indeed.

2. Quite a lot.

3. Not very often.

4. Not at all.

Loneliness (UCLA)

How often do you feel you lack companionship?

Some of the time

Hardly Ever or

Never

How often do you feel left out?

Some of the time

Hardly Ever or

Never

How often do you feel isolated from others?

Some of the time

Hardly Ever or

Never

How often do you feel in tune with the people around you?

Some of the

time

Hardly Ever or

Never

How often do you feel lonely?

Some of the

time

Hardly Ever or

Never

Behavioural Health

Alcohol (CAGE)

Have you ever felt that you should cut down on drinking?

Yes No

Have people ever annoyed you by criticising your drinking?

Yes No

Have you ever felt bad or guilty about drinking?

Yes No

Have you ever ta ken a drink first thing in the morning to steady your nerves or get rid of a hangover?

Yes No

Appendix 4: Independent Variables from Health Assessment

Cognitive Health

Mini Mental State Examination (MMSE)

The MMSE is used as a global measure of cognition and takes approximately 5 minutes to administer. It assesses different cognitive domains: attention and concentration, memory, language, visuo-constructional skills, calculations and orientation. The individual's response was recorded for each item.

Orientation to time: The first 5 questions assessed the individual's orientation to time.

”What is the year?”

“What is the season?”

“What is the month of the year?”

“What is the day of the week?”

“What is the date?”

One point was awarded for each item answered correctly (maximum 5 points).

Scoring the season can be difficult as it can be somewhat arbitrary. The Irish calendar does not observe the typical astronomical seasons (beginning, in the Northern Hemisphere, on the equinoxes and solstices), or the meteorological seasons (beginning on March 1, June 1, September 1 and December 1). Rather, it centres the seasons around the solstices and equinoxes, beginning the seasons at the approximate halfway points between solstice and equinox. For example, in Ireland, the autumn months according to the national meteorological service, Met Éireann, are September, October and November. However, according to the Irish Calendar, the autumn months are August, September and October.

To score this question correctly, either season if the season is within one month of changing (see table below) was accepted. So for example, if the month is August, either summer or autumn was accepted.

Month	Accept Season
January	Winter
February	Winter / Spring

March Spring

April Spring

May Spring / Summer

June Summer

July Summer

August Summer / Autumn

September Autumn

October Autumn

November Autumn / Winter

December Winter

Orientation to place: The next 5 questions assessed the individual's orientation to place. In TILDA, these questions are slightly different to those on the MMSE sheet.

"What is the name of this country?"

"What is the name of this county?"

"What is the name of this city?"

"What is this building?" (either type or name of building)

"What floor are we on?"

One point was scored for each item answered correctly (maximum 5 points).

Registration: This tests a person's ability to learn and retain three unrelated words, as well as his/her level of alertness and attentiveness. Three words (apple, penny, table) were read out slowly to the participant and they were asked to repeat them and then keep them in mind as they would be asked them again in a few minutes.

Each correct answer received 1 point (maximum 3 points). The order of the words did not matter. If the respondent did not successfully repeat all three words on the first trial, they were repeated until he/she was able to say all three words back (in any order). This is important as the person needs to "make" the memory if they are to "retrieve" it later. A maximum of five trials was allowed to repeat all three words. Respondents were scored on the first trial only.

Attention and Calculation: The serial 7s and WORLD tasks both assess the respondent's attention and mental calculation abilities. The respondent was asked both components of the test but only the best score was used to calculate the MMSE score.

For the serial 7s, the respondent was asked to subtract 7 from 100 then keep subtracting 7 from each answer until told to stop. A total of five answers was required and all answers given by the respondent were recorded. One point was scored for each correct answer (maximum 5 points). An answer was considered correct if it was exactly 7 less than the previous answer, regardless of whether that previous answer was correct.

In the WORLD task, the respondent was asked to spell WORLD forwards then backwards. Only the backward spelling was scored, giving one point for each letter that appeared in the correct order with the highest number of consecutive letters being scored (e.g. DLROW = 5, DLORW = 2) (maximum 5 points).

Recall: The next task assessed the individual's ability to recall the three words he/she learned during the registration task (apple, penny, table) without prompts or clues. One point was given for each correct answer (maximum 3 points) regardless of the order they were provided in.

