PHYSICAL ACTIVITY AND SEDENTARY BEHAVIOUR IN OLDER ADULTS: ASSOCIATIONS WITH PHYSICAL AND MENTAL HEALTH

By

SAENGRYEOL PARK

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ABSTRACT

With an increasing ageing population, it is important to explore factors that can contribute to healthy ageing. Physical activity (PA) and sedentary behaviour (SB) are associated with psychological and physical health in older adults. This thesis therefore aims to explore the associations between PA as well as SB and a range of health, motivational, environmental factors in older adults from assisted living facilities (ALFs) and community settings using various methodological approaches.

Study 1 used latent profile analyses to group people based on PA, SB, and physical function in resident of ALFs. It was found that those classed as high physical function with an active lifestyle had better mental health compared to those who had lower physical function and an inactive lifestyle. These findings suggest that in order to improve mental health in older adults, interventions should take all these variables into account.

Study 2 used latent profile analyses to classify people based on the degree of autonomy support from important others and perceptions of the physical environment, and subsequently examined differences in engaging in light PA and moderate-to-vigorous PA (MVPA) between these groups. Results suggest that perceptions of the physical environment should be taken into account along with support from important others to facilitate increases in levels of PA.

Study 3 employed ecological momentary assessment to examine the within-person association of light PA, MVPA, and SB in relation to bodily pain and fatigue in older community dwelling adults. This study revealed associations between bodily pain and PA, as well as SB. Furthermore, daily fatigue was influenced by typical fatigue and physical health. The overall conclusion of the studies presented in this thesis implies that individual, social, and environmental factors and its interactions can all contribute to mental health, PA, SB, bodily pain, and fatigue outcomes in older adults.

I would like to dedicate this thesis to my parents

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CONTENTS LISTING

LIST OF PAPERS and CONFERENCE PRESENTATIONS

This thesis consists of the following three papers. Three empirical chapters have been submitted to journals and are currently under review.

Journal Articles

1. Park, S., Thøgersen-Ntoumani, C., Ntoumanis, N., Stenling, A., Fenton, S.A.M., Veldhuijzen Van Zanten, J.J.C.S. (2017). Profiles of physical function, physical activity, and sedentary behaviour and their associations with mental health in residents of assisted living facilities *Applied Psychology: Health and Well-being*.

2. Park, S., Fenton, S.A.M., Stenling, A., Veldhuijzen Van Zanten, J.J.C.S., Ntoumanis, N., Thøgersen-Ntoumani, C. (2017). A person-centred analysis of motivation for physical activity and perceived neighbourhood environment in residents of assisted living facilities. *Environment and Behavior* (in revision).

3. Park, S., Veldhuijzen Van Zanten, J.J.C.S., Thøgersen-Ntoumani, C. Ntoumanis, N. (2016). Disentangling daily associations from individual differences in studying the interplay between physical activity, sedentary behaviour, bodily pain and fatigue in older adults: an ecological momentary assessment. *Annals of Behavioural Medicine* (in press).

Conference Presentations

1. Park, S., Veldhuijzen Van Zanten, J.J.C.S., Thøgersen-Ntoumani, C. & Ntoumanis, N. (2015).
Associations between mental health and physical function, physical activity, and sedentary behaviour in elderly people, the Autumn Post Graduate research day, School of Sport, Exercise, and Rehabilitation Sciences, University of Birmingham, UK (Oral presentation).

2. Park, S., Veldhuijzen Van Zanten, J.J.C.S., Thøgersen-Ntoumani, C. & Ntoumanis, N. (2015).
Associations between behavioural regulation and mental as well as physical health in older adults: mediating roles of physical activity and sedentary behaviour, 8th Euro-Korean Conference on Science and Technology, EKC 2015, Strasbourg, France, Poster & Oral poster presentation (3min), funded by Euro-Korean Conference on Science and Technology (200 Euros).

3. Park, S., Veldhuijzen Van Zanten, J.J.C.S., Thøgersen-Ntoumani, C. & Ntoumanis, N. (2013).
Post Graduate Research Day, Active Living, Health and Well-Being of Residents in Assisted Living Centres, University of Birmingham, UK (Oral presentation).

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CHAPTER 1

GENERAL INTRODUCTION

With the improvements in medical care and industrialisation in the western world, people are living longer, which results in an ageing population. In 2015, 901 million adults aged over 60 years represented 12.3% of the world population (United Nations, 2015b), which is an increase compared to 2000 when older adults represented 9.9% of the world population (United Nations, 2015a). A recent projection by the United Nations (2015a) indicated that by 2045-2050, older females (over 60 years) are expected to live 24.4 additional years. This is an increase compared to 1950-1955 when older females were expected to live another 15.0 years (United Nations, 2015a). Similar trends are seen in male older adults, whereas 60 years old males were expected to live another 13.0 years in 1950-1955, this is projected to increase to 21.9 years by 2045-2050. In combination with the expected decrease in child birth rate (i.e., from 2.5 children per woman in 2010-2015 to 2.4 children per woman in 2025-2030; United Nations, 2015b), these trends (longer life expectancy and a decrease in child birth) are contributing to an ageing society, particularly, in high-income countries (e.g., Europe, North America, Oceania). Indeed, the proportion of older adults (≥60) is expected to have increased to 16.5% (1.4 billion) in 2030, and to 21.5% (2.1 billion) in 2050 (United Nations, 2015b).

There has been a continuous increase in the population of older adults in the UK, in line with the global increase in the number of older adults (over 60 years; United Nations, 2015b). Adults aged over 60 are expected to make up 27.8% (19.5 million) of the total UK population by 2030 and 30.7% (23.2 million) by 2050, compared to 23% (14.9 million) in 2015. As with the global population, this is largely due to the increase in life expectancy of this population. The Office for National Statistics (2015) specified that female older adults were expected to live another 25.13 years by 2010-2015 and 29.55 years by 2045-2050, and male older adults an additional 22.0 years by 2010-2015 and 27.45 years by 2045-2050. In addition, the consecutive increase in life expectancy at birth (1990-1995: 76.2 years, 2005-2010: 79.6 years, 2010-2015: 80.4 years) has further supported the trend of longevity of older adults compared to previous decades in the UK (United Nations, 2015b). As is evident from the figures reported, the life expectancy is somewhat higher in the UK compared to the world population (United Nations, 2015a), most likely due to the better living conditions and care facilities available in a developed western country like the UK.

These increases in life expectancy do not necessarily reflect an increase in healthy life expectancy, as a range of health challenges can be experienced by older adults. For example, older adults are likely to experience a decline in cognitive function (National Institutes of Health, 2011), decline in movement functions (e.g., gait, muscle strength), decline in sensory functions (e.g., vision, hearing), dementia and an increased risk of falling (World Health Organization, 2015) as well as poorer mental health (e.g., depression, anxiety; WHO, 2016). These health challenges can impact on the quality of life of older adults (Charness, 2008; Zubritsky et al., 2013). Furthermore, older adults are also likely to suffer from chronic diseases such as high blood pressure, cardiovascular disease, and diabetes (Centres for Disease Control and Prevention and The Merck Company Foundation, 2007). These chronic diseases can contribute towards the loss of physical function or cause pain (Centres for Disease Control and Prevention and The Merck Company Foundation, 2007). This increased prevalence of health challenges in older adults is associated with increased costs for healthcare and therefore societal burden (e.g., medical care expenses; Cracknell, 2010; National Institutes of Health, 2011). Therefore, attention should be focused on finding solutions to reduce the ageing-related health problems and to facilitate healthy ageing.

Prevalence and Increase of Assisted Living Facilities

The living circumstances of older adults vary. Some older adults live independently in the community, others live in nursing homes, and some live in assisted living facilities (ALFs). For example, of the older adults receiving long-term care in the United States in 2014, the highest proportion (45.1%) lived in residential care facilities, which is approximately double the proportion living in nursing homes (23.3%; Harris-Kojetin et al., 2016). ALFs are a form of housing for older adults that supports independent living (Hawes, Rose, & Phillips, 1999) by providing person-specific services based on the residents' choice and need (Mollica & Johnson-Lamarche, 2005). Different terms have been used to describe these facilities, including extra care housing, very sheltered housing (NHS, 2015a), and residential care communities (Harris-Kojetin et al., 2016; Mollica & Johnson-Lamarche, 2005). Residents in ALFs can live independently, but, if necessary, support is provided for activities of daily living (Mollica & Johnson-Lamarche, 2005). For example, services typically include 24-hour support staff, a full-time or part-time nurse, provision of three meals a day, housekeeping, assistance with bathing and dressing, medication reminders, or assistance and central storage of medication (Hawes et al., 1999). Typically, residents in ALFs need assistance with at least one aspect of ADL, such as bathing, eating, or getting dressed. Residents most commonly have problems with mobility, which is evident from the use of mobility aids, such as a wheelchair (13%-18%), walker (23%-36%), or cane (10%-12%). Some residents also experience some mental health disorders, such as mild dementia (25%), severe dementia (4%), and depression (24%; Kraditor et al., 2001), and, therefore, ALFs also provide support for mental health. As stated above, these services are provided on the basis of the needs and preferences of the residents, which means that residents have autonomy over which services they take advantage of.

Perhaps not surprisingly given the increase in older adults reported above, there is a tendency towards an increase in ALFs provision. For example, even though there is wide variability, an increase of more than 20% in ALFs was seen from 2002 to 2004 in some States in the USA (Mollica & Johnson-Lamarche, 2005). In England, an increase in number of ALFs has been reported from 2012 to 2015 (55,675 places to 60,022 places; Elderly

Accommodation Counsel (EAC; 2012, 2015). The increasing importance of the ALFs has resulted in an increase in funding from the UK government to support ALFs (Darton et al., 2012). Although this provides interesting information about the growth of ALFs, care should be taken when interpreting these figures as different definitions and names for ALFs are used within and between nations (Harris-Kojetin et al., 2016; Mollica & Johnson-Lamarche, 2005; NHS, 2015a).

The majority of residents moved into ALFs from their homes (46%) and other ALFs (20%; National Centre for Assisted Living, 2001). In case of deterioration of health, residents will be discharged from ALFs and moved to facilities where more intensive care is provided (e.g., nursing homes, hospital; Kraditor et al., 2001). Another common reason for leaving an ALF is death of the resident (National Centre for Assisted Living, 2001).

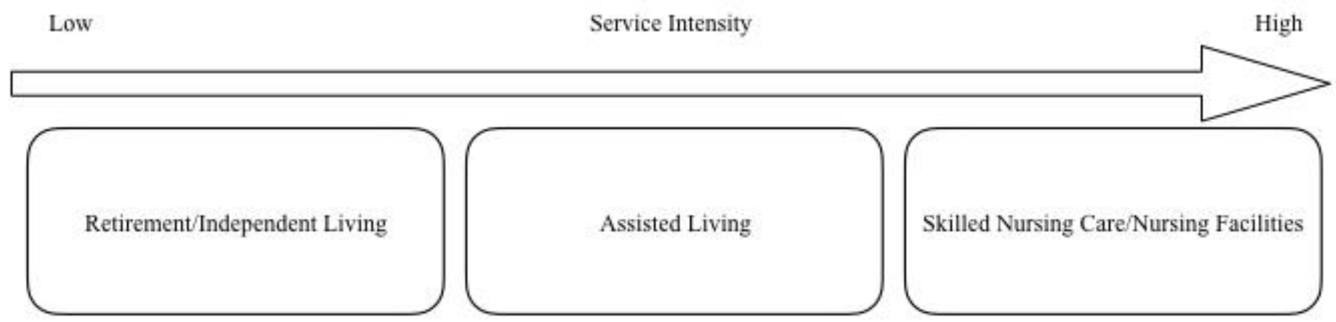


Figure 1.1 The Long Term Care Continuum, modified from National Centre for Assisted Living (2001)

Residents in ALFs tend to have better levels of physical health than those in nursing or care homes (see Figure 1.1; Sloane et al., 2003; Resnick & Galik, 2015), and increasing transfers to nursing homes may incur societal burden (e.g., medical expenses; National Institutes of Health, 2011). Therefore, it is important to investigate the determinants and characteristics of the residents who are able to maintain their independent lifestyle for longer, rather than transitioning to intensive care settings.

Physical Activity and Sedentary Behaviour in Older Adults

Background. In the past, people tended to have more active lifestyles. Due to advances in modern society, we are living in environments designed for less PA (e.g., less manual labour at work, less active commuting) and more sedentary activities (e.g., watching television, using computers; Hill et al., 2003). It has been suggested that these changes in lifestyle have been suggested to contribute to the increased prevalence of diseases such as diabetes mellitus and obesity, which can be prevented by an active lifestyle (Manini & Pahor, 2009; Miles, 2007; Santos et al., 2012). Therefore, promoting physically active lifestyles is crucial to maintaining health, and perhaps even more so in older adults.

Definition. Physical activity (PA) is defined as "any bodily movement produced by skeletal muscles that results in energy expenditure" (p 126; Caspersen, Powell, & Christenson, 1985). PA can be classified in different ways, which can be based on the context in which the PA occurs (e.g., PA at work and leisure) or on the intensity of the PA (Caspersen et al., 1985). The intensity of PA can be described based on energy expenditure using metabolic equivalents (METs). The definition of 1 MET is "the resting metabolic rate, that is, the amount of oxygen consumed at rest, sitting quietly in a chair" (p. 555; Jetté, Sidney, & Blümchen, 1990). Light PA is defined as activities from 1.5–3 METs, moderate PA is 3–6 METs, and vigorous PA as > 6 METs (Troiano et al., 2008). Moderate and vigorous PA are often summed and reported as moderate to vigorous PA (MVPA; Loprinzi, 2013; Troiano et al., 2008).

Ainsworth et al. (2000) identified a range of activities that can be classified as light PA, moderate PA, and vigorous PA. Light PA consists of activities that people conduct in everyday life settings, including walking at a slow pace and doing light house chores, such as washing dishes, and is, therefore, an interesting behaviour to explore in older adults. Examples of moderate PA include walking (≥ 2.5 mph), heavy house work (washing windows, car), bicycling (<10 mph), playing golf, and running at moderate intensity (Ainsworth et al., 2000). Examples of vigorous PA include walking at speed of 5.0 mph, carrying heavy loads and bicycling at higher speed (Ainsworth et al., 2000). Walking has been reported to be the most common form of PA in older adults (Brawley, Rejeski and King., 2003). Older adults are reported to spend more time in SB compared to young adults (Matthews et al., 2008), but less time in light PA (Colley et al., 2011) and also in MVPA (Troiano et al., 2008) than younger adults. Methods to assess PA in older adults will be described in more detail below.

