CORRELATES OF SEDENTARY BEHAVIOUR IN MID-AGE AND OLDER ADULTS

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Sedentary behaviour (SB) is prevalent across all ages, but particularly in older adults aged 50 years and above. Given that older adults spend more than 60% of waking hours sedentary, enhancing our understanding of the correlates of SB will be important to inform the development of interventions to reduce SB in mid-age and older adults. This thesis provides five studies focusing on the correlates of SB in mid-age and older adults. Firstly, Chapter 2 presents a literature review using behaviour epidemiology framework to examine the existing evidence on sedentary behaviour in general adults in order to identify the gap of current knowledge in sedentary behaviour. Chapter 3 presents a systematic review which included the existing evidence on correlates of SB in mid-age and older adults and provides evidence-based conclusions on the topic. Chapter 4 presents a study examining the association of demographics and physical activity (PA) with daily sitting time in mid-age and older adults, and found behavioural correlates of SB and PA in mid-age and older adults. Chapter 5 presents a secondary data analysis using the data of the older office worker from the Stormont study. This chapter uses the results from the cross-sectional and longitudinal data to examine the association of demographics and behaviours with domain-specific sitting time among the older office workers. In this study, differences were found in demographic and behavioural correlates according to the studied domain of sitting. Chapter 6 presents a 6-month longitudinal study, which was designed to fill the gaps of our understanding of the associations between demographics, health and PA with SB in older adults aged 65 years and above. This chapter also looked into the changes of sitting time and its correlates. Together, these four studies provide adequate evidence on the demographics and behavioural correlates of SB and also identified the determinants of SB in mid-age and older adults. This thesis found that demographics had limited associations with SB, and sociodemographics were associated with work-related sitting time. Health behaviour was generally inversely associated with SB. These findings provide information to the correlates and determinants of mid-age and older adults SB and will inform further research on behaviour change strategies.

Dedication

To my parents and the One who is the

light of my life

Praise God!

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Chapter1

Introduction

1 Introduction

The importance of the roles that physical activity plays in public health has been widely studied over the past decades. Research within the field of 'physical activity and health' started in 1953 with the observation of the association between physical activity and heart disease through Morris' seminal study of London bus drivers and conductors (1). Since then, an increasing number of studies have been conducted to examine the relationship between physical activity, physical inactivity and health-related factors. Since then, an increasing amount of research is conducting to exam the association between physical activity and sedentary behaviour with health. However, the definition of sedentary behaviour has not always been clear as it was usually seen as the opposite to physical activity. Some research articles use the term "sedentary" to describe "physically inactive" and have measured it by asking if the individual meets physical activity guidelines. Thus, sedentary behaviour researchers have introduced sedentary behaviour as a new and distinctive paradigm. Yates and colleagues suggest that any non-exercise activity that involves sitting or lying can be considered sedentary (2). Pate and colleagues also defined sedentary behaviour as the activities that do not increase energy expenditure substantially above the resting level and includes activities such as sleeping, sitting, lying down, and watching television and other forms of screen-based entertainment. They also suggest that sedentary behaviour includes activities that involve energy expenditure at the level of 1.0-1.5 metabolic equivalent units (METs) (3). The definition published by the Sedentary Behaviour Research Network (SBRN) suggests that sedentary behaviour is "as any waking behaviour characterized by an energy expenditure ≤1.5 METs (Metabolic Equivalent of Task) while in a sitting or reclining posture" (4). That includes sitting behaviours such as television viewing, computer use, driving, reading etc. The SBRN also suggests that authors use the term "inactive" to describe those who are performing insufficient amounts of moderate-vigorous physical activity (i.e., not meeting typical physical activity guidelines). Figure 1.1 illustrates these behaviours along a continuum of energy expenditure. It is also possible to classify behaviours in this way by posture. In general, sedentary behaviour can be simply defined as a class of behaviours characterised primarily by sitting during waking hours with associated low levels of energy expenditure.

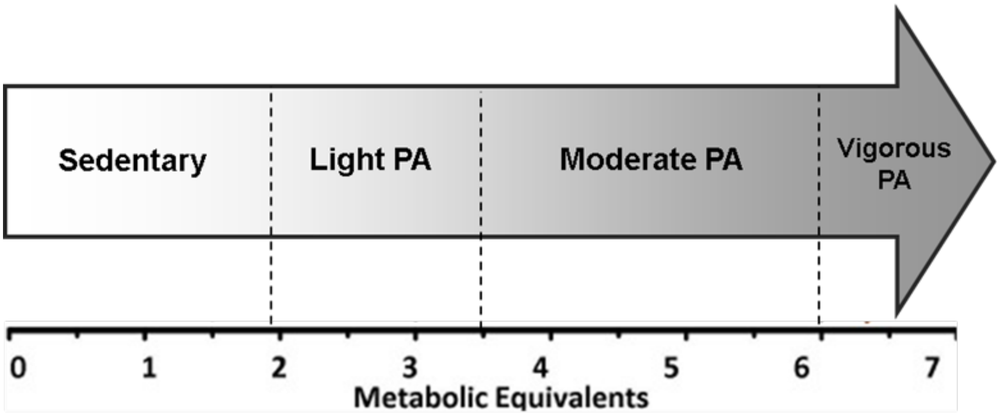

Figure 1.1. The movement continuum: Metabolic Equivalents Categorising Sedentary Behaviour and Physical Activities

1.1 Old Age: Mid-age and Older Adults

The definition of "old age" is not clear. The chronological definition of old age refer to those who are 65 and above, and define age 65-74, 75-84, 85-99 and 100 and above as young-old, old, old-old and oldest old, respectively(5)(6). However, it is arguable that using the chronological definition of old age in public health research would ignore the fact the different individuals' changes and difference through the aging process(6). According to the World Health Organisation (WHO), the world population is rapidly ageing. Between 2000 and 2050, the proportion of the world's population over 60 years will double from 11% to 22%. The absolute number of people aged 60 years and over is expected to increase from 605 million to 2 billion over the same period(7). However, although the average life expectancy is rising, it does not always mean these additional years of life are spent in a favourable health and independent lifestyle. The survey conducted by the Office for National Statistics, UK reveals after the age of 65 men and women could have an additional 17.6 and 20.2 years of life expectancy, respectively. However, along these additional years of life, male and female individuals could only expect 9.9 and 11.5 years of very good or good health (8). Therefore, it is not only extending the years that people live, but how to increase healthy life expectancy and aging successfully that are important. Reducing sedentary behaviour has been shown to be associated with successful ageing in research by Dogra and colleagues (9). Their study used three components (physical, psychological, and sociological) to assess successful aging and found for middle-aged adults, those who were least sedentary were 43% more likely to age successfully. Therefore, the current thesis focuses on the sedentary behaviour of mid-aged and older adults. In this thesis, mid-age adults refer to those aged 50 to 64 years, and older adults are those aged 65 and above. Typically, studies have only studied older adults. It is important to also study mid-aged adults as they approach, or are in, the transition to older adult status.

1.2 Prevalence of sedentary behaviour

The 2008 Health Survey for England (HSE) used both self-report and accelerometer assessments to measure physical activity and sedentary behaviour in a representative sample of the population(10). The main findings showed that sedentary behaviour accounted for the largest amount of time with 20-65% of people aged over 16 years and above reporting that they spent 6 or more hours sedentary (not including occupational sedentary time) on a weekday, with the proportion being higher on a weekend day. The prevalence of prolonged sedentary behaviour increases with age especially among adults aged 55 years and above(10). Harvey et al.(11) reviewed the evidence from research studies and reported that older adults aged 60 years and above have a high prevalence of prolonged sedentary behaviour. In the studies of sedentary behaviour in adults aged 50 years and above, although the ways of reporting the prevalence of sedentary behaviour were diverse across the studies, TV viewing time has been the most frequently reported sedentary behaviour. A range of 44-74% of the samples studied reported spending at least 2 hours watching TV daily (12-17); 31-34% reported watching at least 3 hours of TV/day(18-20); 19-47% reported at least 4 hours(14,15,19,21-23) and 14-34% reported watching over 5 hours(20,24-27). 33-58% of participants reported at least 3 hours of screen time per day(28) and 29-34% of the studied participants reported over 4 hours(29-31). A broad range of 30.2-81.8% of the studied samples reported spending at least 4 hours sitting per day (9,19,27,32-39). The existing evidence shows an average TV time is between 1.6-4.2 hours per day (16,22,40-50). Total sedentary behaviour time was reported to be between 480 and 553 minutes (8 to 9.2 hours) per day (43,47,51-54) and self-reported sitting times ranged from 2.6 to 6.1 hours per day (34,55-58).Objective measurement shows adults aged 50 years and above have 511-643 minutes (8.5 to 10.7 hours) of objectively-determined sedentary time per day (59-64). Studies where the mean age of participants has been over 60 years report a range of 492-732 minutes (8.2-11.2 hours) of objective measured sedentary time per day (34,54,65-69).

Behavioural Epidemiology Framework

In 2000, Sallis et al. (70) proposed the behavioural epidemiology framework to specify a systematic sequence of studies on health-related behaviours, and also is leading to evidence-based interventions directed at populations. The framework including five phases of research: Phase 1-establish links between behaviour and health; Phase 2-develop measures of the behaviour; Phase 3-identify factors that influences on the behaviour; Phase 4-evaluate interventions to change the behaviour; and Phase 5: translate research into practice. Each phase of the behavioural epidemiology framework builds upon the previous phases. Phase 1 is aiming to identify the importance of researching the behaviour. Phase 2 and 3 are aiming to develop a basic understanding of the behaviours. Phase 4 aiming to test and evaluate the approach theoretically. And Phase 5 makes explicit the need to diffuse intervention found to be effective in Phase 4. The detailed context of each phase is described in Table 1.1. Although it could be argue that use term "Behaviour Epidemiology" could be concerned with 1).the misleading of the framework related specifically to diseases and; 2). the absent of implication on the central role of intervention. However, since the behavioural epidemiology framework was published, it has been widely adopted and highly suggested as the guide of the research of health behaviour including in the research of physical activity and sedentary behaviour(71,72).

1.3 Overview of this thesis

Overall, the research contained within this thesis aims to increase our understanding of the sedentary behaviour in mid-age and older adults in order to provide more information for the fourth of five stages of the behavioural epidemiological framework – the development of interventions to reduce sedentary behaviour in mid-age and older adults. First of all, Chapter 2, a literature review presents the existing evidence and understanding on the research topic of sedentary behaviour in mid-age adults and older adults using behavioural epidemiology framework. Chapter 3 presents a 71-study systematic review which synthesises the evidence on correlates of sedentary behaviour in adults aged 50 years and above. The review yields evidence on sociodemographics, physical health and behavioural correlates. The correlation of psychological health and the environment with sedentary behaviour in older adults has been less frequently studied and remains unclear.

Table 1.1 The detailed context of each phase of the behavioural epidemiology framework by Sallis et al.

Phase 1	Establish Links Between Behaviour and Health	Basic epidemiological studies document the associations between behaviour and health. This phase could provide a rationale for proceeding of the behavioural epidemiology research.
Phase 2	Develop Measures of the Behaviour	High-quality measures are essential for all stages of research and it should be positioned at the early stage of the research. This includes the establishing of the reliability and validity of extant measures, new measures, and field-testing new tools.
Phase 3	Identify Factors That Influences the Behaviour	Describing the demographic correlates of the behaviour is the priority of this phase so the most in need population could be identified. A theory-derived constructs can be applying in identifying modifiable psychological, social, and environmental factors that may influence the behaviours.
Phase 4	Evaluate Interventions to Change the Behaviour	Intervention programs drawing on the knowledge derived from studies in Phases 1,2, and 3 needs to be developed and tested systematically. The modifiable factors identified in Phase 3 may be considered as potential mediators of intervention trial. Evaluation could be conducted using randomized trials or in effectiveness studies. And ideally to identify the most cost-effective strategy in this phase.
Phase 5	Translate Research Into Practice	The identified effective interventions then have to be used in the suitable environment and population before they can impact the population's health. Research in this phase evaluates the efforts to disseminate programs as well as identify determinants of program adoption.

Hence, in order to enhance our understanding of sedentary behaviour among mid-aged and older adults, a secondary data analysis was conducted using data collected across five countries to examine the correlates of sedentary behaviour and physical activity in adults aged 50 years and above. The results of this analysis are presented in Chapter 4. A survey which was originally designed to assess the walking behaviour among adults included data from the IPAQ for assessing the participants' time in physical activity and sedentary behaviour. In this study, more evidence on the correlation of MVPA, total physical activity and walking with sitting time was generated, and some demographic correlates were identified. However, the weak correlation which was found in this study suggests that further research is required. Moreover, Chapters 4 is a cross-sectional study so the evidence is limited to determine the direction of the association.

Therefore, Chapter 5 presents the results of a secondary data analysis, which data was collected in the workplace in Stormont, UK in 2012 and 2014. It included the data from a subgroup of older office workers (aged 50 and above) who provided information on their general and work-related demographic and health behaviours, as well as sitting time in different domains. In fact, this study applied the self-report domain-specific sitting time questionnaire to assess the time the office workers spend sitting in four domains (travel, work, screen time and other leisure activities). This dataset allows the conducting of both cross-sectional and longitudinal data analysis. The cross-sectional data analysis focuses on the examination of the difference of domain-specific sitting time across demographics and health behaviour. And the longitudinal data analysis is conducted to identify the consistent correlation between demographics and health behaviours with domain-specific sitting times among older office workers. Moreover, the longitudinal data analysis also aims to identify potential predictors of domain-specific sitting time in older office workers. Together from both the results of the cross-sectional and longitudinal data analyses, this study provides reliable evidence on the correlates of domain-specific sitting time and shows consistent correlations with the same domain of sitting at both baseline and follow-up. However, the weak relationship between potential predictors and domain-specific sitting time suggests that factors such as physical health, psychological health and the environment should be considered in further research.

To enhance the findings in Chapter 4 and Chapter 5, and to identify more correlates of sedentary behaviour particular in older adults, Chapter 6 reports a longitudinal study with six months follow up which was conducted to determine the direction of association and to identify potential predictors of sedentary behaviour. It also uses both self-report and objective measurements to assess the sedentary time of community-dwelling older adults (aged 65 and above). Participants were recruited in the UK and visited in person. In this study, BMI, physical activity, the number of medicines taken and living alone were found to be correlated with self-reported sitting time or objectively assessed sedentary time. However, the small sample size and short follow-up period limit the findings.

The studies presented in this thesis have been conducted by the author. However, the systematic review presented in Chapter 3 was completed with supervision and assistance from Dr Natalie Pearson and Professor Stuart Biddle. The data used for the secondary analyses in Chapters 3, and 5 were from studies conducted by Dr Stacy Clemes and her research team. The processing of the data was conducted under the supervision of Dr Clemes. The data collection of the longitudinal study in Chapter 6 was done solely by the author and with the supervision of Professor Stuart Biddle. Some of the findings of the thesis have been disseminated in conference presentations or are in various stages of submission for publication (See Appendices).

Chapter2

Literature Review

Chapter 2

Literature Review

This chapter presents a literature review on the existing evidence on the sedentary behaviour in adults and particularly in mid-age and older adults. The behaviour epidemiology framework is adopted in order to identify the gap of the current knowledge in sedentary behaviour in mid-age and older adults.

2 Literature Review: Sedentary Behaviour in mid-age and older adults

Research in health behaviour is encouraged to adopt the behaviour epidemiology framework(72) as the guide for the research. Therefore, the current chapter presents a literature review based on the five phases of the framework to exam the existing evidence on sedentary behaviour especially in mid-age and older adults. Moreover, this review also aims to identify the gaps in our understanding and knowledge of research in sedentary behaviour in mid-age and older adults.

2.1 Phase 1-Links between sedentary behaviour and health

In the past decades, the independent effect of too much sedentary behaviour (i.e. TV viewing and sitting time) on health has been identified. Thorp and colleagues conducted a systematic review of longitudinal studies on sedentary behaviour and subsequent health (73). The review synthesised the findings of 48 longitudinal studies and concluded that sedentary behaviour may be a distinct risk factor for ill health, independent of Body Mass Index (BMI) and physical activity. It found that increased sedentary behaviour is consistently associated with the risk for mortality from all-causes and cardiovascular disease (CVD), independent of BMI and physical activity. The review suggested that there is a reasonable level of evidence to conclude associations between sedentary behaviour and health outcomes are not mediated by time spent in physical activity. Therefore, a new concept of the relationship between sedentary behaviour and physical activity and cardiovascular outcomes was introduced by Ford and Caspersen (74). They suggested that sedentary behaviour is distinct from physical activity and recognized that high levels of sedentary behaviour can coexist with high levels of moderate to vigorous physical activity (MVPA) (Figure 2.1).

The outcomes of prolonged sedentary behaviour in mid-age to older adults (aged 50 years and above) have been frequently studied. Sedentary behaviour is found to be positively associated with BMI, overweight/obesity, and body fat in older adults (75). A positive relationship has also been found between sedentary behaviour and circulating levels of triglycerides and low-density lipoprotein (LDL) cholesterol, while an inverse relationship has been seen between sedentary behaviour and levels of high-density lipoprotein (HDL)(18,46,50,62,67,76-78).

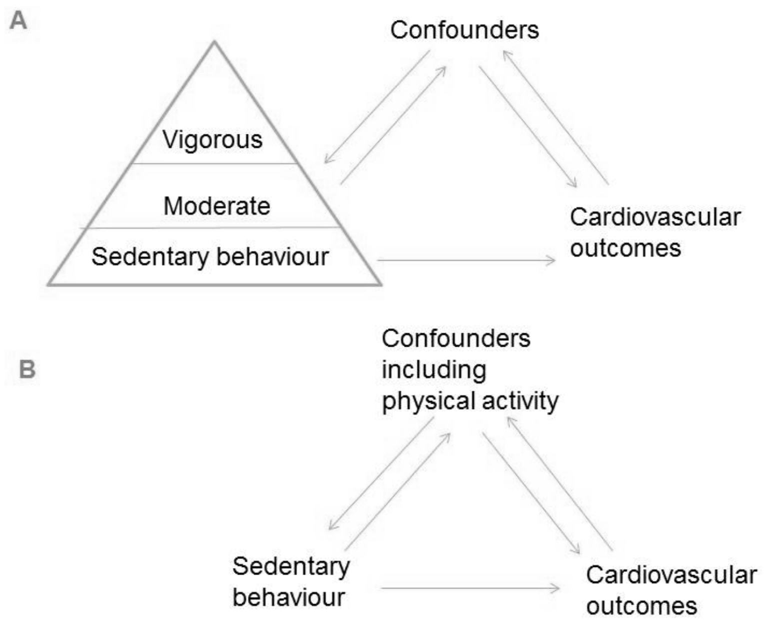

Figure 2.1. Traditional (A) and emerging (B) conceptualization of the relationships between sedentary behaviour and physical activity and cardiovascular outcomes (Ford & Caspersen, 2012)

More time in sedentary behaviour has been linked to a higher risk of having the metabolic syndrome (18,23,50,77,79,80), cardiovascular disease (31,33,41,44,81,82) and higher mortality rates (31,36,83). Leisure time sedentary behaviour is independently associated with poorer mental health (29). Rezende et al. reviewed 24 studies investigating sedentary behaviour and health outcomes among adults aged over 60 years (84). The review supports the relationship between sedentary behaviour and mortality, and finds evidence of a relationship between sedentary behaviour and the metabolic syndrome, increased waist circumference, and overweight/obesity. However, the review suggests more studies with high methodological quality are needed to strengthen the existing evidence.

2.2 Phase 2-Develop measures of sedentary behaviour

The measures of sedentary behaviour is summarised in two categories by. Atkin et al. (85): (i) Subjective measures, including self- and proxy-report questionnaires and diaries; (ii)

Objective measures, including accelerometers, posture monitors, heart rate (HR) monitoring and combined sensing, multi-unit monitors.

Self-report questionnaires are commonly used to measure adults' sedentary behaviour, especially assessing TV viewing time, which is sometimes used as a proxy marker of total sedentary behaviour. Other self-report questionnaires assess the overall sedentary behaviour by asking a single question on the time spent sitting daily, such as the widely used International Physical Activity Questionnaire (IPAQ). This measure is reasonably reliable, but its validity is a cause for concern (86). In addition, self-report multiple-item questionnaires assessing domain-specific sitting time have been developed to collect detailed information on the contexts in which sedentary behaviours occur (87). It is suggested that multiple-item questionnaires could capture more accurately total daily sitting time (88); and these tools may be preferable, over single-item measures, for use in sedentary behaviour prevalence and surveillance studies. For measuring sedentary behaviour in older adults, the 'Measure of Older Adults' Sedentary Time (MOST) has been developed, which assesses sedentary time on weekdays and weekends in behaviours including watching television, computer use, reading, socialising, transport and hobbies, which are common among older adults.

While self-report measurements can provide fairly reliable information on sedentary behaviour and identify the type of sedentary behaviour being adopted, assessment of the type of behaviour being undertaken is complicated, as multiple sedentary behaviours could be conducted at the same time. Nevertheless, despite the limitations of self-report instruments, they do provide a cost-effective method of assessing sedentary behaviour in large-scale studies.

Objective measurement instruments are increasingly being used to assess sedentary behaviour. Accelerometers, especially the ActiGraph (ActiGraph LLC, Pensacola, FL, USA), is to date the most widely used objective measure of sedentary behaviour. It is a small lightweight device usually worn on an elastic belt positioned on the hip or lower back. Although, recently researchers have started to use this device in other body locations such as the wrist and thigh. Accelerometers detect the movement (acceleration) of the body and estimate the total volume of sedentary behaviour through the accumulation of low or no movement counts at specified cut points. In sedentary behaviour research in adults, sedentary time is commonly defined as <100 counts per minute (cpm) (89). Nevertheless, evidence shows adequate cut points vary for different age groups (90), so it is necessary to choose an appropriate cut point for measuring sedentary behaviour in older adults when using accelerometers.

Other types of objective measurement, such as heart rate monitoring and posture monitors, are also used to assess sedentary behaviour. The activPAL (PAL Technologies Ltd, Glasgow, UK) inclinometer has recently been widely used to assess sedentary behaviour; it is attached to the thigh and records the time spent in different postures (e.g. lying, sitting, standing and stepping). There are relatively few studies that have explored the criterion validity of the activPAL for measuring sitting time in older adults (91).

2.3 Phase 3-Identify the factors that influence sedentary behaviour

It is suggested by Sallis et al.(72) that by understanding the demographics and biological factors of a behaviour could identify the population which is the most in need of intervention. Studies in the modifiable factors of the behaviour could then help influence the behaviour. When using physical activity as an example, the identified correlates of physical activity in adults include demographics, biological, psychological, behavioural attribution, social, cultural and physical environment factors. Most of these identified factors are reported by several studies and result a consistent association with physical activity. Review conducted by Trost et al.(92) found that older age, female, overweight/obesity, non-white race, education and incomes are the most studied and consistently inversely associated with physical activity. Modifiable factors including attitudes, barriers to exercise, control over exercise, self-efficacy, smoking and social support influenced physical activity levels. This knowledge could provide the design and implementation of intervention promoting physical activity.

In comparison to the studies on the factors of physical activity, research into the correlates of sedentary behaviour is limited. A systematic review conducted by Rhodes et al. including 109 studies reporting the correlates of sedentary behaviour in adults(93). This review concluded that an association exists between age, level of education, unemployment, and leisure time physical activity with TV viewing time. However, the correlation of other sociodemographic correlates with sedentary time in adults was not clear. Another review by Chastin et al.(94) reported twenty-two articles which studied the correlates of sedentary behaviour in older adults aged 65 and above. Overall, both reviews found that demographics such as gender and age are the most reported correlates of sedentary behaviour. Other studies have also reported correlates such as social-demographics, physical activity, BMI and environment were found associated with sedentary behaviour. Nevertheless, at present no literature exists to aid the understanding of correlates of sedentary behaviour in mid-age adults specifically. Rhodes et al.'s review did however include studies on adults 18 years and above whilst Chastin et al.'s review included studies on older adults who aged 65 and above.

In addition, further research on studying novel variables and possible correlates in adults is needed based on the existing evidence on the correlates of adults and older adults. Based on the ecologic model proposed by Owen et al.(95), correlates of sedentary behaviour could be categorised into four domains. These include sedentary behaviour during leisure time, transportation, within the household and within ones occupation. These domains could be affected by factors such as intrapersonal (demographics, biological, psychological and family situation) and environment factors (perceived, policy, social-cultural, information and natural environment). Further studies should examine the correlation of intrapersonal variable such as physical function psychological health with sedentary behaviour, or examine the association of social-cultural environment with sedentary behaviour using multi-nation data. This would provide a broader understanding of correlates of sedentary behaviour in mid-age and older adults.

Moreover, given the majority of the existing studies on correlates of sedentary behaviour have cross-sectional designs, it is difficult to conclude the direction of the correlation and to identify the determinants of sedentary behaviour. In addition to this the consistency of the associations between the correlates and sedentary behaviour is weak. Thus, longitudinal studies are required to strengthen the findings on the correlations and to also identify the determinants of sedentary behaviour in mid-age and older adults.