Naming: The next task assessed the individuals' ability to recognise and name two common objects. The respondent was shown a pencil/pen, watch or other common object (e.g. eyeglasses, chair or keys). One point was given for each object correctly identified (maximum 2 points)

Repetition: This single-item task assessed the respondent's ability to precisely repeat a series of unrelated word that are not frequently said together. The respondent was asked to repeat "NO IFS, ANDS OR BUTS". The research nurse spoke slowly and articulated clearly so that all the "s" endings were audible. One point was given if the respondent repeated the entire phrase correctly; otherwise he/she received 0. If the respondent did not hear the phrase the first time, the sentence was repeated a second time. If the sentence needed to be repeated a third time, the respondent scored 0.

Comprehension: This task assessed the respondent's ability to attend to, comprehend and carry out a complex three-stage command "Take this paper in your right hand, fold it in half and put it on the floor". If a respondent was disabled or physically positioned in such a way that he/she could not place the paper on the floor, he/she could place the paper on a table. The scoring sheet or any blank sheet of paper was used. Care was taken so that the paper was not handed to the respondent until after the entire 3 stage command was given and that it was handed to the space in between their hands and not preferentially towards their right or left hand.

One point was given for each of the following: respondent took the paper in his/her right hand, he/she folded the paper in half (the fold did not need to be perfect), he/she put the paper on the floor (or table, if appropriate) (maximum 3 points). If the respondent asked if they could use both hands to fold the sheet, it was clarified that they could. If necessary, the instructions were repeated but this was done in their entirety (i.e. all 3 stages together).

Reading: The next section assessed the respondent's ability to read and understand a simple sentence. They were shown a paper with CLOSE YOUR EYES written on it. The respondent could read it aloud if preferred and they received one point if they closed their eyes. This instruction was given only once.

Writing: The next task tested the respondent's ability to write a sentence. A sentence is the largest independent unit of grammar: it begins with a capital letter and ends with a period, question mark, or exclamation point. The sentence is traditionally defined as a word or group of words that expresses a complete idea and must include a subject and a verb. One point was given for a comprehensible sentence; minor grammar or spelling errors were ignored. Respondents were prompted to write a longer sentence if their initial sentence was incomplete in which case they could still score on this task.

Drawing: The drawing task assessed the individual's visuo-spatial ability. Respondents were asked to copy a design comprising two 5-sided figures that intersect to form a 4-sided figure. One point was given if the respondent copied the design accurately. The two figures did not have to be perfect pentagons, equivalent in size or have perfectly straight lines, but they both needed to be 5-sided and their intersection needed to form a 4 sided shape.

The total MMSE score was calculated by summing the item scores across all 11 tasks, taking the higher score of either the WORLD or Serial 7's (maximum 30 points).

Physical Health

Height

Height was measured (in wave 1 only) using a Seca 240 wall mounted measuring rod. Footwear (shoes, slippers, sandals, etc), heavy outer clothes (coat, jackets, etc) and head gear (hat, cap, hair accessories, etc) were removed. The respondent was asked to stand with his/her back to the measuring rod facing forward and straight ahead, feet together and knees straight. The head stop was slid along the measurement rod until it lightly touched the respondent's head. The respondent was asked to move away from the rod and measurements were taken to one decimal place.

Weight

Weight was measured (in wave 1 only) using a SECA electronic floor scales. The respondent removed heavy outer garments (jackets, coats, etc) and footwear (shoes, slippers, sandals, etc), stepped onto the scales and stood still, facing forward with arms by the sides. Weight was measured in kg to one decimal place.

Body Mass Index

Body mass index (BMI) was calculated from measured height and weight as: weight / (height2). This provides a quantitative measure of obesity.

Waist Circumference

The waist was defined as the point midway between the iliac crest and the costal margin (lower rib). Men's waists tend to be above the top of their trousers whereas women's waists are often under the waistband of their trousers or skirts. If the respondent had a waistband at the correct level of the waist (midway between the lower rib margin and the iliac crest), waist circumference was measured over the waistband. The respondent was asked to breathe out gently and to look straight ahead (to prevent them contracting their muscles or holding their breath). The tape was kept horizontal and the measurement to the nearest mm was taken at the end of a normal expiration.

Caution was taken with female respondents where the waistband of jeans was on the waist at the back but dipped down at the front. In such instances, the waist measurement was taken on the waist band at the back and off the waist band at the front.