Sedentary behaviour (SB) is defined as “any waking behaviour characterised by an energy expenditure ≤1.5 METs while in a sitting or reclining posture” (Sedentary Behaviour Research Network, 2013). Typically, SB activities range from 1.0-1.5 METs (Pate, O’Neill, & Lobelo, 2008), and can include activities such as watching television or using a computer (Edwardson, Gorely, Davies, Gray, & Khunti, 2012). Historically, SB was considered as the absence of any PA. However, there is now evidence that SB and PA are separate behaviours that independently impact on health (Matthews et al., 2012; Santos et al., 2014). The evidence for SB and PA being independent behaviours comes from different lines of research. Firstly, relatively weak associations are reported between SB and PA (Mansoubi, Pearson, Biddle, & Clemes, 2014). Furthermore, even when meeting the guidelines for MVPA, SB is associated with an increased risk for poorer health outcomes (Matthews et al., 2012). High levels of SB engagement (television viewing; ≥7 h/d) were associated with an increased risk for all-cause mortality (1.5-to 2-fold increases) and cardiovascular mortality (2-to 2.5-fold increases), even in those meeting the public health guidelines for MVPA. Further evidence for the independence of SB and PA comes from the difference in the physiological processes of these behaviours (Hamilton, Hamilton, & Zderic, 2007; Tremblay, Colley, Saunders, Healy, & Owen, 2010). More specifically, the effects of SB and PA on molecular and cellular processes, such as lipoprotein lipase, are not just the reverse of each other, but have differential effects (Hamilton et al., 2007). Taken together, it can be concluded that SB and PA are separate behaviours. In the subsequent sections, measurement and participation rates of light PA, MVPA, and SB in older adults will be described.

Measurement. Light PA, MVPA and SB can be measured using both subjective self-reports (e.g., questionnaires) and objective measures (e.g., accelerometers, pedometers) in older adults (Kowalski et al., 2012). With regards to self-report measures, a wide range of questionnaires has been used. Some of the advantages of using questionnaires are that is it easier to reach a large number of participants, relatively cheap to conduct, and easy for participants to participate (Aguilar-Farías, Brown, Olds, & Peeters, 2015; Bauman, Phongsavan, Schoeppe, & Owen, 2006; Celis-Morales et al., 2012; Chastin, Culhane, & Dall, 2014; Healy et al., 2011). Several PA questionnaires have been used and validated for older adults. A commonly used questionnaire is the Physical Activity Scale for the Elderly (PASE; Washburn, Smith, Jette, & Janney, 1993; Mudrak, Stochl, Slepicka, & Elavsky, 2016), which is the questionnaire that is used in the work presented in this thesis. In this questionnaire, participants are asked to indicate the amount of PA they have engaged in over the last seven days (Washburn et al., 1993). Participants are instructed to record what types of PA (e.g., walking, light, moderate, strenuous, muscle strength sport/recreation, household PA, work-related PA) they did, as well as its intensity (e.g., light, moderate, strenuous PA), duration (e.g., less than 1 hour, 1 to 2 hours, 2 to 4 hours, more than 4 hours), and frequency (e.g., never: 0 days, seldom: 1 to 2 days, sometimes: 3 to 4 days, often: 5 to 7 days). A higher PASE score indicates a higher overall level of PA, however, this questionnaire does not provide separate scores for PA intensity (Washburn et al., 1993). Another commonly used PA questionnaires is the International Physical Activity Questionnaire (IPAQ; Craig et al., 2003), which has been modified and validated for older adults (Hurtig-Wennlöf & Hagströmer, 2010). In the IPAQ, participants are asked to record their activities from the previous seven days in four domains: occupational, transport, household, and leisure. For each domain, participants are asked to specify the duration of light, moderate, and vigorous levels of activity. Participants are also asked to indicate the amount of time they spent sitting (Craig et al., 2003).

With regards to SB, a number of self-report measures are available. A commonly used questionnaire to assess SB in older adults is the Measure of Older adults` Sedentary Time (MOST; Gardiner et al., 2011). MOST aims at recording time spent on specific behaviours over the previous seven days (e.g., watching television, using a computer, reading).

Even though these self-report measures are tailored to and validated for older adults, there are also some weaknesses of using these questionnaires. Despite the ease of use of self-reported questionnaires, there is evidence that retrospective methods can underestimate SB and overestimate PA (Aguilar-Farías et al., 2015; Celis-Morales et al., 2012; Chastin et al., 2014; Tudor-Locke & Myers, 2001).

To overcome the weakness of self-report measurements, objective methods, such as using accelerometers and pedometers can serve as an alternative. In particular, using accelerometers is becoming common (Gorman et al., 2014; Healy et al., 2011). Accelerometers can detect activities of different intensities, whereas a pedometer only records the number of steps (Le Masurier & Tudor-Locke, 2003). The small monitor (popular types of accelerometers: GT3X+, WGT3X-BT; ActiGraph, Pensacola, FL) can be worn on the waist on the right side of the hip, and does not interfere with daily activities because the monitor may best capture activities on the hip (Schrack et al., 2016). Data is collected in three axes/planes (i.e., vertical, anterior-posterior and medio-lateral), but the vertical axis is most commonly used for analyses (Freedson, Melanson, & Sirard, 1998; Troiano et al., 2008). Data are digitised over 60 seconds in the form of activity counts (Troiano et al., 2008), where the "count" represents the number of movements based on the magnitude of activities captured (Pruitt et al., 2008). The sum of all activity counts is transformed into counts per minute (CPM) for the purpose of analysis (Murphy, Smith, Clauw, & Alexander, 2008; Schrack et al., 2016). As a result, the number of counts per minute reflects the intensity of activity, and certain thresholds (i.e., cut-points) have been established to classify the activity into SB, light PA, moderate PA, or vigorous PA.

Most commonly, participants are asked to wear accelerometers for seven days (Troiano et al., 2008). A day tends to be included in the analyses when the participants have worn the accelerometer for at least 10 hours. This is considered to be a valid day and provides a reliable estimation of PA and SB for that day (Troiano et al 2008). As there are variations between in the number of hours of wear time per day, it is important to correct for the wear time when interpreting the data. It is recommended to use both automated wear time algorithms and diary logs to record when the participants started and stopped wearing the monitor to get the best estimate of valid wear time (Schrack et al., 2016). Apart from classifying wear time, it is also important to define non-wear time. In general, if the monitor does not detect any activity for 90 minutes, except for sporadic movements occurring below 100 cpm within a period of two minutes, it is considered non-wear time (Choi, Liu, Matthews, & Buchowski, 2011). Given that there are variations in wear time, adjustments for these differences will need to be made to allow for comparisons between individuals. One method is to express each activity as the proportion of the day that was spent on that activity (e.g., SB proportion: {SB min/day} ÷ wear time/hrs x 100; Bankoski et al., 2011). Another common method is to statistically control for wear time in the statistical analyses.

Unfortunately, not all participants manage to wear the accelerometer for the full 7 days. Therefore, analyses have been done to establish the minimum amount of valid days that need to be included in order to provide a representative measure of PA and SB. In studies in older adults, accelerometer data was typically included when there were at least 3 valid days (10 hours a day; Gorman et al., 2014). It is also important to include one weekend day (Gorman et al., 2014) to reflect possible variation between weekdays and weekends, due to the tendency of older adults to be less physically active during the weekend (Arnardottir et al., 2013).

In addition, there are a variety of cut points in the literature to define especially SB (cut point range: 50-500) and MVPA (cut point range: 574-3,250; Gorman et al., 2014). In particular, two sets of cut-points for MVPA (≥1952 cpm; Freedson, Melanson, & Sirard, 1998, ≥2,020; Troiano et al., 2008) are frequently used in the literature, for both adults and older adults (Gorman et al., 2014). However, using two different sets of cut points did not statistically influence the amount of PA measured (Orme et al., 2014). To date, there are no standardised cut points for older adults. However, in this thesis, the following cut points will be used: light PA (100-2,019 cpm), moderate PA (2,020-5,998), and vigorous PA (≥ 5,999). These have been validated across different age groups (6-11, 12-15, 16-19, 20-29, 30-39, 40-49, 50-59, 60-69, 70+; Troiano et al., 2008), which allows for the comparison of levels of activity between different age groups. The cut-point for SB (<100) is the most commonly used across all age groups (Gorman et al., 2014; Hagströmer, Oja, & Sjöström, 2007; Hagströmer, Troiano, Sjöström, & Berrigan, 2010; Matthews et al., 2008), and is used in the current thesis.

As mentioned above, objectively assessing SB and PA with an accelerometer has been shown to be more accurate in comparison to self-report measures. More specifically, people tend underestimate the amount of time spent sitting (Aguilar-Farías et al., 2015; Chastin & Granat, 2010; Harvey, Chastin S, & Skelton, 2014) and over-estimate the amount of time spent on moderate PA, vigorous PA and MVPA (Tucker, Welk, & Beyler, 2011), but the objective and subjective measures tend to be associated with each other (Skender et al., 2016). These differences between subjective and objective assessments have been reported in adults in all ages, including older adults (Celis-Morales et al., 2012) and clinical populations, such as those with rheumatoid arthritis (Yu et al., 2015). This can, perhaps, be explained by the fact that people might not remember all of the light PA they have engaged in as these activities do often not tend to be planned activities (e.g., walking intensity or speed; Mâsse et al., 1998; Tudor-Locke & Myers, 2001; Skender et al., 2016). However, there is also a report of higher levels of SB using self-report measures compared to accelerometer based sitting data (Hagstromer, Ainsworth, Oja, & Sjostrom, 2010). One explanation for the differences between the self-report and objective data for sitting was found by van Uffelen, Heesch, Hill, and Brown (2011), who showed that even though older adults completed the questionnaires, a qualitative approach revealed that participants had difficulties remembering the frequency of sitting and the scope of sitting activities.

Despite the objective data providing a seemingly more accurate report of SB and PA, there are also downsides to using an accelerometer as well. The main disadvantage is that it is not possible to determine the kind of activity the person has conducted. Therefore, using both self-report and objective measures is recommended as that provides information about the intensity and duration, as well as the specific types, of activities (Healy et al., 2011; Skender et al., 2016). Accelerometers are also less reliable at detecting certain types of activities that occurred above the waist, as well as some other activities (e.g., cycling; Tucker et al., 2011).

Therefore, as stated above, use of both self-reported and objective measures at the same time is recommended.

Physical Activity Guidelines

Regular engagement with PA and low levels of SB have been associated with health benefits in the general population, as well as among older adults (Lillo, Palomo-Vélez, Fuentes, & Palomo, 2015; Miles, 2007; Wullems, Verschueren, Degens, Morse, & Onambélé, 2016). Guidelines and recommendations have been established which suggest the levels of PA that are necessary in order to achieve these health benefits. The World Health Organisation recommends that adults aged 18-65 should engage in at least 150 minutes of moderate PA or 75 minutes of vigorous PA per week (World Health Organization, 2011). In addition to this aerobic exercise, adults should conduct muscle-strengthening activity at least two days a week (World Health Organization, 2011). The guidelines for adults aged 65 years and older are similar to the ones reported above regarding aerobic and strength exercises. However, it is acknowledged that some older adults might not be capable of meeting these recommendations due to poor functional ability or health. For these older adults, it is recommended that they should complete as much PA as they can do. In other words, even though they might not meet the guidelines, there are still health benefits related to PA at lower levels (Warburton & Bredin, 2016). Therefore, advice should include ‘move more and sit less’ (Warburton & Bredin, 2016). In addition, older adults with poor mobility are advised to conduct PA that will improve their balance and prevent falls on at least 3 days a week (World Health Organization, 2011). Similarly, older adults were encouraged to engage in regular light PA for at least 300 min/wk in order to achieve positive health outcomes (Loprinzi, Lee, & Cardinal, 2015). With regards to SB, the guidelines are similar for all adults, regardless of their age, and recommend that people should avoid being sedentary for prolonged periods of time (Healy et al., 2008; NHS, 2015b; Powell, Paluch, & Blair, 2011).

Physical Activity Participation Rate

Despite the known health benefits of regular PA, compliance with the recommended PA guidelines, measured objectively, is poor in the general population and even worse in older adults (Troiano et al., 2008). As people get older, they tend to lead a more sedentary lifestyle (McPhee et al., 2016), and to be less physically active (objectively-assessed: Arnardottir et al., 2013; Berkemeyer et al., 2016; Harvey et al., 2014; subjectly-assessed: Pereira, Baptista, & Cruz-Ferreira, 2016; both subjectly and objectively-assessed: Wullems et al., 2016).

For example, whereas 30-39 years old males spent 43 minutes per day in objectively-assessed MVPA and females 21 minutes per day, males over 70 years old spent only 9 minutes/day in objectively-assessed MVPA and for females this was 5 minutes per day (Troiano et al., 2008). When exploring the different intensities of objectively-assessed PA in more detail, the differences between the time spent sedentary and those in objectively-assessed PA of different intensities was striking for both male and female older adults (males: 539 min/day in SB; 227 min/day in low PA; 66 min/day in lifestyle PA; 15 min/day in moderate PA; females: 501 min/day in SB; 261 min/day in low PA; 60 min/day in lifestyle PA; 10 min/day in moderate PA; Hagströmer, Troiano, Sjöström and Berrigan., 2010b). Other examples suggest that older adults engaged 294.5 min/day in objectively-assessed light PA for 294.5 min/day, and in objectively-assessed MVPA for only 10.0 min/day (Loprinzi., 2013). Moreover, while gradual decreases in objectively-assessed PA were found when comparing those between 66-69 years old with those aged 80 years and older (low-light PA: 272.4 min/day to 232.3 min/day; high-light PA: 33.1 min/day to 16.2 min/day; MVPA: 22.3 min/day to 10.7 min/day), gradual increases in objectively-assessed SB were also found leading to 630 minutes per day of objectively-assessed SB for those aged 80 and older (Buman et al., 2010). Davis et al. (2014) found a substantial amount of time in objectively-assessed SB (71.3%) compared to other objectively-assessed PA categories (very light PA: 18.2%, light PA: 9.0%, MVPA: 1.5%) in older adults. This proportion of SB is even higher than a previous study showing approximately 60% of daily activities in objectively-assessed SB in older adults (Matthews et al., 2008). The results reported above are from a range of countries, including Europe, America and Asia. When specifically focussing on PA participant rate in the UK, the evidence also suggests low levels of engagement. For example, a study reported that older adults (over 70 years old) living in urban settings engaged in only 13.48% (1.9 hours/day) – 20.98% (3 hours/day) in objectively-assessed light PA and 0.43% (3.6 minutes/day) – 3.25% (27.9 minutes/day) in objectively-assessed MVPA (Davis, Fox, Hillsdon, Sharp, et al., 2011). Withall et al. (2014) reported older adults (over 70 years old) spent 18.6 minutes of their waking hours/day in objectively-assessed MVPA; the proportion of time spent in objectively-assessed SB was also high (approximately 11.3 hours/day; mean age = 78 years; Davis et al., 2011; 11.1 hours/day; mean age = 78). Given these numbers regarding SB and PA, it is important to understand which factors are related to PA and SB in older adults, as that can help to develop interventions to reduce SB and increase PA in this population.