2.4 Phase 4-Evaluate interventions to change the behaviour

In the early stages of research, sedentary behaviour was more likely to be the secondary outcome variable of an intervention studying changes in physical activity in adults. Interest into sedentary behaviour research has increased in the past decade; interventions have been conducted with a priority of reducing sedentary time in adults. The existing studies have predominantly aimed to reduce adults' sedentary behaviour by targeting occupational sitting time. Evans et al.(96) conducted an intervention aiming to reduce the participants' prolong sitting time at work. The study found computer that a reminder to encourage standing every 30 minutes combined with education on the health risk on sitting resulted in a reduction in prolong sitting time. Similar studies conducted in the workplace also showed reduced in sitting time at work. In 2004, Gardinar et al(97) conducted one of the first studies examining the feasibility of an intervention in reducing and breaking the sedentary time in older adults in Australia. Behaviour change techniques included one-to-one consultations where the participants received feedback on their accelerometer-derived activity levels. A 3.2% of reduction in daily sedentary time was found among the participants, moreover, an increase in sedentary time breaks and increased physical activity levels were found. Fitzsimon et al.(98) conducted a similar study and using the same behaviour change techniques to manipulate the total sedentary time in older adults in the UK. A reduction in sedentary time was also found among these participants.

Gardner et al.(99) conducted a systematic review on 26 studies researching interventions reducing sedentary behaviour among adults; the review included five studies in older adults. It found that randomised control trials (RCT) were the most popular study design, and fewer studies applied a theory of behaviour to design the intervention. The main behaviour change techniques used were setting goals and providing unspecified forms of social support. Several studies used workplace the setting of the intervention. However, the majority of the included intervention studies primarily aiming to increase the individuals' physical activity level rather than reduce sedentary behaviour. Furthermore, the review also found that those primarily aiming to change physical activity are less effective on changing the individuals' sedentary behaviour. Despite existing studies showing that interventions successfully change sedentary behaviour in adults and older adults. The evidence is however limited to draw any further conclusion on the most effective and eligible approach to reduce sedentary time in the population of mid-age and older adults. Further research is needed to improve the understanding of intervention research for sedentary behaviour and evaluate the effectiveness across interventions and different behaviour change techniques.

2.5 Phase 5-Translate research into practice

Currently, studies in this phase are limited. So far the impact from the studies in the previous four stages enables including reducing sedentary behaviour in the national physical activity guidelines. However, guidelines on sedentary behaviour in adults and older adults are less detailed compared to guidelines for physical activity. For example, the UK physical activity guidelines(100) suggest older adults should participate at least 150 minutes moderate intensity activity in bouts of 10 minutes or more weekly. Active individuals are also encouraged to achieve the guidelines through 75 minutes of moderate to vigorous intensity activity weekly. Furthermore, older adults are recommended to participate in activities to improve muscle strength, balance and co-ordination two days a week. The guidelines also recommend that older adults should minimise being sedentary/sitting for extended periods. Australia's physical activity and sedentary behaviour guidelines(101) for adults aged 18-64 years and older adults aged 65 years or above suggest similar weekly physical activity levels to the UK guidelines(100). Also suggesting adults should break up long periods of sitting as often as possible and minimise prolonged sitting and. However, there is no mention of sedentary behaviour in the Australia's Physical Activity Guidelines for older adults. Canada published sedentary behaviour guidelines independent from physical activity guidelines. However, the Canadian Sedentary Behaviour Guidelines(102) only cover youth (aged 0 to 17 years). The Canadian Sedentary Behaviour Guidelines for youth provides more detailed guidelines. The guidelines for children aged 12-17 years, suggest "youth should limit recreational screen time to no more than 2 hours per day." Also it encourages children to choose active transportation, active play and active family time. It is arguable that adults and older adults' behaviour and life pattern are more complex than school children. However, there is a lack of evidence and studies on the evaluation, adaptation, implementation and maintenance of sedentary behaviour in adults and especially in older adults.

2.6 Conclusion

Overall, sedentary behaviour in mid-age and older adults is still in its infancy. A good amount of evidence exists linking sedentary behaviour and health, however most evidence is based on results of observational and predominantly cross-sectional studies. Studies on the subjective and objective measures of sedentary behaviour in adults and older adults provide good knowledge into the measurement of sedentary behaviour in this age group. However, further research is needed to improve the validity and reliability on both types of measures. By using the behavioural epidemiology framework, it reveals that in comparison to Phase 1 and Phase 2, limited studies in Phase 3, 4 and 5 are available to inform the understanding of sedentary behaviour in mid-age adults and older adults. It has however seen an increase in interest into understanding the underlying factors of sedentary behaviour. Overall, more studies are needed to profile sedentary behaviour in this age group to assist the design of interventions for changing sedentary behaviour. It would then be possible to provide detailed sedentary behaviour guidelines to inform a policy on reducing sedentary behaviour in mid-age and older adults.

Chapter3

Correlates of Sedentary Behaviour in Older Adults: A Systematic Review

Chapter 3

Systematic Review

This chapter presents a systematic review on sedentary behaviour amongst adults aged 50 years and above. It summarises the evidence from 71 articles and provides a overview of the correlates of sedentary behaviour amongst mid-age and older adults.

3 Correlates of Sedentary Behaviour in Older Adults: A Systematic Review

3.1 Introduction

According to the World Health Organisation, the proportion of the world's older population, will double from approximately 11% to 22% from the year 2000 to 2050 (7). As people are living longer, the importance of healthy ageing among middle- and older-aged adults becomes more significant. It is known that a lifestyle including adequate amounts of physical activity (PA) and low levels of sedentary behaviour (SB) are important factors for maintaining good health. In the past decade there has been a rapidly growing interest in research concerning SB. Although there was definitional ambiguity in the early stages of SB research, SB now is commonly defined as "any waking behaviour characterized by an energy expenditure of ≤1.5 METs while in a sitting or reclining posture(4). SB is associated with both immediate and long-term ill-health including obesity(34), Type 2 diabetes(103), metabolic syndrome(18,77) and poor cardiometabolic health(62). Moreover, the associations between SB and poor health appears to be independent of levels of moderate-to-vigorous physical activity (MVPA)(104). Together, such evidence has provided the impetus for governments across the globe to make recommendations for SB (100-102).

Despite the increasing level of awareness of the deleterious health outcomes of SB, SB is an extremely prevalent behaviour in all age groups, and particularly increases from late mid-adulthood(10). In fact, middle age and older adults spend at least 60% of their waking hours being sedentary(105,106), with the average older adult spending between 8 to 11 hours a day sedentary(107). Given that SB dominates the waking hours of older adults, interventions to reduce and break up sedentary time in adults and older adults are urgently needed. To inform the development of behaviour change interventions, it is important to understand the types of SB that are most prevalent in mid-age and older adults and to identify the characteristics and modifiable correlates of behaviour in this age group.

Longitudinal evidence suggests that SB is not a stable behaviour from mid-life to older adulthood(108). Such evidence highlights the importance of understanding the unique correlates of SB according to age group as these are likely to differ as adults age. There have been several reviews synthesising the evidence on correlates of SB in adults (aged 18 years and above) as well as in older adults (aged 65 years and above) (94). However, to the best of our knowledge, there have been no attempts to synthesise the evidence on the correlates of SB specifically in mid-age and older adults together in one review. The distinction and comparison of the correlates of SB between mid-aged adults and older adults would specifically provide insight into potential avenues for the development of interventions to reduce SB for these specific populations. It is opportune, therefore, to synthesis the evidence and on the correlates of SB in mid-age and older adults.

3.2 Evidence acquisition

To produce an evidence-based systematic review, and identify the correlates of sedentary behaviour in mid-age and older adults, the current review was designed and conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement(109).

3.2.1 Search Strategy

The original search was performed in January, 2011, and for updating the data the literature search was performed again in July 2015. The search was built around three groups of key words: Population (e.g., “adults”, “men”, “women”, “older adults”); Behaviour (e.g., “sedentary behaviour”, “inactivity”, “television”, “computer”, “sitting at work”, “reading”, “listening to music”, “screen time”), and Study type (e.g., “correlates”, “factors”, “determinants”). Key terms were used in combination to locate potentially relevant studies. PubMed, ScienceDirect, Web of Science and PsycINFO electronic databases were searched. In addition, manual searches of personal files were conducted along with the screening of reference lists of primary studies and identified articles for titles that included the key terms.

Example of search terms used in PubMed publication database

((Sedentary behaviour[Title/Abstract] OR inactivity[Title/Abstract] OR television[Title/Abstract] OR computer[Title/Abstract] OR video games[Title/Abstract] OR small screen[Title/Abstract] OR sitting[Title/Abstract] OR riding in a car[Title/Abstract] OR commute[Title/Abstract] OR travel[Title/Abstract] OR workplace sitting[Title/Abstract] OR sitting at work[Title/Abstract] OR at desk[Title/Abstract] OR reading[Title/Abstract] OR listening to music[Title/Abstract] OR screen time[Title/Abstract) AND (Adults[Title/Abstract] OR men[Title/Abstract] OR women[Title/Abstract] OR older adults[Title/Abstract) AND (Correlates[Title/Abstract] OR factors[Title/Abstract] OR determinants[Title/Abstract])).

3.2.2 Inclusion Criteria

To be included, studies were required to (1) be an observational study or report baseline data from an experimental study; (2) include adults ≥ 50 years of age (or with a sample mean age over 50); (3) have at least one outcome measure of SB that was reported using either self-report or objective methods; (4) quantitatively report on at least one statistical association between a potential correlate of SB; (5) be a published full paper in a peer-reviewed journal in the English language up to and including July 2015.

3.2.3 Identification of Relevant Studies

Potentially relevant articles were selected by (i) screening the titles; (ii) screening the abstracts; and (iii) if abstracts were not available or did not provide sufficient data, the entire article was retrieved and screened to determine whether it met the inclusion criteria. Screening was conducted by the author of the current thesis. Discussions were held with the second author (Dr. Natalie Pearson) and third author (Professor Stuart Biddle) in cases where it was unclear whether a paper should be included or not. In cases of missing/incomplete or unclear information, authors of manuscripts were contacted to provide further details on the paper before it was deemed eligible or not.

3.2.4 Assessment of Methodological Quality

The methodological quality of studies was assessed by an 8-item quality assessment scale used previously (see Table 3.1) (110). Each study was given a score (0-2) based on sample size, sampling methods, response rates, the level of reporting the validity and reliability of measures used to assess SB, and whether or not confounders were included in analyses. Study quality scores could range from 0-16, a score of 1-6, 7-12, and score 13 and above was considered as low, moderate and high quality, respectively.

3.2.5 Data Extraction and Coding Associations

Data from each study were extracted by the first author onto standardised forms developed for this review. Descriptive data extracted included: authors, country of the study, study design, participant characteristics (sample size, gender and age), measures of sedentary behaviour, SB outcomes and assessment methodology, reliability and validity of SB measures, and identified correlates. In the studies that included adults with a wide age range (e.g. 20-70 years), only data on adults aged 50 years and above were extracted and used in this review.

Identified correlates of SB were categorised into four domains: Socio-demographical, behavioural, physical and psychological health, and environmental correlates. The study findings were extracted and results were synthesised according to the type of SB ((screen-based (e.g. TV, computer and total screen time) and non-screen based (e.g. reading, total sitting and objectively derived sedentary time)). Findings are presented separately for mid-age (aged 50-64, Tables 3.3 and 3.5) and older (aged ≥65, Tables 3.4 and 3.6) adults*. An independent sample was used as the unit of analysis and was defined as the smallest independent subsample for which relevant data were reported (e.g. men/women). The column “No. of samples” in Tables 3.3-3.6 displays the number of samples that have been studied for each correlate. The “Summary” column contains the number of samples finding significant positive (+), significant inverse (–), and no (0) associations between correlates and SB. All identified correlates are displayed in the summary tables, but only those reported in three or more samples (defined as having three or more samples in the ‘No. of samples' column in Tables 3.3-3.6) are presented in the results. These coding rules are based on the previous work of Sallis et al.(111).

Table 3.1. Study Quality Assessment

Criteria	Score		
	0	**1**	**2**
Sample Size N	<100	100-999	1000+
Sampling	No specific procedure	Narrow	Diverse
Response Rate	Not reported	<60%	>60%
Validity of sedentary behaviour measure	Not reported	"Fair"	"Good"
Validity of measure of correlate assessed	Not reported	"Fair"	"Good"
Reliability sedentary behaviour measure	Not reported	"Fair"	"Good"
Reliability Measure of correlate assessed	Not reported	"Fair"	"Good"
Confounders included in analysis	No	-	Yes

3.3 Evidence synthesis

Overall, 9589 references were retrieved from the electronic databases and manual searches and 71 articles presenting 59 studies and 88 samples met the inclusion criteria and were eligible for this review (see Figure 3.1).

Thirty-three articles (n=28 studies, 48 samples) of mid-age adults and thirty-eight articles (29 studies, 34 samples) of older adults were eligible for review (see Table 3.2). The majority of studies in mid-age adults were conducted in the USA (n=8 studies, 13 samples), the UK (n=5 studies, 9 samples) and Australia (n=4 studies, 7 samples). Most of the studies examined men and women together (n=26 studies, 34 samples), and most utilised a cross-sectional design (n=20 studies, 34 samples). SB was most commonly assessed via self-report (n=21 studies, 39 samples), and total sitting time was the most commonly assessed SB (n=14 studies, 24samples), followed by television (TV) viewing (n=7 studies, 13 samples).

Objectively assessed SB was reported in eight studies (9 samples). Study quality scores for papers including mid-aged adults were mostly moderate (n=21 studies, 38 samples).

The majority of studies in older adults were conducted in the UK (n=8 studies, 9 samples), the USA (n=6 studies, 7 samples), and Australia (n=4 studies, 6 samples). Most of the studies examined men and women together (n=31 studies, 32 samples), and most utilised a cross-sectional design (n=29 studies, 35 samples). SB was most assessed via self-report (n=21 studies, 26 samples), and total sitting time was the most commonly assessed SB (n=14 studies, 16 samples), followed by television (TV) viewing (n=5 studies, 7 samples). Objectively assessed SB was reported in 17 studies (20 samples). Study quality scores for studies including older adults were mostly moderate (n=21 studies, 26 samples). Correlates of screen-based and non-screen based SB in older adults are presented separately.

<u>3.3.1 Correlates of Screen-based Sedentary Behaviour</u>

Fifteen and thirty-one correlates were identified in association with screen-based SB in mid-age and older adults, respectively. Three out of fifteen correlates of screen-based SB of mid-age adults (Table 3.3) and four out of thirty-one correlates of screen-based SB of older adults (Table 3.4) were studied three or more times. Gender was unrelated to screen-based SB in both mid-age (n=6 out of 6 samples) and older adults (n=2 out of 3 samples). Age was unrelated to screen-based SB in mid-age adults (n=2 out of 3 samples) and older adults (n=2 out of 3 samples). Being retired or unemployed was only found in mid-age adults, and it was positively associated with screen-based SB (n= 4 out of 6 samples). Education and income were only found associated with screen-based SB in older adults. Education was inversely (n=3 out of 4 samples) and positively (n=1 out of 4 samples) associated with screen-based SB in older adults. Income was unrelated to screen-based SB (n=3 out of 4 samples).

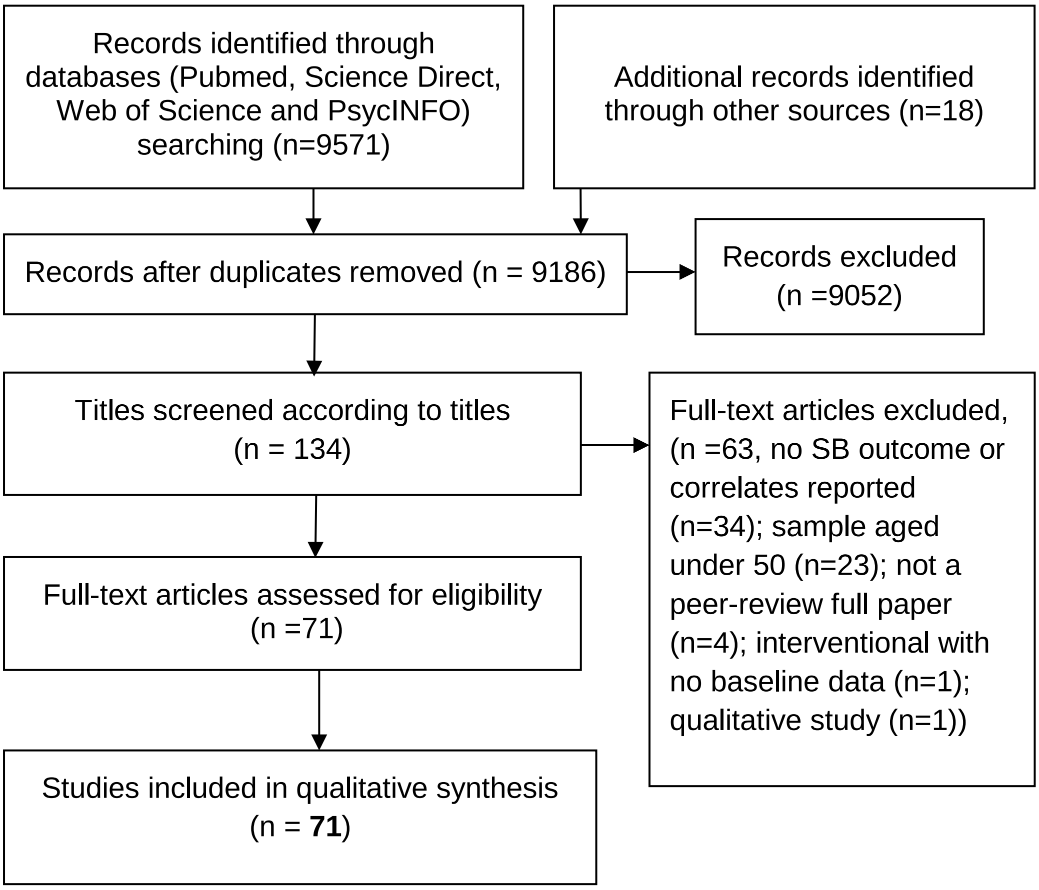

Figure 3.1. Flow Diagram of the article searching

Table 3.2. Characteristics of studies included in the review: sample size, gender, study design, country and quality of study

	Mid-age Adults (50-64 years)			Older-adults (65+ year)		
	References	No. of samples	%	References	No. of samples	%
Sample size		48	100		43/40ǂ	100
<100	42	1	2	21,23,30,68	4	10
100-199	25	1	2	9,69	2	5
200-299	51,52Nw	2	4	14,45,50,71	4	10
300-499	55	1	2	6,67Wh,67F,70	4	10
500-999	22,28,41,44,62,64MNs**H**,64MS**H**,64FS**H**,66F, 66M	10	21	2A,8,13M,13F,18,26,33**D**,48,54**A**	9/8 ǂ	20
1000-2999	5(112)(112)(112)(112)(109),7Fr**G**,7Nfr**G**,10,31,52,52 W,59M,59F,64FNs**H**, 66	11	23	4,11,13,17G,19**G**,20,29,34**D**,35,37**G**,46**C**,63	12/9ǂ	23
3000-4999	15E,47(57)E,56E,59,60	5	10	24,38	2	5
≥5000	1,3,12,12M,12F,12Wh,12Bk,27C,32H,36,39,43, 57,58B,61H,65M,65F	17	35	16,40**B**,49,49NW,49W,53	6	15
Gender						
Male only	12M,64MNs**H**,64MS**H**,65M,66M	5	10	13M,33**D**,34**D**,70	4	10
Female only	22,42,57**B**,58**B**,12F,64FNs**H**,64FS**H**,65F,66F	9	19	13F,30,40**B**,67F	4	10
Male and Female combine	1,3,5,7Fr**G**,7Nfr**G**,10,12,12Wh,12Bk,15**E**,25,27**C**, 28,31,32**H**,36,39,41,43,44,47**E**,51,52,52Nw,52W,5 5,56**E**,59,59M,59F,60,61**H**,62,66	34	71	2**A**,4,6,8,9,11,13,14,16,17**G**,18,19**G**,20,21, 23,24,26,29,35,37**G**,38,45,46**C**,48,49,49Nw, 49W,50,53,54**A**,63,67Wh,68,69,71	35/32ǂ	80
Study Design						
Longitudinal	64MNs**H**,64MS**H**,64FNs**H**,64FS**H**	4	8	23,40**B**,46**C**,63	4	10
Randomised Control Trial	28	1	2	21	1	3

Table 3.2. Continued

	Mid-age Adults (50-64 years)			Older-adults (65+ year)		
	References	No. of samples	%	References	No. of samples	%
Study Design						
Cross-sectional	3,5,7Fr**G**,7Nfr**G**,10,15**E**,25,27**C**,31,36,41,42,43,44,47 **E**,51,52,52Nw,52W,55,56**E**,59,59M,59F,60,62, 65M,65F,66,66M,66F	31	63	2**A**,4,6,8,9,11,13,13M,13F,14,16,17**G**,18, 19**G**,20,24,26,29,30,33**D**,34**D**,35,37**G**,38,454 8,49,49NW,49W,50,53,54**A**,67F,67Wh,6869, 70,71	38/35ɨ	88
Prospective	1,12,12M,12F,12Wh,12Bk,22,32**H**,39,57**B**,58**B**,61**H**	12	29		0	0
Assessment of SB						
Self-report						
Screen-based SB	1,10,15**E**,22,31,32H,39,52,52Nw,52W,64MNsH, 64MS**H**,64FNs**H**,64FS**H**	14	29	35,53,63	3	8
Non-screen based SB	12,12M,12F,12Wh,12Bk,25[b] ,36,41[b] ,44,47**E**,55, 56**E**,57**B**,58**B**,59,59M,59F,60,61**H**,62,65M,65F,666 6M,66F	25	52	4[b],6,9[b],13[b],13M[b],13F[b],16,18,24,29,38,40**B**, 46**C**,48,50,67Wh,67F,69,	18	45
Both type of self-report SB	3,43	2	4	49[b],49NW[b],49W[b],11[b], 70[b]	5	13
Objective measurement	5,7Ff**G**,7Nfr**G**,25[b],27**C**,28,41[b],42,51	9	19	2**A**,4[b],8,9[b],13[b],13M[b],13F[b],14,17**G**,19**G**,20, 21,23,26,3033**D**,34**D**,37**G**,45,48[b],54**A**,68, 71	23/20ɨ	50
SB Outcomes						
Self-report						
Total Sitting/SB	3,12,12M,12F,12Wh,12Bk,25,36,39,41,43,44, 47**E**,55,56**E**,57**B**,58**B**,59,59M,59F,62,66,66F, 66M	24	50	4,6,9,16,18,24,29,38,40**B**,49,49NW,49W,5063 ,69,70	16	40
Sitting at work	43,60	2	4	70	1	3
Leisure time sitting	65M,65F	2	4	13,13M,13F,67Wh,67F	5	13

Table 3.2. Continued

	Mid-age Adults (50-64 years)			Older-adults (65+ year)		
	References	No. of samples	%	References	No. of sampl es	%
SB Outcomes						
Self-report						
Reading		0	0	11,70	2	5
Transportation[T]	43,55	2	4	49,70	2	5
TV viewing	1,10,15**E**,22,32**H**,43,52Nw,52W,61**H**,64MNs**H**,64MS**H**, 64FNs**H**,64FS**H**	13	27	35,46**C**,49,49NW,49W,53,70	7	18
PC	43	1	2	49,70	2	5
TV+PC	3,59,59M,59F	4	9		0	0
TV+Radio		0	0	11	1	3
Screen time	31	1	2		0	0
Objective derived sedentary time	5,7Fr**G**,7Nfr**G**,25,27**C**,28,41,42,51	9	19	2**A**,4,8,9,13,13M,13F,14,17**G**,19G,20,21, 23,26,30,33**D**,34**D**,37**G**,45,48,54**A**,68,71	23/20ɨ	50
Study Quality						
1-6	1,3,10,22,25,32**H**,61**H**,65M,65F	9	19	2**A**,9,11,14,18,21,23,24,30,63,67Wh,67F,68,69	14	35
7-12	5,7Fr**G**,7Nfr**G**,12,12M,12F,12Wh,12Bk,15**E**,27**C**,28,31,36,39,41,42,43,44,47**E**,51,52,52Nw,52W,55, 56**E**,57B,58B,59,59M,59F,62,64MNs**H**,64MS**H**, 64FNs**H**,64FS**H** ,66,66F,66M	38	79	4,6,8,13,13M,13F,16,17G,19**G**,20,26,29, 33**D**,34**D**,35,37**G**,38,45,46**C**,48,49,49Nw, 49W,50,53,54**A**,70,71	28/26ɨ	65
≥13	60	1	2	40**B**	1	3
Country						
UK	5,28,32**H**,61**H**,62,64MNs**H**,64MS**H**,64FNs**H**, 64FS**H**	9	19	14,23,29,33**D**,34**D**,48,50,68,71	9	23
Spain		0	0	24,63	2	5

Table 3.2. Continued

	Mid-age Adults (50-64 years)			Older-adults (65+ year)		
	References	No. of samples	%	References	No. of samples	%
Country						
Norway		0	0	26	1	3
Finland	43	1	2		0	0
Portugal		0	0	45	1	3
France	52,52Nw,52W,59,59M,59F	6	13		0	0
Belgian	55	1	2	53	1	3
Iceland		0	0	2**A,**54**A**	2/1ɨ	3
Germany	60	1	2	69	1	3
USA	1,7Fr**G**,7Nfr**G**,12,12M,12F,12Wh,12Bk,22,25,39,42,51	13	27	4,8,9,17**G**,19**G**,20,37**G**,67Wh,67F	9/7ɨ	18
Canada		0	0	13,13M,13F,16,21,70	6	15
Brazil		0	0	38	1	3
Australia	3,15**E**,27**C**,47**E**,56**E**,57**B**,58**B**	7	15	18,40**B**,46**C**,49,49Nw,49W	6	15
Taiwan	10,66,66F,66M	4	9		0	0
Japan	31	1	2	30,35	2	5
China	41,65M,65F	3	6	6,11	2	5
India	44	1	2		0	0
Iran	36	1	2		0	0

Table3.2. Continued

Note: [b]=literature reported both self-report and objective sedentary behaviours, and was counted twice in the no. of sample and % column; M: Male, F: Female; Wh: white race, Bk: black race; Fr-frail participants, Nfr: Non-frail participants; W:Working, Nw: Non-Working; Ns: Non-manual social class, S: Manual social class; **A**: AGES-ReykjavikII study, **B**: The Australian Longitudinal Study on Women's Health (ALSWH), **C**: The Australian Diabetes, Obesity and Lifestyle (AusDiab) study , **D**: British Regional Heart Study; **E**: WELL study, **G**: The National Health and Nutrition Examination Survey (NHANES); **H**: European Prospective Investigation into Cancer and Nutrition (EPIC)-Norfolk; ɫ:Study 17, 19 and 37 used the same sample from NHANES 03/04&05/06 and Study 2 and 54 used the same sample from AGES-ReykjavikII study, so it would be counted as one sample when the studies appear in the same column.