Timed up and go (TUG)

The timed “Up & Go" test measures, in seconds, the time taken by an individual to stand up from a standard arm chair (approximate seat height of 46 cm, arm height 65 cm), walk a distance of 3 meters (approximately 10 feet), turn, walk back to the chair, and sit down again.

Respondents wore their regular footwear and if assistive devices such as canes or walkers were usually used by the respondents, they were asked to use them during the test.

Grip Strength

Hand-grip strength affects every day function and declines with age. It is an indicator of frailty in older persons and lower grip strength is associated with higher morbidity and mortality. Grip strength was measured with a Baseline (Fabrication Enterprises Inc, White Plains, NY) hydraulic hand dynamometer which consists of a gripping handle with a strain-gauge and an analogue reading scale.

Respondents with swelling, inflammation, severe pain or recent injury to their hand/wrist, and those with surgery to their hand/wrist in the last 6 months were excluded. If there was a problem with one hand, measurements were taken with the other hand. The grip strength test was explained and demonstrated before the test was carried out. Each respondent was asked to indicate their dominant hand.

Large rings were removed before the test and the handle was set to a comfortable grip ensuring that the metal bar (grip) rested on the middle piece of the four fingers. The upper arm was kept tight against their trunk and the forearm was kept at a right angle to the upper arm. If the respondent found the dynamometer too heavy to hold in this position, either they or the nurse were allowed use their free hand to rest the dynamometer on. The test was carried out standing; if this was not possible, the respondent was allowed to sit in an upright chair. If necessary, the table could be used for arm support ensuring the forearm was still at a right angle to the upper arm. The respondent was asked to squeeze the handle with maximum force for a few seconds. The value to the nearest whole number in kg was recorded by viewing the scale when held at nose level.

In wave 1, two values were recorded for each hand alternating between hands, starting with the non-dominant hand (4 values all together).

Appendix 5: Missing data

	N	Mean	Std. Deviation	Missing	
				Count	Percent
MHhadsa_scq	2060	4.72	3.409	300	12.7
MHcasp19_total	1768	45.01	7.081	592	25.1
MHucla_loneliness	2084	1.93	2.125	276	11.7
MHcesd_capi	2318	5.45	6.388	42	1.8
Age_Categories	2360			0	.0
Gender	2360			0	.0
Education	2357			3	.1
Employment	2360			0	.0
Medical_Cover	2359			1	.0
Location	2358			2	.1
Marital_Status	2360			0	.0
Social_Connection	2178			182	7.7
Chronic_Health_Problem	2358			2	.1
Self_rated_Physical_Health	2360			0	.0
Self_rated_Vision	2360			0	.0
self_rated_Hearing	2360			0	.0
Functional_Limitations	2360			0	.0
BMI_CVD	2341			19	.8
WC_Obesity	2360			0	.0
Falls	2359			1	.0
FOF	2357			3	.1
Pain	2358			2	.1
Sleep_trouble	2360			0	.0
Life_Threatening_Illness	2094			266	11.3
Alcohol_Problem	2115			245	10.4
Self_rated_Mental_Health	2359			1	.0
Sitting_Time	2341			19	.8
IPAQ_Level_1	2360			0	.0
Smoker	2360			0	.0
MMSE	2351			9	.4
MOCA	2334			26	1.1
TUG	2316			44	1.9
GRIPSTRENGH	2360			0	.0
HBP	2360			0	.0
Diabetes	2360			0	.0
High_Cholesterol	2360			0	.0