The data reported above are related to older adults living in the community, however, less data is available for SB and PA in people living in ALFs. The majority of those studies use self-report measures of SB and PA (Chen, Li & Yen, 2015; Graafmans, Lips, Wijlhuizen, Pluijm & Bouter, 2003; Lu, 2010; Lu, Rodiek, Shepley & Tassinary, 2015; Phillips & Flesner, 2013; Resnick, Galik, Gruber-Baldini & Zimmerman, 2010; Zalewski, Smith, Malzahn, VanHart & O'Connell, 2009) as recently reviewed (Haselwandter & Corcoran, 2015). In general, people in ALFs are more likely to be sedentary and physically inactive. For example, it has been reported that residents of ALFs spend 82% of their day sedentary, with 16% spent in light PA, and only 2% in lifestyle activity or MVPA (Corcoran et al., 2016).

Physical Activity and Sedentary Behaviour-Relations with Health Indicators

Background. Light PA, MVPA, and SB are associated with a variety of health indicators in older adults (Biswas et al., 2015a; McPhee et al., 2016). For example, engagement in MVPA predicted lower weight, body mass index, waist circumference and diastolic blood pressure, as well as fewer functional limitations (Gennuso, Gangnon, Matthews, Thraen-Borowski, & Colbert, 2013). Specifically looking at studies conducted in the UK, objectively-assessed MVPA has been related to various health indicators in older adults. For example, low levels of MVPA have been associated with a greater likelihood of a diagnosis of chronic illnesses and all-cause mortality in older adults (≥70; Fox et al., 2015), poorer physical well-being (Withall et al., 2014) and numbers of prescriptions as well as unplanned hospital admissions (Simmonds et al., 2014).

It is not just MVPA that is related to health outcomes, engagement in light PA has also been related to health benefits. Positive associations were found between light PA and better physical health (Buman et al., 2010), cardiometabolic health (e.g., elevated triglycerides, low HDL-D, elevated waist circumference; Camhi, Sisson, Johnson, & Katzmarzyk, 2011) and psychosocial well-being in older adults (Thraen-Borowski, Trentham-Dietz, Edwards, Koltyn, & Colbert, 2013). In contrast, SB is related to poorer health outcomes. For example, high levels of time spent in SB was an independent risk factor for mental health, as well as physical health issues such as cancer, obesity, and cardiovascular diseases (Biswas et al., 2015a; de Rezende, Rey-López, Matsudo, & do Carmo Luiz, 2014; Withall et al., 2014a). It is also worth emphasising that, even when people are physically active, prolonged sedentary periods can still have a negative impact on health (Biswas et al., 2015a). However, it should be noted that there have been studies showing no significant associations between SB and the number of chronic illnesses in older adults in the UK (Fox et al., 2015). The following sections present a brief description of the health outcomes which are reported in the current thesis.

Physical function. Older adults can experience difficulties in conducting everyday activities, such as getting up from a chair (Hortobágyi, Mizelle, Beam, & DeVita, 2003), climbing stairs (Startzell, Owens, Mulfinger, & Cavanagh, 2000), and getting dressed (Vaughan et al., 2016), due to limited physical function. It is, therefore, not surprising that physical function is related to independency, which in turn, is related to healthcare service use (e.g., hospitalisation, nursing home admission; Painter, Stewart, & Carey, 1999). For example, the impact of physical dependency is considerable both for healthcare expenditure and healthy ageing, with a large part of health care expenditure spent on physically dependent adults (Fried et al., 2001). Poor physical function not only has financial consequences, there is also substantial evidence that it is related to poorer quality of life in older adults (Li et al., 2014; Vaughan et al., 2016; Warren, Ganley, & Pohl, 2016), most likely due to the associated lack of independence.

Physical function can be measured by both subjective and objective measures. Regarding objective measures for physical function, a variety of methods are used, such as the grip dynamometer for grip strength, the spirometer for lung function, the body mass index (BMI), and the timed up and go test for gait speed (Podsiadlo & Richardson, 1991). In particular, there are several tests which examine different aspects of mobility. The timed up and go test is an objective test commonly used for frail older adults because it is relatively easy to complete and only takes about 20 seconds (Browning, Sims, & Kendig, 2009). Results show that when individuals need more time for the timed up and go test, they tend to be more obese (Riebe et al., 2009) and at high risk of falling (Schoene et al., 2013) than individuals who need less time for this test. The timed up and go test assesses gait speed, but also the ability to get out of a chair and elements of balance, as participants are asked to stand up from a seated position, walk 3 metres, turn around and return to the chair. Another commonly used test is the 4-metre walking test (Lauretani et al., 2003; Ostir, Volpato, Fried, Chaves, & Guralnik, 2002). However, as this test only includes walking in one direction, it does not assess lower limb functional ability in the same detail as the timed-up-and go test. An individual measure of balance includes the assessments of the time taken to stand up and sit down without support from the chair (Rossiter-Fornoff, Wolf, Wolfson, & Buchner, 1995). A commonly used measure of walking endurance is the two-minute walk test (Butland, Pang, Gross, Woodcock, & Geddes, 1982), where participants are instructed to walk for 2 consecutive minutes at the fastest speed possible and the distance covered in these 2 minutes is recorded. All the tests reported above cover a range of measures related to lower extremity functional ability. The Short Physical Performance Battery (SPPB) includes several tasks which assess different aspects of lower extremity functional ability and is widely used (Guralnik et al., 1994). SPPB measures of three dimensions of physical function: static balance, gait speed and walking from a chair (Chen, Blake, Genther, Li, & Lin, 2014). The advantage of this task is that it covers different dimensions of functional ability, however due to the series of tests, it can take longer to complete this assessment compared to for example the timed up and go test. Finally, self-reported measures can be used to investigate functional ability. Activities of daily living can be used for self-reported physical function in older adults. For example, daily activities are measured by asking the levels of ability to conduct daily life activities such as shopping and cooking (Lawton's Insturmental Activites of Daily Livings; Eells, Kane, & Kane, 2004).

With regard to subjective measures of physical function, the Modified Health Assessment Questionnaire (MHAQ; Pincus, Summey, Soraci, Wallston, & Hummon, 1983) assesses the ability to perform activities of daily living (e.g., dressing, grooming, rising, walking, grip strength). The RAND-36 health survey (physical functioning dimension; Hays, Sherbourne, & Mazel, 1993) is a modified version of the SF-36 questionnaire (Ware & Sherbourne, 1992). In this questionnaire, participants are asked to rate their perception of general physical function, which is one of the sub-scales (e.g., physical function, role limitations because of physical health, energy, pain) of the physical health component of RAND-36. The question of physical function assesses of daily participation in the following activities: vigorous activities, moderate activities, lifting or carrying groceries, climbing stairs, bending, kneeling or stopping, walking, and bathing or dressing (Hays et al., 1993). However, subjective measures tend to overestimate physical function reporting more pain than objective measures (Mizner et al., 2011). Therefore, objective measures of physical function or both should be used. As stated, several measures have been used to assess physical function but simple and objective measures should be used for frail older adults.

In the literature, gait speed is considered one of six important signs of physical function in older adults (Fritz & Lusardi, 2009). Furthermore, walking speed and grip strength were negatively associated with depression and anxiety (Ní Mhaoláin et al., 2012). Moreover, negative associations were found between restrictive lung function and mental health outcomes (well-being, vitality, self-control) in adults (Goodwin, Chuang, Simuro, Davies, & Pine, 2007). Higher levels of BMI (i.e., being obese) are more likely to be related to dysregulation of physical function, leading to negative physical health (i.e., coronary heart disease; Li et al., 2006), as well as higher levels of depression even though the relation is not stronger (Atlantis & Baker, 2008).

A number of studies have explored the relationships between physical function, PA and SB in older adults. For example, less time spent in SB and more engagement in MVPA were reported to be associated with less functional limitation in older adults (Gennuso et al., 2013). Moreover, older adults showed positive associations in chair rise and walking when they were highly physically active (MVPA) and also in balance, chair rise, and walking when sedentary time breaks occurred frequently (Davis et al., 2014). Furthermore, more engagement in PA is associated with less decline in physical performance (Stenholm et al., 2015), and sustaining physical function contributes to the maintenance or even increase in physically active lifestyles (Resnick & Galik, 2013). In line with this, Bethancourt, Rosenberg, Beatty, and Arterburn (2014) found a number of functional barriers (e.g., physical pain, decreased endurance, balance) and facilitators (e.g., current physical condition management, balance, and strength maintenance) toward PA engagement in older adults. Lower physical function and PA have also been related to poorer mental health (Ní Mhaoláin et al., 2012).

With regard to residents in ALFs, the association between physical function and PA is not clear. Even though physical function, assessed by the use of a walker, a cane, or neither, was not associated with PA, depression, fatigue or perceived health (Wyrick, Parker, Grabowski, Feuling, & Ng, 2008), another study revealed that residents living in ALFs who engaged in more MVPA showed better physical function assessed with functional measures, such as 400 metre walk speed or handgrip strength (Corcoran et al., 2016). Thus, as it is evident that many residents in ALFs are in need of assistance to perform ADL (e.g., wheelchair, walker, cane; National Centre for Assisted Living, 2001), lower levels of physical function may lead to poor quality of life in residents in ALFs. Thus, more attention should be paid to investigating factors related to the physical function of residents of ALFs, as well as older adults.

Mental health. Mental health is defined as “a state of well-being in which every individual realises his or her own potential, can cope with the normal stresses of life, can work productively and fruitfully, and is able to make a contribution to her or his community” (World Health Organization, 2014b). Mental health disorders are prevalent in 15% of older adults (World Health Organization, 2016c), and, as mentioned above, they are even more prevalent in older adults living in ALFs (e.g., residents` depression rate: 24%; National Centre for Assisted Living, 2001). The proportion is similar to the proportion of mental disorder prevalence in children and adolescents (approximately 20%) around the world (World Health Organization, 2014a). Therefore, it is imperative to examine mental health (e.g., more depression predicting less quality of life; Cao et al., 2016). In this section, quality of life, vitality, anxiety, depression, and fatigue will be described in a bit more detail.

Quality of life. Quality of life, which is defined as “a conscious cognitive judgment of one's life in which the criteria for judgment are up to the person” (p. 164, Pavot & Diener, 1993), is an important outcome measure for older adults. As mentioned above, even though people are living longer, this does not necessarily mean that people maintain health and independence throughout their life. Therefore, the individual’s perceptions of their life can be assessed by measuring quality of life, and this is typically assessed using self-reports. Quality of life can be influenced by different aspects of a person’s life, which include psychological health, physiological health, and also environmental aspects. Questionnaires to assess quality of life, therefore, often include a range of questions to reflect these different domains. For example, 26 items from the WHO Quality of Life, brief version (WHOQOL-BREF; Skevington, Lotfy & O’connell, 2004) assesses quality of life by reflecting different domains (i.e., physical, psychological, social and environmental aspects) and derive a measure of overall quality of life. Another measure is the Dartmouth CO-OP Chart (Jenkinson, Mayou, Day, Garratt, & Juszczak, 2002). This scale assesses a range of components that contribute to quality of life including physical fitness, feelings, daily activities, social activities, pain, change in health, overall health, social support and perceived quality of life. This questionnaire uses 9 figures to visualise the individual questions, which make it easier to understand what the questions are assessing and, therefore, more user-friendly (Anderson, Aaronson, & Wilkin, 1993). Associations have been reported between quality of life and measures of PA and SB. Older adults who engaged in more MVPA (Hart, 2016) or leisure time PA (Balboa-Castillo, León-Muñoz, Graciani, Rodríguez-Artalejo & Guallar-Castillón, 2011) have been reported to have a better quality of life compared to those who do not. Interestingly, quality of life in these studies was assessed based on a variety of indicators, including physical health, mental health, bodily pain, social functioning, and healthy days. Therefore, this suggests that PA could have an impact on the overall wellbeing of older adults. While PA has been positively related to quality of life, higher levels of SB have been associated with poorer quality of life (Balboa-Castillo et al., 2011; Meneguci, Sasaki, Santos, Scatena & Damião, 2015). Finally, the combination of being active and less sedentary was related to better quality of life compared to those who were less active and more sedentary (Bampton, Johnson & Vallance, 2015; Hart, 2016).

ALFs aimed to provide residents with person-tailored assistance to maintain an independent lifestyle (Hawes et al., 1999; Mollica & Johnson-Lamarche, 2005), which contributes to quality of life. There are reports of associations between PA/SB and aspects related to quality of life, such as falling incidence (Graafmans et al., 2003), better perceived health, muscle tone, balance improvement, better sleep and mood and more energy (Phillips & Flesner, 2013). However, to our knowledge more evidence should be added to the existing literature in terms of the associations between validated measures of quality of life and PA or

SB in people living in residential care settings and ALFs. For example, most studies reported in the literature have focused on older adults from community settings (Balboa-Castillo, León-Muñoz, Graciani, Rodríguez-Artalejo & Guallar-Castillón, 2011; Balboa-Castillo et al., 2011; Meneguci, Sasaki, Santos, Scatena & Damião, 2015). In addition, much of the research up to now in ALFs tend to have considered limited dimensions of quality of life rather than a wide range of factors (Graafmans et al., 2003; Phillips & Flesner, 2013). Given that the construct of quality of life is multidimensional, consisting of a range of factors (Costanza et al., 2007), this is an important limitation that needs to be addressed. Therefore, it would be interesting to explore how PA and SB are related to overall quality of life, as well as the factors that can contribute to quality of life in this particular population.

Vitality. Another facet that may contribute to mental health is vitality. According to Ryan and Frederick (1997), vitality is defined as "health of spirit" that is the consequence of both psychological and somatic factors. Vitality therefore assesses positive wellbeing. They also indicated that a greater experience of subjective vitality is related to more health-related behaviours, such as lower anxiety and depression, or better bodily functioning. Within the context of PA, it has been found that vitality was predicted by adequate engagement in PA (used the World Health Organisation guideline) in adults (mean age = 42.1; Marques et al., 2016). Moreover, subjective vitality has been increased by autonomy supportive instructing style, through an exercise intervention in middle-aged women (Kabitsis, 2012). In addition, another intervention study supported the previous study, showing increases of subjective vitality as a result of taking part in walking with an autonomy supportive leader in inactive adults (mean age= 46.59 years; Kinnafick, Thøgersen-Ntoumani, Duda, & Taylor, 2014). In older adults, those with greater levels of leisure time PA also had higher levels of vitality (Balboa-Castillo et al., 2011). Whereas PA is positively associated with vitality, time spent watching TV has been reported to be a predictor of poorer vitality scores in adults (Dempsey, Howard, Lynch, Owen, & Dunstan, 2014).