References :1.(Anuradha et al., 2011)(113), 2(Arnardottir et al., 2013)(65), 3.(Banks et al, 2011)(75), 4.(D. Bann et al., 2015)(114), 5.(D. Bann et al., 2014)(112), 6.(Barnett et al., 2015)(115), 7.(Blodgett et al., 2015)(116), 8.(Buman et al., 2010)(59), 9.(Bustamante et al., 2013)(117), 10.(Chang et al., 2008)(118), 11.(Chou et al., 2004)(119), 12.(Cohen et al., 2013)(51), 13.(Copeland et al., 2015)(120), 14.(Davis et al., 2011)(66), 15.(De Cocker et al., 2013)(45), 16.(Dogra & Stathokostas, 2014)(33), 17.(Dunlop et al., 2015)(121), 18.(Espinel et al., 2015)(122), 19.(Evenson et al.2012)(53), 20.(Evenson et al., 2014)(123), 21.(Fleig et al., 2015)(124), 22.(George et al., 2013)(83), 23.(Godfrey et al., 2014)(125), 24.(Gomez-Cabello et al., 2012)(34), 25.(Grimm et al., 2012)(54), 26.(Hansen et al., 2012)(68), 27.(Healy et al., 2008)(77), 28.(Henson et al., 2013)(62), 29.(Heseltine et al., 2015)(126), 30.(Ikezoe et al., 2013)(55), 31.(Ishii et al., 2013)(127), 32.(Jakes et al., 2003)(46), 33.(Jefferis et al., 2015)(128), 34.(Jefferis et al., 2014)(129), 35.(Kikuchi et al., 2013)(130), 36.(Koohpayehzadeh et al., 2013)(56), 37.(Martin et al., 2014)(131), 38.(Meneguci et al., 2015)(132), 39.(Patel et al., 2010)(36), 40.(Peeters et al., 2014)(133), 41.(Peters et al., 2010)(63), 42.(Pettee Gabriel et al., 2012)(64), 43.(Piirtola et al., 2014)(134), 44.(Rastogi et al., 2004)(82), 45.(Sardinha et al., 2015)(135), 46.(Shibata et al., 2015)(136), 47.(Sodergren et al., 2012)(57), 48.(Stamatakis et al., 2012)(78), 49.(Stamatakis et al., 2014)(137), 50.(Stubbs et al., 2014)(138), 51.(Swartz et al., 2012)(69), 52.(Touvier et al., 2010)(48), 53.(Van Cauwenberg et al., 2014)(139), 54.(van der Berg et al., 2014)(140), 55.(Van Dyck et al., 2015)(141), 56.(Van Holle et al., 2014)(142), 57.(van Uffelen et al., 2011)(58), 58.(van Uffelen et al., 2012)(143), 59.(Wagner et al., 2012)(80), 60.(Wallmann-Sperlich et al., 2014)(144), 61.(Wijndaele et al., 2011)(50), 62.(Yates et al., 2012)(145), 63.(Balboa-Castillo et al. 2011)(146), 64.(Barnett et al. 2014)(147), 65.(Du et al. 2013)(148), 66.(Ku et al. 2011)(149), 67.(Larsen et al. 2014)(150), 68.(Lord et al. 2011)(151), 69.(Ortlieb et al. 2014)(152), 70.(Vallance et al. 2013)(153), 71.(Withall et al. 2014)(154)

Table 3.3. Correlates of Screen-based SB of Mid-age (50-64 years) Adults

Correlates	Related to screen-based sedentary behaviours: References Association (+)	Related to screen-based sedentary behaviours: References Association (-)	Unrelated to screen-based SB: References	No. of samples	Summary (n): +	Summary (n): -	Summary (n): 0
Socio-demographic correlates							
Gender (Male)			31,32,43,43[PC], 52NW, 52W	5	0	0	6
Age	10		31,43	3	1	0	2
Ethnicity			1	1	0	0	1
Education			15,31	2	0	0	2
Married		31		1	0	1	0
Retired/ Unemployed	64MNS,64FNS, 64MS,64FS	31	52	6	4	1	1
Income			31	1	0	0	1
Living alone		31		1	0	1	0
Behavioural Correlates							
MVPA		22		1	0	1	0
Leisure time PA			10	1	0	0	1
Occupation activity			10	1	0	0	1
Total activity /Weekly session of PA			3,10	2	0	0	2
Standing			3	1	0	0	1
Physical Health Correlates							
BMI	3			1	1	0	0
Long-term illness/with chronic disease	59		61	2	1	0	1

Note: References: See Table 3.2; Underline: objectively-measured; PC: Computer using only, V: Sitting in car/passive transportation ; W :Working participant, NW : Not-working participants, NS: Non-manual social class, S: Manual social class
*If in one study, a correlate is examined in relation more than one outcomes (e.g. objective derived and self-report total sitting) and the results of each outcome is counted as one record in summary (e.g. gender was reported correlated with objective and self-report measurement, the study is counted once in the 'No. of samples' column, and twice in the 'Summary' column).

Table 3.4. Correlates of Screen-based SB of Older (65+ years) Adults

	Related to screen-based sedentary behaviours		**Unrelated to screen-based SB**		**Summary (n)**		
Correlates	References Association (+)	References Association (-)	References	No. of samples	+	-	0
Socio-demographic Correlates							
Gender (Men)		53	11,35	3	0	1	2
Age	53		11,35	3	1	0	2
Education	49W[PC]	35,49W,53	49Nw,49 Nw[PC]	4*	1	3	2
Married		53	11	2	0	1	1
Employed		11,35		2	0	2	0
Income/Financial status	49W[PC]	49W,53	11,49Nw,49Nw[PC]	4*	1	2	3
Area level socioeconomic advantage			49W/Nw,49WPC/Nw[PC]	2	0	0	4
Living alone			11,35	2	0	0	2
Living in urban area	53			1	1	0	0
Behavioural Correlates							
MVPA		35		1	0	1	0
Driving			35	1	0	0	1
Recreational walking/cycling		53		1	0	1	0
Have a dog			35	1	0	0	1
Physical/Psychological Health Correlates							
Normal weight		35		1	0	1	0
Perceived Health			11,35	2	0	0	2
Long-term illness/Chronic Disease			11	1	0	0	1
Physical function limitation	5		11	2	1	0	1
Sight			11	1	0	0	1
Pain			11	1	0	0	1
Psychological mental health			11	1	0	0	1
Loneliness	53			1	1	0	0

Table 3.4 Continued

	Related to screen-based sedentary behaviours		Unrelated to screen-based SB		Summary (n)		
	References Association (+)	References Association (-)	References	No. of samples	+	-	0
Social and Physical environmental Correlates							
Frequency of contacts with neighbour	53			1	0	0	1
Satisfaction of contacts with neighbour	53			1	0	0	1
Quality of contacts with neighbour	53			1	0	0	1
Distance to facilities		53		1	0	1	0
Absence of decay		53		1	0	1	0
Absence of noise	53			1	1	0	0
Exist of street light		53		1	0	1	0
Feeling unsafe	53			1	1	0	0
Walkability of the area		53		1	0	1	0
Neighbourhood involvement			53	1	0	0	1
Weekday		70,70^{PC}		1	0	2	1

Note: References: See Table 2.1; ^{PC}: Computer using only, ^{V}:car/passive transportation ; W :Working participant, Nw: not-working participants; ^{R}: Reading; *If in one study, a correlate is examined in relation more than one outcomes (e.g. objective derived and self-report total sitting) and the results of each outcome is counted as one record in summary (e.g. gender was reported correlated with objective and self-report measurement , the study is counted once in the ‘No. of samples’ column, and twice in the ‘Summary’ column).

3.3.2 Correlates of Non-screen Based Sedentary Behaviour

Forty-six and sixty-eight correlates were identified in association with non-screen based SB in mid-age adults and older adults, respectively. Eighteen out of forty-six correlates were studied three of more times in mid-age adults (Table 3.5); twenty-one out of sixty-eight correlates were studied three of more times in older adults (Table 3.6).

3.3.2.1 Demographic correlates

Gender, age, education, employment status and income were the most studies correlates of non-screen based SB in both mid-age and older adults. Gender was reported by most samples that was unrelated to non-screen based SB in mid-age (n=10 out of 10 samples) and older adults (n=13 out of 22 samples). Age also was unrelated to non-screen based SB by most samples in mid-age adults (n=5 out of 7 samples) and older adults (n=8 out of 15 samples) However, in older adults, some samples showed that being male (n=8 out of 22 samples) and age (n=7 out of 15 samples) could also be positively associated with non-screen based SB. Education was found unrelated to non-screen based SB in mid-age (n=4 out of 8 samples) and older adults (n=8 out of 10 samples), but education was also found positively associated non-screen based SB in mid-age (n=4 out of 8 samples) and older adults (n=5 out of 10 samples). Type of job was found unrelated to non-screen based SB in mid-age adults (n=3 out of 3 samples). In older adults, employment status (e.g. working full-time) was unrelated to non-screen based SB (n=5 samples). Meanwhile, it is also found that being unemployed or retired was positively associated with non-screen based SB in older adults (n=5 out of 5 samples). In older adults, ethnicity (n=3 out of 5 samples), marital status (n=6 out of 6 samples), and area level socioeconomic status (n=4 out of 4 samples) were all unrelated to non-screen based behaviours.

3.3.2.2 Behavioural correlates

MVPA, and light PA were inversely associated with non-screen based SB in both mid-age (n=2 out of 3 samples) and older adults (n=2 out of 4 samples). However, one sample did report a positive association of High intensity PA, MVPA and light PA with non-screen based SB in older adults. Moreover, in older adults, weekly sessions of PA/total PA level was inversely (n=2 out of 5 samples) associated with and unrelated to (n=2 out of 5 samples) non-screen based SB. Meeting PA guidelines was found inversely associated with non-screen based SB (n=4 samples), but also found unrelated to non-screen based SB (n=3 samples) in older adults. Smoking was found unrelated to non-screen based SB in mid-age adults (n=3 samples), and positively associated with non-screen based SB in older adults (n=3 out of 4 samples). Additionally, learning well-being (i.e. leaning new knowledge and skill) was inversely associated with non-screen based SB in mid-age adults (n=3 out of 3 samples).

3.3.3.3 Physical and psychological health correlates

BMI was unrelated to non-screen based SB in mid-age adult (n=5 out of 7 samples). In older adults a positive association was found between BMI/overweight/obesity with non-screen based SB (n=4 out of 6 samples). Mixed findings were found on the association between waist circumference and non-screen based SB in older adults; an inverse association and no association was found in two and four samples, respectively. Correlates including musculoskeletal disease, cardiovascular/heart disease, respiratory/lung disease, metabolic disease, high blood pressure and diabetes mellitus were synthesised into the category "long term illness/chronic disease". This was found to be unrelated to non-screen based behaviours in mid-adults (n=2 out of 3 samples). In five out of nine samples of older adults long term illness/chronic disease was unrelated to non-screen based SB and in 4 out of nine samples it was positively associated with non-screen based SB. Perceived health was unrelated to non-screen based SB in older adults in 9 sample and positively associated in 5 samples. Physical function was unrelated to non-screen based SB in 2 out of 3 samples of older adults.

In mid-age adults, one study found that physical well-being (n=3 out of 3 samples), psychological well-being (n=3 out of 3 samples), life independence (n=3 out of 3 samples), social well-being (n=3 out of 3 samples), environment well-being (n=3 out of 3 samples) and material well-being (n=2 out of 3 samples) were inversely associated with non-screen based SB. In older adults, depression (n=2 out of 3 samples), and psychological well-being/mental health (n=2 out of 3 samples) were found to be unrelated to non-screen based SB.

In summary, correlates of non-screen based SB in mid-aged adults appear to be higher income, lower levels of well-being, and lower physical activity. Correlates of non-screen based SB in older adults appear to be being retired, being a smoker, having higher BMI, and lower levels of physical activity.

Table 3.5. Correlates of Non-screen based SB of Mid-age (50-64 years) Adults

	Related to non-screen based SB		**Unrelated to non-screen based SB**		**Summary (n)**		
Correlates	References Association (+)	References Association (-)	References	No. of samples	+	-	0
Socio-demographic Correlates							
Gender (Male)	41,41,62,66		5,25,25,36,43[OT],43,43[V],47, 55[V],59	10*	4	0	10
Age	41	12,66	43,43[V],51,65M[L],65F[L]	7*	1	2	5
Acculturation			58	1	0	0	1
Education	12M,12F,65M[L],65F[L]		41,55,58,60[WK]	8	4	0	4
Married			12,58	2	0	0	2
Employed/Full-time working			12	1	0	0	1
Retired/ Unemployed			58	1	0	0	1
Full-time house duty			58	1	0	0	1
Types of Job (Skilled/Blue Collar/Manual)			58,65M,65F	3	0	0	3
Income	12,65M,65F		58,60[WK]	5	3	0	2
Live in urban			58	1	0	0	1
Behavioural Correlates							
MVPA		28,51	27	3	0	2	1
Light PA		47,51	27	3	0	2	1
Lifestyle PA		51		1	0	1	0
Leisure time PA/Exercise	44		39	2	1	0	1
Occupational PA		60[WK]		1	0	1	0
Weekly session of PA/Total PA		28	58	2	0	1	1
Formal sitting job			55	1	0	0	1
Smoking	12		41,58	3	1	0	2
Drinking			58	1	0	0	1
Energy Intake			41	1	0	0	1
F&V intake			47	1	0	0	1

Table 3.5. Continued

	Related to non-screen based SB		Unrelated to non-screen based SB		Summary (n)		
Correlates	References Association (+)	References Association (-)	References	No. of samples	+	-	0
Physical/Psychological Health Correlates							
Cognitive (awareness of being sedentary)			60[WK]	1	0	0	1
Learning well-being		66,66F,66M		3	0	3	0
BMI	12Wh,51		3,12Bk,41,43,55	7	2	0	5
Waist circumference	51		41	2	1	0	1
Total body fat/abdominal fat	51			1	1	0	1
Long-term illness/Chronic Disease	59M		58,59F	3	1	0	2
Physical well-being		66,66F,66M		3	0	3	0
Degree of frail	7			1	1	0	0
Psychological well-being		66,66F,66M		3	0	3	0
Life independence		66,66F,66M		3	0	3	0
Social and Physical Environmental Correlates							
Social participation		56		1	0	1	0
Social support (family)			56	1	0	0	1
Social support (friends/colleagues)		56		1	0	1	0
Descriptive norms			56	1	0	0	1
Social trust and cohesion			56	1	0	0	1
Personal safety			56	1	0	0	1
Aesthetics		56		1	0	1	0
Destinations			56	1	0	0	1
Social well-being		66,66F,66M		3	0	3	0
Environment well-being		66,66F,66M		3	0	3	0
Material well-being	66, 66M	66F		3	2	1	0
No. of TV in the house (two TVs)			56	1	0	0	1
No. of TV in the house (≥3 TVs)			56	1	0	0	1

Table 3.5. Continued

Correlates	Related to non-screen based SB: References Association (+)	Related to non-screen based SB: References Association (-)	Unrelated to non-screen based SB: References	No. of samples	Summary (n): +	Summary (n): -	Summary (n): 0
Social and Physical Environmental Correlates							
Sunday/Weekend-day	7Fr, 7Nfr		42,57	4	2	0	2

Note: References: See Table 3.2; Underline: objectively-measured; [V]: sitting in car/passive transportation, [OT]: other SB; [WK]: Sitting at work; [L]: Leisure sitting/SB; Fr-frail participants, Nfr-Non frail participants; Wh :white race; Bk: black race; M :Male ; F:Female

*If in one study, a correlate is examined in relation more than one outcomes (e.g. objective derived and self-report total sitting) and the results of each outcome is counted as one record in summary (e.g. gender was reported correlated with objective and self-report measurement, the study is counted once in the 'No. of samples' column, and twice in the 'Summary' column).

Table 3.6 Correlates of Non-screen based SB of Older (65+ years) Adults

	Related to non-screen based sedentary behaviours		**Unrelated to non-screen based sedentary behaviours**		**Summary (n)**		
Correlates	References Association (+)	References Association (-)	References	No. of samples	+	-	0
Socio-demographic Correlates							
Gender (Men)	2,4/4,8,11[R],14,21, 54,	24,26,67Wh[L]	9/9,17,18,20,23,25,25,29,37,38,45,68,69	22/20ǂ*	8	3	13ǂ
Age	8,9/9, 14,16, 34,69		2,11R,17,18,19,20,21,23,29	15/13ǂ*	7	0	8ǂ
Ethnicity (Black)	67F#[L]	67F#[L]	17,19,20,68	5/4ǂ	1	1	3ǂ
Acculturation			9/9	1*	0	0	2
Education	9,29, 49W,54,11[R]		9,16,17,18,38,49Nw,49Nw[V], 49WV	10*	5	0	8
Marital status		16	9/9,11R,18,54,68	6*	0	1	6
Employed/Full-time working			11[R],13,13M,13F,29	5	0	0	5
Retired/ Unemployed	13[L],13M[L],16	23	13F[L]	5	3	1	1
Income/ Financial Status	49W	29	9/9, 11R,16, 17,49WV,49Nw	7*	1	1	7
Economic hardship			9/9	1*	0	0	2
Area level socioeconomic status			18, 49W,49Nw,49WV	3*	0	0	4
Medicated Insured			17	1	0	0	1
Living in an apartment	16,54			2	2	0	0
Living alone			18	1	0	0	1
Living as a couple			29	1	0	0	1
Live in major city			18	1	0	0	1
Behavioural Correlates							
High Intensity PA	8			1	1	0	0
MVPA	8	9, 18	48	4	1	2	1
Light PA	8	9, 18	48	4	1	2	1
Household PA			9	1	0	0	1

Table 3.6. Continued

Correlates	Related to sedentary behaviours: References Association (+)	Related to sedentary behaviours: References Association (-)	Unrelated to sedentary behaviours: References	No. of samples	Summary (n): +	Summary (n): -	Summary (n): 0
Behavioural Correlates							
Weekly session of PA/Total PA level	29	16,40	67,68	5	1	2	2
Leisure time PA/Exercise	9			1	1	0	0
Meet PA guideline		13, 13M,13F,13M	13,13F,17	4*	0	4	3
Absence of PA			38	1	0	0	1
Daily journey			14	1	0	0	1
No. of steps			30	1	0	0	1
Smoking	29,34,54		17	4	3	0	1
Energy Expenditure			68	1	0	0	1
Physical/Psychological Health Correlates							
BMI /Obesity/Overweight	16,29,50Cm,54		2,68	6	4	0	2
Normal weight	14	34		2	1	1	0
Waist circumference		13/13F	13,13M,13M/F	3*	0	2	4
Perceived health		13,13M,13F, 16,29	8,9,11[R],13[L],13M[L],13F[L],18,38,71	11*	0	5	9
Long-term illness/Chronic Disease	16,34,50,54		9,11[R],17,18,38	9	4	0	5
No. of medication taking	29		38	2	1	0	1
Time since fracture			21	1	0	0	1
Experience of fall	33			1	0	0	1
Gait Speed		21		1	0	1	0
Not using walking aid	29			1	1	0	0
Physical function limitation	50Cm		11[R],68	3	1	0	2
Sight			11[R]	1	0	0	1
Pain			11[R]	1	0	0	1

Table 3.6 Continued

Correlates	Related to sedentary behaviours References Association (+)	References Association (-)	Unrelated to sedentary behaviours References	No. of samples	Summary (n) +	-	0
Physical/Psychological Health Correlates							
Life independence	29		38	2	1	0	1
Fear of fall/Fall	50Cm		68	2	1	0	1
Mood disorder	16			1	1	0	0
Loneliness	16			1	1	0	0
Life satisfaction			16,71	2	0	0	2
Depression	34		9,68	3	1	0	2
Psychological well-being/Mental health	11[R]		8,71	3	1	0	2
Quality of life		50Cm	21	2	0	1	1
Cognitive function			68	1	0	0	1
Anxiety			68	1	0	0	1
Social well-being			71	1	0	0	1
Social and Physical Environmental Correlates							
Weak Sense of belonging to community			16	1	0	0	1
Easy use public transportation	29,6[V]	6		2*	2	1	0
Distance of recreational distance			6,6[V]	1*	0	0	2
Distance to facilities/shops			6,6[V],46	2*	0	2	3
Distance to entertainment			6,6[V]	1*	0	1	2
Exist of health clinics/services			6,6[V]	1*	0	0	2
Exist of place of worship	6,6[V]			1	2	0	0
Exist of restaurant			6,6[V]	1*	0	0	2
Multiple choice of walking route			46	1	0	0	1
Neighbourhood aesthetic			46	1	0	0	1

Table 3.6. Continued

	Related to sedentary behaviours		Unrelated to sedentary behaviours		Summary (n)		
	References Association (+)	References Association (-)	References	No. of samples	+	-	0
Social and Physical Environmental Correlates							
Exist of footpath			46	1	0	0	1
Exist of park/nature/green			6,6[V],46	2*	0	0	3
Exist of bike/walk track			46	1	0	0	1
Traffic			46	1	0	0	1
Safety			46	1	0	0	1
Weekday	70,70WK	70[L]	70[V]	1*	2	1	1

References: See Table 3.2; Underline: objectively-measured; [V]: sitting in car/passive transportation, [OT]: other SB; [L]: Leisure time SB/Sitting, [WK]: Sitting at work; W: Working participants; Nw: Not-working participants; Cm: participants with chronic musculoskeletal disease; Wh :white ethnicity; M: Male ; F: Female; #: African-America women had higher and less leisure sitting time than Filipina and White women, respectively. ƗStudy 17, 19 and 37 used the sample from the same research project (NHANES03/04&05/06) reported the same results of correlation, so it was only counted as one sample; *If in one study, a correlate is examined in relation more than one outcomes (e.g. objective derived and self-report total sitting) and the results of each outcome is counted as one record in summary (e.g. gender was reported correlated with objective and self-report measurement , the study is counted once in the 'No. of samples' column, and twice in the 'Summary' column).

3.4 Discussion

The purpose of this study was to synthesise the evidence on correlates of SB among mid-age and older adults. To date, several reviews have been conducted to examine the evidence on the correlates of SB in adults and older adults (Rhodes et al.(93), O'Donoghue et al.(155), Chastin et al.(94) and Prince 2014, protocol registered number. CRD42014009814)). The present review builds on and further develops these reviews by providing the evidence on the correlates of SB in both mid-age and older adults. These populations have the highest prevalence of SB(10), and synthesising and comparing the evidence on correlates of these age groups in one review was deemed as important for the purpose of informing targeted behaviour change interventions.

We are also the first to distinguish between screen and non-screen sedentary behaviours. We showed that in both age groups, more evidence was available in understanding the correlates of non-screen based SB than screen-based SB. In mid-age adults, age and gender were most studied and consistently unrelated to both screen-based and non-screen based SB. In older adults, education was the only identified correlate which showed different associations for screen-based and non-screen based SB. In general, the present review found more studies had been conducted on the correlates of non-screen based SB in older adults than mid-age adults. However, the limited evidence highlights the need for further research on the influence of the environment on SB in both mid-age and older adults.

In terms of demographics correlates of SB, the current review reveals the diversities and similarities in comparison to the existing reviews on the correlates of SB in adults and older adults. In the present review it was found that biological-related correlates, such as age and gender had limited association with screen-based SB in both age groups However, O’Donoghue et al. found age to be positively associated with sedentariness in adults(155) and Chastin et al. found that age is positively associated with screen-based SB in older adults(94). Moreover, the general trend in findings of the current review suggests that gender has a limited effect on the level of sedentariness in mid-age adults and older adults. However, there was some evidence suggesting that male older adults were more likely to spend more time in non-screen based SB than older females. The literature on PA has shown that older men tend to be more physically active than women of the same age(92,156), suggesting that efforts should be made to tailor PA promotion by gender. The findings from the current review suggest that more research needs to be done to further understand the diversity in findings of the impact of age and gender on SB.