Appendix 6: Internal reliability of scales used in the analysis

IPAQ-SF – A measure of physical Activity

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.305	.643	9

CESD – A measure of depression symptoms

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.900	.952	20

CASP - A measure of Quality of Life

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.486	.619	19

UCLA – A measure of Loneliness

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.691	.689	5

HADS-A – A measure of Anxiety

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items

.577	.658	7

CAGE – A measure of an Alcohol problem

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.964	.967	4

Appendix 7: SPSS syntax

```
/*THIS FILE WAS CREATED BY NATHANIEL R. HERR, FEBRUARY, 2006 */.
/*http://nrherr.bol.ucla.edu/Mediation/logmed.html  */.

/*Gives you Standard Deviations for your variables*/.
DESCRIPTIVES
  VARIABLES=xvar mvar yvar
  /STATISTICS=MEAN STDDEV MIN MAX .

/*Gives you Covariance between X and M (top right or lower left box)*/
CORRELATIONS
  /VARIABLES=xvar mvar
  /PRINT=TWOTAIL NOSIG
  /STATISTICS XPROD
  /MISSING=PAIRWISE .

/*Gives you "a" coefficient and "a" coefficient standard error - Find
these in "Variables in the Equation" box in output */
LOGISTIC REGRESSION VAR=mvar
  /METHOD=ENTER xvar
  /CRITERIA PIN(.05) POUT(.10) ITERATE(20) CUT(.5) .

/*Gives you "c" coefficient and "c" coefficient standard error - Find
these in "Variables in the Equation" box in output */
LOGISTIC REGRESSION VAR=yvar
  /METHOD=ENTER xvar
  /CRITERIA PIN(.05) POUT(.10) ITERATE(20) CUT(.5) .

/*Gives you BOTH the "b" coefficient and the " c' " coefficient and their
standard errors - Find these in "Variables in the Equation" box in output
*/
LOGISTIC REGRESSION VAR=yvar
  /METHOD=ENTER xvar mvar
  /CRITERIA PIN(.05) POUT(.10) ITERATE(20) CUT(.5) .
```

Appendix 8: Mediation with Dichotomous Variables

THIS SPREADSHEET WAS CREATED BY NATHANIEL R. HERR, FEBRUARY, 2006. Updated July 2016
http://www.nrhpsych.com/mediation/logmed.html

Mediation with Dichotomous Variables (adapted from Kenny, 2006)

Use this spreadsheet to calculate Baron and Kenny's Percentage (Proportion) of Effect Mediated

Remember: *Sobel Test* *is unaffected by dichotomous outcomes, so this spreadsheet is not needed if only reporting on the Sobel test*

X=Causal variable
M=Mediator variable
Y=Outcome variabe

a=path from X to M
b=path from M to Y (controlling for X)
c=direct path from X to Y
c'=path from X to Y
(controlling for M)

Run descriptive statistics in SPSS for your variables for SDs

SD(X)=		Var(X)=	0
SD(M)=		Var(M)=	0
SD(Y)=		Var(Y)=	0

Run correlate with X and M variables and check "covariance matrix" box in options
COV(X,M)=

Run regressions for continuous variables and logistic regressions for dichotomous outcome variables

a=		SE(a)=	
b=		SE(b)=	
c=		SE(c)=	
c'=		SE(c')=	

Var(Y')=	3.29	SD(Y')=	1.81383571
Var(M')=	3.29	SD(M')=	1.81383571
Var(Y")=	3.29	SD(Y")=	1.81383571

comp a=	0	SE(comp a)=	0
comp b=	0	SE(comp b)=	0
comp c'=	0	SE(comp c')=	0

comp c=	0	SE(comp c)=	0
ab+c'=	0		

Baron and Kenny's Percentage (Proportion) of Effect Mediated:

Sobel test is unaffected by dichotomous outcomes, but here are the values of the Sobel test for your data:

	Aroian	Goodman	Sobel
Sab =	0	0	0
Sobel Z=	#DIV/0!	#DIV/0!	#DIV/0!

Compare values on this row to Z-score table to check for significance 1.96 or higher indicates significance at .05 or less

Appendix 9

Baseline Physical Activity: Initial logistic regression model with a total of 34 variables