With regard to ALFs, higher levels of moderate PA were found to be positively correlated with vitality (Lobo, Santos, Carvalho, & Mota, 2008), however, to our knowledge, little is known about vitality in relation to SB in ALFs. In general, older adults tend to have higher levels of vitality when active, but an inverse association with anxiety (Losada Baltar et al., 2015), which indicates that lack of vitality may affect poor quality of life in residents in ALFs. Thus, more investigation may be needed to explore the role of subjective vitality in relation to PA and SB in older adults, particularly, among residents of ALFs.

Anxiety. Anxiety is defined as being "excessively fearful, anxious, or avoidant of perceived threats in the environment (e.g., social situations or unfamiliar locations) or internal to oneself (e.g., unusual bodily sensations)" (p.1; Craske & Stein, 2016). Anxiety symptoms have been reported to be prevalent in 3.2% to 15.4% in older adults (Wolitzky-Taylor, Castriotta, Lenze, Stanley, & Craske, 2010). Given that anxiety has been associated with health-related factors in older adults, it is interesting to explore the associations between anxiety and PA as well as SB. For example, there was a significant association of higher levels of anxiety and lower levels of self-reported PA in older adults (McKee, Kearney, & Kenny, 2015). Reviews have shown that moderate exercise (e.g., yoga, Tai chi; Sarris et al., 2012) was associated with lower anxiety. In contrast, SB was reviewed to be a positive determinant of anxiety in the general population (Teychenne, Costigan, & Parker, 2015). Moreover, evidence showed that there was a positive association between fear of falling and levels of anxiety (Sharaf & Ibrahim, 2008), which might negatively affect quality of life in residents of ALFs. Therefore, further research examining a range of factors that affect anxiety, in particular, in residents of ALFs, can be useful for health care providers to understand PA-related factors in residents of ALFs.

Depression. Depression is defined as “a common mental disorder that presents with depressed mood, loss of interest or pleasure, decreased energy, feelings of guilt or low self-worth, disturbed sleep or appetite, and poor concentration.” (p.6; World Health Organization, 2012). Depression is one of the detrimental symptoms that may lead to poor quality of life and weaker physical function (Gabriel & Bowling, 2004; Vanoh, Shahar, Yahya, & Hamid, 2016). In particular, lower performance was shown in those older adults who had depressive disorders (Vanoh et al., 2016). Seven percent of older adults suffer from unipolar depression (World Health Organization, 2016), which, in extreme cases, it can lead to suicide. It was also reported that a total number of 350 million people globally were influenced by depression (World Health Organization, 2012), which emphasises the need to explore factors that are related to depression. Previous research has shown associations between depression and PA. For example, in a cross-sectional study examining adults (aged over 20), Song, Lee, Baek and Miller (2011) found that engagement in light and moderate PA was associated with lower depression, which is in line with other studies (Catalan-Matamoros, Gomez-Conesa, Stubbs, & Vancampfort, 2016; Mura & Carta, 2013). Moreover, having higher depression was significantly associated with less engagement in self-reported PA in older adults (McKee et al., 2015). Looking specifically at older adults, a significant difference in depression was found between less active and more active older adults (Fernandez-Alonso, Muñoz-García, & Touche, 2016). In addition, maintenance of PA was related to reduced depressive symptoms during a 3-year follow up period (Yoshida et al., 2015). There was also a significant difference between those with and those without depressive symptoms in older adults in relation to self-reported SB time and PA time, with those with depressive symptoms spending more time sitting and less time being active in those with depressive symptoms (Teychenne, Abbott, Ball, & Salmon, 2014). It was found that more self-reported sitting time was associated with depression in adults (mean age= 43.55; Asztalos, Cardon, De Bourdeaudhuij, & De Cocker, 2015).

In ALFs, approximately, one third of residents were diagnosed as depressed (13%) or on antidepressants (18%; Watson, Garrett, Sloane, Gruber-Baldini, & Zimmerman, 2003). Moreover, there was an inverse association between depression and fear of falling in ALFs (Sharaf & Ibrahim, 2008). Thus, being depressed might lead to low quality of life in residents of ALFs. Given the known associations between depression and PA and SB in community dwelling older adults, it will be interesting to explore these associations in residents in ALFs using objective measures of PA.

Fatigue. Fatigue is defined as "an overwhelming experience [which] constrains physical capacity and the energy reserve required for appropriate functioning and social participation, as well as worsens their morbidity and mortality outcomes" (p. 216; Yu, Lee, & Man, 2010). Although fatigue was traditionally viewed as the notion of depleting energy resource, a modern concept of fatigue is articulated as a momentum to stop behaviours which consume too much energy and a motivational transition of behaviours (Eccleston, 2015). This is also in line with a physiological view of fatigue as a functional limitation which results in reduced muscle strength, increased errors of behaviours (Barsevick et al., 2010), and reduced work performance (Harrington, 2012). The central nervous system is implicated in two aspects of fatigue, mental and physical fatigue (Harrington, 2012). Adults commonly experience fatigue: 25% with a mean age of 47.1 years (Cullen, Kearney, & Bury, 2002); 41.3% of those aged 18 – 64 years (McAteer, Elliott, & Hannaford, 2011), and the proportion increases with age (29% of 70 year olds, 53% of 78 year olds and 68% of 85 year olds; Moreh, Jacobs, & Stessman, 2010). Evidence has shown that fatigue can result in depression, pain, and poorer walking performance, which may impact on the quality of life of older adults living in a long-term care setting (Liao & Ferrell, 2000). Furthermore, older adults who experience fatigue were more likely to have worse health status, poorer physical function, and more mortality than those without fatigue (Moreh et al., 2010; Hardy & Studenski, 2008). It is also acknowledged that fatigue was an important barrier for activities (e.g., staying in bed or restricted usual activities due to illness, injury, and other problems) for older adults (Gill, Desai, Gahbauer, Holford, & Williams, 2001). A previous study indicated that self-reported PA predicted mental fatigue in older adults, but this association was no longer evident when controlling for depression and sleep quality in community-dwelling older adults (Valentine, Woods, McAuley, Dantzer, & Evans, 2011). However, another study reported no such association between fatigue and PA in residents of ALFs (Wyrick et al., 2008), which may be due to small sample sizes or differences between older adults from two distinctive living settings (i.e., community, ALFs). Thus, exploring these associations in more detail is needed in residents of ALFs.

Bodily Pain. Bodily pain is frequently experienced by older adults (Patel, Guralnik, Dansie, & Turk, 2013; Sarkisian, Steers, Hays, & Mangione, 2005) in the form of negative sensations that do not easily disappear (Eccleston, 2015). Pain is a multidimensional construct affected by environmental (family, friends, community, culture), psychological (beliefs, mood), and physiological factors (somatic input: nociception; George et al., 2008; Turk & Okifuji, 2002). Pain has been associated with multiple mental and physical diseases (e.g., depression, anxiety, disability, social role loss, arthritis; Eccleston, Morley, & Williams, 2013; Breivik, Collett, Ventafridda, Cohen, & Gallacher, 2006; Caporali, Cavagna, & Montecucco, 2009). It may also lead to a poor quality of life due to function and health problems (Blyth et al., 2001;

Smith et al., 2001), as well as limiting behaviours (Eccleston, Morley, & Williams, 2013). If no relevant coping or treatment strategy is implemented, chronic pain could exacerbate and lead to disability (Eccleston, Tabor, Edwards, & Keogh, 2016). For example, a review showed a higher proportion of pain in general adults (11% to 60%) and this may be higher in older adults (Incayawar & Todd, 2013). Many older adults take medication to relieve the pain (Reid, Eccleston, & Pillemer, 2015). Importantly, pain is associated with negative health indicators such as depression (Reid, Williams, Concato, Tinetti, & Gill, 2003; Jacobs, Hammerman-Rozenberg, Cohen, & Stessman, 2006), loneliness (Jacobs et al., 2006), and fibromyalgia (McBeth, Lacey, & Wilkie, 2014). Both PA and SB have been related to bodily pain. For example, higher levels of PA in older adults (Balboa-Castillo et al., 2011; Cecchi et al., 2006; Silva, Queirós, Sá-Couto, & Rocha, 2016) were associated with lower bodily pain. However, an opposite association also existed (more acute pain after engaging in more PA than usual; Andrews, Strong & Meredith, 2015). With regard to SB, higher SB was associated with more pain (Balboa-Castillo et al., 2011). As addressed above, bodily pain has been linked with many health-related factors (Blyth et al., 2001; Smith et al., 2001), which may decrease the quality of life in older adults. Therefore, further research may be needed to add more evidence to the relation of bodily pain, PA, and SB.

For the most part, previous studies tended to focus on the independent relationships between PA and SB on mental health outcomes (e.g., the association between PA and depression; Song et al., 2011), and SB and quality of life (Meneguci et al., 2015). Moreover, MVPA and SB are known to independently predict physical health outcomes (e.g., metabolic syndrome; Bankoski et al., 2011, body strength, balance, aerobic endurance, upper flexibility; Santos et al., 2012) in older adults. Therefore, it is interesting to explore the combined prediction of health-related factors (e.g., SB, light PA, MVPA, physical function) on mental health outcomes.

Self-Determination Theory and Physically Active Lifestyles

Self-determination theory (SDT; Deci & Ryan, 2000; Ryan & Deci, 2000) is a motivation theory that explains the process of adoption of and adherence to behaviours. The theory states that there are three innate psychological needs the satisfaction of which predicts higher quality of motivation, which is subsequently related to beneficial health outcomes (Deci & Ryan, 2000). In this section, I will introduce the components and propositions of self-determination theory and how the components of this theory can contribute to PA and SB research.

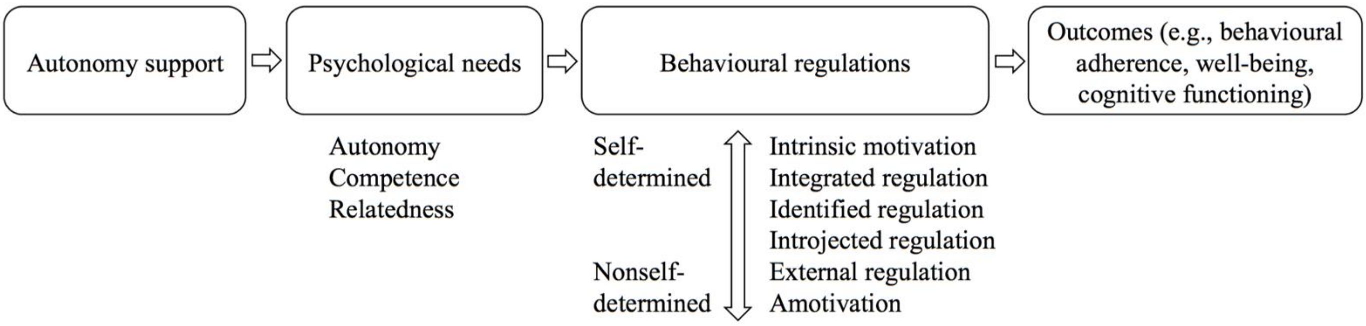


Figure 1.2. Self-determination process model showing autonomy support, psychological need, behavioural regulations, and outcomes, modified from Deci and Ryan (2000).

Autonomy support. Autonomy support from contextual factors such as friends, partners, and family members is important for the satisfaction of basic psychological needs (Deci & Ryan, 2000; Williams, Lynch, et al., 2006). Examples of autonomy support include the provision of choice, acknowledgment of negative affect, perspective taking, and the provision of rationale (Williams et al., 2006).

Psychological needs. Basic psychological needs are defined as “innate psychological nutriments that are essential for ongoing psychological growth, integrity, and well-being” (p.

229, Deci & Ryan, 2000). There are three innate psychological needs according to SDT, those for *autonomy*, *competence*, and *relatedness* (Deci & Ryan, 2000). Competence refers to the feeling “that one can effectively bring about desired effects and outcomes” (p. 420, Reis, Sheldon, Gable, Roscoe, & Ryan, 2000). Autonomy “involves perceiving that one`s activities are endorsed by or congruent with the self” (p. 420, Reis et al., 2000). Relatedness “pertains to the feeling that one is close and connected to significant others” (p. 420, Reis et al., 2000). When these psychological needs are satisfied, then one can experience psychological growth, integrity, and well-being (Deci & Ryan, 2000). Lack of need satisfaction results in psychological degradation or illness (Deci & Ryan, 2000).

Behavioural regulations. SDT also articulates that needs satisfaction influences the quality of motivation one holds (Deci & Ryan, 2000). According to Deci and Ryan (2000), there are six forms of motivation: namely, intrinsic motivation, integrated regulation, identified regulation, introjected regulation, external regulation, and amotivation. Intrinsic motivation refers to the most self-determined form of motivation, under which behaviours occur with intrinsic interest and enjoyment (Ryan & Deci, 2000). In the context of PA, older adults who are intrinsically motivated engage in a brisk walk because they enjoy walking. Integrated regulation is defined as “When identifications have been evaluated and brought into congruence with the personally endorsed values, goals, and needs that are already part of the self” (p. 18, Ryan & Deci, 2002). For example, older adults would go for a walk on a regular basis because being a regular walker is part of who they are. Identified regulation “involves a conscious valuing of a behavioural goal or regulation, an acceptance of the behaviour as personally important” (p. 17, Ryan & Deci, 2002), and is classified as a more self-determined form of extrinsic motivation than integrated motivation (Ryan & Deci, 2002). For example, some people may go to the gym because their doctors prescribed regular participation in exercise to maintain their physical health. Therefore, they are aware that they need to engage in PA because it is personally beneficial. Introjected regulation refers to “a type of extrinsic motivation that, having been partially internalised, is within the person but is not considered part of the integrated self” (p. 17, Ryan & Deci, 2002), and it is considered to be a controlled form of motivation (Ryan & Deci, 2000). An example of introjected regulation is engagement in a group exercise class in ALFs or retirement villages, where participants take part in a walking programme because they would feel guilty if they didn’t. External regulation refers to “the classic instance of being motivated to obtain rewards or avoid punishments” (p. 17, Ryan & Deci, 2002), and is the least self-determined form of extrinsic motivation (Ryan & Deci, 2000). In the context of PA, this could be a competition to win a prize for completing a 10,000 step walk within a certain period. When individuals are amotivated, this refers to “the state of lacking the intention to act” (p. 17, Ryan & Deci, 2002). Autonomous forms of motivation (intrinsic motivation, as well as integrated and identified regulations) are considered to be higher quality motivation in comparison to controlled motivation (introjected and external regulations; Deci & Ryan, 2000). Furthermore, it is believed that, by providing autonomy support, the basic psychological needs are met, which leads to higher quality of motivation and more positive outcomes (e.g., more engagement in PA; Ng, Ntoumanis, & Thøgersen-Ntoumani, 2014). Previous studies testing the SDT propositions within the contexts of PA and SB will be addressed in the following section.