Socio-demographic correlates were evident, including education and income for mid-age and older adults. Chastin et al.'s review(94) found that education was inversely associated with SB whereas we found education to be unrelated to non-screen based SB in the majority of studies in both age groups, but some evidence suggested that education was inversely related with screen-based SB and positively associated with non-screen based SB in older adults. Moreover, evidence showed that among mid-age adults, income was positively associated with non-screen based SB, but not in older adults. Stamatakis et al.(137) assessed domain-specific sitting time and suggested that socio-economic position is linked to higher total sitting time but lower TV viewing time in middle and older-aged adults. Therefore, the mixed evidence could be further understood if a domain-specific sitting time tool was used for assessing SB. Clemes et al.(157) found when assessed sitting time in different domains, it showed that correlates differed according to the domain of sitting. Thus, further research assessing domain-specific sitting time is encouraged to understand the associations between socio-demographics with specific domains of SB in these age groups. Furthermore, the mixed associations found in the current review showed employed/full-time working was unrelated to screen-based SB, but being retired or unemployed were positively associated with non-screen based SB in older adults. Although a review has shown that retirement is positively associated with PA(158), it is unclear how total PA increased and if there was time displacement between PA and SB. Therefore, as retirement is an important life period for this population(48), further research is needed to understand the association between retirement and older adults' domain-specific SB in non-working/leisure time.

This review shows that among mid-aged and older adults there is some evidence of an inverse association between MVPA and non-screen based SB, and between light PA and non-screen based SB. These findings support and add to the work of others. For example, a recent review on adults found that all types of SB were associated with lower levels of PA(159). Such findings are suggestive of behaviour displacement where, for example, high levels of SB displace time that could be spent being active, and this is consistent with the findings by Mansoubi et al. (159), which found that the strength of the association between SB and PA appeared to be stronger for light PA. This is logical as time created from reductions in sitting time is more likely to transfer into light rather moderate-to-vigorous physical activity. Indeed, the act of standing up from a chair is an immediate shift from sedentary to light physical activity. In the context of mid-age and older adulthood, these findings, in addition to the findings of the current review, suggest that interventions targeting breaking up SB, and/or reductions in SB should initially target increases in light intensity activity. Moving populations, particularly older adults, from sedentary/sitting behaviours into activities involving light intensity activity will likely be more achievable and sustainable than, for example, promoting MVPA, and could have substantial effects on public health(77,160,161). This can be in the form of both more standing ('low' light PA) and light ambulation ('high' light PA).

In addition to physical activity, smoking behaviour was found to be unrelated to non-screen based SB in mid-age adults, but positively related to non-screen based SB in older adults. Moreover, older adults who reported lower levels of PA and smoking behaviour were more likely to report higher levels of non-screen based SB. This suggests that unhealthy behaviours could co-exist in later life, however, with limited evidence no conclusion could be made on the direction of the associations and the cause of the unhealthy behaviours. It is unclear if health behaviour habits, including SB, PA and smoking, would transition from mid-age to older adulthood, but longitudinal research has shown that the habit of screen viewing tracks from adolescence to early adulthood(162). Moreover, the continuity theory of normal aging (163) suggests that mid-age adults do not really change as they age, rather they just become "more" of what they have always been. Further research should consider examining the transition into older adulthood and associations between smoking and SB in older adults from midlife to later life.

This review found that BMI was unrelated to non-screen based SB in mid-age adults but positively associated in older adults. This suggests that interventions to reduce SB could target older adults with a higher BMI. Also it is important to note that the current review excluded studies where BMI (and other health conditions) were analysed as outcomes of SB. And a negative health condition was found positively associated with non-screen based sedentary time in older adults, despite insignificant associations being found in some cases. Evidence was lacking for associations between psychological health and SB in both age groups. Given the unclear direction of association between protective health behaviour with health observed in the present review, future studies using longitudinal data are needed to investigate the interaction and the direction of association between protective health behaviour, SB and health outcomes in this population. Studying the association between mental health and sedentary behaviour, either as a correlate or health outcome is a research priority.

Strengths and Limitations

Strengths of the review include the systematic approach adopted and the summary of seventy-one published articles, the clear definition of associations between correlates and SB by examining and reporting screen-based and non-screen based SB separately, and the use of coding associations. The current review also examined and reported the results of mid-age and older aged adults separately using individual samples as units of analysis. There are limitations to the present review, some of which are due to gaps in the literature itself. Studies were diverse in character (e.g. measures used, correlates studied, and SB outcome) and so it is difficult to assess the overall consistency of associations. A large number or correlates were identified, but few studies have examined the same specific combination of correlate and SB outcome, thus limiting the possibilities of drawing strong or consistent conclusions. The majority of studies reviewed were cross-sectional, making conclusions about the direction and causality of associations difficult. Only English-language papers were included in the review. This limits the study results from non-English speaking country, and could exclude the cultural and social influence on the results. The other bias is that the first step of literature screening was conducted by the first author. Although the selection of papers was agreed by all author and the uncertainties were discussed with the second and third author, the progression of screening could be improved by using independent screener. Moreover, an independent data extractor could also be used to improve the quality of the current review.

3.5 Conclusion

A large number of correlates have been studied among mid-age and older adults, and it is clear that SBs of mid-age and older adults are complex and influenced by multiple factors that are, in some cases, different across age stages. The findings of current review show that age and gender are the most studied correlates but that these have unclear effects SB in both age groups. PA level was inversely associated with screen-based and non-screen based SB in both age groups Such an association offers a potential avenue for intervention, whereby adults should be encouraged to break up sedentary time and replace sitting with light activity. Moreover, in mid-age adults, intervention to reduce SB could priority target those who with higher income and higher BMI. In older adults, intervention to reduce SB could consider to be implanted prior to those who have higher education, higher BMI, and worse health condition. The existing evidence shows a difference of SB between mid-age and older adults, however, there is a lack of evidence from which to draw strong conclusions. Longitudinal studies investigating correlates following mid-aged adults into older adulthood are needed.

Chapter4

Correlates of Sedentary Behaviour I

A Multi-geographic Data Analysis

Chapter 4

Correlates of Sedentary Behaviour Ⅰ

This chapter uses data collected in five countries including the UK, Germany, Italy, Spain and USA to examine the correlation between demographic and behavioural variables with self-reported sitting time and physical activity in mid-age and older adults.

4 Correlates of Sitting Time of Mid-age and Older Adults in Europe and the USA

4.1 Introduction

Since the association of physical activity with health was first found decades ago(1), physical activity has been widely studied within the public health research field. More recently however, sedentary behaviour has been found to be independently associated with chronic diseases and the risk of mortality (34,38). Sedentary behaviour is now regarded as an important health-related behaviour, with its link between immediate and long-term ill-health in older adults increasingly reported (84). Despite this, in the UK 35% of mid-age adults (aged 55-64 years) and 50% of older adults (aged over 65 years) reported spending at least six hours per day being sedentary, with the prevalence of sedentary behaviour increasing with age(10). It has also been revealed that adults aged over 50 years spend more than 60% of their daily time being sedentary(51). Existing studies have provided evidence on the correlates of physical activity and sedentary behaviour in adults(92,93), and the review-level evidence also suggests more studies are needed to understand the correlates od sedentary behaviour in older adults. Moreover, the correlates of sedentary behaviour in mid-age adults are less solely studied and remain unclear. The existing evidence covers mainly the association between demographics and sedentary behaviour, evidence on the potential correlates such as social and cultural factors are relatively less studied. Given the prevalence of sedentary behaviour rises rapidly from mid-age, and demographics and culture factors are less studied, this study aims (i) to understand the individual correlates and cultural factors of sedentary behaviour in mid-age and older adults using the data collected from multiple countries; (ii) to examine the correlates of sitting time and physical activity in mid-age and older adults in order to understand if there is difference in correlates between sitting and physical activity in this age group.

4.2 Methods

4.2.1 Participant recruitment

Recruitment had been done cross nine different countries (UK, Italy, France, Switzerland, German, Portugal, Austria, Spain and USA) in 2009. The original data was collected from 9709 adults aged 18 years and above in 2009 and the original purpose of the study was to increase the understanding of walking behaviour across nine European countries and the USA. A survey was created using online survey software and questionnaire tool (https://www.surveymonkey.com) and it was disseminated via a commercial website which was available in all respective countries in their native languages. The survey was disseminated further by the research team who also emailed the link to academic contacts in the respective countries. Then the participants were recruited via email invitation and word of mouth by the researchers from the collaborating research institution. The current study extracted the participants in the subgroups of aged 50-59 and 60+ years. Data from four countries (France, Switzerland, Portugal and Austria) were excluded due to the lack of data from these subgroups.

4.2.2Measurement

A survey including questions asking about basic- and socio-demographics and time spent sitting and in physical activity was used to collect data from the participants.

4.2.2.1 Outcomes Variables

The self-administered, short version of the International Physical Activity Questionnaire (IPAQ)(164) was included in the survey and was used to assess both sitting time and physical activity levels. Thus, participants reported the amount of time spent sitting in hours and minutes on a typical weekday during the last 7 days. Furthermore, participants reported the frequency and duration of walking, moderate and vigorous intensity physical activities lasting for at least ten minutes, over the last 7 days. Data were processed according to the guidelines of the IPAQ scoring protocol (165) in which all physical activity data are summarised and expressed as total MET-minutes/week. This measure of physical activity was developed to facilitate international comparisons and the short form is recommended for large populations making it ideal for use in this study(86). The reliability and validity of the IPAQ has been reported to be comparable to other established self-report methods(86). Additionally, the sitting time question from the IPAQ has been used previously in epidemiological studies exploring socio-demographic predictors of sitting in international samples(166).

4.2.2.2 Independent Variables

Other information including country of residence, basic demographics (age and sex), biological (height and weight, allowing the calculation of BMI) socio-demographic (marital status, the number of people living in the same household), physical activity related (perceived physical activity level) variables were also asked in the survey. The question on perceived physical activity level asked the participants to rate their activity level from five choices: very active, active, somewhat active, inactive and very inactive.

4.2.3 Statistical analyses

All analyses were conducted using IBM SPSS Statistics for Windows version 22. Descriptive statistics were used to summarise the characteristics of the sample. All the numerical data were not normal distributed, non-parametric tests were therefore used to examine the difference and correlation of sitting time and physical activity across variables. Mann-Whitney tests were performed to examine the differences in sitting and physical activity time across variables with two categories, such as age (50-59 and 60+), sex, marital status (single and not-single), living arrangement (living alone and with the others), and occupational status (employed and unemployed). Any differences in sitting time between categorical variables, which had more than two categories such as countries (UK, Italy, Germany, Spain and USA), perceived PA level (very active, active, somewhat active, inactive and very inactive), and BMI status (underweight, normal weight, overweight and obese), were compared by performing Kruskai-Wallis tests. Bonferroni-corrected post hoc comparisons were undertaken in the event of a significant Kruskal-Wallis test result for the independent variables which included more than two categories such as BMI and perceived PA level. Spearman correlation coefficients were performed to examine the correlation of the independent variables (countries, age, sex, marital status, living arrangement , occupational status, BMI, perceived and PA level), with sitting time, total PA, MVPA and walking. Moreover, the association of total PA, MVPA and walking with sitting time were also presented by Spearman correlation coefficients. Further linear regression was used to examine the relationship between the identified correlates ($r>0.1$, $p<0.05$) with sitting time, total PA, MVPA and walking.

4.3 Results

4.3.1 Sample characteristics

A total 1481 adults aged 50 years and above were included in the current study, the exclusion were due to missing data on sitting time (n=256), time in physical activity (n=254) and demographics (n=111). The characteristics of the participants and the medium sitting, total PA, MVPA and walking time are presented in Table 4.1. Most participants were aged 50-59, were female, married/co-habiting, and working. The prevalence of overweight and obesity was high in the samples and more than half of participants considered themselves active or very active.

4.3.2 Sitting time

For the sample as whole, participants reported a median sitting time of 6 (IQR=4) hours/day. No significant differences in reported sitting times were found across most independent variables, with the exception of perceived physical activity level. The more active the participants rated themselves, the less sitting time they reported. Moreover, a significant correlation was found between perceived PA level and sitting time ($r=0.34$, $p<0.01$); participants who rated themselves less active reported more sitting time. No other significant correlations were observed between the demographic variables and sitting time. Total PA time, MVPA and walking were all significantly inversely correlated with sitting time (Table 3.2). Participants who reported more total PA, MVPA and walking time were more likely to report lower sitting times. Perceived PA level ($F=198.10$, $p<0.001$), total PA ($F=97.38$, $p<0.001$), MVPA ($F=79.43$, $p<0.001$) and walking ($F=44.28$, $p<0.001$) accounted for 11.8%, 6%, 5% and 3% of the variation in sitting time, respectively.

4.3.3 Total Physical Activity

For the sample as whole, the median time reported in total PA was 120 (IQR=180) minutes/day. No significant differences in total PA time were found across most the independent variables, with the exception of the perceived physical activity level category. The participants rated themselves as very active also spent most time in total PA. The significant correlation found between country and total PA time was very small (Table 3.2), however perceived PA level was moderately and significantly correlated with total PA. Participants who rated themselves as more active also reported more total PA time.

Table4.1. The characteristic of the studied sample and the median (IQR) sitting, total PA, MVPA and walking time

	N(%)	Sitting Time(h/d)	p-value	Total PA (min/d)	p-value	MVPA (min/d)	p-value	Walking	p-value
Countries									
UK	291(19.6)	6(4)	0.23	105(120)	0.06	40(105)	0.02	50(60)	0.01*
Italy	250(16.9)	5(4)		120(165)		60(90)		60(60)	
Germany	279(18.8)	5(4)		120(154)		60(100)		60(90)	
Spain	315(21.3)	6(4)		130(200)		60(150)		60(60)	
USA	346(23.4)	6(4)		120(203)		60(154)		60(90)	
Gender									
Male	537(36.3)	6(4)	0.48	120(180)	0.13	60(110)	0.21	60(90)	0.53
Female	944(63.7)	6(4)		120(175)		60(105)		60(90)	
Age									
50-59	1102(74.4)	6(4)	0.14	120(180)	0.47	60(105)	0.83	60(90)	0.08
≥60	379(25.6)	6(4)		120(180)		60(110)		60(90)	
Relationship Status									
Single	335(22.6)	5(5)	0.14	120(165)	0.39	60(105)	0.29	60(90)	0.08
Not singe	1146(77.4)	6(4)		120(180)		60(105)		60(75)	
Working Status									
Working	1139(76.9)	6(4)	0.23	120(180)	0.12	60(110)	0.05	60(90)	0.92
Not working	342(23.1)	6(4)		130(178)		60(102)		60(79)	
Living arrangement									
Live alone	330(23.3)	6(4)	0.73	128(184)	0.10	60(130)	0.04*	60(90)	0.42
Live with someone	1151(77.7)	6(4)		120(180)		60(110)		60(90)	

Table4.1. (Continued)

	N(%)	Sitting Time(h/d)	p-value	Total PA (min/d)	p-value	MVPA (min/d)	p-value	Walking	p-value
Weight Status									
Underweight	16(1.1)	5(5)	0.70	140(245)	0.93	65(208)	0.57	60(55)	0.20
Normal weight	533(37.3)	6(4)		120(180)		60(100)		60(60)	
Overweight	570(38.5)	6(4)		120(180)		60(110)		60(90)	
Obese	342(23.1)	6(4)		120(180)		60(120)		60(90)	
Perceived Physical Activity level									
Very active	174(11.7)	4(3)	<0.001***	180(188)	<0.001***	120(180)	<0.001***	60(75)	<0.001***
Active	693(46.8)	5(5)		150(210)		80(145)		60(90)	
Somewhat active	458(30.9)	7(4)		180(210)		30(60)		60(46)	
Inactive	143(9.7)	8(4)		60(90)		10(45)		30(40)	
Very inactive	13(0.9)	8(7)		10(45)		0(0)		10(45)	

*p-value<0.05, **p-value<0.01, ***p-value<0.001

4.3.4 Moderate to Vigorous Physical Activity

The median time reported in MVPA was 60 (IQR=105) minutes/day for the sample as a whole. No significant differences in time in MVPA time were found across most the independent variables, with the exception of living arrangement. It was found that participants who reported living alone reported more time in MVPA than those living with someone (p<0.05). Difference were also found in the perceived physical activity level category (p<0.001), and the correlation of perceived PA level with time in MVPA was significant and moderate (p<0.01) (Table 3.2). Participants who rated themselves as more active also reported more time in MVPA.

Table 4.2. Spearman's Correlation coefficient of sitting, VPA, MPA and Walking time and behavioural variables

	Sitting	Total PA	MVPA	Walking
Country	<0.01	0.08**	0.12**	0.01
Gender	-0.02	0.04	0.03	0.01
Age	0.03	-0.02	<-0.01	-0.05
Marital Status	0.04	-0.02	-0.03	-0.05
Employment Status	0.03	0.04	0.05	<-0.01
Living arrangement	0.01	-0.04	-0.05*	-0.02
BMI	-0.01	<0.01	-0.05*	0.02
Perceived PA	0.34**	-0.40**	-0.41**	-0.23**
Sitting time	1.00	-0.28***	-0.20***	-0.25***

*p-value<0.05, **p-value<0.01, ***p-value<0.001

4.3.5 Walking

The studied participants reported spending a median time walking of 60 (IQR=90) minutes/day. No significant differences in walking time were found across most independent variables, with the exception of country of residence. German participants reported a significant higher amount of walking time than Italian, Spanish and the UK participants (p<0.01). Differences were also found in walking time across the perceived PA groups. The correlation of perceived PA level with walking time was significant but relatively small (Table 3.2).

4.4 Discussion

This study using the five-country data of sitting, physical activity and walking in adults aged 50 years and above to examine the potential correlates including geographic, demographics and physical activity level with sitting time. In addition, the current study also examines the correlates of physical activity. In general, physical activity is associated with sitting time, and perceived physical activity level is also associated with sitting time. However, no other correlate is identified, and evidence of significant correlations of the studied demographic variables with sitting and PA were limited in the current study

The finding of the medium 6 hours of sitting time per day in the current study reflects the existing evidence, which using self-report measurement found sedentary time ranged from 2.63 to 6.1 hours/day in mid-age and older adults(56-58). It also reflects the median 6 hours of sitting time per day found in Buaman et al.'s 20-country IPAQ study. In the current study, no significant difference of sitting time between countries was found. It is suggested in Buaman et al.'s study that reported sitting time could be related with economic development and possibly to climate effects. Thus the lack of differences of sitting time across countries could because the studied counties in the current study share similar economic status; they are all fully developed countries, and in general they have similar culture background: western culture. Furthermore, there is no significant association of demographics with sitting time found in the current study. The limited findings in correlates of sitting time in the present study partly reflect the results of the review by Rhodes et al. (93). It concluded that there is no strong evidence on whether sitting time correlates with age and employment status, and that no correlations were observed between sex and sitting time. Marital status has been found to be inversely and BMI found to be positively correlated with sitting time in population-based (n>8000) studies in adults aged 50 and above(51,143). The smaller sample size included in the present study may explain the differences in these findings. However, the present study did find correlations between sitting time and PA-related behaviours. The inverse correlation between PA and sitting time was consistent across all types of PA. Moreover, participants considering themselves as more active and those reporting more time in total PA/MVPA/Walking were more likely to report less sitting time. These findings reflect existing evidence on the associations between PA and sedentary behaviour (62,78,159).

The current study found a median total PA level (120 minutes/day) amongst the participants which is higher than the current physical activity guidelines. Within friction of difference on the details of physical activity guidelines across countries, the basic physical activity guidelines recommend that adults and older adults should "*150 minutes of moderate-intensity aerobic physical activity throughout the week or do at least 75 minutes of vigorous-intensity aerobic physical activity throughout the week or an equivalent combination of moderate- and vigorous-intensity activity*". This higher level of PA found in the current study could be as the result of the active participants, who rated themselves as very active, active and somehow active, reported the significant higher amount of MVPA time and walking time than those who rated themselves as inactive and very inactive. In fact, the current study found that the perceived PA level was also positively correlated with total PA, MVPA and walking. This shows the correlation of the perceived PA level with time spent in physical activity is promising. This suggests that perceived PA level could be a correlate which could primarily be used to indicate an individuals' physical activity level. Moreover, further study may consider using perceived PA level as a screening tool to identify those who are at high risk of prolonged sitting and low PA time.

In the current study, the only difference across countries is found in the walking time. German participants reported a significant higher amount of walking time than the Italian, Spanish and the UK participants. According to the physical activity factsheet(167-170) published by WHO, these four European countries all have a government published physical activity guidelines and also the promotion of physical activity are supported by the government policy and marginalized groups. In fact, prevalence of adults meeting physical activity guideline is higher in Spain and the UK (England, Scotland and North Ireland) within over 60% of prevalence of meeting physical activity guideline than the 31-39% found in the physical activity factsheet in Italy and German and UK (Wales). Bauman et al.'s 20-country study on physical activity using IPAQ also found the prevalence of adults meeting physical activity guideline is various between 57-93% across countries. Moreover, the data collection of the current study was conducted using online survey, and this could results the bias of participant's recruitment. Therefore, a concussion on geographic effect on walking time or physical activity cannot yet be draw based on the data of the current study.

On the other hand, the association between demographics with physical activity and walking is not significant in the current study. In comparison to the existing evidence, gender and age are the two most examined demographic and biological correlates of PA in adults, and they are found to have a consistent association with physical activity(92). However, evidence of the correlates and determinants of physical activity in older adults is insufficient (171), and findings of the associations of other demographic and biological variables with physical activity are mixed and vary from study to study(92).

Strength and limitation

The current study used the data collected from multiple countries and provided a unique overview of the correlates of sitting time of mid-age and older adults across countries. However, as one of the main limitations of the current study, the uneven weight of the sample across the variables studied could have affected the presence of any potential correlates with sitting time and all types of physical activity. Moreover, although the IPAQ is a reliable instrument to assess adults' physical activity, self-report questionnaires specifically designed for older adults and objective measurement may improve the assessment in this population. Furthermore, evidence suggests that the assessment of domain-specific sitting times improve the accuracy of self-reported sitting over single item measures, as sitting time has been significantly underestimated using a single-item specific-day question on weekdays and weekend days(87,88).

4.5 Conclusion

In conclusion, no biological or demographic correlates of sitting time and PA were observed in the present study within a sample of older adults. Perceived PA level was the only identified correlate of sitting, total PA, MVPA and walking. Time spent in all types of PA was inversely correlated with sitting time. Further research using improved instruments to assess physical activity and sitting time (for example, domain-specific sitting and/or objective measures) in mid-age and older adults is required to increase our understanding of sedentary behaviour and physical activity in this age group.

Chapter5

Correlates of Sedentary Behaviour II

A Workplace Data Analysis

Chapter 5

Correlates of Sedentary Behaviour II

This chapter uses data collected in UK offices to examine domain-specific sitting times on workdays and non-workdays in older office workers (aged 50 and above). The data analyses include one analysis of cross-sectional data and one 2-year longitudinal data. The differences in sitting in each domain on workdays and non-workdays are examined, along with correlations in domain-specific sitting across occupation-related demographic and health behaviour groups.

5 Correlates of Sedentary Behaviour in Mid-age and Older Adults Using a Survey Conducted in the Workplace

5.1 Introduction

Sedentary behaviour is currently defined as the cluster of behaviours in waking hours that involves low levels of energy expenditure (MET<1.5) such as sitting and lying (4). Although links between adverse health conditions and prolonged sitting have been reported, along with links between premature mortality and sedentary behaviour (103,172), the prevalence of sedentary behaviour is high across populations. According to the Health Survey for England, 2008, younger adults (aged 16-24) and mid-aged and older adults (aged 55 and above) reported the highest prevalence of sedentary time in comparison to all other age groups (10). It is also found that older age is correlated with more TV time (25,29,76). Studies using objectives measures have observed that older adults (age >65 years) are sedentary for an average of 9.4 hours a day (107).

Sitting at work is the main contributor of total daily sitting time in working adults, and sitting at work contributes to approximately 60% of total daily sitting time in UK samples (157,173). More sitting at work is associated with increased sitting time out of work (157). While the age of retirement is increasing and life expectance is getting longer, it is import to understand sedentary behaviour and its correlates in older workers if we are to inform effective intervention in the future. Results from the Australian cohort study conducted by Sodergren et al. revealed an inverse association between fruits and vegetable (F&V) intake and physical activity with prolonged sitting time in older adults aged 55-65 years(57). A Canadian study on the correlates of prolonged sitting in older adults aged 65 years and above, conducted by Dogra et al (33) have reported that age, retirement, dwelling type, chronic disease, perceived health, BMI, mood disorder, sense of belonging to community and lower physical activity level were associated with prolonged sitting time. Limited longitudinal research on sedentary behaviour levels and correlates currently exists however within UK populations. Therefore, the purpose of the current study was to (i) profile the sedentary behaviour using cross-sectional data and (ii) identify any consistent correlates of domain-specific sitting time using longitudinal data in a sample of older office workers.