							95% C.I.for EXP(B)	
	B	S.E.	Wald	df	Sig.	Exp(B)	Lower	Upper
Age_Categories			7.191	2	.027			
Age_Categories(1)	-.299	.168	3.184	1	.074	.742	.534	1.030
Age_Categories(2)	-.469	.176	7.080	1	.008	.625	.443	.884
Gender(1)	-.607	.148	16.725	1	.000	.545	.408	.729
Education			3.118	2	.210			
Education(1)	-.177	.151	1.377	1	.241	.838	.623	1.126
Education(2)	.079	.172	.212	1	.645	1.082	.773	1.515
Employment			5.504	2	.064			
Employment(1)	.306	.237	1.670	1	.196	1.358	.854	2.158
Employment(2)	-.300	.171	3.078	1	.079	.741	.530	1.036
Medical_Cover			.524	2	.769			
Medical_Cover(1)	-.176	.370	.226	1	.635	.839	.406	1.733
Medical_Cover(2)	-.069	.369	.035	1	.852	.933	.453	1.925
Marital_Status(1)	-.107	.153	.491	1	.483	.899	.666	1.212
Social_Connection	-.053	.158	.113	1	.736	.948	.696	1.292
Chronic_Health_Problem	.263	.139	3.605	1	.058	1.301	.992	1.707
Self_rated_Physical_Health	.291	.163	3.185	1	.074	1.338	.972	1.843
Self_rated_Vision(1)	.017	.215	.007	1	.936	1.018	.667	1.551
self_rated_Hearing(1)	-.230	.159	2.090	1	.148	.794	.581	1.085
Functional_Limitations(1)	-.452	.180	6.283	1	.012	.636	.447	.906
BMI_CVD(1)	-.158	.156	1.019	1	.313	.854	.629	1.160
WC_Obesity(1)	.021	.151	.020	1	.887	1.022	.760	1.373
HBP(1)	-.077	.129	.352	1	.553	.926	.719	1.193
Diabetes(1)	-.529	.205	6.659	1	.010	.589	.394	.880
FOF(1)	-.249	.142	3.089	1	.079	.779	.590	1.029
Pain(1)	-.248	.135	3.396	1	.065	.780	.599	1.016
MHcasp19_total	.041	.012	11.218	1	.001	1.041	1.017	1.066
TUG(1)	-	.185	.489	1	.484	.878	.611	1.263

	.130							
GRIPSTRENGH(1)	-.275	.129	4.572	1	.033	.760	.590	.977
Self_rated_Mental_Health (1)	-.257	.242	1.127	1	.289	.774	.482	1.243
MHcesd_capi	-.034	.013	7.141	1	.008	.967	.943	.991
MHhadsa_scq	.052	.022	5.372	1	.020	1.053	1.008	1.100
MHucla_loneliness	.001	.039	.001	1	.974	1.001	.928	1.080
MMSE(1)	-.155	.220	.494	1	.482	.857	.557	1.319
MOCA(1)	-.388	.180	4.661	1	.031	.678	.477	.965
Alcohol_Problem(1)	-.007	.241	.001	1	.976	.993	.619	1.592
Sleep_trouble(1)	.230	.135	2.887	1	.089	1.258	.965	1.639
Sitting_Time(1)	-.958	.182	27.665	1	.000	.384	.268	.548
Location(1)	-.137	.126	1.190	1	.275	.872	.681	1.116
High_Cholesterol(1)	-.070	.125	.318	1	.573	.932	.730	1.190
Falls(1)	-.016	.142	.013	1	.909	.984	.745	1.299
Smoker(1)	-.065	.201	.103	1	.748	.937	.632	1.391
Constant	.597	.813	.539	1	.463	1.817		

a. Variable(s) entered on step 1: Age_Categories, Gender, Education, Employment, Medical_Cover, Marital_Status, Social_Connection, Chronic_Health_Problem, Self_rated_Physical_Health, Self_rated_Vision, self_rated_Hearing, Functional_Limitations, BMI_CVD, WC_Obesity, HBP, Diabetes, FOF, Pain, MHcasp19_total, TUG, GRIPSTRENGH, Self_rated_Mental_Health, MHcesd_capi, MHhadsa_scq, MHucla_loneliness, MMSE, MOCA, Alcohol_Problem, Sleep_trouble, Sitting_Time, Location, High_Cholesterol, Falls, Smoker.

Physical Activity Change (Active Maintainer vs Relapers): Initial logistic regression model with a total of 29 variables