Relationships between SDT Constructs and Motivation-Related Outcomes

Numerous studies have been conducted using SDT to predict PA and motivation-related outcomes (Teixeira, Carraça, Markland, Silva, & Ryan, 2012). For example, autonomy support from important others, such as a spouse or friend, was related to more autonomous regulation and, subsequently, to higher subjective vitality in an exercise referral scheme

(Rouse, Ntoumanis, Duda, Jolly, & Williams, 2011). In addition, an intervention study revealed that people who received more autonomy supportive exercise classes reported a higher degree of autonomy support, autonomy, and competence need satisfaction, identified and intrinsic motivation, and subjective vitality in middle-aged women (mean age: 44.26; Kabitsis, 2012). In a meta-analysis, Ng et al. (2012) tested a model of the SDT continuum within health-related outcomes (e.g., mental health, physical health). They found that a greater level of autonomy support led to better satisfaction of three psychological needs, which, in turn, were associated with positive autonomous motivation, as well as mental and physical health. Ng, Ntoumanis, and Thøgersen-Ntoumani (2014) further examined the operation of the abovementioned SDT construct in an exercise and weight management setting in adults (Ng et al., 2014). They found that more autonomy supportive environments, provided by important others, positively influenced satisfaction of psychological needs and autonomous motivation, which, in turn, led to more engagement in PA and healthy eating. This finding is also in line with a study conducted by Yu et al. (2015) in rheumatoid arthritis patients (mean age = 58 years), in which autonomy support was related to need satisfaction, which was subsequently related to autonomous motivation, which in its turn was associated with more PA and higher vitality. With regard to SB, autonomy support from coaches has been found to predict less time spent in SB via more autonomous motivation in young children (Fenton, Duda, Quested, & Barrett, 2014).

However, there is still need for more research on SDT and its relation to lifestyle factors. For instance, relatively little is known about the relationship between SDT factors and PA or SB in older adults. Given that satisfaction of the three identified needs may vary as people age (Ryan & Deci, 2000), it is interesting to explore these factors in more detail in this population. Moreover, the SDT based literature tend to use self-reported measures of PA or exercise (Adie, Duda, & Ntoumanis, 2008; Ng et al., 2014; Rouse et al., 2011). In this regard, it may be interesting to examine the different forms of motivation in relation to objectively-assessed light PA, MVPA, and SB in older adults. Furthermore, SDT generally focuses on the individuals' perceptions of whether significant others are supportive or not (Ng et al., 2014; Yu et al., 2015). However, relatively little research has been done on whether the physical environment plays a role in individual's need satisfaction and quality of motivation. Hence, it would be worth examining SDT components and how they relate to the perception of the physical environment, particularly in older adults.

Physical Environment and Social Ecological Models

Physical environments are closely related to physically active lifestyles (Saelens, Sallis, & Frank, 2003). In a UK-based study, greater levels of objectively-assessed PA were evident when there were more places to visit in the neighbourhood (e.g. shops, post office), as well as increased participation in social activities (e.g., meeting friends; Davis, Fox, Hillsdon, Sharp, et al., 2011; Davis, Fox, Hillsdon, Coulson, et al., 2011). In addition, accessibility and positive perceptions of the environment with regard to physical environments were positively associated with objectively-assessed PA participation (Stathi et al., 2012), although the results have not always been consistent (Van Cauwenberg et al., 2011). Interestingly, there is also evidence for interactions between the physical environment, PA and basic psychological needs satisfaction; when the perceptions of the environment are more favourable, people tend to have high levels of basic psychological needs satisfaction, which leads to increased levels of PA (Gay, Saunders, & Dowda, 2011). In particular, social ecological models demonstrate that behaviours can be influenced by intrapersonal factors (demographics, psychological factors), perceived environment (safety, attractiveness), behaviour (active recreation, active transport), behaviour settings (recreation environment, neighbourhood) and policy environment (transport investments and regulations, public recreation investments; Sallis et al., 2006; Sallis, Owen, & Fisher, 2008). The models suggest that a range of variables (e.g., perceived environment, access to PA facilities) play a role in explaining physically active lifestyles (Sallis et al., 2006; Sallis et al., 2008), as different individuals perceive their physical environment differently (Kurka et al., 2015). For example, the degree of positive perception of the neighbourhood environment (e.g., based on existence of litter and garbage, sidewalk maintenance, aesthetic) is associated with more physically active lifestyles in female adults (Lees et al., 2007). This is particularly interesting to explore in older adults given that this population engages in less PA (Hagströmer et al., 2010; Troiano et al., 2008) and more SB (Davis et al., 2014; Matthews et al., 2008).

Relationships between Physical Activity, Sedentary Behaviour, and the Physical Environment. Evidence suggests that older adults engaged in more walking activities when they considered their environments to be safe and close to recreational facilities (Li, Fisher, Brownson & Bosworth, 2005). Self-reported PA was positively predicted by better perceptions of the physical environment, i.e., when older adults indicated that their neighbourhood characteristics were perceived as more encouraging for PA (e.g., biking and walking trails, street light, recreational facilities; Chad et al., 2005). In contrast, higher levels of SB have been reported in areas with a high crime rate (Schutzer & Graves, 2004). Furthermore, according to a review (Schutzer & Graves, 2004), older adults were significantly more likely to be sedentary when they lived far away from exercise and PA-related infrastructures (e.g., a recreational facility, park, golf course, swimming pool).

Rodiek (2008) identified that residents of ALFs considered the physical environment (e.g., plants, views and seating facilities) as a determinant of greater engagement in outdoor activities. Moreover, previous studies in ALFs showed the importance of the physical environment in relation to more engagement in PA (Lu et al., 2015). However, little is known about the association between the perceptions of the physical environment and SB in residents of ALFs. In addition, it is also not yet clear how the perception of the physical environment can interact with the motivational contexts (Zhang & Solmon, 2013). For example, it has recently been suggested that the integration of two different concepts (motivation and physical environment) may fill a gap in understanding the associations with engagement in PA and avoidance of prolonged SB (Fleig et al., 2016; Zhang & Solmon, 2013). This is because social ecological models may not specify key factors to incorporate with targeted interventions, whereas psychological concepts such as motivation could better identify key factors in relation to behaviours (Sallis et al., 2008; Zhang & Solmon, 2013).

Latent Profile Analysis and Ecological Momentary Assessment

Latent Profile Analysis. There are different statistical approaches to exploring associations between variables, a variable-centred approach and a person-centred approach. The variable-centred approach is used "to predict outcomes, study how constructs influence their indicators, and relate independent and dependent variables in structural equations" (p. 882; Muthén & Muthén, 2000). The variable-centred approach aims to examine whether independent variables predict dependent variables or the relationships between variables such as through regression analysis, factor analysis, and structural equation modelling (Muthén & Muthén, 2000). For example, in multiple regressions, the extent to which the variance in the predicted outcome measure (e.g., PA or SB) can be explained by several measures (e.g., depression, functional ability) is assessed. In this variable centred approach, the aim of study is to examine which variable significantly and independently predicts the outcome variable. However, as described above, there are many factors that can influence PA and SB, such as motivational factors (Deci & Ryan, 2000) and perceptions of the neighbourhood environment

(Adams et al., 2011), therefore in order to get a better understanding of the factors related to PA and SB, another approach might provide more information.

The person-centred approach is used “to group individuals into categories, each one of which contains individuals who are similar to each other and different from individuals in other categories” (p. 882; Muthén & Muthén, 2000). The person-centred approach focuses on the unobserved relationships by grouping individuals based on patterns of indicators (Muthén & Muthén, 2000), so that individuals within the same group have the homogeneous profiles. This approach can produce certain distinct classes of participants within a sample, whereas the variable-centred approach mainly considers associations among variables, not people (Berlin, Williams, & Parra, 2014). As an example, a research question that can be answered using multiple regression (i.e., a variable-centred approach) is “Does a supportive social and physical environment predict engagement in physical activity in older adults?” In contrast, a research question that can be answered using LPA (a person-centred approach) is “Are individuals who are classified as highly supported by social and physical environments, more physically active than individuals who are less supported by social and physical environments?” Examples of person-centred approaches are latent class analysis, latent transition analysis (Muthén & Muthén, 2000), and latent profile analysis (LPA; for continuous indicators; Laursen & Hoff, 2006). LPA classifies typical patterns of information (e.g., types of people in group) in individuals (e.g., types of people within the context of theories; Bergman & Magnusson, 1997) based on their similarities within classes and dissimilarities between classes (Muthén & Muthén, 2000). Therefore, this approach enables researchers to explore if people in the same groups have statistically similar indicators (e.g., backgrounds, personality, similar levels of PA). For instance, Gerber et al. (2014) found that individuals who were classified as engaging in more self-reported MVPA were less likely to be “highly burdened (a higher level of effort-reward imbalance, job demand and control, burnout symptoms, depression, anxiety)" and "stressed (lower levels of all variables than highly burdened)" than adults who were classified as less physically active. In another study, LPA grouped adult individuals (mean age= 44.0 years) based on neighbourhood environment (measured by geographic information system; Adams et al., 2015). A comparison between the groups showed that the proportion that met objectively-assessed MVPA recommendation was significantly higher among those living in a more PA friendly environments (e.g., high residential density, land use mix, pedestrian-oriented design, intersection density, transit access, and access to fitness facilities and parks) compared to those living in less PA friendly environments (Adams et al., 2015). Taken together, LPA may provide new insights in exploring a range of determinants of PA and SB based on unobserved individual differences. Given that a person-centred approach is based on the concept that individuals have different profiles, and, therefore, differences in patterns of variables may exist, whereas the variable-centred approach is based on the assumption that individuals are homogeneous with respect to predicting variance in outcomes (Laursen & Hoff, 2006), the person-centred approach might be most effective in exploring a range of factors related to PA and SB. Therefore, LPA could be particularly relevant in older adults, whose health indicators are known to vary. Furthermore, with regard to residents of ALFs, who can have considerable differences in health status (Kraditor et al., 2001), it can be very informative for staff of ALFs to know which "types of residents", based on statistical properties, might benefit most from changing behaviour or are most at risk for developing health problems. As a result, services or PA programs tailored to residents can be more effective. Furthermore, as mentioned above, in order to identify "types of resident", a range of indicators that represent residents based on both psychological and physical health is needed. In this case, a person-centred approach is a robust option to employ.

There are a few steps to follow when conducting LPA (Muthén & Muthén, 1998-2017). First, profile indicators were standardised (z scores) to allow for differences in the measurement scale of the variables. Then, it was considered if the *k* model fits better than the *k-1* model based on a number of statistical indices [p value, the Akaike Information Criterion (AIC), the Bayesian Information Criterion (BIC), and the proportion of participants in each class]. Furthermore, the conceptual interpretation of the distribution of characteristics within each class was taken into account to determine the number of classes. Although LPA offers several indices to make such decisions, model selection is not always objective (Tein, Coxe, & Cham, 2013) as the final class solution needs to make conceptual sense.

Ecological Momentary Assessment. Ecological momentary assessment (EMA) is a method to collect self-reported (which can be objective when it comes to biofeedback measurement) data in the real-world environment (Shiffman, Stone, & Hufford, 2008). The authors use the word of "ecological" to identify that the information is based on participants' real lives. The word "momentary" is used to specify that the information is collected at that time, which may improve the quality of answers compared to typical retrospective questions. In particular, bias from retrospective questions are common across all age groups (Celis-Morales et al., 2012), therefore, using EMA can be especially useful for older adults because they may be more likely to answer correctly.

Recent advances in technology (e.g., smart phone) have facilitated the EMA method to collect data in a real-time setting. Typically, a smart phone application can be developed for the use on Windows OS or Mac OS (Bolger & Laurenceau, 2013). For example, researchers are able to add a number of questions and set times with alarms to be prompt participants to answer regarding their momentary state (Bolger & Laurenceau, 2013). This is certainly beneficial for older adults, as participants do not need to think too far back into their past (e.g., 7days, 1month), which is less burdensome from a cognitive perspective (Bolger & Laurenceau, 2013). In addition to reducing the bias from retrospective assessments, EMA also allows researchers to collect data regarding variables which may vary between and within days.

In general, there are two steps to the process of collecting data using the EMA method, which includes baseline data and daily data. To collect baseline data (which can be called typical data), participants are asked to complete baseline questionnaires that refers to their general state over a certain period. Thus, the baseline questionnaires allow for the assessments of associations at the between-person level. To collect the daily data, participants are provided with a mobile device on which they will be prompted to complete a series of questions over the course of several days. In general, one or two questions related to the construct of interest are selected and participants are asked to answer these on the mobile phone or tablets (Maher & Conroy, 2016). Although, this still relies on self-reports, this method is useful to overcome memory bias as it asks about either the current or very recent state of the person instead of the last week or month (Wenze & Miller, 2010; Schiepek et al., 2016). Therefore, the use of daily questions may reduce data bias, particularly with older adults (Shiffman, 2009). In EMA studies, researchers install an application to ask daily questions on either smart phones, tables, or other similar devices. When prompted, participants answer the question by clicking the icons on the device screen. All data provided by participants will be stored either on the device or a server via online networks and are time stamped. Precautions and additional training is needed when the participants are not familiar with these devices, as this can influence their ability to answer the questions correctly (Heron & Smyth, 2010). The timing of the prompts should also be considered carefully. Even though it may be tempting to ask the questions frequently throughout the day, this could influence the compliance with the data collection (Intille, Haynes, Maniar, Ponnada, & Manjourides, 2016).

Multilevel modelling can be used to explore within- and between-person associations of lifestyle factors. Multilevel modelling also has the strength of being able to examine variance even if an assumption of homoscedasticity is observed, therefore, the model even make it possible to explore heterogeneity of variance (Kuppens & Yzerbyt, 2014). Real-time data facilitates analysing repeated observations at the within-person level and the between-person level (Bolger & Laurenceau, 2013; Heck & Thomas, 2015). Typically, person-mean centred daily data are used as within-person level variables (Bolger & Laurenceau, 2013). Uncentred means of variables from baseline questionnaires or other relevant covariates (e.g., demographics) can be added as between-person level variables. As a result, researchers are able to identify whether fluctuation of data is different within individuals (using person-mean) or between individuals (using baseline mean).

Using this method, Maher et al. (2013) found the within-person association between subjective well-being and PA suggesting that more engagement in daily self-reported PA predicted higher levels of subjective well-being in adults (mean age 18-25). Moreover, several studies have been conducted using EMA in relation to PA or SB in various age groups. For example, daily subjective well-being was predicted by daily PA at the within-level (Maher et al., 2013). A separate within-person association was observed between daily SB (objective measure) and daily life satisfaction, between daily PA (self-report) and daily life satisfaction (Maher & Conroy, 2015). Therefore, by examining the within and between-person associations in relation to activity and mental health indicators, we would be able to identify relationships of lifestyle-related factors in a more specific way.