5.2 Methods

5.2.1 Participants

The participants were invited to participate in an online survey conducted as part of the Stormont Study in September 2012 and September 2014. This is tracking a large cohort of employees within the Northern Ireland Civil Service (NICS, civil servants are public sector workers, employed within a UK national government department or agency). This study was originally designed to collect the data on psychosocial risk among civil servants in in the Northern Ireland so that could produce a wealth of data on psychosocial risk among civil servants(174). This includes staff of the 12 devolved Northern Ireland ministerial departments and the Public Prosecution Service for Northern Ireland. All NICS employees with an occupational email address (~26,000) were invited to participate in the survey. The current study included the subgroup of participants who were aged 50 and above and the results of one cross-sectional data analysis (Analysis 1) and a longitudinal data analysis (Analysis 2) were presented. Analysis 1 used both the 2012 and 2014 data from the participants who undertook either the 2012 or 2014 survey and provided valid data on sitting time and demographic variables. Analysis 2 included participants who were aged 50 years and above at the baseline assessment (2012) and provided valid data on sitting time and demographic variables at both baseline (2012) and follow-up (2014).

5.2.2 Measurement of sedentary behaviour

The Domain-Specific Sitting Time questionnaire was used to report the time participants usually spend sitting (hours/minutes) across 5-domains (travel, at work, watching television, using a computer at home, other leisure activities) on a typical workday and non-workday(87). This self-report tool provides a valid and reliable measure of total sitting time (87,88,175), and domain-specific sitting on workdays in adults, and is recommended for use in research examining links between sedentary time and health in working populations (87,175). Total daily sitting times on workdays and non-workdays were calculated for each participant by summing reported sitting times across the domains.

5.2.3 Basic and occupation-related demographic variables

Participants reported their sex, age, educational attainment, marital status, full-time or part-time work pattern, and salary band. Educational attainment was coded into four groups (school level, further education, university degree, or higher degree). Marital status was recoded into two groups (married/cohabiting and single/divorced/widowed). BMI was calculated from self-reported height and weight, participants were categorised as normal-weight (BMI <25 kg/m2), overweight (BMI 25–29.9 kg/m2) or obese (BMI ≥30 kg/m2)(176).

5.2.4 Health behaviour variables

Physical activity was assessed using a valid and reliable single-item measure of physical activity (177,178). This provided an assessment of physical activity against the 2004 physical activity guidelines for England(179). Participants reported the number of days they conducted at least 30-minutes of moderate-to-vigorous activity over the past week. Participants were classified as meeting the 2004 guidelines if they reported participating in at least 30-minutes of moderate-to-vigorous activity on 5 days or more (100). Participants were asked if they drink alcohol and smoked. Participants were also asked to report the number of portions of fruits and vegetables they ate daily. Participant who reported consuming at least 5 portions of fruit and vegetables daily were classified as meeting the National Health Service (NHS) fruits and vegetable (F&V) guidelines (180).

5.2.5 Data cleaning

Data cleaning was undertaken by the author, a value of zero minutes was inputted for no reported minutes spent sitting while travelling, TV viewing, computer use and/or other leisure activities if participants had left any domain blank, but reported sitting times in other domains. However, participants' data were excluded if (i) no data were provided for sitting time at work on workdays; (ii) there were missing data from more than two domains of sitting time on workdays; (iii) there were missing data from any independent variable; (iv) total sitting time was more than 1080 minutes/day. Time spent sitting for TV viewing and computer use at home were added up and categorised as home screen time. Time spent sitting whilst travelling, TV viewing, computer use, and other leisure activities were added up and categorised as sitting outside of work on workdays.

5.2.6 Statistical analyses

All analyses were conducted using IBM SPSS Statistics for Windows version 22. The Kolmogorov-Smirnov normality tests were performed before the analyses.

In Analysis 1, The Kolmogorov-Smirnov normality test showed non-normal distribution of sitting time data across the whole sample. Therefore, the median and interquartile ranges(IQR) of sitting times were reported throughout the results for descriptive purposes. For the sample as a whole, domain-specific daily sitting times were compared between workdays and non-workdays using a Wilcoxon Related-sample test. Mann Whitney U tests were used to compare total daily sitting times, and domain-specific sitting times across two groups. For example, when participants were grouped according to sex, age group (50-64 years versus ≥65 years), marital status (married/cohabiting versus single/divorced/widowed), dependent status (yes versus no), employment status (permanent versus temporary), work pattern (full-time versus part-time), and whether they reported drinking alcohol, smoked and met PA and fruit and vegetable guidelines. Kruskal-Wallis tests were performed to compare the differences in total daily sitting times, and domain-specific sitting across variables with at least three groups such as BMI-category (normal weight versus overweight versus obese), job grade (principal versus deputy principal versus staff officer versus executive officer versus administrative officer versus other), salary band (10001-15000 versus 15001-20000 versus 20001-25000 versus 25001-30000 versus 30001-35000 versus 350001-40000 versus ≥40001) and education level (no academic qualification versus GCSE versus A Level versus BA versus Higher degree). Bonferroni-corrected post hoc comparisons were undertaken in the event of a significant Kruskal-Wallis test result. To account for multiple domains of sitting included in each between-group comparison, the p value of 0.05 was divided by the number of tests performed for each variable of interest (e.g. a significant p value for the examination of BMI category was 0.017 (0.05/3, due to 3 comparisons, normal weight versus overweight, normal weight versus obese, overweight versus obese)). Spearman correlation coefficients were applied to examine the presence of any associations between domain-specific sitting on workdays and non-workdays.

In Analysis 2, total sitting time and sitting out of work on workdays at baseline and follow-up were normally distributed, parametric tests were applied to these two normally distributed domains of sitting times. Non-parametric tests were applied to the non-normally distributed domains of sitting times including sitting at work on non-workdays, sitting in transportation, home screen sitting and other leisure activities on workdays and non-workdays. Descriptive analyses were performed to examine the sample characteristics. The mean and standard deviation (SD) of the normally distributed variables and the median and interquartile range (IQR) of the non-normally distributed variables were reported throughout the results for descriptive purposes.

Paired t-tests were used to compare total daily sitting times on workdays, and sitting outside of work on workdays, between the 2012 and 2014 data. Wilcoxon tests were used to compare any differences of repeated-measured time spent sitting in transportation, at work, for home screen time and other leisure activities between baseline and follow-up assessments. Bivariate correlation coefficients (Pearson's and Spearman's) were used to identify the correlations between continuous variables (age and BMI) and scale variables (education, job grade and salary bands) with domain-specific sitting times at baseline and follow-up. Moreover, bivariate correlation coefficients were also used to examine the correlation of the baseline variables with follow-up domain-specific sitting times. Once the baseline correlate of sitting time at follow-up was identified, linear regressions were then performed to determine the extent to which there is a linear relationship between identified correlates with domain-specific sitting time.

5.3 Results

5.3.1 Analysis 1-The Cross-sectional Dataset

A total of 2942 (1722 from the 2012 survey and 1220 from the 2014 survey) office workers aged 50 and above provided valid workday sitting time data and 86.1% of this sample (n=2534) also provide valid sitting time data on non-workdays. 295 participants were excluded as a result of incomplete answers on the survey. The excluded data were obtained from participants who were slightly older (55.2 versus 54.7 years, p=0.47) and who had a significantly lower BMI (25.4 versus 27.6kg/m^2), $p<0.05$) than the compliant participants. Please see Table 5.1 for the characteristics of the included participants. In general, half of the participants were male, most participants were married (71.7 %), had a permeant job (98.8%), were working full-time (81.6%), and were aged between 50 and 64 years (98.6%).

Table 5.1. Characteristics of the studied participants (Analysis 1)

	Total	2012	2014
N	2942	1722	1220
Age, yrs (SD)	54.7(3.7)	54.9(3.7)	54.7(3.7)
Gender (% males)	50.9		
BMI, kg/m^2(SD)	27.6(4.7)	27.5(4.7)	27.8(4.7)
Weight status (%)			
Normal weight	29.4	30.8	27.5
Overweight	45.4	44.9	46.1
Obese	25.2	24.3	26.4
Marital Status (%)			
Married/Cohabiting	74.4	73.1	76.3
Single	25.6	26.9	23.7
Dependents (%)			
None	42.1	41.3	43.2
One or more	57.9	58.7	56.8
Highest Education level (%)			
No academic qualification	1.3	1.3	1.2
School level	29.0	28.0	30.5
Further education	31.7	31.4	32.2
University degree	13.8	13.9	13.5
Higher degree	24.2	25.4	22.5
Job Grade (%)			
Principal	20.3	13.5	30.0
Deputy Principal	11.5	19.7	0
Staff Officer	19.3	19.9	18.4
Executive Officer	29.0	28.9	29.1
Administrative Officer	18.0	16.8	19.8
Other	1.8	1.2	2.6
Salary Band (%)			
≤£20,000	11.4	11.5	11.4
£20,001-25,000	23.8	22.7	25.4
£25,001-30,000	21.9	22.4	21.1
£30,001-35,000	13.8	14.0	13.5
£35,001-40,000	15.4	15.5	15.3
≥£40,001	13.7	13.9	13.3
Employment Type (%)			
Permanent	98.8	98.8	98.9
Fixed term or contract/Casual/Temporary	1.2	1.2	1.2
Work Pattern (%)			
Full-time	81.6	82.1	80.8
Part-time/ Job-share/Term-time	18.4	17.9	19.2

Table 5.1. (Continued)

	Total	2012	2014
Meet Physical Activity Guidelines (%)			
Yes	1.9	2.0	1.7
No	98.1	98.0	98.3
Drink Alcohol (%)			
Yes	72.2	73.8	70.0
No	27.8	26.2	30.0
Current Smoker (%)			
Yes	10.7	11.0	10.3
No	89.3	89.0	89.7
Meet Fruit and Vegetable Intake Guidelines (%)			
Yes	50.3	52.5	47.3
No	49.7	47.5	52.7

5.3.1.1 Domain-Specific Sitting Time on a Work-day and Non-work-day

Table 5.2 describes the median time spent sitting in each domain on workdays and non-workdays for the sample as a whole, along with the correlations between sitting reported in each domain on workdays and non-workdays. The median total sitting time on workdays was 650 (IQR 210) minutes/day. On workdays, sitting at work accounted for 60% of total daily sitting time, followed by home screen time (23%), travelling (9%) and other leisure sitting (5%). On non-workdays, participants reported the highest percentage of sitting time in home screen time (38%), followed by leisure sitting (19%), travelling (10%) and sitting at work (<1%). Reported total daily sitting times were significantly higher on workdays in comparison to non-workdays ($p<0.001$). On workdays, participants reported sitting for significantly longer in the domains of travel and work in comparison to non-workdays ($p<0.001$). In contrast, on non-workdays participants reported sitting for longer under the domains of home screen time and other leisure activities when compared to workdays ($p<0.001$).Workday home screen time and total daily sitting time were moderately to highly correlated with non-workday home screen time and total daily sitting time, respectively (Table 5.2). Workday travelling was weakly correlated with non-workday travelling. Time spend sitting at work on workdays and non-workdays was not significantly correlated.

Table 5.3 presents the correlation of each domain of sitting time with total sitting time on workdays and non-workdays. On workdays, all domains of sitting time were correlated with total sitting time, especially home screen time, sitting out of work and sitting at work were highly associated with total sitting time. On non-workdays, the correlation between home screen time and total sitting time was the strongest. Sitting out of work on workdays was moderately correlated with total sitting time on non-workdays.

Table 5.2. Median (± IQR) and Correlation of total and domain-specific daily sitting times (minutes/day) reported on workdays and non-workdays

	Travel	**Work**	**Home Screen**	**Other leisure**	**Out of work**	**Total sitting**
Work-day (N=2942)	60±80*	390±110*	150±120	30±60	270±175	650±210*
Non-work-day (N=2534)	60±50	0±120	240±150*	120±90*	-	630±750
Spearman correlation coefficient between work-day and non-work-day (r)	**0.07**	0.02	**0.52**	**0.35**	-	**0.66**

*significant differences, p<0.01; **Boldface**: significant correlation coefficient, p<0.01

Table 5.3 Spearman's correlation coefficient between total sitting time and other sitting activities on workdays and non-workdays

	Workdays					Non-Workdays			
Total Sitting	Travel	Work	Home Screen	Other leisure	Out of work	Travel	Work	Home Screen	Other leisure
Workdays	**0.25**	**0.53**	**0.66**	**0.37**	**0.78**	**0.09**	0.03	**0.36**	**0.16**
Non-Workdays	**0.07**	**0.07**	**0.35**	**0.21**	**0.38**	**0.23**	**0.30**	**0.45**	**0.32**

Boldface: significant correlation coefficient, p<0.01

5.3.1.2 Sitting Time across Demographic and Socio-demographic groups

Table 4 shows the median domain-specific sitting times reported on workdays and non-workdays according to demographic group. Generally, there were no significant differences in reported sitting times between the two age groups (p>0.05). There were no significant differences in total daily sitting times between males and females on workdays (p>0.05), however, males reported significantly longer daily sitting times on non-workdays (p<0.01). Males also reported longer times spent sitting in the domains of home screen time on both workdays and non-workdays (p<0.001), and traveling (p<0.001) and leisure activities (p=0.01) on workdays. Females reported sitting for significantly longer at work than males (p<0.001) on workdays.

No significant differences were found in total daily sitting times between married and single participants, although married participants reported significantly longer sitting times in transportation on workdays (p<0.01), and single participants reported longer leisure time sitting on non-workdays(p<0.01). Participants with no dependents reported significantly higher total daily sitting times and home screen time on workdays and non-workdays than those with dependents (p<0.01). Moreover, on non-workdays, participants with no dependents also reported higher sitting times in other leisure activities (p<0.01). Longer sitting times in transportation were reported by participants with dependents on workdays (p<0.01).

On workdays, participants with the lowest level of education reported the lowest total daily sitting times, along with lower levels of sitting at work and sitting for travel than those with higher education levels (p<0.01). On non-workdays, participants with both the highest and lowest education levels reported less total daily sitting times than the other educational attainment groups (p<0.01) The effect of education level on sitting time was not consistent

5.3.1.3 Sitting Time across Occupation-related Demographic Variables

Table 5 shows the median domain-specific sitting times across occupational-related demographic groups on workdays and non-workdays. On workdays, participants with a 'principle job' reported significantly higher sitting times whilst travelling and at work. Total daily sitting times were also significantly higher in this group, compared to office workers with job grades as 'deputy principal', 'staff officer', 'executive officer', 'administrative officer' or 'other' job grade. Those with a job grade in a principle position, also reported significantly higher sitting times during other leisure activities, and had significantly higher total daily sitting times than office workers in the other job grades. On non-workdays, participants with job grade 'administrative officer' reported significantly more time sitting at work than office workers in the other job grades. On workdays, there were no significant differences in total daily sitting times when participants were grouped according to salary band. Participants with an annual salary between £25k to 30k reported significantly less time sitting at work on workdays, in comparison to all other salary band groups (p<0.001). Participants with an annual income below £25k reported significantly less sitting time in transportation in comparison to those individuals earning above £25k annually (p<0.001). Domain-specific sitting times did not vary significantly between permanently and temporarily employed participants. No significant difference was found in total sitting time between full-time workers and part-time workers.

Table 5.4. Mean (± SD) total and domain-specific daily sitting times (minutes±day) reported on workdays and non-workdays according to *basic demographic variables*

	Workday domain specific sitting and total sitting (mins±day)							Non-workday domain specific sitting and total sitting (mins±day)					
	N	Travel	Work	Home Screen	Other leisure	Out of work	Total sitting	n	Travel	Work	Home Screen	Other leisure	Total sitting
Age Group													
50-64	2901	79±56	368±112	158±109	45±56	282±138	649±173	2501	61±52	77±110	237±121	109±85	783±485
65+	41	97±66	344±104	163±148	77±100	336±197	680±187	33	82±64	77±126	253±144	134±127	851±478
Gender													
Male	1498	83±57	354±116	167±108a	48±58a	298±140a	652±177	1276	62±54	81±120	254±125a	107±86	812±496a
Female	1444	75±55	381±106a	148±112	43±55	266±136	648±169	1258	60±50	74±100	222±116	112±85	755±473
BMI Categories													
Normal Weight	866	75±52	371±107	144±106c	43±54	262±132	633±169	773	62±49	73±101	217±113c	108±81	727±453
Overweight	1336	79±58	362±113	160±109	47±57	285±140	648±173	1147	62±52	76±111	237±121	110±90	790±491b
Obese	740	82±56	371±113	172±144	47±59	301±144a	672±177a	614	59±56	86±122	264±129	109±83	842±507b
Marital Status													
Married/Cohabiting	2190	80±56a	367±111	157±108	44±55	282±138	648±174	1893	61±51	77±109	235±119	106±82	788±490
Single/divorced	752	75±56	369±113	161±116	49±60	285±142	654±172	641	62±55	78±116	244±130	120±95a	771±469
Dependents													
Yes	1704	81±56a	365±111	152±107	44±54	278±138	643±173	1479	61±51	75±106	229±119	104±84	758±478
No	1238	76±55	370±112	166±114a	47±60	289±141a	659±173a	1055	61±53	81±117	250±125a	116±87a	820±493a
Education													
No academic qualification	37	51±40c	308±144c	129±87	54±66	234±131	541±206c	25	74±67	77±99	213±179	103±77	681±452
GCSE	854	72±53	373±110	166±119	45±59	283±152	656±176	717	61±53	86±110	245±132	109±84	815±502
A Level	934	81±55	358±118	157±111	46±57	284±142	642±181	789	62±54	79±112	234±119	106±82	790±502
BA	405	78±52	372±98	152±99	47±54	277±123	649±193	363	58±47	76±116	248±115	117±94	785±447
Higher degree	712	82±61	373±110	156±105	44±54	286±128	659±163	640	61±51	67±106	228±113	110±86	742±465

a sitting times were significantly higher than the remaining group(s) within each category; b In the category with more than two categories, sitting times were significantly than the remaining group(s); c sitting times were significantly less than the remaining group(s) within each category

Table 5.5. Mean (± SD) total and domain-specific daily sitting times (minutes/day) reported on workdays and non-workdays according to *occupation-related demographic variables*

	Workday domain specific sitting and total sitting (mins/day)							Non-workday domain specific sitting and total sitting (mins/day)					
	N	Travel	Work	Home Screen	Other leisure	Out of work	Total sitting	n	Travel	Work	Home Screen	Other leisure	Total sitting
Job Grade													
Principal	598	86±55a	390±93a	150±92	44±48	281±120	670±143a	544	60±40	0±120	240±131	120±120a	960±840a
Deputy Principal	339	86±55	370±104	155±105	44±53	286±131	656±171	305	60±30	0±120	240±150	120±120	450±275
Staff Officer	568	85±58	382±96	158±109	42±54	285±131	667±156	497	60±30	0±120	240±130	120±83	600±700
Executive Officer	853	77±56	343±129	161±117	46±57	284±149	627±191	724	60±60	0±150	240±150	120±105	650±750
Administrative Officer	531	62±51	373±107	163±118	50±64	275±150	647±183	423	60±70	60±180a	220±160	120±90	720±800
Other	53	89±64	273±131	162±132	57±86	308±181	580±225	41	60±90	60±165	240±135	120±120	960±885
Salary Band													
10k01-15k	94	59±41	349±102	164±103	47±61	270±132	618±168	77	60±68	50±120a	210±143	120±120	745±795
15k01-20k	242	68±54	357±117	159±120	57±72	281±162	638±195	202	60±70	0±180	240±180	120±60	645±718
20k01-25k	701	68±54	366±117	163±121	46±58	277±152	643±184	571	60±60	0±180	240±150	120±120	680±810
25k01-30k	643	85±61a	347±127c	158±113	45±57	288±141	635±183	556	60±60	0±150	240±150	90±90	600±703
30k01-35k	406	86±53a	379±92	162±109	43±57	291±133	670±163	356	60±30	0±120	240±128	120±90	610±745
35k01-40k	454	85±54a	378±101	156±100	43±60	284±124	662±160	401	60±30	0±120	150±120	120±120	680±720
40k01+	403	87±55a	387±90	147±90	45±49	278±119	665±145	371	60±50	0±120	240±150	120±120	780±750
Employment Type													
Permanent	2908	80±60	369±111	152±108	42±52	274±135	643±170	2507	61±52	77±110	237±122	109±85	783±484
Fixed term/ Temporary	34	83±60	353±94	143±96	46±47	272±113	626±149	27	40±27	97±129	256±110	124±83	816±586
Work Pattern													
Full-time	2400	81±56	368±114	158±109	46±56	284±139	652±173	2062	61±53	78±112	238±123	109±86	781±485
Part-time	542	70±53	363±101	160±115	45±57	275±141	638±174	472	60±48	73±102	237±116	110±82	795±489

a sitting times were significantly higher than the remaining group(s) within each category

5.3.1.4 Sitting Time across Health and Behaviour Variables

Table 5.6 shows the median domain-specific sitting times across health and behaviour variables on workdays and non-workdays. Obese participants reported significantly higher total daily sitting times on workdays in comparison to normal weight and overweight individuals ($p<0.001$). Obese and overweight participants reported higher total daily sitting times on non-workdays in comparison to normal weight participants ($p<0.001$). Normal weight participants also reported less home screen time sitting on workdays and non-workdays in comparison to overweight and obese participants($p<0.001$). Participants in the obese category reported longer sitting times out of work on workdays than overweight and normal weight participants ($p<0.001$).

Participants who reported not meeting PA guidelines reported significantly higher total daily sitting times, higher levels of sitting at work on workdays, and higher home screen time on non-workdays than those who reported meeting the PA guidelines ($p<0.05$). However, individuals who met the PA guidelines reported longer sitting times in transportation on workdays and longer sitting time in other leisure activity on non-workdays in comparison to those who did not meet PA guidelines ($p<0.05$).

Participants who reported drinking alcohol reported significantly higher total daily sitting times and home screen time on workdays than those reporting not drinking alcohol ($p<0.05$). No other significant differences were observed regarding domain-specific sitting between alcohol drinkers and non-drinkers. Total daily sitting time did not differ significantly between smokers and non-smokers on workdays and non-workdays. However, smokers reported significantly higher sitting times than non-smokers during screen time ($p<0.001$) on workdays and non-workdays. Participants who did not meet the fruit and vegetable intake guidelines reported significantly higher home screen time on workdays and non-workdays, and higher sitting times in other leisure activity on non-workdays than those meeting the fruit and vegetable intake guidelines.

Table 5.6. Mean (± SD) total and domain-specific daily sitting times (minutes/day) reported on workdays and non-workdays according to *health and behaviour variables*

	Workday domain specific sitting and total sitting (mins/day)							on-workday domain specific sitting and total sitting (mins/day)					
	N	Travel	Work	Home Screen	Other leisure	Out of work	Total sitting	n	Travel	Work	Home Screen	Other leisure	Total sitting
BMI Categories													
Normal Weight	866	75±52	371±107	144±106c	43±54	262±132	633±169	773	62±49	73±101	217±113c	108±81	727±453
Overweight	1336	79±58	362±113	160±109	47±57	285±140	648±173	1147	62±52	76±111	237±121	110±90	790±491b
Obese	740	82±56	371±113	172±144	47±59	301±144a	672±177a	614	59±56	86±122	264±129	109±83	842±507b
Meet PA Guideline													
Yes	56	90±48a	318±126	157±111	47±48	294±135	612±193	45	73±55	101±127	223±123	124±108a	778±494
No	2886	79±56	368±111a	158±110	46±57	282±139	651±173a	2489	61±52	77±110	238±122a	109±85	784±485
Alcohol Drinking													
Yes	2124	79±55	269±109	161±110a	45±55	285±137	654±169a	1819	61±52	75±110	242±119	111±85	781±487
No	818	79±59	363±118	150±111	46±60	275±144	638±182	715	60±51	83±112	226±129	104±85	791±482
Smoking													
Yes	315	78±60	374±112	169±113a	42±53	289±147	663±179	263	60±66	89±123	259±118a	108±91	821±520
No	2627	79±55	367±112	157±110	46±57	282±139	648±173	2271	61±50	76±109	235±122	109±85	779±481
Meet F&V Guideline													
Yes	1481	79±55	367±111	150±109	46±56	275±139	642±173	1287	60±50	76±107	225±116	109±85	746±470
No	1461	78±7	368±112	167±110a	45±57	290±139a	658±173a	1247	62±54	79±115	251±126a	109±85	823±497

[a] sitting times were significantly higher than the remaining group(s) within each category

5.3.2 Analysis 2-The longitudinal Dataset

A total of 233 office workers who were aged 50 years and above and provided valid sitting time data at both baseline (2012) and follow-up (2014) and were included in Analysis 2. 198 out of 233 (85%) participants provided complete longitudinal data. Some missing follow-up data were seen within the descriptive variables as follows: dependent status (n=7), drinking alcohol (n=7), smoking status (n=7), meeting PA guidelines (n=5), meeting fruit and vegetable guidelines (n=5), salary (n=4) and BMI (n=4).

The characteristic of the 233 participants are presented in Table 5.7. In brief, the median age of the sample was 53.0 years. More than half of the sample were female (55.4%) and had a higher than high school education (79.9%). Participants were more likely to be overweight or obese, married or cohabiting. Forty percent of the participants had a 'principal' job grade, worked full time and all of them had a permanent job contract. The percentage of participants was evenly spread across salary bands. Less than 30% of participants met the 2004 PA guidelines; more than half of them met the fruit and vegetable guidelines. Most participants reported drinking alcohol and were non-smokers. The significant differences of sample characteristics of follow-up from the baseline were found in: salary band, work pattern and meeting PA guidelines.