							95% C.I.for EXP(B)	
	B	S.E.	Wald	df	Sig.	Exp(B)	Lower	Upper
Age_Categories			1.558	2	.459			
Age_Categories(1)	.165	.210	.622	1	.430	1.180	.782	1.780
Age_Categories(2)	.275	.223	1.527	1	.217	1.317	.851	2.036
Gender(1)	.426	.186	5.255	1	.022	1.531	1.064	2.205
Education			2.025	2	.363			
Education(1)	-.174	.194	.806	1	.369	.840	.574	1.229
Education(2)	-.301	.213	1.988	1	.159	.740	.487	1.124
Employment			.939	2	.625			
Employment(1)	-.270	.292	.854	1	.355	.764	.431	1.353
Employment(2)	.043	.235	.034	1	.854	1.044	.659	1.656
Medical_Cover			1.345	2	.511			
Medical_Cover(1)	-.150	.441	.115	1	.734	.861	.363	2.044
Medical_Cover(2)	.097	.438	.049	1	.824	1.102	.467	2.599
Chronic_Health_Problem(1)	.282	.177	2.548	1	.110	1.326	.938	1.875
Self_rated_Physical_Health(1)	-.199	.214	.864	1	.353	.819	.538	1.247
Self_rated_Vision(1)	-.232	.292	.633	1	.426	.793	.447	1.405
self_rated_Hearing(1)	-.377	.195	3.738	1	.053	.686	.468	1.005
Functional_Limitations(1)	-.309	.275	1.266	1	.260	.734	.429	1.258
WC_Obesity(1)	.230	.195	1.396	1	.237	1.258	.859	1.842
HBP(1)	.086	.164	.273	1	.601	1.090	.790	1.503
FOF(1)	.153	.192	.632	1	.427	1.165	.799	1.699
Pain(1)	.095	.178	.283	1	.594	1.099	.776	1.558
MHcasp19_total	-.013	.015	.687	1	.407	.987	.958	1.018
TUG(1)	.265	.262	1.022	1	.312	1.303	.780	2.177
Self_rated_Mental_Health(1)	-.241	.332	.524	1	.469	.786	.410	1.508
MHcesd_capi	.019	.018	1.074	1	.300	1.019	.984	1.055
MHhadsa_scq	-	.028	.178	1	.673	.988	.935	1.045

	.012							
MHucla_loneliness	.026	.048	.305	1	.581	1.027	.935	1.127
MMSE(1)	.327	.323	1.024	1	.312	1.387	.736	2.612
MOCA(1)	-.018	.260	.005	1	.943	.982	.589	1.635
Smoker(1)	.513	.254	4.071	1	.044	1.669	1.015	2.747
Sleep_trouble(1)	.183	.174	1.104	1	.293	1.201	.853	1.690
Sitting_Time(1)	.725	.267	7.365	1	.007	2.064	1.223	3.484
BMI_CVD(1)	.193	.203	.909	1	.340	1.213	.815	1.806
Diabetes(1)	-.128	.308	.172	1	.678	.880	.482	1.609
Falls(1)	.137	.188	.532	1	.466	1.147	.794	1.656
GRIPSTRENGH(1)	.074	.166	.198	1	.656	1.077	.778	1.491
Constant	-.605	1.045	.336	1	.562	.546		

a. Variable(s) entered on step 1: Age_Categories, Gender, Education, Employment, Medical_Cover, Chronic_Health_Problem, Self_rated_Physical_Health, Self_rated_Vision, self_rated_Hearing, Functional_Limitations, WC_Obesity, HBP, FOF, Pain, MHcasp19_total, TUG, Self_rated_Mental_Health, MHcesd_capi, MHhadsa_scq, MHucla_loneliness, MMSE, MOCA, Smoker, Sleep_trouble, Sitting_Time, BMI_CVD, Diabetes, Falls, GRIPSTRENGH.

Physical Activity Change (Inactive Maintainer vs Adopter): Initial logistic regression model with a total of 26 variables.