Objectives of Dissertation and Outline of Studies

The overarching aim of this thesis was to investigate the relationships between factors associated with objectively assessed light PA, MVPA, and SB in older adults. More specifically, we used an array of measures to assess physical (e.g., gait speed, grip strength, spirometry, BMI) and mental health, motivational processes, and perceived physical environment. We also examined the within-person association of light PA, MVPA, and SB, and bodily pain and fatigue using a mobile application in a real-life setting.

In Study 1 (Chapter 2), latent profile analysis was conducted to develop profiles based on light PA, MVPA, SB, and physical function (gait speed, grip strength, spirometry, BMI) of residents in ALFs. Subsequent analyses were conducted to explore differences between the profiles on a range of mental health indicators (e.g., perceived mental health, quality of life, vitality, anxiety, depression, fatigue). Eighty-five residents from ALFs were recruited, who completed baseline questionnaires for mental health factors and demographics and conducted physical function tests. Afterwards, an accelerometer was distributed to participants to observe their activity factors (light PA, MVPA, and SB) over seven days. In the analyses, profiles were classified based on the homogeneity of participants and theoretical concepts. Finally, we conducted difference tests of the profile groups on mental health indicators. It was hypothesised that individuals with higher levels of engagement in light PA and MVPA may also have better physical function, but lower levels of engagement in SB, which, in turn, predicts better scores in relation to mental health outcomes.

In Study 2 (Chapter 3), we examined a theory integration of SDT and physical environment. In total, 87 participants from ALFs participated in the study. Participants competed baseline questionnaire in two concepts: SDT and the perception of physical environment. To measure objective light PA and MVPA, each participant was instructed to wear an accelerometer over 7 consecutive days during waking hours. Latent profile analysis was used to develop profiles based on the degree of perceived autonomy support by important others, perceived physical environment within a PA regime, basic psychological needs, and motivation. Difference tests were conducted between profile groups and levels of PA (light PA, MVPA). It was hypothesised that individuals with better levels of self-determination and perception of the physical environment showed more engagement in light PA and MVPA.

In Study 3 (Chapter 4) within-person associations of light PA, MVPA, and SB with bodily pain and fatigue were tested. In total, 63 older adults from community-living settings completed the assessments. PA was assessed objectively using accelerometers. Ecological momentary assessment using a mobile phone was conducted to ask about their perceived bodily pain and fatigue at the end of each day. Participants were instructed to wear an accelerometer and carry a smart phone (or a PDA) to measure PA and daily questions respectively for seven days. Within-person associations between daily light PA, MVPA, and SB in relation to fatigue were tested using multilevel modelling. In addition, interaction effects of typical fatigue, physical health between light PA, MVPA, SB and fatigue were examined. It was hypothesised that daily PA and SB would fluctuate at the within-level and would be moderated by typical fatigue and physical health outcomes. The hypothesis for bodily pain has not been set because inconsistent literature was found.

Chapter 2

Profile of Physical Function, Physical Activity, and Sedentary Behaviour and their Associations with Mental Health in Residents of Assisted Living Facilities

Abstract

The risk of mental health problems increases with aging. The current study used latent profile analyses (LPA) to identify classes of participants based on physical health, physical function, light physical activity (PA), moderate-to-vigorous physical activity (MVPA), and sedentary behavior, and then examined differences in mental health between these classes. 85 residents (*M* = 77.5 years old, *SD* = 8.2) from assisted living facilities participated in this study. Light PA, MVPA, and sedentary behaviour were assessed by accelerometers, physical function was measured using different tasks (mobility, grip strength, and spirometry), and BMI was calculated. Mental and physical health were assessed by questionnaires. LPA revealed three classes: 'Class 1: Low physical function and PA with a highly sedentary lifestyle' (27.1%), 'Class 2: Moderate physical function and PA with a moderate sedentary lifestyle' (41.2%), 'Class 3: High physical function and PA with an active lifestyle' (31.8%). The results revealed that the latter class reported better mental health than the other two classes. This study suggests that health promotion for older adults might benefit from identifying profiles of movement-related behaviours when examining the links between PA and mental health. Future research should test the intervention potential of this profiling approach.

Introduction

With an increasingly aging population, it is important to explore factors related to maintaining good physical and mental health in older age. Recent evidence indicates that approximately 15% of older people (≥ 60 years) across the world are diagnosed with a mental health disorder (WHO, 2016). This study examined mental health and some of its movement-related correlates in residents in assisted living facilities (ALFs). ALFs offer assistance with daily living activities, but the residents are largely independent (Carder, 2002). Poor mental health is prevalent in older adults residing in these settings and related to transfers to nursing homes (Aud & Rantz, 2005; Watson et al., 2003) such transfers have individual and societal costs (Hawes et al., 1999).

A physically active lifestyle is central to maintaining mental health in older adults. For example, engagement in objectively-assessed daily moderate-to-vigorous physical activity (MVPA) is related to lower prevalence of depressive symptoms (Vallance et al., 2011). Light physical activity (PA), the most common intensity of PA for older adults, can also be important for reaping mental health benefits (Buman et al., 2010; Song, Lee, Baek, & Miller, 2011). Recent evidence also indicates that sedentary behaviour (SB; e.g., television viewing) is negatively associated with psychological health in adults independently of PA. For example, higher levels of television viewing predicted poorer mental health (Hamer, Stamatakis, & Mishra, 2010) and increased risk of depression in adults (Teychenne, Ball, & Salmon, 2010).

Older adults living in ALFs are at greater risk of experiencing compromised psychological health (Watson et al., 2003), and have lower levels of light PA compared to those living independently (Moran et al., 2015). Given the important roles of PA and SB in mental health in community dwelling older adults, gaining more knowledge about these associations in people living in ALFs might be informative to improve mental health in this particular population of older adults.

Physical function is another factor related to physical and mental health in older adults. For example, better physical function has been related to less time spent sedentary (Lee et al., 2015) and a smaller risk for re-hospitalization (Soley-Bori et al., 2015). However, the reported associations between physical function and mental health in people living in ALFs are inconsistent. For example, a pilot study of ALF residents revealed no associations between the use of a walking aid and depressive symptoms (Wyrick et al., 2008), but grip strength and repeated chair rise were related to depression in another study (Giuliani et al., 2008). Such inconsistent findings might suggest that when exploring the associations between functional ability and mental health, it is important to incorporate a range of measures of physical function. Given that some of the measures have been reported to be influenced by PA, levels of PA should also be taken into consideration. Unfortunately, studies that reported on associations between physical function and mental health in residents of ALFs did not report PA.

Latent profile analysis (LPA) was used to identify such profiles. With this method, individuals are classified into distinct classes on the basis of their homogeneity of scores for different behaviours (i.e., light PA, MVPA, physical function, and SB; Soley-Bori et al., 2015). Subsequently, differences between the classes of people on dependent variables of interest can be explored. This person-centred model can be distinguished from a variable-centred model (e.g., regressions, ANOVAs) in which the aim is to explore relations between variables, ignoring how these variables are combined within people. A person-centred model is more appropriate when individuals in a sample have heterogeneous characteristics (Muthen & Muthen, 2000). In addition, it is possible to determine the scores of indicators in each group, which may help to find indicators with big effect sizes among each class of participants (Marsh, Lüdtke, Trautwein, & Morin, 2009). In particular, LPA is robust enough to test multiple predictors for group classification and dependent variables for comparison tests (Wurpts & Geiser, 2014). In contrast, multivariate tests with the variable-centred models are sometimes challenging due to assumptions (e.g., number of variables, normality). As such, this model is more suitable for use when considering the variable health status of residents in ALFs. Previous studies adopting LPA revealed that different profiles reflecting mental health and health-related variables were related to self-reported PA in middle aged adults (Gerber & Jonsdottir, 2014). To date, LPA has not been used to explore the associations between physical function, light PA, MVPA, SB, and mental health in older adults. The primary aim of this study was, therefore, to examine such associations using LPA. We hypothesized that a number of distinguishable profiles would be identified based on individuals' physical function, physical health, light PA, MVPA, and SB proportions. Further, we expected the individuals in profiles with better physical function, more light PA, more MVPA, and less SB would report better mental health than those individuals in profiles with worse physical function and less movement.

Methods

Participants

Participants were recruited from 13 ALFs across England. ALFs were identified through either online searches or via websites (www.housingcare.org). Following approval from managers of interested facilities, residents were informed of the study through their ALF newsletter or well-being staff, as well as during coffee morning or monthly meetings (a tea time in which residents are free to meet and chat with other residents in the lounge of ALFs). Therefore, samples were randomly selected. Participants were all volunteers and were not compensated with any physical rewards for their participation. A total of 85 residents (female= 68.2%, male= 31.8%, M_{age}= 77.46, SD= 8.17 years) took part in the study (see

Table 2.1). Demographic information and disease prevalence are reported in Table 2.1. Residents who needed a wheelchair or scooter for their daily activities were excluded from the study. The majority of the participants did not use an assistive device for walking (80%); only 9 participants (10.6%) used a stick and 8 participants (9.4%) used a walking frame. The study was approved by the Ethical Review Committee of a UK university. All participants provided informed consent before participating.

Procedures

All assessments were carried out in a dedicated space in the participants' ALF. All participants completed two testing sessions, which were scheduled one week apart. At the beginning of the first session, research staff explained all procedures to the participants. After this, body composition, spirometry, grip strength, and timed up and go assessments were conducted. These measurements took approximately 40 minutes and were carried out between 9 am and 4 pm. Following these measurements, a questionnaire pack was given to participants, who were asked to complete it during the next week. In addition, participants were given an accelerometer to wear during that week, and were asked to keep an activity diary to record the wear time of the accelerometers.

Measures

Body composition: A portable body composition monitor (TANITA BC-545N) was used to measure weight (kg). Height (m^2) was measured using a stadiometer (Seca Leicester Height Measure). BMI was calculated using the formula: weight [kg] / height [m^2].

Lung function: *S*pirometry was conducted to measure lung function using a hand-held spirometer (Micro Medical Micro Ms03 spirometer). Participants were seated for at least 5 minutes before the assessment was taken, and remained seated throughout. First, a clip was placed on the nose of the participants to prevent exhaling or inhaling through the nose. All participants conducted this assessment twice with a short break in between the assessments.

Forced expiratory volume in 1 second was provided and reported on the screen of the monitor. Forced expiratory volume in 1 second was recorded as the highest volume of exhaling (American Thoracic Society, 1987). The mean of two forced expiratory volume in 1 second results was taken and was standardised by height^2 (forced expiratory volume in 1 second/ht^2) (Miller, Pedersen, & Dirksen, 2007).

Grip strength test: Grip strength was measured using a digital dynamometer (TAKEI T.K.K. 5401 Grip-D, Japan). Participants were asked to stand up and grip the dynamometer as tight as possible with their dominant hand (Shinkai et al., 2003). The test was conducted twice, with the second test done approximately 10 seconds after the first assessment. The average of the two measurements of grip strength was calculated and expressed in kg.

Mobility test: The Timed Up and Go test was conducted to measure mobility, including the use of assistive device, and balance (Podsiadlo & Richardson, 1991). Participants were asked to get up from their chair, walk 3 meters and return to the chair. A researcher demonstrated the procedure and participants were given the opportunity to practice.

Subjective physical and mental health: The SF-12 was used to measure physical health and mental health of the participants (Ware, Kosinski, & Keller, 1996). In this 12-item questionnaire (6 items for each sub scale) participants were asked to respond to statements which asked about their general physical and mental health over the last 4 weeks (e.g., “During the past 4 weeks, how much did pain interfere with your normal activities?”; “During the past 4 weeks, did you have a lot of energy?”). Items were weighted and summed according to existing guidelines (Ware, Kosinski, & Keller, 1998). A higher score of subjective physical health and mental health indicates better physical and mental health respectively.

Subjective vitality: The 5-item subjective vitality scale was selected (Ryan & Frederick, 1997). Items (e.g., “I felt alive and full of vitality”) were rated on a 7-point scale ranging from 1 (*not at all true*) to 7 (*very true*). Participants' responses across the 5 items were averaged to provide an overall score for subjective vitality.

Anxiety and depression: The Hospital Anxiety and Depression Scale (HADS) was used to measure anxiety and depressive symptoms (Zigmond & Snaith, 1983). This questionnaire comprises 7 items to measure anxiety (e.g., "I can sit at ease and feel relaxed") and 7 items for depression (e.g., "I still enjoy the things I used to enjoy"). The items were summed for analysis.

Fatigue*:* Feelings of "general fatigue", "physical fatigue", "reduced activity", "mental fatigue", "reduced motivation" were assessed using the Multiple Fatigue Index (MFI-20; Smets, Garssen, Bonke, De, & Haes, 1995). A five-point scale was used ranging from (1) *yes, that is true* to (5) *no, that is not true* to answer questions (e.g., "I feel fit"). For the purpose of LPA, individual subscales were calculated and all subscales were summed to represent the overall degree of fatigue experienced.

Quality of life: Quality of life was measured using the Dartmouth CO-OP Chart (Jenkinson, Mayou, Day, Garratt, & Juszczak, 2002). The scale identifies 9 domains relevant to quality of life (i.e., physical fitness, feelings, daily activities, social activities, pain, change in health, overall health, social support, and quality of life), and a reference is made to the past 4 weeks (e.g., for emotional problems: "During the past 4 weeks, how much have you been bothered by emotional problems such as feeling anxious, depressed, irritable or downhearted and sad?"). A total score was used for the purposes of LPA.

Physical activity and sedentary behaviour*:* Activity monitors (models: GT3X+, WGT3X-BT; ActiGraph, Pensacola, FL, USA) were used to assess SB, light PA, and MVPA. These two accelerometer models have demonstrated high intra-monitor reliability and have been validated with acceptable criteria (Miller, 2015). The monitors were set to collect counts at 60s epochs. An algorithm was adopted to classify non-wear time (consecutive zeros: 90

minutes, tolerance allowance: 2 minutes between 0 and <100 counts; Choi, Ward, Schnelle, & Buchowski, 2012). Participants were instructed to wear their monitor on their right hip and to remove it during sleep and water-based activities (e.g., showering, swimming). Based on the daily start and stop times of wearing accelerometers recorded in a time log by participants, we set a time frame to represent waking hours (7 am – 10:30 pm). Data recorded during this time frame were extracted to determine minutes per day spent sedentary and in different intensities of PA. Inclusion criteria for valid accelerometer data were 10 hours of wear time per day, on a minimum of 3 days, including a weekend day. Data from participants meeting these criteria were retained for use in subsequent analyses (*N* = 101, accelerometer protocol compliance = 89, no questionnaire responses = 4). The final sample, therefore, included *N* = 85 participants. Classification of the accelerometer data was conducted using criteria by Matthews et al. (2008) for SB, and Troiano et al. (2008) for light PA and MVPA: sedentary = 0 to 99 counts per minute (cpm), light PA = 100-2019 cpm, moderate PA = 2020-5998 cpm, vigorous PA = ≥5999 cpm. The sum of moderate PA and vigorous PA represented MVPA.