Table 5.7. Characteristics of the studied participants (Analysis 2)

	Baseline	Follow-up	p-Value
Female (N)	129	129	1.00
Marital Status (%)			
Married/Cohabiting	75.2	60.7	0.48
Single/divorce/widow	24.8	39.3	
Dependents (%)			
One or more	60.7	53.6	**0.02**
None	39.3	46.4	
Employment Type (%)			
Permanent	100	99.6	0.37
Fixed term or contract/Casual/Temporary	0	0.4	
Job Grade (%)			
Principal	40.8	42.1	0.31
Staff Officer	22.7	21.0	
Executive Officer	25.8	24.0	
Administrative Officer	9.4	9.4	
Other	1.3	3.4	
Salary Band (%)			
≤£20,000	6.9	6.1	**<0.01**
£20,001-25,000	19.7	21.0	
£25,001-30,000	23.6	15.3	
£30,001-35,000	15.9	21.8	
£35,001-40,000	19.7	19.2	
≥£40,001	14.2	16.6	
Work Pattern (%)			
Full-time	82.5	77.1	**0.02**
Part-time/ Job-share/Term-time	17.5	22.5	
BMI, kg/m^2(Median±IQR)	26.5±5.3	26.5±5.3	0.44
BMI-category (%) (4 missing)			
Normal weight	32.1	31.3	0.52
Overweight	45.7	44.8	
Obese	22.2	23.9	
Meet Physical Activity Guidelines (%)			
Yes	20.2	28.9	**<0.01**
No	79.8	71.1	
Drinks Alcohol (%)			
Yes	77.4	77.9	0.83
No	22.6	22.1	
Current Smoker (%)			
Yes	6.8	6.6	0.56
No	93.2	93.4	
Meet Fruit and Vegetable Intake Guidelines (%)			
Yes	56.0	56.1	1.00
No	44.0	43.9	

Boldface: p<0.05 (significant difference between baseline and follow-up assessment)

5.3.2.1 Domain-specific sitting time between baseline and follow-up (Observed changes in Sitting time)

On workdays, the mean reported total daily sitting time rose slightly from 639 mins/day to 645 mins/day at follow-up, but the change was not significant. In fact, most of the domain-specific sitting times on workdays did not change significantly from baseline to follow-up, with the exception of sitting in transportation which rose at follow-up (Table 5.8). However, on non-workdays, most domain-specific sitting times rose significantly at follow-up. The mean reported total daily sitting time was 420 mins/day at baseline, this rose to 480 mins/day at follow-up ($p<0.05$). Significant increases in non-workday sitting times at follow-up were found in the domains of transportation, at work and other leisure activities. Home screen time was the only domain that did not change significantly on non-workdays (Table 5.8).

Table 5.8. Domain-Specific Sitting Time at Baseline (2012) and Follow-up (2014)

Workdays			
	Baseline	Follow-up	p-Value
Travel (Median±IQR)	60±90	60±80	**0.01**
Work (Median±IQR)	420±90	390±90	0.99
Home Screen (Median±IQR)	120±120	135±138	0.90
Other leisure (Median±IQR)	15±60	20±60	0.30
Total sitting (Mean±SD)	639±155	645±167	0.62
Out of work ((Mean±SD)	248±130	259±133	0.26
Non-workdays			
	Baseline	Follow-up	p-Value
Travel (Median±IQR)	45±30	60±60	**0.04**
Work (Median±IQR)	0±120	0±150	**0.04**
Home Screen (Median±IQR)	240±149	240±120	0.21
Other leisure (Median±IQR)	120±150	120±120	**0.04**
Total sitting (Median±IQR)	420±284	480±290	**0.01**

Boldface: $p<0.05$ (significant difference between baseline and follow-up assessment)

5.3.2.2 Correlates of Domain-specific Sitting Time

The correlations between the identified correlates ($p<0.05$) with domain-specific sitting time at baseline are presented in Table 5.9. In general, the associations were weak (r=0.13-0.23) and thirteen (eleven) correlates were identified. Being male was associated with more home screen time. Participants with no dependents were positively associated with sitting time in other leisure activity and total sitting time. Occupation-related correlates including grade, salary and work pattern showed the greatest associations with domain-specific sitting time. On workdays, job grade was positively associated with total sitting time, out of work sitting time and more sitting time in travel, work, and other leisure activities. Job grade was also positively associated with home screen time. Meanwhile, salary was positively associated with total sitting time, out of work sitting time and sitting in travel on workdays, and home screen time on non-workdays. Working full time was positively associated with sitting time in travel. BMI was only associated with sitting time on non-working days. It was inversely associated with sitting time in travel, and positively associated with total sitting time and home screen time. Currently drinking alcohol was positively associated with home screen time and sitting for other leisure activities on non-workdays. Not meeting PA guidelines was positively associated with sitting time in travel on workdays. However, it was also found that meeting PA guidelines was positively associated with home screen time and sitting out of work. Similar results were found with the association between the number of days participating in PA with sitting time. The number of days with at least 30 minutes of MVPA were negatively associated with sitting in travel on workdays and sitting at work, but positively associated with home screen time.

Table 5.9. Identified Correlates of Domain-Specific Sitting Time on Workdays and Non-workdays at Baseline (2012)

	Work-days						**Non-workdays**				
	Travel	Work	Home Screen	Other Leisure	Total Sitting	Out of Work	Travel	Work	Home Screen	Other Leisure	Total Sitting
Gender[G]			0.14*						0.22**		
Dependent[D]										0.17*	0.14*
Education				-0.15*							
Grade	0.22*	0.15*		0.14*	0.24***	0.19**			0.15*		
Salary	0.23***				0.22**	0.17**			0.16*		
Work Patten[W]	0.14*										
BMI							-0.15*		0.21**		0.15*
BMI Group							-0.13*		0.18**		0.16*
Drinking[Dk]									0.14*	0.15*	
Meet PA Guidelines[G]	0.15**		-0.19**			0.15*					
PA days	-0.2**		0.18**			-0.16*					

Note: *p<0.05, **p<0.01, p<0.001; [G]: Positive association: Male had more sitting time; [D]: Positive association: Participant without dependent had more sitting time; [W]: Positive association: participant with full-time job had more sitting time; [Dk]: Positive association: Participant who drank alcohol had more sitting time; [G]: Positive association: Participants did not meet guidelines had more sitting time

The correlations between the identified correlates (p<0.05) with domain-specific sitting time at follow-up are presented in Table 5.10. Overall, the associations were weak (r=0.13-0.20) and eight (seven) correlates were identified. Being male was associated with more home screen time on non-workdays. Education level was inversely associated with sitting in travel on non-workdays. Job grade was positively associated with sitting in travel and at work on workdays. Salary and working full time was positively associated with sitting in travel on workdays. BMI was also positively associated with home screen time and total sitting time on workdays and non-workdays. BMI was also positively associated with out of work sitting time on workdays. Not meeting F&V guidelines was positively associated with sitting time in travel.

The correlations of variables at baseline with the domain-specific sitting time at follow-up were weak (r=0.13-0.23) and eight correlates were identified. Participants who were married at baseline were found to report more sitting time at work on non-workdays at follow-up (r=-0.13, p<0.05). Higher education level at baseline was inversely associated with sitting in travel on non-workdays at follow-up (-0.14, p=0.04). Higher job grade (r=0.23, p<0.001) and salary (r=0.21, p=0.001) at baseline was positively associated with higher sitting time in travel on workdays at follow-up. Higher BMI at baseline was positively associated with home screen time (r=0.14, p<0.05) on workdays at follow-up. Participants who reported drinking alcohol at baseline were positively associated with total sitting time (r=0.13, p<0.05) and sitting for other leisure activities (r=0.18, p<0.01) on non-workdays at follow-up. Not meeting F&V guidelines at baseline was positively associated with screen time on non-workdays at follow-up (r=0.16, p<0.05).

The results from linear regressions showed only job grade (F=9.4), salary (F=9.4), drinking alcohol (f=6.6) and meeting F&V guidelines (F=7.6) could potentially predict the domain-specific sitting time at follow-up (p<0.01). Job grade and salary accounted for 3.9% and 2.5% respectively of the variation in sitting time in travel on workdays. Drinking alcohol accounted for 2.8% of the variation in time spent sitting for other leisure activities on non-workdays. Meeting F&V guidelines accounted for 3.2% of home screen time on non-workdays.

Table 5.10. Identified Correlates of Domain-Specific Sitting Time on Workday and Non-work Day at Follow-up (2014)

	Work-days						**Non-workdays**				
	Travel	Work	Home Screen	Other Leisure	Total Sitting	Out of Work	Travel	Work	Home Screen	Other Leisure	Total Sitting
Gender[G]									0.15*		
Education							-0.14*				
Grade	0.19**	0.13*									
Salary	0.20**										
Work Patten[W]	0.15*										
BMI			0.21**		0.15*	0.14*			0.21**		0.14*
BMI Group			0.17**		0.14*				0.19**		
Meet F&V Guidelines[G]							0.15*				

Note: *p<0.05, **p<0.01, p<0.001; [G]: Positive association: Male had more sitting time; [W]: Positive association: participant with full-time job had more sitting time; [G]: Positive association: Participants did not meet guidelines had more sitting time

5.3.2.3 Changes in domain-specific sitting time across participant groups (factors associated with changes in sitting time)

Table 5.11 presents the mean/median change in domain-specific sitting time from baseline to follow-up. It shows that on workdays increased sitting times were observed in the domain of travel and other leisure activity, but decreased sitting times were reported in the domain of work and home screen time. Overall, participants in general reported increases in time spent sitting out of work, with total daily sitting time outside work increasing at follow-up. On average the participants reported higher sitting times in every domain on non-workdays in 2014. Differences of changes in sitting time were found across sex, dependent status, marital status and meeting PA guidelines. Mean (±SD) change in total sitting time on non-workdays was found for sex. Males reported a greater increase in total sitting time than females (mean±SD 70±262 min/day verses 35±192 min/day). Participants who had dependents also reported a greater increase in sitting time on non-workdays than those who had no dependents, significant differences were found in the domains of home screen time (mean±SD 25±141 min/day verses -10±91 min/day, p=0.04), leisure activity (22±106 min/day verses 0±101 min/day, p=0.04), and total sitting on non-workdays (mean±SD 74±237 min/day verses 15±203 min/day). Married participants reported a greater increase in sitting time in transportation on workdays than those who were single/widow/divorced (mean±SD 10±46 min/day verses -2±46 min/day, p=0.02). Participants who did not meet PA guidelines reported a greater increase in sitting in home screen time on workdays than those who met PA guidelines (mean±SD 16±134 min/day verses 10±121 min/day, p=0.002).

Table 5.11. Change of domain-specific sitting time (Mean±SD)

	Workdays	Non-workdays
Travel	7±46	8±61
Work	-5±97	19±131
Home Screen	-2±121	11±125
Other Leisure	5±57	13±104
Total	6±179	51±226
Out Work	11±150	N/A

Non-parametric tests were conducted for not-normally distributed data, the mean and SD are reported for descriptive purposes as the median values were zero.

5.4 Discussion

The purpose of this study was to examine domain-specific sitting times across demographic variables and to identify any correlates of sitting time in older office workers in Northern Ireland in the UK. The accumulated volume of sitting time is high in the older office workers in this age group on both workdays and non-workdays (10.8 hours/day). The studied individuals reported significantly longer sitting times on workdays than non-workdays, with the main contributors of sitting being sitting at work on workdays, and leisure-time and screen time on non-workdays. It was also observed that participants who reported longer sitting times on workdays were more likely to report longer sitting times on non-workdays.

The cross-sectional data shows a high volume of sitting time on workdays (10.8 hour/day), which reflects the existing evidence that sitting times are generally higher in adults with full time office jobs (181). The present study also shows that the majority of sitting time on workdays was spent sitting at work which is less likely to be a voluntary choice. However, the high volume of non-workday sitting (11.5 hours/day) shows that these older office workers reduce their sitting time on non-workdays to compensate the prolong sitting time on workdays Older office workers who spent more time sitting out of work on workdays also reported more sitting time on non-workdays. This high volume of total sitting time and home screen time found in the current study reflects the findings on the prevalence of sedentary behaviour in mid-age adults from the literature. Existing studies show that adults aged 52 to 58 years accumulate over 60% of their day in sedentary behaviour, using objective measures (51,62). Evidence from the Scottish Health Survey found that older adults (aged 64.9 years) reported an average of 4 hours of screen time per day (29).
In older office workers, the present study found no association between sitting at work and sitting outside of work. Time reported sitting outside of work was in fact more strongly associated with total daily sitting time in this sample. This suggests that despite the observation that sitting at work contributes a significant portion of daily sitting time, reducing the time spent sitting outside of work is equally important in older office workers. Moreover, as working hours are less likely to be changeable, interventions for reducing sitting time among older office workers could focus on increasing the numbers of breaks in sitting at work and reducing the amount of time older office workers spend sitting outside work.

The results from the cross-sectional data also showed that reported screen times are generally higher in males, younger-aged older office workers, obese individuals, those who were not married and those not meeting PA guidelines. These results are similar to the findings in the longitudinal data set. But in general, basic-demographics and health and behaviour correlates showed limited associations with sitting time in the present study. The consistent correlations found were for males who reported higher home screen times on non-workdays, and positive associations between BMI and home screen time and total sitting time on non-workdays. The present findings support existing evidence showing positive associations between TV viewing and BMI(46,50). The findings of the regression analyses were non-significant however, implying that BMI is a weak predictor of screen time in mid-age and older adults.

The current study also found that older office workers who did not meet the PA guidelines were more likely to report higher total sitting times on workdays in the cross-sectional data analysis. This finding is similar to the existing evidence showing inverse associations between physical activity and self-reported sitting time in mid-age and older adults (120,122). However, the inverse association observed in the present study was only found in the baseline assessment within the longitudinal data analysis, this association was not present at follow-up. This could be due to the fact that physical activity was measured by asking how many days a week the participant had undertaken MVPA instead of using a detailed self-report questionnaire. Moreover, more studies using longitudinal methods are required to determine the correlates and determinants of domain-specific sitting time.

The differences in domain-specific sitting times across occupational demographic groups were limited in the cross-sectional data. However, consistent correlations between job grade and salary and domain-specific sitting times were observed in the longitudinal data. Participants with higher job grades and salaries were more likely to report higher sitting times in travel and sitting at work on workdays. Interventions promoting active transportation and breaking up sitting time at work could be appropriate to target those with higher job grades and salaries.

Some of the findings from the current study did not show consistent results when compared to the existing evidence. For example, a cross-sectional study conducted by van Uffelen et al. (143) in mid-aged women found full-time work and higher education levels were positively correlated with sitting time. However, the current study did not find differences in domain-specific sitting times between full-time and part-time office workers. Differences between the studies may explain these differences in findings. Van Uffelen et al. measured total daily sitting time, as opposed to domain-specific sitting, and recruited women only. Another study conducted by Proper et al. (182) in older adults found paid work, education, income and SES level were correlated with higher total daily sitting times, and longer sitting times during computer use and TV viewing. However, these correlates were not significantly associated with domain-specific sitting in the current study. An explanation for these differences in findings could be due to the fact that the present study recruited office workers only, whereas a range of occupational groups were included in the study of Proper et al.

In addition to identifying the correlates of domain-specific sitting time, the current study also found that the studied office workers reported increasing levels of sitting time, most notably on non-workdays in 2014. Comparing domain-specific sitting times at baseline and follow-up, time reported sitting on workdays remained consistent between surveys, with participants reporting a slightly greater (non-significant) total daily sitting time of 6 minutes/day in 2014. Unlike workdays however, most domain-specific sitting times on non-workdays rose significantly in 2014, including total daily sitting time, sitting in transportation, sitting at work and sitting for leisure activities. The rising levels of leisure time sitting seen in the current sample could be detrimental to public health, if such trends are seen in other samples. Rezende et al. (2015) has reviewed the evidence on the relationship between sedentary behaviour and health outcomes in older adults. The Rezende review concludes that sedentary behaviour is associated with mortality in older adults, and also reports links between sedentary behaviour and deleterious health. The increases in leisure time sitting seen in the present sample between 2012 and 2014 highlight the need for interventions targeting reductions in sitting time, outside the workplace, in older adults.

Strengths and Limitations

The current study provides novel information on the descriptive epidemiology of domain-specific sitting times in older office workers. Strength of the study is the relatively large sample size. However, the typical retirement age of 65 in the UK reduces the number of office worker participating in this study who were over 65 years. As a result, the comparison of sitting times reported between the two age groups (50-64 vs 65) was limited. Further research is required to examine sedentary behaviour levels and correlates in older adults. As the participants in the current sample are restricted to office workers, the findings cannot be generalised to older adults who are either not in employment, or employed within other occupational sectors.

Whilst the cross-sectional data analyses (Analysis 1) provides the evidence on the association of sitting time with demographics and behaviour correlates base on the evidence from a large sample, the cross-sectional design prevents a conclusion on the causality. This limitation then was enhancing by the longitudinal data analyses (Analysis 2). The 2-year longitudinal data with both surveys conducted at the same time of the year (September 2012 and 2014), thus eliminating potential biases associated with seasonal changes in behaviours. It also provides novel evidence on the consistency of domain-specific sitting times on workdays. However, according to the ecologic model proposed by Owen et al.(95), the studied correlates in the current study only included intrapersonal factors, and there are also some other correlates including psychological health, physical health and the environment which should be considered as factors which could be correlated with sedentary behaviour.

Moreover, whilst subjective measures of sedentary behaviour provide an efficient approach of assessing sedentary behaviour in large samples, and the domain-specific sitting time questionnaire is a valid and reliable measure of total daily sitting time and domain-specific sitting(87), the validity coefficients are lower for this measure on non-workdays. Future research applying objective measurement to assess sitting time could help overcome the limitation of self-report measurements (85), and enhance the validity of the sedentary behaviour assessment.

5.5 Conclusion

The current study used both cross-sectional and longitudinal datasets with reasonable sample size which identified that gender, BMI, salary and job grade were consistent correlates of domain-specific sitting time. It is also found that older office workers had high volumes of total daily sitting time and high sitting times in the domains of work and home screen time. Furthermore, those who spent more time sitting at work on workdays did not necessarily compensate by reducing their sitting times outside of work on workdays. Further study using longitudinal designs and objective measures of sitting time are required to strengthen the findings. Moreover, a wide range of correlates such as physical health, mental health and the environment should also be assessed.

Chapter 6

Correlates of Sedentary Behaviour III
A Longitudinal Study

Chapter 6

Correlates of Sedentary Behaviour lll

This chapter presents a 6-month longitudinal study, conducted among community-dwelling older adults. Both self-report and accelerometer measurements were used to assess sedentary behaviour. Potential correlates including demographics, physical health, psychological health and physical activity are assessed by questionnaire to examine their association with sedentary behaviour.

6 Correlates of Sedentary Behaviour in Older Adults in the UK: A Longitudinal Study

6.1 Introduction

Sedentary behaviour (SB) is currently defined as the cluster of behaviours during waking hours that involves low levels of energy expenditure (MET<1.5) such as sitting and lying(4). Sedentary behaviour is positively correlated with deleterious health outcomes, such as metabolic disease (23,183) cardiovascular disease (31), obesity (75) and risk of mortality (140). The prevalence of sedentary behaviour is high, especially in older adults aged over 65 years (10). It is also found that older adults spend at least 60% of their waking time being sedentary(51) and the average daily sedentary time of older adults ranges from 8-11 hours(65,67,69). Therefore, the importance of studying sedentary behaviour in older adults is clear. It is suggested that identifying the correlates of sedentary behaviour is a priority in order to inform interventions to reduce sedentary behaviour (95).

According to the systematic review conducted by Rhodes et al. (93) on sedentary behaviour of adults, demographics, social factors and health behaviours are the three domains of correlates which have been assessed in adults' sedentary behaviour research. Existing evidence shows gender (65,66), age (66,129), education (137,184), employment status(33), perceived health (33,68), BMI (140), consumption of medicine (138), physical function(141), depression (129) and life satisfaction (33) are correlated with sedentary behaviour in older adults. However, as most of the evidence is based on cross-sectional studies, the use of longitudinal designs have been recommended to allow for a better understanding of the determinants of sedentary behaviour in older adults. Therefore, the purpose of the current study was to use a longitudinal design to (i) examine the correlates including demographics, physical function, physical health and psychological health; (ii) identify the potential determinants of sedentary behaviour in community-dwelling older adults.

6.2 Methods

A pilot study was conducted in April, 2013, in the town of Shrewsbury, UK, to examine the feasibility of the study. The main study was conducted in Loughborough, and in Horsham, Sussex. Baseline measurements were conducted from September to November 2013, with follow-up assessments conducted in April to July, 2014.

6.2.1 Recruitment

Participants of the pilot study were recruited from the residents of the Sevenside House, a company which manage a site of sheltering house in Shrewsbury. The house visiting and recruitment was conducted by the supporting staffs from the Sevenside House. A briefing of the pilot study was delivered by the author of this thesis to introduce the purpose of the study, to explain the use of the questionnaire and the accelerometer.

In the main study, participants were recruited by leaving leaflets in the meeting venues of older adults, such as community centres, cafes, the local library, and charity shops. The local council and related organisations (Age UK, University of 3rd Age), local groups (Cancer self-help group, green gym, church) were contacted to support recruitment. Participants were also recruited via word of mouth. Eligibility criteria included: being aged 65 years or older, able to walk with/without walking aid and having no neuropsychological disease that could affect memory. For the purpose of the current study, only participant who was diagnosed with neuropsychological disease by the psychiatrists/GP was excluded, no extra examination was done prior to the study. All participants were volunteers and the details of the study were explained to them before they took part in the baseline assessment. Six months after the baseline assessment, the participants were contacted and encouraged to take part in the follow-up assessments. To meet the 80% power, at least 32 eligible participants were required to be included in the analysis. Therefore, the original goal of recruitment was to recruit at least 60 participants at the baseline of the study to allow 50% of drop-out rate. Ethical approval was obtained from the Loughborough University Ethical Advisory Committee. The participants were asked to sign a consent form before taking part.

6.2.2 Measurements

One general survey on demographics, physical health, functional ability and psychological health, and one behavioural questionnaire on sedentary behaviour and physical activity were used to collect data. Also an accelerometer was given to the participants for objective measurement of participants' physical activity and sedentary behaviour. For a sample of the survey please see Appendix 1.

6.2.2.1 Physical activity and Sedentary Behaviour

(i) Self-report

Physical activity (PA) was self-reported using the Physical Activity Scale for the Elderly (PASE) (185). PASE scores have been moderately correlated with several self-reported health status measures (r ranges between 0.34 and 0.42) and this measure has been found to have a good validity especially in healthy older adults, aged 65 years and above (186-188). Participants were asked the days and times they spent on 12 types/intensities of PA such as walking, light sports, moderate sports, strenuous sports, muscle strength training, light housework, heavy housework and volunteer work in the past 7 days. The results were then calculated into a PASE score according to its scoring instruction manual (189), which scored from zero to 400. For the current study the time the participants spent in each PA was also summed to provide an estimate of participants' daily time in PA**.** The higher the scores, the more active the participants were. A PASE score of 143 is approximately equal to a weekly 3476 MET-minutes recording by the 7-day International Physical Activity Questionnaire(190).

Sedentary behaviour was self-reported by the participants using as the Measure of Older Adults' Sedentary Time (MOST) (97); this measure has been shown to have acceptable test-retest reliability (i.e., Spearman r = 0.52–0.90). The measure includes metrics for a variety of sedentary behaviours (TV viewing, computer use, reading, socialising, driving, doing hobbies, and others) and the times on a weekday and a weekend day were reported separately. Sitting times reported in each sedentary behaviour domain were added up as total sitting time for the statistical analysis.

(ii) Objective measurement

At the initial discussion within the pilot study in Shrewsbury, a waist-worn accelerometer (ActiGraph) and a posture monitor (ActivPAL) were suggested for use to measure sedentary behaviour. However, pilot study participants suggested that for improved comfort and study compliance, a 7-day monitoring period using a wrist-worn ActiGraph GT3X (ActiGraph, Florida) accelerometer was preferred. Participants were given instructions for wearing the accelerometer on their wrist and were requested to keep a diary of their wear time. The reason for, and any duration of, non-wear times were recorded in the diary by the participants. Wrist-worn accelerometers were preferred by the older adults because they found them more comfortable and easier to manage. Moreover, the National Health and Nutrition Examination Survey (NHANES), which is a population-based survey among a representative sample of the population in the United States is also using wrist-worn accelerometers in their latest phase. The sampling epoch for the accelerometer was 1 minute and non-wear time was defined as a period of at least 60 consecutive minutes of 0 counts per minute (cpm). The accelerometry data were processed using specialist software (KineSoft, New Brunswick). For a day to be valid for inclusion in the analyses, participants had to have worn the accelerometer for a minimum of 600 minutes. At the time of processing the accelerometer data, there were no published cut points from NHANES for wrist -worn accelerometers in older adults to define time spent sedentary, and time in different intensities of physical activity. Therefore, this study used a cut point of 250 cpm that was generated from the results of a laboratory test conducted by the physical activity research team at Loughborough University. The 250 cpm cut point has been used by the research team in a larger study employing wrist- worn accelerometers. Unpublished research from investigators at Loughborough University has shown that a cut-point of 250 cpm applied to wrist-worn accelerometers provides a good estimate of distinguishing between sedentary (<250 cpm) and non-sedentary (>250 cpm) time.