	B	S.E.	Wald	df	Sig.	Exp(B)	95% C.I.for EXP(B) Lower	Upper
Age_Categories			1.352	2	.509			
Age_Categories(1)	-.046	.305	.022	1	.881	.955	.525	1.737
Age_Categories(2)	-.312	.311	1.007	1	.316	.732	.397	1.347
Gender(1)	-.353	.257	1.882	1	.170	.703	.425	1.163
Medical_Cover			1.259	2	.533			
Medical_Cover(1)	.880	.818	1.158	1	.282	2.412	.485	11.993
Medical_Cover(2)	.934	.835	1.250	1	.264	2.544	.495	13.068
Marital_Status(1)	-.009	.263	.001	1	.974	.991	.593	1.659
Social_Connection(1)	.408	.285	2.054	1	.152	1.504	.861	2.630
Chronic_Health_Problem(1)	.078	.242	.105	1	.746	1.082	.673	1.739
Self_rated_Physical_Health(1	.872	.302	8.313	1	.004	2.392	1.322	4.327
Self_rated_Vision(1)	.356	.389	.836	1	.360	1.427	.666	3.059
Functional_Limitations(1)	-.109	.292	.138	1	.710	.897	.506	1.590
WC_Obesity(1)	-.281	.218	1.668	1	.197	.755	.493	1.157
HBP(1)	-.324	.222	2.123	1	.145	.724	.468	1.118
FOF(1)	-.196	.230	.722	1	.395	.822	.523	1.292
Pain(1)	-.464	.230	4.069	1	.044	.629	.401	.987
MHcasp19_total	.001	.021	.002	1	.963	1.001	.961	1.043
TUG(1)	-.628	.312	4.036	1	.045	.534	.289	.985
MHcesd_capi	.003	.018	.021	1	.885	1.003	.967	1.039
MHucla_loneliness	-.007	.067	.011	1	.918	.993	.871	1.133
MMSE(1)	-.754	.375	4.042	1	.044	.470	.226	.981
MOCA(1)	.250	.314	.631	1	.427	1.283	.693	2.376
Smoker(1)	-.110	.368	.090	1	.764	.896	.435	1.843
Sitting_Time(1)	-.040	.284	.019	1	.889	.961	.551	1.677
Education			6.284	2	.043			
Education(1)	-.664	.269	6.076	1	.014	.515	.304	.873
Education(2)	-.308	.307	1.009	1	.315	.735	.403	1.341
Employment			1.727	2	.422			
Employment(1)	-.582	.454	1.648	1	.199	.559	.230	1.359
Employment(2)	.041	.286	.020	1	.886	1.042	.595	1.824
GRIPSTRENGH(1)	-.128	.229	.311	1	.577	.880	.562	1.378
Social_Connection(1)	.422	.243	3.010	1	.083	1.525	.947	2.455
Self_rated_Physical_Health(1)	.843	.248	11.541	1	.001	2.324	1.429	3.780
HBP(1)	-.339	.211	2.568	1	.109	.713	.471	1.079
Pain(1)	-.435	.212	4.226	1	.040	.647	.427	.980
TUG(1)	-.808	.268	9.096	1	.003	.446	.263	.753
MMSE(1)	-.592	.322	3.373	1	.066	.553	.294	1.041
Education			6.936	2	.031			
Education(1)	-.669	.259	6.648	1	.010	.512	.308	.852
Education(2)	-.273	.277	.971	1	.325	.761	.442	1.310
Constant	-.183	.344	.281	1	.596	.833		

a. Variable(s) entered on step 1: Age_Categories, Gender, Medical_Cover, Marital_Status, Social_Connection, Chronic_Health_Problem, Self_rated_Physical_Health, Self_rated_Vision, Functional_Limitations, WC_Obesity, HBP, FOF, Pain, MHcasp19_total, TUG, MHcesd_capi, MHucla_loneliness, MMSE, MOCA, Smoker, Sitting_Time, Education, Employment, GRIPSTRENGH, Self_rated_Mental_Health, Sleep_trouble.

Appendix 10: Lost to follow up

	Grouping	N	Mean	Std. Deviation
Age	Active	2076	.9277	.84145
	Lost	283	1.1979	.86072
Gender	Active	2076	.5169	.49984
	Lost	283	.5512	.49825
Education	Active	2074	.9094	.80067
	Lost	282	.6950	.78185
PAL	Active	2076	.6643	.47236
	Lost	283	.5406	.49923
SRPH	Active	2076	.8449	.79821
	Lost	283	1.0106	.82292
CVD	Active	2076	.1657	.37190
	Lost	283	.2403	.42801

		Levene's Test for Equality of Variances		t-test			
		F	Sig.	t	df	Sig. (2-tailed)	Mean
Age	Equal variances assumed	4.220	.040	-5.052	2357	.000	
	Equal variances not assumed			-4.966	359.436	.000	
Gender	Equal variances assumed	9.715	.002	-1.086	2357	.278	
	Equal variances not assumed			-1.088	363.752	.277	
Education	Equal variances assumed	1.032	.310	4.229	2354	.000	
	Equal variances not assumed			4.306	365.844	.000	
PAL	Equal variances assumed	29.872	.000	4.102	2357	.000	
	Equal variances not assumed			3.933	354.315	.000	
SRPH	Equal variances assumed	.185	.667	-3.264	2357	.001	
	Equal variances not assumed			-3.189	358.175	.002	
CVD	Equal variances assumed	32.400	.000	-3.105	2357	.002	
	Equal variances not assumed			-2.791	342.542	.006	