Minutes spent sedentary, in light PA, and in MVPA recorded across all valid days were summed and divided by the number of valid days to determine minutes/day spent in each activity. For the purpose of LPA, activities were expressed as a percentage of wear time (calculated as minutes spent in each activities (min/day) / average wear-times (min/day) x 100), in order to adjust for inter-participant variability in accelerometer wear time (Booth et al., 2014).

Statistical analysis

IBM SPSS version 22.0 was used to calculate descriptive statistics and estimate bivariate correlations. Missing data (26 items from different questionnaires were missing) were imputed using the expectation maximization (EM) algorithm (Enders, 2001). We ran LPA in Mplus version 7.4 (Muthén & Muthén, 2015) using the robust maximum likelihood

(MLR) estimator. All physical function variables (continuous) were standardized into *z*-scores. The BCH method (Asparouhov & Muthén, 2014) was employed for class comparisons using the mental health variables as (continuous) as auxiliary distal outcomes. A nested model comparison approach was used, comparing more complex models (*k*-class model) with simpler models (*k*-1 class model) to determine the number of classes to retain in the final model. We estimated models with one to four latent classes. When deciding on the final latent class solution, we used a number of statistical criteria, such as the Akaike information criterion (AIC), Bayesian information criterion (BIC), the sample-size adjusted BIC (SSA-BIC), Lo-Mendell-Rubin adjusted LRT test (adjusted LMR), bootstrapped likelihood ratio test (BLRT), entropy, and proportion of participants in each class. Lower AIC, BIC, and SSA-BIC values indicate better model fit. Statistically, significant adjusted LMR and BLRT values indicate that the *k*-class model provides a better fit to the data compared to the *k*-1 class model. In addition, higher entropy and the proportion of participants in each class were also considered when comparing the nested models. We took the class size into account because very small class sizes may result in imprecision and low power (Berlin et al., 2014). These statistical criteria, in combination with substantive meaning, guided the choice of the final model (Marsh et al., 2009). Finally, we conducted chi-square difference tests using the BCH method to examine differences amongst the classes regarding mental health. Initially, 100 starting values were used with the 20 best retained for the final solution. The final model was also replicated using 500 random start values.

Results

Table 2.2 displays the descriptive statistics and bivariate correlations between the study variables. The participants spent on average 201.13 min/day (SD= 71.96) in light PA, 9.74 min/day (SD= 9.62) in MVPA, and 511.93 min/day (SD= 105.72) in SB. As can be seen from Table 2.2, light PA, MVPA, subjective physical health, forced expiratory volume in 1 second, and mobility were positively correlated with mental health, whereas SB was negatively correlated with mental health. No statistically significant correlations were found between grip strength, BMI, and mental health.

Table 2.1

Demographics and Characteristics of Participants

Variable	
Age, *M* (*SD*)	77.46 (±8.17)
Sex, *n* (%)	85
Male	27 (31.8 %)
Female	58 (68.2 %)
Education	
Secondary, *n* (%)	26 (30.6 %)
Higher, *n* (%)	8 (9.4 %)
Post graduate, *n* (%)	1 (1.2 %)
Other, *n* (%)	8 (9.4 %)
None of above, *n* (%)	32 (37.6 %)
Missing	10 (11.8 %)
Age left school, *M* (*SD*)	15.29 (*SD* 1.13)
Missing, n (%)	3 (3.5 %)
Marital status	
Married/co-habitated, *n* (%)	35 (41.2 %)
Widowed, *n* (%)	39 (45.9 %)
Single (never married), *n* (%)	2 (2.4 %)
Separate, *n* (%)	9 (10.6 %)
No. of children, *M* (*SD*)	2.4 (*SD* 1.29)

Missing, *n* (%)	2 (2.4 %)
Alcohol consumption	
Current, *n* (%)	51 (60.0 %)
Previous, *n* (%)	17 (20.0 %)
Never, *n* (%)	15 (17.6 %)
Missing, *n* (%)	2 (2.4 %)
Smoking	
Currently, *n* (%)	4 (4.7 %)
Previously, *n* (%)	43 (50.6 %)
Never, *n* (%)	37 (43.5 %)
Missing, *n* (%)	1 (1.2 %)
Ethnicity	
White British, *n* (%)	81 (95.3 %)
Irish, *n* (%)	2 (2.4 %)
Other white, *n* (%)	1 (1.2 %)
Asian, *n* (%)	1 (1.2 %)
Annual income before retirement or current	
< £20,000, *n* (%)	50 (58.8 %)
£20,000 - £35,000, *n* (%)	18 (21.2 %)
£35,000 - £45,000, *n* (%)	2 (2.4 %)
> £45,000, *n* (%)	2 (2.4 %)
Missing, *n* (%)	13 (15.3 %)
Self-reported disease	
Diabetes, *n* (%)	10 (12.0%)
Cardiovascular disease, *n* (%)	53 (62.4%)

Musculoskeletal disease, *n* (%)	46 (54.1%)
Kidney/liver disease, *n* (%)	3 (3.5%)
Lung disease, *n* (%)	12 (14.1%)
Cancer, *n* (%)	8 (9.4%)
Parkinsons disease, *n* (%)	2 (2.4%)
Other, *n* (%)	16 (18.8%)

The statistical criteria indicated that the three-class model had a better model fit compared to the two-class model (except for the lower entropy value; Table 2.3). Some model fit indices indicated a slightly better model fit for a four class model compared to the three-class model. Adding a fourth class, however, did not provide a better understanding of the data and one of the classes in the four-class solution was very small ($n \approx 11$). In line with recommendations by Marsh et al. (2009), we considered the theoretical and substantive meaning of each class and concluded that adding a fourth class did not contribute to a better understanding of the data in the current study. The three latent classes are graphically depicted in Figure 2.1. The first class (class 1) was labeled 'low physical function and PA (including light PA and MVPA) with a highly sedentary lifestyle' and contained 27.1% of the sample. Class 1 was characterized by people who were not very physically active, perceived their physical health as poor, and showed poor physical functioning. The second class (class 2) was referred to as 'moderate physical function and PA with a moderate sedentary lifestyle' and consisted of 41.2% of the sample. Class 2 was characterized by moderately active people who reported moderate levels of physical health and showed moderate physical functioning. The third class (class 3) was labeled 'high physical function and PA with an active lifestyle' and included 31.8%. Class 3 was characterized by physically active people that reported that their physical health was good and showed a high level of physical functioning. The largest mean differences across all profile indicators were found between class 1 (low physical function and PA with a highly sedentary lifestyle) and class 3 (high physical function and PA with an active lifestyle).

Table 2.4 shows the latent profile characteristics of the three-class model. Large effect sizes (Cohen's $d \geq 0.8$; Cohen, 1988) were observed across all profile indicators between class 1 and class 3. In contrast, the effect sizes of the differences between class 2 and class 1 ranged from medium to large, and those between class 3 and class 2 ranged from small to large (small = 0.2, medium = 0.5; Cohen, 1988). Participants were younger in Class 2 (76.24 years) and Class 3 (74.41 years), compared to Class 1 (82.90 years) and also predominantly female (Class 3: 66.7%, Class 2: 60.0%, Class 1: 82.6%). Individuals in Class 1 ($n = 2.35$) had a greater number of chronic diseases than individuals in Class 2 ($n = 1.77$) and Class 3 ($n = 1.26$).

The mental health scores of the three classes are presented in Table 2.5. The means of subjective mental health and vitality (higher values indicate better mental health) increased from class 1 to class 2 to class 3. The means of quality of life, anxiety, depression, and fatigue (higher values indicate worse mental health) showed an opposite pattern and decreased from class 1 to class 2 to class 3 (Table 2.5). The overall tests for the class comparisons were statistically significant for all mental health variables, except subjective mental health, indicating an overall difference amongst the three classes. The specific class comparisons showed that people in class 1 reported lower quality of life, less vitality, and higher levels of depression and fatigue, compared to individuals in classes 2 and 3. People in class 1 also reported lower levels of subjective mental health and higher levels of anxiety compared to individuals in class 3. In class 2 people also reported lower quality of life, less vitality, and higher levels of anxiety, depression, and fatigue compared to individuals in class

3. Large effect sizes were found between class 1 and class 3 in quality of life, vitality, anxiety, depression, and fatigue.

Given the high correlation between SB and light PA, an additional LPA was conducted without light PA as one of the factors. These analyses revealed that taking out light PA did not significantly influence the number of participants in each class (class 1: 28.2%, class 2: 42.4%, class 3: 29.4%). Importantly, the reported differences between the classes with regard to the mental health outcomes remained similar to the ones presented above.

Discussion

The present study used LPA to classify individuals, based on their physical health, physical function, PA, and SB proportions, in one of three distinct classes. All class indicators were standardized and the classes were compared against each other on the basis of whether their mean score on each class indicator was around the mean ($z = 0$) of the whole sample, above the mean (positive *z* scores) or below (negative *z* scores) the mean. The first class (27.1% of the sample) included individuals who, compared to the other two classes, had much lower levels of PA, higher levels of SB, were more overweight, and had poorer functional health. The second class was the largest class (41.2%) and included individuals who had average scores, compared to the other two classes, on all class indicators. The third class (31.8%) included individuals who were substantially more active and less sedentary than the rest of the sample, were somewhat leaner, and had somewhat better physical health and functioning.

The most notable differences between classes 1 and 3 were found in SB, light PA, MVPA, mobility, and perceived physical health. The results showed a large effect size (Cohen`s $d \geq 0.8$; Cohen, 1988) in mobility between classes 1 and 3 and 1 and 2. Given that older adults spend a great amount of time engaging in light PA (e.g., walking; Ainsworth et al., 2000; Westerterp, 2008), this suggests that walking might be particularly important in terms of supporting the mental health of older adults in ALFs. It is also worth noting that SB and light PA were highly correlated, and that the associations between SB and light PA with mental health and functional measures were the reverse of each other. This suggests that the message for residents of ALFs would be to spend less time in SB and more time in light PA. Indeed, the importance of replacing SB with this 'nonexercise' activity (light PA) has recently been reported to have a significant effect on mortality risk (Matthews et al., 2015).

However, the classes not only differentiate between health behaviours, there are also notable differences in physical function, with lung function, grip strength, and mobility being substantially poorer in class 1 compared to class 3. From a clinical perspective, this suggests that those with poorer physical function could also be at higher risk to suffer from poorer mental health. Of particular interest is perceived physical health, given that poorer perceived physical health is a strong predictor of all-cause mortality (Phillips, Der, & Carroll, 2010).

The results of the present study also indicated differences between class 1 and class 3 in several mental health indicators. Specifically, we found large effect sizes between class 1 and class 3 for fatigue (d = -1.89), depression (d = -1.67), anxiety (d = -1.02), and quality of life (d = -1.43). These results are in line with previous studies showing that lower anxiety and depression symptoms (Azevedo Da Silva et al., 2012; Song et al., 2011), lower fatigue (Vallance, Boyle, Courneya, & Lynch, 2014), and higher walking speed (Ní Mhaoláin et al., 2012) were related to higher levels of PA.

These results further show that those with greater physical function and a more active and less sedentary lifestyle had better mental health compared to those with poorer functional ability and low PA and highly sedentary lifestyle. This finding emphasises that interventions aimed at improving physical function and encouraging an active lifestyle are likely to have an important impact on mental health. Despite the effect sizes being somewhat smaller, it is also worth noting the differences in mental health between class 1 and class 2. This shows that even those with moderate physical function and PA with a moderately sedentary lifestyle have better mental health compared to those with low physical function and PA and a highly sedentary lifestyle. This implies that a small change in lifestyle and physical function could lead to improvements in mental health. This is in line with PA guidelines which state that even if older adults cannot achieve the recommended level of PA, some PA engagement is better than no PA engagement (Warburton & Bredin, 2016).

The present study incorporated a range of profiles based on movement-related behaviours and functional abilities and examined differences amongst these profiles in mental health outcomes. Importantly, our findings extend previous findings by taking a person-centred approach and examining how PA, SB, physical function, and health combine into distinct profiles, instead of examining them as independent predictors of mental health. For example, inspecting the effect sizes of the differences between all three classes (Table 2.4), shows consistently high effect sizes in terms of levels of PA, SB, and physical health. Differences in functional ability and BMI are also important but smaller in size, depending on which classes are compared. Identifying classes of individuals is important for reaching better conclusions. For example, comparing individuals on the basis of their physical functioning scores, without taking into consideration how active these individuals are, is likely to give a false indication of how their functional ability relates to their mental health.

This study is not without limitations. The cross-sectional study design does not allow for the assessment of temporal patterns or causal relations between the variables in the profiles and the mental health variables. Further, the stability of the class membership over time could not be tested. No information was available regarding the medication taken by the participants, therefore future studies could explore the impact of medication on the outcome measures and class profiles. Another limitation is the small sample size. In the current study we used many and high quality indicators (e.g., objectively-assessed PA, SB and physical function), two factors that can compensate for small sample sizes, for example, by decreasing mean class proportion bias (Wurpts & Geiser, 2014). Small sample sizes in LPA with a moderate numbers of classes can explain more variance compared to many classes derived from large sample sizes (Marsh et al., 2009). However, future research with large sample sizes should further examine the profiles and the associations found in the present study. Participants were recruited from different ALFs. As the number of participants from each ALF ranged from 1 to 33 residents, it is not possible to conduct any meaningful comparisons between the residents from the different ALFs. Similarly, the majority of the participants did not use a walking aid, therefore, it was not possible to explore the influence of the use of walking aids on our results. In addition, no data were collected considering the person-centred care activities in each ALF, which could have an impact of some of the outcome measures. Therefore, future research is warranted to explore the impact of these kinds of activities on the associations reported in the current study. An additional LPA with covariates of age and number of diseases was performed for covariate effects. The results were similar, with almost no changes in all values in the Class classification compared to the original results. In addition, although using LPA is imperative to identify classes of residents, this study focused on the main hypotheses to group profile indicators and comparison with mental health outcomes, however further studies are warranted to control covariates for better results. Notwithstanding these limitations, the study makes several unique contributions to the literature. Strengths of this study include objective assessments of physical function, PA, and SB in ALF residents. This is particularly relevant given the known underestimation of SB and over estimation of PA when using self-reported measures (Tudor-Locke & Myers, 2001). Another strength is the inclusion of multiple mental health indices, both negative (e.g., depression) and positive (e.g., vitality). The majority of the studies which assessed the associations between PA, SB, and functional ability have limited their assessment to only a few measures of mental health (Biswas et al., 2015b; Chodzko-Zajko et al., 2009; Turvey, Schultz, Beglinger, & Klein, 2009). The person-focused approach we used provides an alternative view to the traditional variable-centred approach utilized in the literature that examines activity-related correlates of mental health in older adults. Lastly, our research investigates older adults in ALFs, an under-researched group of older adults.