6.2.2.2 Demographics

Questions including age, gender, education, occupation, dwelling status (number of people the participant lived with), marital status and ethnicity, were asked using a questionnaire. Height and weight were also assessed by questionnaire and converted to body mass index (BMI). These variables were used as individual-level covariates.

6.2.2.3 Physical Health

Physical health was assessed by adapting the questions which were used in the study conducted by Buman et al. on the associations of light physical activity with rated health in older adults (59). The details of the self-reported health outcomes are presented in Table 6.1.

Table 6.1. Details of the physical health questions

Health Indicator	**Details**
No. of medications	How many medications do you currently take regularly? (On a scale of 0-6, none to ≥5)
No. of chronic medical conditions	Have you ever been diagnosed by a doctor consider of the following chronic conditions? (Number of medical conditions was chosen from a list of chronic conditions including: Rheumatoid arthritis, Osteoarthritis , Lupus , Parkinson's disease or other, Neurologic disorder, High blood pressure , Diabetes , Heart attack (or heart condition or angina) and Cancer.
Experience of fall in the past year	Have you fallen in the past 12 months (includes falling on the ground or some other level, such as a chair) On scale of 1-2, Yes and No)
General health rating	In general, how would you say your health is? On a scale of 1-5, Very poor to very good
Pain interference	During the past 4 weeks, how much did pain interfere with your normal work (including both work outside the home and housework)? On scale of 1-5, Not at all to all the time

6.2.2.4 *Physical function ability*

The 32-item function component (191) from the Late Life Function and Disability Instrument (LLFDI) assessed the physical function of the participants, which is an outcome instrument developed specifically for community-dwelling adults aged 60 years and older. Questions on the difficulty the participants felt to complete some daily activities were scored on a scale of 1-5 (none, a little, some, quite a lot, and cannot do). It assessed the participants' ability to do discrete actions or activities and focused on three dimensions - upper extremity, basic lower extremity, and advanced lower extremity functions. The results of the function instrument were then calculated into the LLFDI score according to the manual instructions. Sayers et al. examined the validity of the LLFDI scale among older adults and found it has a moderate correlation (r=0.65-0.69) with the short physical performance battery (SPPB) and the 400-m self-paced walk (400-m W) test. They also suggested that LLFDI scales could be a substitute for physical performance tests when self-report is a preferred data-collection format (192). Four levels of functioning limitation were categorised using mean LLFDI score: 41.7, severe limitations; 53.2, moderate limitations; 65.6 slight limitations; 75.6, no limitations (193).

6.2.2.5 Psychological Health

Table 6.2 presents the questions used assessing the experience or feeling of confusion, depression, life satisfaction and isolation. The experience of confusion was assessed using a validated single-question on a self-rated scale 0-4 (194); feeling of depression was assessed using a validated YES/NO question (195); life satisfaction was assessed using a validated single-question on a self-rated scale 1-5 (196); experience of isolation was assessed using a validated single-question on a self-rated scale 1-3 (197). The original 14- item Perceived Stress Scale (PSS) was applied to assess the stress level of the participants. This version of the PSS was suggested to be used to understand the experience of stress among older adults (198); this measure is a global assessment of an individual's perception of psychological stress during the past month (199). PSS measures the degree to which situations in one's life are appraised as stressful. The scale contained six negatively worded items and seven positively worded items. Participants scored each item according to their experience in the past one month. Scores were calculated after reverse-keying positive items and summation of scores; this was according to the PSS scoring instruction (200). However, PSS is not a diagnostic instrument, and no predetermined cut-points delineate different levels of perceived stress.

Table 6.2. Details of the psychological health questions

Health Indicator	Details
Confusion	In the past year, about how often did you get confused? On a scale 1-5, never to often.
Depression	During the past year, have you had 2 consecutive weeks or more during which you felt sad, blue, or depressed or lost pleasure in things you usually cared about or enjoyed? Yes and No
Satisfaction with life	All things considered, how satisfied are you with your life as a whole? On a scale 1-5, Very dis satisfied to very satisfied
Isolation	How often do you feel isolated from others? On a scale 1-3, Hardly ever to often

6.2.3 Statistical Analysis

Analyses were conducted using IBM SPSS Statistics for Windows version 22. Participants provided valid self-report sitting time at both baseline and follow-up were included in Analysis 1. The Shapiro-Wilk normality tests showed normal distribution of total sitting time on weekdays and weekends across the whole sample. Therefore, parametric tests were performed in Analysis 1. Descriptive analyses were performed to examine the sample characteristics. Independent t-tests were used to compare total sitting times on weekdays and weekends at baseline and follow-up across two groups. For example, when participants were grouped according to sex, marital status (single/married), live alone (yes/no), experience fall (yes/no), and depression (yes/no). One-way ANOVAs were performed to compare the differences in total sitting time on weekdays and weekends at baseline and follow-up across variables with at least three groups such as education (primary school/secondary school/high school/college/university/postgraduate), perceived health (very poor/poor/fair/good/very good), experience of pain (not at all/rarely/sometimes/ often/all the time), experience of confusion (never/seldom/sometimes/often), life satisfaction (very dissatisfied /dissatisfied /just fine/satisfied/very satisfied), and feeling of isolation (hardly ever/sometimes/often). Bonferroni-corrected post hoc comparisons were undertaken in the event of a significant One-way ANOVA result. The repeated measures of self-reported total sitting time between "weekdays and weekends", and "baseline and follow-up" were examined using paired-t tests. Pearson's correlation coefficients were applied to examine the presence of any associations between total sitting time on workdays and non-workdays with continuous variables including age, BMI, number of medicines taken, number of chronic diseases, LLFDI scores, PSS score, and PASE score. In addition to identify the potential determinants of self-reported sitting time, Pearson's correlation coefficients were used to examine the correlation of the continuous variables at baseline with weekdays and weekends sitting time at follow-up. Independent t-tests and One-Way ANOVAs were applied to examine the differences of weekday and weekend total sitting time at follow-up.

Participants who provided valid objectively determined sedentary time at both baseline and follow-up were included in Analysis 2. The Shapiro-Wilk normality tests showed non-normal distribution of accelerometer determined sedentary time across the whole sample. Therefore, non-parametric tests were performed in Analysis 2. Descriptive analyses were performed to examine the sample characteristics. Mann Whitney U tests were used to compare objectively determined sedentary time at baseline and follow-up across variables with at two groups. Kruskal-Wallis tests were performed to compare the differences in objectively determined sedentary time at baseline and follow-up across variables with at least three groups. The groups of each variable were the same as described in Analysis 1. Bonferroni-corrected post hoc comparisons were undertaken in the event of a significant Kruskal- Wallis test result. The differences of objectively derived sedentary time between baseline and follow-up were examined using Wilcoxson tests. Spearman correlation coefficients were applied to examine the presence of any associations between objectively determined sedentary time with continuous variables as described in Analysis 1. Furthermore, to identify the potential determinants of objectively-determined sedentary time, Spearman's correlation coefficients were used to examine the correlation of the continuous variables at baseline with objectively derived sedentary time at follow-up. Mann Whitney U and Kruskal- Wallis tests were applied to examine the differences of objectively derived sedentary time between baseline and follow-up.

6.3 Results

6.3.1 Sample Characteristics

Initially 58 participants completed the baseline assessment, with 46 completing the follow-up assessment. In total 44 participants providing valid sedentary behaviour data (self-report or accelerometer derived) at baseline and follow-up (see Figure 6.1). Of 44 included participants, 39 and 37 were included for analyses 1 and 2 respectively (see below). Missing data were excluded, and the excluded samples were younger than the included samples (mean age 71.5, $p>0.05$). All 44 participants were white European and 57% were female (n=25), not working (98%, n=43) and the mean age of the participants at baseline was 71.5(±5.5) years old.

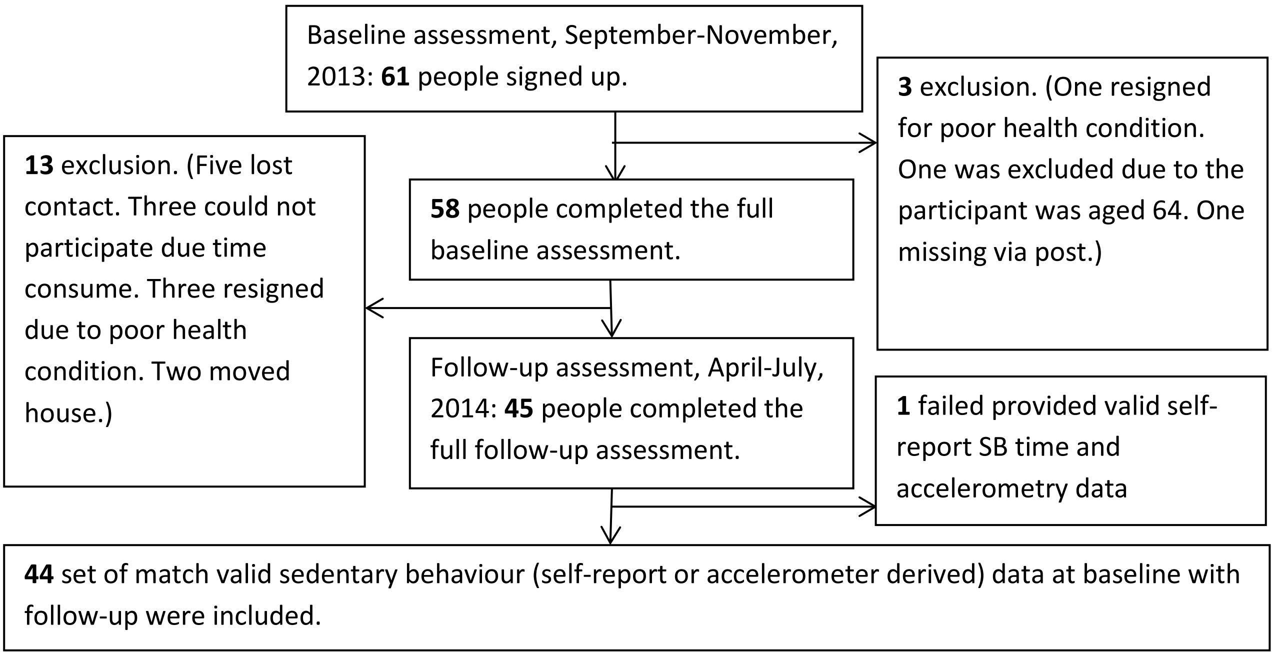

Figure 6.1. The process of the recruitment and inclusion of the participants and data

6.3.2 Analysis 1-Self-reported sitting time

Table 6.3 shows the characteristics of the included 39 participants at baseline and follow-up in Analysis 1. Most participants were married, lived with someone, and had an education level of college/university or higher. Participants had a BMI bordering on normal and overweight at baseline (25.7 kg/m^2) and follow-up (25.2 kg/m^2). Most participants took 2-4 types of medication, had 1-2 chronic diseases, had good self-rated health, reported no pain interference, never had confusion, reported no depression, hardly ever felt isolation and were very satisfied with life. Participants were described as slightly functioning limitation according to the mean LLFDI scores. There were no significant differences found in most of the participants' characteristics but stress (PSS score) and physical activity (PASE scores) were increased and decreased respectively at follow-up compare to baseline. There was no significant difference in sitting time on weekdays and weekend between baseline and follow-up (Table 6.4).

6.3.2.1 Correlates of self-report sitting time at baseline

At baseline, the reported mean (±SD) total sitting time was 441 (±188) min/day on weekdays and 487 (±169) min/day on weekends. The difference between weekday and weekend total sitting time was not significant and the correlation was moderate (r=0.68, p<0.01). No significant difference of total sitting was observed in any variable. On weekends, BMI was positively correlated with total sitting time (r=0.38, p=0.03), and number of medicines taken (r=-0.34, p=0.04) was inversely correlated with total sitting time.

6.3.2.2 Correlates of self-report sitting time at follow-up

At follow-up, the reported mean (±SD) total sitting time was 471 (±194) min/day on weekdays, and 507 (±195) min /day on weekends. No significant differences were found between reported total sitting times on weekdays and weekends, and no significant correlations of total sitting time on these two types of day were found (r=-0.34, p=0.13). On weekdays, numbers of medicines taken was inversely correlated with total sitting time(r=-0.40, p-0.03), and PASE score was also inversely correlated with sitting time (r=-0.39, p=0.03).

6.3.2.3 Predictors of self-report sitting time

No significant correlations were found between the continuous variables at baseline with sitting time on weekdays or weekends at follow-up. Differences of weekday sitting time were found across the level of perceived health (p=0.03). Post hoc tests could not be used as the group of “poor health” had only one case. The data showed that at baseline the participants who rated themselves as in “very good health” reported the most mean (±SD) weekday sitting time (574 (±154)min/day) at follow-up, followed by those in “good health” (448 (±195)min/day), and those in “fair health” (375 (±114)min/day). In addition, differences in weekend sitting times were found across the feeling of isolation groups at baseline (p=0.04). Participants who sometimes felt isolation at baseline reported a significantly higher sitting time on weekends at follow-up than those who hardly ever felt isolated (555(±445) min/day versus 503(±180) min/day).

Table 6.3. Characteristic of the participants (Analysis 1)

	Baseline	Follow-up
Gender, N (%)		
Male	18(46.2)	18(46.2)
Female	21(53.8)	21(53.8)
Marital Status, N (%)		
Single/Divorced/Widowed	8	8
Married/Cohabiting	31	30
Living Arrangement, N (%)		
Live alone	10	9
Live with one person and more	29	29
Education, N (%)		
Primary School	1(2.6)	1(2.6)
Secondary School	8(21.1)	8(21.1)
High School	9(23.7)	9(23.7)
College/University	15(39.5)	15(39.5)
Postgraduate	5(13.2)	5(13.2)

Table 6.4. Health, physical activity and sitting time at baseline and follow-up (Analysis 1)

	Baseline	Follow-up
BMI, kg/(m^2) Median (IQR)	25.6(2.5)	24.3 (5.0)
No. of medicine taking, N (%)		
0-1	15(38.5)	14(37.8)
2-4	18(46.2)	16(43.2)
5+	6(15.4)	7(18.9)
No. of diagnosed chronic disease		
0	12(31.6)	11(28.9)
1-2	20(52.6)	22(57.9)
3-4	4(10.5)	3(7.9)
≥5	2(5.3)	2(5.3)
Fall, Yes, N(%)	10(26.3)	10(26.3)
Perceived health		
Very poor	0(0)	0(0)
Poor	1(2.6)	1(3.4)
Fair	7(17.9)	8(27.6)
Good	19(48.7)	13(44.8)
Very good	12(30.8)	7(24.1)

Table 6.4. (Continued)

	Baseline	Follow-up
Pain interference		
Not at all	23(59.0)	19(51.4)
Rarely	9(23.1)	11(29.7)
Sometimes	5(12.8)	5(13.5)
Often	1(2.6)	1(2.7)
All the time	1(2.6)	1(2.7)
Confusion		
Never	22(56.4)	20(52.6)
Rarely	13(33.3)	11(28.9)
Sometimes	4(10.3)	5(13.2)
Often	0(0)	2(5.3)
Depression, YES, N(%)	4(10.8)	4(10.3)
Life satisfaction		
Very dissatisfied	3(7.7)	2(5.3)
Dissatisfied	0(0)	0(0)
Just fine	3(7.7)	4(10.5)
Satisfied	12(30.8)	11(28.9)
Very satisfied	21(53.8)	21(55.3)

Table 6.4. (Continued)		
	Baseline	**Follow-up**
Isolation		
Hardly ever	36(92.3)	33(86.8)
Sometimes	3(7.7)	5(13.2)
Often	0(0)	0(0)
LLDFI score, Mean(SD)	72.69(13.48)	71.27(11.87)
PSS score, Mean(SD)*	39.79(5.11)	41.57(9.9)
PASE score, Mean(SD)*	167.41(89.02)	140.40(48.85)
Sitting time, Mean(SD)		
Weekdays	441(188)	470(194)
Weekends	487(169)	507(195)

*Significant difference between baseline and follow-up (p-value<0.05)

6.3.3 Analysis 2-Objective measurement

Table 6.5 shows the characteristics of the included 37 participants at baseline and follow-up in Analysis 2. All participants had at least six valid days, and on average the participants wore the accelerometer for 1043±227 min/day at baseline and 1027±249 min/day at follow-up. Most participants were married, lived with someone, had an education level of college/university or higher. Participants had a mean BMI 25.6 kg/m^2 at baseline and follow-up. Most participants took 2-4 types of medication, had 1-2 chronic diseases, self-rated their health as good, reported no pain interference, never had confusion, reported no depression, reported hardly ever feeling isolated, and were very satisfied with life. Participants were described as slight functioning limitation according to the mean LLFDI scores. The included sample reported few significant differences in measures between the baseline and follow-up assessments. However, significant increases were seen in BMI, stress (PSS) score, and accelerometer derived sedentary time, and a significant decrease was seen in reported physical function (LLFDI) (Table 5.6). The median (±IQR) objectively derived sedentary time was 266 (±328) min/day at baseline, and 496 (±395) min/day at follow-up. The difference in sedentary time between baseline and follow-up was significant, significant correlations in sedentary time were also observed however between these two occasions (Spearman's r=0.77, p<0.001).

Table 6.5 Characteristic of the participants (Analysis 2)

	Baseline	Follow-up
Gender, N (%)		
Male	15(40.5)	15(40.5)
Female	22(59.5)	22(59.5)
Marital Status, N (%)		
Single/Divorced/Widowed	8(21.6)	8(21.6)
Married/Cohabiting	29(78.4)	29(78.4)
Living Arrangement, N (%)		
Live alone	10(27.0)	8(21.6)
Live with one person and more	27(73.0)	29(78.4)
Education, N (%)		
Primary School	1(2.8)	1(2.8)
Secondary School	10(27.8)	10(27.8)
High School	7(19.4)	7(19.4)
College/University	13(36.1)	13(36.1)
Postgraduate	5(13.9)	5(13.9)

6.3.3.1 Correlates of objectively derived sedentary time

At baseline, participants who lived alone had more daily median (±IQR) objectively derived sedentary time than those who lived with one person or more (495 (±381) min/day versus 241 (±182) min/day, p=0.03). At follow-up, although the p-value was at the edge of significance, participants who lived alone had more daily median objectively derived sedentary time per day than those who lived with one person or more (633 (±372) min/day versus 470 (±351) min/day, p=0.05).

6.3.3.2 Predictors of objectively derived sedentary time

No significant correlations were found between continuous variables at baseline with objectively derived sedentary time at follow-up. Differences of objectively derived sedentary time were found in living arrangement (p=0.03). Participants who lived alone at baseline had a higher median(±IQR) objectively derived sedentary time at follow-up, 633(±337)min/day versus 414(±351)min/day

Table 6.6. Health and physical activity at baseline and follow-up (Analysis 2)

	Baseline	**Follow-up**
BMI, kg/(m^2), Mean (SD)*	26.5(2.9)	26.5(3.5)
No. of medicine taking, N (%)		
0-1	13(35.1)	11(30.6)
2-4	17(45.9)	17(47.2)
5+	7(18.9)	8(22.2)
No. of diagnosed chronic disease		
0	11(30.6)	9(24.3)
1-2	22(58.9)	23(62.1)
3-4	3(10.5)	3(8.1)
No. of diagnosed chronic disease		
≥5	0(0)	2(5.4)
Fall, Yes, N(%)	8(21.6)	6(16.2)
Perceived health		
Very poor	0(0)	0(0)
Poor	2(5.4)	1(2.7)
Fair	9(24.3)	11(29.7)
Good	16(43.2)	18(48.6)
Very good	10(27.0)	7(18.9)
Depression, YES, N(%)	4(10.8)	5(13.5)

Table 6.6. (Continued)

	Baseline	Follow-up
Pain interference		
Not at all	20(54.1)	16(44.4)
Rarely	7(18.9)	12(33.3)
Sometimes	7(18.9)	5(13.9)
Often	1(2.7)	2(5.6)
All the time	2(5.4)	1(2.8)
Confusion		
Never	20(54.1)	18(48.6)
Rarely	13(35.1)	12(32.4)
Sometimes	3(8.1)	5(13.5)
Often	1(2.7)	2(5.4)
Life satisfaction		
Very dissatisfied	3(8.1)	2(5.4)
Dissatisfied	1(2.7)	1(2.7)
Just fine	3(8.1)	5(13.5)
Satisfied	12(32.4)	11(29.7)
Very satisfied	18(48.6)	18(48.6)
Isolation		
Hardly ever	32(86.5)	31(83.8)
Sometimes	4(10.8)	5(13.5)
Often	1(2.7)	1(2.7)
LLDFI score, Mean(SD)*	69.10(15.46)	67.61(12.74)
PSS score, Median (IQR)*	40.0(10.0)	42.5(14.0)
ACC[a] SB and Non-SB,		
Non- sedentary time* (≥250cpm) (min/day), Mean(SD)	709 (84)	462(113)
Sedentary time* (<250cpm) (min/day), Median (IQR)	266(328)	496(395)

*Significant difference between baseline and follow-up (p-value<0.05), [a]: Accelerometer derived

6.4 Discussion

This longitudinal study examined the intrapersonal correlates of self-reported sitting and accelerometer derived sedentary time in older adults using 6 month longitudinal data. It was found that BMI, and self-reported physical activity were correlated with self-reported total sitting time. Consistent associations across baseline and follow-up were found for the number of medicines taken and living arrangements. The number of medicines taken was inversely correlated with self-reported sitting time on weekdays, and living alone was positively correlated with objectively derived sedentary time. Perceived health and the feeling of isolation could potentially predict self-reported sitting time, and living alone could predict objectively derived sedentary time.

In general, participants reported relatively good physical and mental health. There was found to be little difference between baseline and follow-up, this could be due to the fact that six months is not a long enough time for changes to occur. No significant differences were found in self-reported sitting times between baseline and follow-up, but there were no significant correlations between the two either which may call in to question the long term reliability of this self-report tool, especially given significant correlations were observed between accelerometer-determined sedentary time at baseline and follow-up. Nevertheless, there were significant differences found in accelerometer-derived sedentary time between baseline and follow-up. Given the substantial difference between the self-report sitting time and accelerometer-derived sedentary time shows the questionable use of the wrist-worn accelerometer, especially that the cut-off of the accelerometer used in the current study cannot separate the participants sitting time from standing/cycling time. Thus, it is possible that the sedentary time is overestimated in the current study.

Even though the seasonal effect was considered whilst designing the study and the data collection were conducted particular in fall and spring was to avoid the extreme seasonal difference (e.g. between summer and winter). The difference between baseline and follow-up could still be due to the fact that the assessments were undertaken in two different seasons. The significant correlation of accelerometer-derived sedentary time between baseline and follow-up show that the changes of time did not only occur to specific individuals but happened to the entire group. However, the significant correlation also shows older adults who spend more time sedentary in autumn are likely to have more sedentary time in spring.

Limited correlations were observed between most demographic, physical health and behavioural variables with sedentary behaviour in the current study. Most studied variables were unrelated to the time participants spent in sedentary behaviour, and the few associations remained the same across baseline and follow-up. Nevertheless, BMI was positively correlated with self-reported weekend sitting time at baseline but not follow-up, and PASE was inversely correlated with self-reported weekday sitting time at follow-up but not baseline. Although these findings were not consistent across baseline and follow-up, they reflect the correlates identified in the data analysis study presented in Chapter 4. Consistent associations across baseline and follow-up were found in the number of medicines taken with self-reported weekend sitting time. Moreover, it was found in the current study that better perceived health could predict more weekend sitting time. Although this finding is different to the existing evidence (33,120,126), and it could be because regardless of the number of medicines the participants in the current study took, most of them rated themselves in good or very good health. Although the existing evidence found the inverse associations disability and long-term health condition with prolong sedentary time (122), the current study did not find associations between the number of chronic diseases with self-reported or objectively derived sedentary time. In fact, except for the number of medicines taken and perceived health, the current study observed few significant differences of sedentary time across physical health conditions. Because functional ability is inversely associated with less sitting time in older adults (126), and the participants in the current study were on average in good health and had good physical function scores Therefore, this could explain the limited difference in sitting/sedentary time was found in the current study, but further evidence is needed to confirm the association of functioning limitation with sedentary behaviour. The other observed consistent association was found for the variable living alone with objectively derived sedentary time. Participants who lived alone had more objectively derived sedentary time than those who lived with someone. Moreover, the current study also found that living alone could predict more sitting time on weekends. Nevertheless, living arrangement could not complete reflect the participants' real situation of social interaction, and likewise, the feeling of isolation may not accurately represent the level of social interaction of the participants. Hence, future study is needed to investigate the more details on the correlation of psychological health and social environment with sedentary behaviour time in community-dwelling older adults. However, interventions for reducing sedentary time in older adults could priority apply to those who lived alone and feeling isolation, and those who consider themselves less healthy.

Strengths and limitations

This study provides evidence based on longitudinal data and examines a broad range of intrapersonal correlates of sedentary behaviour in older adults. The findings enhance the existing evidence on correlates and provide the identification of potential determinants of sedentary behaviour in older adults. However, the participants' characteristics are narrow and the sample size is small; these limit the findings. Moreover, the short period of observational time (six months) restricts possible changes from baseline to follow-up. The assessments in different seasons (Autumn and Spring) could also be a factor. Objective measurement is used in addition to self-report measurement to assess sedentary behaviour in older adults to reduce any potential bias which may limit self-report data. At the time of the data analysis the choice of the cut point could be arbitrary, the applied 250cpm cut-point was highlighted as a reasonable cut-point for wrist-worn accelerometers. However, validity and reliability information on potential cut points for determining sedentary time using wrist-worn accelerometers is currently lacking in the literature and the validity of the cut point used in the present study has not been tested extensively and has not been used in any published study to date.

Furthermore, other domains of correlates, such as environmental, could also affect the time older adults spend sedentary, and were not considered in this study. Evidence on the association of physical function and physical health with sedentary time is needed to confirm the findings. Therefore, further longitudinal studies using a larger sample size to examine the intrapersonal as well as environmental correlates and determinants of sedentary behaviour in older adults are needed. Moreover, longer observational time intervals and assessments conducted during the same time of the year could enhance the results from the current study.

6.5 Conclusion

This longitudinal study finds physical health (BMI and number of medicines taken), and physical activity are correlated with self-reported sitting time. Living alone is the only correlate of wrist-worn accelerometer derived sedentary time. Perceived health, feeling of isolation and living alone could be potential predictors of prolong sitting/sedentary time. However, further longitudinal research using a larger sample size and longer follow-up is needed to enhance the findings.

Chapter 7

General Discussion

7

General Discussion

Given the findings on the literature review presented in Chapter 2 and 3, more studies and evidence are need to fill in the gaps of the knowledge on the correlates/factors of sedentary behaviour in mid-age and older adults in order to inform the studies on the intervention and translate the research into practice. This thesis has presented four studies on the topic of the correlates of sedentary behaviour in adults aged 50 years and above. This chapter summarises the main findings reported from the four studies which including, a systematic review of the existing evidence on correlates of sedentary behaviour in mid-age and older adults; one cross-sectional study examining the correlates of sitting time and physical activity; one study examining the correlates of domain-specific sitting times among older office workers using cross-sectional and 2-year longitudinal study design; and one longitudinal study with six month follow-up investigating the correlates of both self-report and objectively derived sedentary time among community-dwelling older adults. This thesis focuses on the associations of the intrapersonal factors, such as basic demographics (sex and age), socio-demographics (marital status, dependent status, living arrangement, education, income, and occupation-related demographics), physical and psychological health, and behaviour correlates, with sedentary behaviour. This research provides novel information on factors that have or have no influence on mid-age and older adults' sedentary behaviour, and furthers the evidence on the behavioural epidemiology framework-phase 3 in the research field of sedentary behaviour in mid-age and older adults. A summary of the main findings, strengths and limitations of each study are presented in Table 7.1.

Table 7.1. Overview of key findings, strengths and limitation from individual studies

	Purpose	Methods	Findings	Strength	Limitation
Chapter 3	Review the existing evidence on the correlates of sedentary behaviour in older adults.	Systematic review of the literature. 71 articles, including 33 of mid-age adults (aged 50-64 years) and 38 of older adults (aged 65 years and above)	<u>Mid-age adults</u> Correlates of S-SB: Age(0), Gender (0), Education (0), Being retired (+), Income (0) Correlates of NS-SB: Age (0), Gender (0), Education (0/+), Income (0), PA (-), Smoking (0), Long-term illness (+), non-workdays (+), Physical well-beings (-), Psychological and mental well-being (-), life independence (-), social well-being (-), Learning well-being (-). <u>Older Adults</u> Correlates of S-SB: Age (?), Gender (0), Education (-), Income (0) Correlates od NS-SB: Age (0/+), Male (0/+), Education (+), Income (?), Married (-/?), Ethnicity (0), Employment (0), Unemployment (+), Area SES advantage (0), PA/MVPA/Total PA (-). Meet PA guideline (-/0), Weekly PA (-/0), BMI/Weight (+), Waist circumferences (0), Perceived Health (?), Long-term illness (+), Physical function (0), Depression (0), Psychological health/Mental well-being (0).	✓ Innovative ✓ Systematic approach adopted and the summary of 71 published paper. ✓ Reporting of sedentary behaviour separately. ✓ Examined and reported results of mid-age and older adults separately.	o Conclusion is based on the evidence from mostly cross-sectional studies. o Only articles written in English language

Chapter 4	Basic demographic and behavioural correlates of sedentary behaviour and physical activity in older adults	Cross-sectional survey. n= 1481, Older adults aged 50+ Subjective measurement: International Physical Activity Questionnaire (IPAQ). Studied factors: basic demographics and physical activity.	Correlates of total sitting time: Perceived PA level (-), MVPA (-), total PA (-) and walking (-) Correlates of total PA: Perceived PA level (+) Correlates of MVPA*:* Live with someone (+) Perceived PA level (+) Correlates of Walking time: Italian>German Perceived PA level (+)	✓ Data collected from multiple countries. ✓ Large sample size.	o Self-report measurement only. o Less variety of correlates studied

Chapter 5	Correlates of domain-specific sitting time in office workers.	Cross-sectional and longitudinal survey. Older adults aged 50+ Subjective measurement: Marshall's self-report domain-specific sitting time. Studied factors: basic demographics, socio-demographic, and health behaviour. *Analysis 1:* Cross=sectional data analysis, n=2942	*Analysis 1-cross-setional data* <u>Sitting on Workdays</u> Male>Female (Travel /HS/L) Female>Male (Work) Married>Single (Travel) Education (+) (Total/Travel/ Work) No dependents (+)(Total/HS); (-)(Total) Job grade (+) (Total/Travel/ Work) Salary (0) (Total) Contract type (0), Job type (0) Obese (+) (Total/HS/OW) Meet PA guidelines (+) (Travel); (-)(Total/Work) Alcohol drinker (+) (HS) Smoker (0) <u>Sitting on Non-workdays</u> Male>Female (Total/ HS) Single>Married (L) Education (?) No dependents (+)(Total/HS/L) Job grade (-)(Work) Salary (?) Contract type (0), Job type (0) Obese (+) (Total/HS) Meet PA guidelines (+)(L) ; (-)(HS) Smoker (0)	✓ Large sample size. ✓ Sitting time was reported across different domains. ✓ 2-year longitudinal study.	o Self-report measurement only.

Chapter 5		*Analysis 2:* Longitudinal data analysis, n=233	*Analysis 2-Longitudinal data* The consistency of the association between basic demographic, occupation-related demographics and health behaviour with domain-specific sitting time across baseline and follow-up and the associations were generally very weak. <u>Sitting on Workdays</u> Baseline: Male>Female (HS) Female>Male (Work) Full-time>Part time (OW) Meet PA guidelines (-) Follow-up: Male>Female (HS) <u>Sitting on non-workdays</u> Baseline: BMI (+) (HS) Follow-up: BMI (+) (HS) <u>Change in sitting time</u> <u>Workdays</u> Married>Single (Travel) Meet PA guidelines (+) (HS) <u>Non-Workdays</u> Increasing in sitting time on non-workdays. Male>Female (Total) No dependent (-) (Total/HS/L)			

Chapter 6	Correlates of subjective and objectively measured sedentary behaviour in community-dwelling older adults	Longitudinal study. n=37/39, Older adults aged 65+ Subjective measurement: Measure of Older Adults Sedentary Time (MOST). Objective measurement: wrist-worn accelerometer. Studied factors: basic demographics, socio-demographics, physical and psychological health and physical activity.	<u>Self-report Sitting time</u> Baseline: BMI (+), No. of medicines taken (-) Follow-up: PASE (-), No. of medicine taken (-) <u>Obj-derived sitting time</u> Baseline: Living alone (+) Follow-up: Living alone (+) Feeling of isolation and perceived health at baseline were the identified potential predictors of SB at follow-up.	✓ 6-month follow-up. ✓ Both subjective and objective measures of SB and PA. ✓ Examination of multiple categories of factors. ✓ Longitudinal analyses.	o Narrow and small size of sample. o No standard reference for wrist-worn accelerometry data. o Short gap between baseline and follow-up.
+, Positive association; -, Inverse association; 0, unrelated association; ?, mixed/unclear association; SB: Sedentary behaviour; PA: Physical activity; S-SB: Screen-based Sedentary Behaviour; NS-SB :Non-screen based Sedentary Behaviour; Obj: Objective derived sedentary behaviour; PASE: Physical activity scale for elderly; Total: Total sitting time; Travel: Sitting in transportation; Work: Sitting at work; HS: Home screen sitting time; L: Other leisure activity sitting time; OW: Sitting outside work; F&V: Fruit and Vegetable.					

7.1 Systematic Review

As the research interests in sedentary behaviour in adults is increasing, systematic reviews have been conducted to identify the correlates of sedentary behaviour in adults and older adults. Rhodes et al. (93) reviewed the previous evidence on correlates in adults aged 18 and older, and later on O'Donoghue et al.(155) conducted a similar review but adopted the socio-ecological model to present the identified correlates. The reviews revealed limited and mixed associations between basic demographic, socio-demographic, health and behaviour variables with sedentary behaviour. Chastin et al.(94) conducted a systematic review to examine the quantitative and qualitative evidence on the correlates/factors of sedentary behaviour in older adults aged 65 and above. Chastin et al.'s review reported the limited association between demographics and sedentary behaviour and the lack of evidence on potential correlates/factors (e.g. environmental correlates). To date, there is no review which examines the evidence on correlates of sedentary behaviour specifically in mid-age and older adults. Given the surveillance evidence suggests adults aged 55 years and above had a high prevalence of prolonged sedentary time, and this prevalence increased with age(10), and the high prevalence of sedentary behaviour in older adults is supported by review-level evidence (11), it is important to generate more knowledge on sedentary behaviour in the ageing population by improving the understanding of sedentary behaviour in mid-age and older adults. Therefore, Chapter 3, the systematic review, was conducted to gather the existing evidence to assist researchers in better understanding sedentary behaviour in this important age group. The findings of Chapter 3 show that basic demographics such as age and gender had limited associations with all types of sedentary behaviour. Socio-demographics including unemployment and education were positively associated with non-screen based sedentary behaviour, but income was unrelated to any type of sedentary behaviour. Smoking was found to be unrelated in mid-age adults and positively associated in older adults with non-screen based sedentary behaviour. Long-term illness/chronic disease was positively associated with non-screen based sedentary behaviour in older adults. Moreover, physical activity-related correlates were inversely correlated with non-screen based sedentary behaviour. The findings in Chapter 3 provide a profile of the potential correlates of sedentary behaviour in mid-age and older adults based on the evidence from 71 research papers. However, the majority of the evidence were from cross-sectional studies, and it is suggested that longitudinal studies are needed to identify the determinates of sedentary behaviour in mid-age and older adults. The reported associations of the correlates with sedentary behaviour were more likely to be unrelated, which was defined in Chapter 3 as the association was "not statistically significant". Moreover, a mixture of positive and inverse associations was found in correlates such as education and income with sedentary behaviour across different studies. Conclusions were therefore not able to be made on the association of many correlates such as marital status, living arrangement , alcohol drinking, psychological health and the environment with sedentary behaviour due to lack of evidence.

Overall, the current systematic review found socio-demographics (education and income), and physical activity related correlates are likely to affect the time mid-age and older adults spend in sedentary behaviour. It also highlights that further evidence is needed to enhance these findings, and also more studies are needed to confirm those unclear associations. This systematic review was of primary importance within this thesis as it was instrumental in shaping and informing the direction of the research described in later chapters.

7.2 Correlates of sedentary behaviour-evidence from cross-sectional data

Given the unclear associations of potential socio-demographic correlates with sedentary behaviour in mid-age and older adults observed in Chapter 3, further research on building up the evidence-base on correlates was suggested. Chapter4 and the Analysis 1 of Chapter 5 were cross-sectional studies, examining the associations of potential basic demographic, socio-demographic and behavioural correlates with sedentary behaviour.

Chapter 4 reported data collected from an online survey, collecting information on self-reported sitting time and physical activity (using the IPAQ), from participants across five countries. The results showed no significant associations between sitting time and basic demographic and socio-demographic variables. Significant associations between behavioural correlates and total sitting time were found however; perceived physical activity level, moderate to vigorous physical activity (MVPA), total physical activity and walking were inversely correlated with total sitting time. Additionally, it was also found that perceived physical activity level was positively correlated with total physical activity, MVPA, walking and sitting time. Although limited evidence of the associations between basic demographic and socio-demographic variables with sitting time were observed in chapter 3, Chapter 4 provided further evidence on the inverse association between self-reported physical activity and sitting time. Moreover, the consistent associations of perceived physical activity level with sitting, total physical activity, MVPA and walking time suggest that perceived physical activity level could be a useful screening tool to identify the individuals who are a high risk of being sedentary. However, only a few correlates were studied in Chapter 4 and the self-reported nature of the sitting time and physical activity variables could result in bias which could limit the findings of this chapter.

To extend the understanding of potential socio-demographic correlates with sitting time, Chapter 5 used data collected from an online survey examining more detailed information including a broader selection of basic demographics and occupation-related demographics. In addition, participants were also asked to report a number of further health-related variables, including drinking alcohol, smoking status and fruit and vegetable (F&V) intake. A self-report questionnaire measured sedentary behaviour was also used in Chapter 5, and participants were asked to report the time they spent sitting in four domains including transportation, work, home screen time, and other leisure activities separately on workdays and non-workdays. This chapter found that participants reported a large proportion of sitting time at work on workdays, and a large proportion of entertainment-based sitting on non-workdays. Potential correlates examined included sex, dependent status, education, job grade, salary, body mass index (BMI), meeting physical activity guidelines, smoking, alcohol drinking, and meeting F&V guidelines. This study used data collected from a large sample of older office workers and provided evidence on the associations of socio-demographic variables with sitting time. Findings from this chapter confirmed earlier findings of inverse associations between PA-related correlates with sitting time which were found in Chapter 4 and 5. Additionally, it also found that participants in the category of "unhealthy behaviours" such as those categorised as overweight/obese, alcohol drinking, smoking and not meeting F&V guidelines reported higher levels of domain-specific sitting time than those engaging in healthier lifestyle behaviours. Although the studied participants were all office workers in the UK, the findings from Chapter 5 extend our knowledge of correlates of sedentary behaviour which might affect different domains of sitting times in employed mid-age and older adults.

Together Chapters 4 and Analysis 1 from Chapter 5 present adequate evidence which cover the associations of most basic demographic and socio-demographic correlates with sitting time in mid-age and older adults. However, as these two analyses were both cross-sectional and only identified associations at one point in time, the need for longitudinal studies to identify potential determinants is warranted.

7.3 Correlates of sedentary behaviour-evidence from longitudinal data

Hence, to give evidence based on longitudinal study, the Analysis 2 in Chapter 5 used the enrolled participants who provided data in both 2012 (baseline) and 2014 (follow-up) to conducted a longitudinal analysis. This is a longitudinal data with two-year interval occurred between the baseline and follow-up assessments, and both assessments took place in September. It found that being male and a higher level of BMI were consistently positively correlated with home screen sitting time on non-workdays. Moreover, participants reported a mean increase in sitting time of 50 min/day on non-workdays between baseline and follow-up. Differences in the changes in sitting times over the follow-up period were observed according to sex, dependent status, marital status and meeting physical activity guidelines status. Male participants reported a greater increase in total sitting time on non-workdays than female participants. Participants who had dependents reported a greater increase in daily sitting time on non-workdays than those who had no dependents, significant differences were also found in the domain of home screen and leisure activity. Nevertheless, overall participants who had no dependents reported more domain-specific sitting times than those had dependent(s). Married participants reported a greater increase in sitting time in transportation on workdays than those who were single/widowed/divorced. Participants who met physical activity guidelines reported a greater increase in sitting time during home screen time on workdays than those who did not meet physical activity guideline. This longitudinal analysis mirrors the findings in the cross-sectional analysis, and provides stronger evidence on the effect of sex, BMI, dependent status and physical activity on sitting time. However, this longitudinal study included the participants mainly aged between 50 to 64 years, and it could because the comment retirement age of 65 years at the time of data collection. Moreover, sedentary behaviour was assessed by only subjective measurements and the studied correlates were limited to demographics and behavioural related factors. Therefore, Chapter 6 applied a longitudinal-design study on community-dwelling older adults and examined the potential correlates of sedentary behaviour including physical function, physical health and psychological health in addition to demographics and physical activity. Moreover, to give stronger evidence, accelerometers were used to assess sedentary behaviour along with a self-report questionnaire, which asked the individuals' about their sitting time in the following domains: TV viewing, computer use, reading, socialising, driving, doing hobbies, and doing others activities on weekdays and weekend-days. The key finding of this chapter was that perceived health, number of medicines taken, feelings of isolation and living arrangement were consistently correlated with sedentary behaviour at baseline and follow-up. It was found that at both baseline and follow-up, participants who rated themselves very healthy had the most self-reported sitting time on weekdays, and taking more medicines was positively correlated with sitting time on weekends. Also participants who sometimes felt isolated had more sitting time on weekends than those who hardly ever felt isolated. Furthermore, increased accelerometer-derived sedentary time was found in those who lived alone in comparison to those who lived with someone(s). Compared to the findings from Chapter 5, the results support the inverse association of physical activity with sitting time. In light of the reported consistent correlations of sex and physical activity, this information could inform future tailored interventions targeting sedentary behaviour in older adults. Although findings from this study add significantly to the existing evidence, there were a few limitations of Chapter 6. These include (i) the sample size, less than 40 out of 59 datasets were valid to be included in the analyses, (ii) the narrow diversity of the sample, all the included participants were retired and generally in a good condition of health, (iii) short period (6 months) between baseline and follow-up, and (iv) the baseline and follow-up measurements were conducted in Spring and Autumn. These imply that the included participants were fairly fit and healthy and this could bias the findings. Furthermore, the change in sedentary behaviour could be due to seasonal differences.

7.4 Further directions

Findings presented in this thesis have important implications for future research and practice in changing mid-age and older adults' sedentary behaviour. These have been organised into critical research priorities within phases 2-4 of the behavioural epidemiology framework applied to sedentary behaviour.

7.4.1 Phase Two-**Develop methods for accurately assessing sedentary behaviour**

In terms of the choice of measure of sedentary behaviour, Chapter 3 highlighted that self-reported sitting time and objectively measured sedentary time were preferable for use in mid-age and older adults' sedentary behaviour research, respectively. In this thesis, self-reported sitting times were the main measure of sedentary behaviour applied in Chapters 4 and 5, which enrolled mainly mid-age participants. The IPAQ (used in Chapter 4) and Marshall's domain-specific sitting time self-report questionnaire (used in chapters 5) have both been shown to be valid and reliable measures of sedentary behaviour. Chapters 4 and 5 report secondary data analyses, and the included participants were subgroups from a larger group of participants (spanning adults aged between 18 – 70 years). The use of a self-report tool in these chapters was the most cost-effective choice in these larger-scale studies. Chapter 6, the study designed by the author of this thesis, was conducted to study the sedentary behaviour in older adults. In this chapter the validated MOST questionnaire was chosen to assess the participants' sedentary behaviour. Given the limitations of self-report tools, such as reporting error and bias, an objective measurement was also used in Chapter 6 on purpose to enhance the validity of the findings.

In the original plan for Chapter 6, an accelerometer (ActiGraph) and a posture monitor (activPAL) were both suggested as objective measures of physical activity and sedentary behaviour. However, during the piloting of this work, older adults expressed concerns regarding comfort when wearing these monitors. At the pilot phase the accelerometer was placed around the waist and the activPAL was attached to the thigh using a sticky pad. Moreover, because these devices were not waterproof, participants needed to keep a diary to record any non-wear times. Older adults participating in the pilot study expressed dissatisfaction with wearing these two devices and advised of an alternative solution for use in the main study. Therefore, to increase the willingness of participants, wrist-worn accelerometry was chosen based on the feedback from the pilot study. This decision was made at the time of data collection for the latest US National Health and Nutrition Examination Survey (NHANES) which was also using wrist-worn accelerometry. The choice of this method was therefore deemed as a suitable alternative.

However, the classification accuracy of cut-points for wrist-worn accelerometry in older adults was not clear at the time of data analysis for this chapter. Indeed, due to delays experienced within NHANES on the most appropriate method of analysing wrist-worn accelerometer data (which still exist at the present time), there is no established or standard approach to extract time spent sedentary from wrist-worn accelerometers. A cut-point of 250 cpm was used in Chapter 6 based on early findings from researchers within the physical activity research team at Loughborough University. Although the 250 cpm cut-point could not identify the intensity of physical activity, it did provide an estimate of participant's sedentary and non-sedentary time. The development of a validated approach for defining sedentary time and time in physical activity intensities using wrist-worn accelerometers in older adults, and all age groups, is needed. Recent evidence has highlighted the activPAL as a valid tool to assess sedentary behaviour in adults (201). Since Chapter 6 was conducted, new model of the activPAL has been developed. This smaller and lighter weight device, along with its waterproofing attachment options could mean that this device may be suitable for further work with older adults. Evidence suggests that the activPAL is a useful device for measuring activity in older adults (91), and this device should be used in future research with older adults to provide a direct measure of sedentary behaviour.

7.4.2 Phase Three-**Identify correlates/factors that influence multiple health behaviour**

Studies in this thesis mainly included the individual level of correlates including basic demographics, socio-demographics, health and behaviour of sedentary behaviour in mid-age and older adults. As found in Chapter 3 that the existing evidence on the associations of psychological health with sedentary behaviour was limited, psychological health was examined its association with sedentary behaviour in older adults in Chapter 6. Feeling of isolation was the only correlates found significantly associated with sedentary behaviour in older adults in Chapter 6. In comparison to the examined evidence of the systematic review in Chapter 3 which found that psychological health such as mood disorder, loneliness, depression and psychological well-being were inversely correlated with sedentary behaviour in older adults; but few studies examined the same psychological health correlates so that no conclusion was able to draw due to limited evidence. More evidence are need to understand the interpersonal level of correlates such as friends or families' support, which might be a moderate of sedentary behaviour by changing the psychological health of the individuals. Moreover, according to the ecology model of sedentary behaviour, environment could also affect an individuals' sedentary behaviour. Owen et al. reviewed the existing evidence of the association of environmental and social contexts with sedentary behaviour to identify potentially modifiable environmental and social determinants. They produced a conceptual model including the built, policy and social environments, which attributed an individual's sedentary behaviour. The existing evidence included in the review presented in Chapter 3 showed that relatively less studies assessing the associations of social and physical environments with sedentary behaviour in mid-age and older adults. No conclusion could be made based on the existing evidence of the associations of the environment with sedentary behaviour in mid-age and older adults. Therefore, future studies should examine the associations of the examined psychological health with sedentary behaviour in mid-age and older adults using cross-sectional and longitudinal research methods. Furthermore, exploring the associations of the environment with sedentary behaviour should be a priority of further research.

7.4.3 Phase Four-**Evaluate intervention to reduce sedentary behaviour**

One of the aims of the thesis was to inform interventions for reducing sedentary behaviour in mid-age and older adults. Findings from this thesis profile the correlates of sedentary behaviour in mid-age and older adults, and enhance our understandings of the intrapersonal factors which could related to a high prevalence of sedentary behaviour in this particular age group. This thesis shows that the intrapersonal correlates, such as basic demographics and socio-demographics, had limited associations or influence on the time mid-age and older adults spent in sedentary behaviour. However, this thesis reveals the trait of individual such as being male, living alone, feeling isolation, having no dependent, being overweight, smoking and taking more medicines are the most likely to be sedentary. Moreover, although sitting at work accounts most sedentary time of the working mid-age and older adults, the prevalence of sedentary behaviour remains high during out-off work time/leisure time. Interventions should aim to reduce sitting time at work and sedentary behaviour during non-working/leisure time, particularly mid-age and older adults with the identified traits.

7.5 Overall conclusion

This thesis presents evidence on correlates of sedentary behaviour in mid-age and older adults. The evidence on correlates, including basic demographics, socio-demographics, health and behaviour with sedentary behaviour found in the thesis add to the existing knowledge within this field of research. Such findings add considerably to the existing public health research in sedentary behaviour in mid-age and older adults and are important as they suggest that further research is needed to understand the interpersonal level of correlates, which might change the individual's psychological health and sedentary behaviour intervention could start in mid-age and older and focus on reducing their sedentary behaviour on non-workdays/weekends. This information may improve the effectiveness of interventions to reduce sedentary behaviour in mid-age and older adults and will likely lead to improvements in health.

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Appendices

Appendix 1

Older adults survey, including participants' information, consent form and questionnaire for collecting personal and health information

Appendix 2

Activity questionnaire, including wearing log for accelerometer, physical activity (PASE) and sedentary behaviour (MOST) questionnaires.

Appendix 3

Correlates of Sedentary Behaviour in Older Adults living in the UK- Poster presentation at 2014 ISBNPA annual conference, San Diego, USA

Appendix 4

Correlates of Sedentary Behaviour in Older Adults: A longitudinal Study-Poster presentation at 2015 ISBNPA annual conference, Edinburgh, UK.