Findings from our study could be utilized to help these individuals remain mobile and mentally healthy, and avoid or prolong move to full care facilities. Our findings can be useful for health promotion research and practice in terms of developing more targeted/profile-based interventions that take into account variations in scores across a range of movement and functional abilities. Further research should develop targeted interventions (focusing on improving physical functioning or levels of physical activity or both) based on individuals' profiles to examine changes in means and proportions of each class, and whether such changes predict changes in mental health outcomes.

Table 2.2.

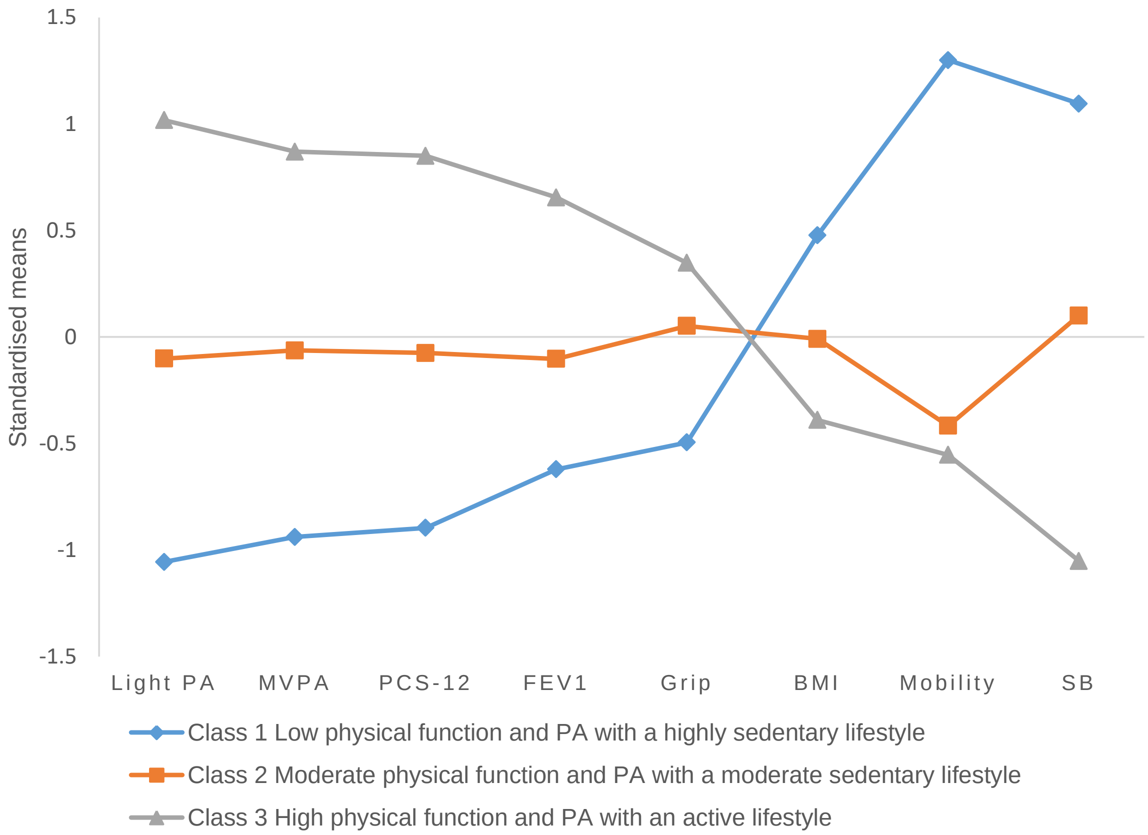
Descriptive statistics and bivariate correlation analyses

	M	*SD*	Skew	Kur	α	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.
1. Wear time (min/day)	722.79	68.71	0.46	-0.84		.30**	-.30**	-.21	-.24*	-.05	-.13	.00	.16	.05	.10	-.09	.05	.01	.07
2. SB (%)	70.52	11.01	-0.08	0.23			-1.0**	-.64**	-.50**	-.30**	-.22*	.20	.56**	-.20	.38**	-.39**	.28*	.37**	.51**
3. Light PA (%)	28.11	10.20	0.02	0.00				.55**	.47**	.27*	.19	-.17	-.53**	.20	-.37**	.39**	-.27*	-.37**	-.49**
4. MVPA (%)	1.37	1.37	1.52	3.91					.48**	.35**	.29**	-.36**	-.50**	.10	-.35**	.21*	-.18	-.28**	-.43**
5. PCS-12	41.34	11.76	-0.30	-1.13	0.84					.37**	.08	-.38**	-.59**	.19	-.70**	.57**	-.43**	-.54**	-.66**
6. FEV_1 (litre/m^2)	0.65	0.18	0.27	-0.07							.52**	-.06	-.49**	.27*	-.39**	.22*	-.35**	-.30**	-.37**
7. Grip (kg)	21.45	10.85	1.13	1.53								.11	-.34**	.02	-.07	.02	-.08	-.04	-.15
8. BMI (kg/m^2)	28.16	4.93	0.66	0.26									.12	.05	.20	-.07	.03	.09	.09
9. Mobility (seconds)	13.58	7.40	1.82	2.76										-.39**	.58**	-.47**	.36**	.52**	.59**
10. MCS-12	53.43	9.29	-1.40	2.20	0.80										-.38**	-.56**	-.46**	-.40**	-.63**
11. Vitality	4.23	1.40	-0.13	-0.39	0.92											-.50**	-.63**	-.69**	-.66**
12. Anxiety	4.82	3.50	0.54	-0.25	0.83												.65**	.55**	.60**
13. Depression	3.92	2.78	0.78	0.26	0.70													.65**	.70**
14. Fatigue	48.80	16.60	0.37	-0.07	0.57-0.82														.64**

15. QoL	21.78	6.34	0.61	-0.18	0.82

Note. *<.05, **<.01, Skew = Skewness, Kur= Kurtosis, α = Cronbach's alpha reliability coefficients, Light PA = Light physical activity, MVPA= Moderate to vigorous physical activity, PCS-12 = Physical health from SF-12, FEV_1 = Forced expiratory volume in 1 second, Grip = Grip strength, BMI = Body mass index, SB = Sedentary behaviour, MCS-12 = Mental health from SF-12, QoL = Quality of life from the COOP Dartmouth chart, Descriptive statistics and bivariate correlation analyses were calculated after imputing missing data points.

Fig. 2.1.



Mean scores of profiles for the three-class model (standardized scores)

Note. Light PA= Light physical activity, MVPA= Moderate to vigorous physical activity, PCS-12= Physical health from SF-12, FEV_1= Forced expiratory volume in 1 second, Grip= Grip strength, BMI= Body mass index, SB= Sedentary behaviour

Table 2.3.

Classes Identified via Latent Profile Analyses

Fit statistics	1 Class	2 Classes	3 Classes	4 Classes
AIC	1961.76	1648.78	1591.90	1550.80
BIC	2000.84	1729.38	1714.03	1714.46
SSA-BIC	1950.36	1625.28	1556.29	1503.09
Entropy	-	0.97	0.92	0.93
BLRT *p*-value	-	0.000	0.000	0.000
Percent of participants per class (%)	100	28.2, 71.8	27.1, 41.2, 31.8	29.4, 30.6, 27.1, 12.9

Note. AIC= Akaike information criterion, BIC= Bayesian information criterion, SSA-BIC= sample-size adjusted BIC, BLRT= Bootstrapped likelihood ratio test, Percent of participants per class (%)= the proportion of participants in each of the classes in the model.

Table 2. 4.

Latent Profile Characteristics in the Three-Class Model (Unstandardised Scores)

	Class 1: (*n* ≈23; 27.1%)		Class 2: (*n* ≈35; 41.2%)		Class 3: (*n* ≈27; 31.8%)				
	M	*SD*	*M*	*SD*	*M*	*SD*	d_{2-1}	d_{3-1}	d_{3-2}
SB (%)	81. 50	9.61	71.63	8.56	59.01	7.31	-1.04	-2.60	-1.57
Light PA (%)	17.40	9.56	27.09	8.80	38.43	6.71	1.06	2.58	1.42
MVPA (%)	0.09	0.08	1.29	1.02	2.56	1.64	1.50	2.05	0.96
PCS-12	30.87	8.69	40.46	10.87	51.28	9.11	0.95	2.29	1.07
FEV_1	0.54	0.15	0.64	0.17	0.77	0.24	0.57	1.13	0.67
Grip	16.11	10.01	22.01	14.01	25.20	11.14	0.47	0.86	0.25
BMI	30.51	5.93	28.11	5.28	26.24	3.40	-0.43	-0.90	-0.41
Mobility	23.14	8.05	10.51	3.01	9.52	2.98	-2.27	-2.31	-0.33
Age	82.90	10.08	76.24	6.01	74.41	6.66	0.80	0.99	0.29
Gender (n, %)									
Male	4 (17.4)		14 (40.0)		9 (33.3)				

Female	19 (82.6)		21 (60.0)		18 (66.7)				
Number of diseases	2.35	1.27	1.77	1.09	1.26	0.71	0.49	1.06	0.55

Note. SB = Sedentary behaviour, Light PA = Light physical activity, MVPA = Moderate to vigorous physical activity, PCS-12 = Physical health from SF-12, FEV_1 = Forced expiratory volume in 1 second, Grip = Grip strength, BMI = Body mass index, *d* = Cohen's *d* effect size statistic, Class 1: Low physical function and PA with a highly sedentary lifestyle, Class 2: Moderate physical function and PA with a moderate sedentary lifestyle, Class 3: High physical function and PA with an active lifestyle

Table 2.5.

Description of the Three Latent Classes and χ^2 test for Differences Between the Classes in Mental Health

	MCS-12		Vitality		Anxiety		Depression		Fatigue		Quality of life	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Class 1	49.50	11.89	3.32	1.27	6.28	3.56	5.95	2.70	61.22	14.97	26.79	6.47
Class 2	54.42	8.40	4.36	1.47	5.20	3.72	3.93	2.75	50.68	14.75	20.92	5.59
Class 3	55.47	7.25	4.81	1.12	3.11	2.63	2.20	1.76	35.94	11.81	18.66	4.90
Class comparisons	χ^2	*p*	χ^2	*P*	χ^2	*p*	χ^2	*p*	χ^2	*p*	χ^2	*p*
Overall test	4.50	.108	19.40	.000	14.15	.001	34.08	.000	46.03	.000	24.58	.000
1 vs. 2	2.91	. 088	8.07	.004	1.20	.273	7. 49	.006	6.83	.009	12.48	.000
1 vs. 3	4.40	.036	19.07	.000	12.39	.000	32.61	.000	42.91	.000	24.42	.000
2 vs. 3	0.26	. 610	1.71	.191	6.26	.012	8.45	.004	17.94	.000	2.69	.101
Cohen`s *d* effect size												
d_{2-1}	0.50		0.80		-0.30		-0.74		-0.71		-1.00	

$d_{3\text{-}1}$	0.62	1.24	-1.02	-1.67	-1.89	-1.43
$d_{3\text{-}2}$	0.59	0.33	-0.63	-0.73	-1.09	-1.39

NOTE. Vitality = MCS-12= Mental health from SF-12, QoL = Quality of life from the COOP Dartmouth chart, Vitality = Subjective vitality, Class 1: Low physical function and PA with a highly sedentary lifestyle (*n* = 23) 27.1%, Class 2: Moderate physical function and PA with a moderate sedentary lifestyle (*n* = 35) 41.2%, Class 3: High physical function and PA with an active lifestyle (*n*= 27) 31.8%.

Chapter 3

A Person-Centred Analysis of Motivation for Physical Activity and Perceived Neighbourhood Environment in Residents of Assisted Living Facilities

Abstract

This study sought to identify profiles of individual, social, and physical environmental correlates of physical activity (PA). Moreover, the study explored differences between the identified profiles in objective levels of PA. Residents of assisted living facilities (N = 87, M age = 77.57 years) reported their perceptions of perceived support from important others for PA, basic psychological needs and motivation for PA, and perceived physical environment around the assisted living facilities. Engagement in light PA and moderate-to-vigorous PA (MVPA) was measured objectively by accelerometers over a one-week period. Latent profile analysis revealed three profiles: "low self-determined and minimally supported (24%)", "moderately self-determined and supported (53%)", and "highly self-determined and supported (23%)". Subsequent difference tests showed that participants in the third profile engaged in higher levels of light PA and MVPA than participants from other profiles. This information can be used to develop tailored interventions aimed at promoting physically active lifestyles.

Introduction

Physical activity (PA) can offer many psychological and physical health benefits in older adults. Several studies have documented that regular moderate-to-vigorous PA (MVPA) improves balance, reduces falls, lowers the risk of heart disease, stroke, osteoporosis, type 2 diabetes, and, cancers in older adults (Chodzko-Zajko et al., 2009; Government of Canada, 2011). More recently, engagement in light intensity PA has also been reported to be associated with several beneficial health outcomes. For example, light PA has been shown to be associated with self-reported physical health, well-being (Buman et al., 2010), and plasma glucose control (Healy et al., 2007). This is particularly encouraging given that engagement in light PA may be perceived by older adults as more achievable than participation in MVPA. Indeed, light PA is characteristic of most of activities of daily living undertaken by this population (e.g., housework, walking; Ainsworth et al., 2000). As such, whilst it is important to understand correlates of MVPA participation in older adults, it is also necessary to examine key correlates of light participation in this population. Hence, this study sought to identify profiles of interpersonal, intrapersonal and environmental correlates of PA, and examine differences amongst these profiles in terms of mild and MVPA.

Most previous studies examining the determinants of PA in older adults have focused on community-dwelling settings (Thøgersen-Ntoumani et al., 2012; Thøgersen-Ntoumani et al., 2008). However, an increasing number of older adults live in assisted living facilities (ALFs; Park-Lee et al., 2011), as they require some level of assistance with daily living. ALFs are designed to keep residents independent (Carder, 2002). PA can play a key role in helping these individuals improve or retain health, independence and well-being (Chen et al., 2010; Friedmann et al., 2015) and can prevent or delay residents moving into nursing/care homes (Watson et al. 2003). However, a large proportion of residents in ALFs are physically inactive (Mihalko, 2006). While much research has been conducted on older adults in free-living settings (Hausdorff et al., 2001), research to understand PA behaviour of institutionalised older people is rather scarce.

Motivation for PA

Self-Determination Theory (SDT; Ryan & Deci, 2000) is a theoretical framework that is increasingly employed to study motivation for PA engagement and well-being. SDT identifies three basic psychological needs *autonomy*, *competence*, and *relatedness*. When such needs are satisfied via PA engagement, high quality of motivation ensues (Deci & Ryan, 2000).

According to SDT, motivation can be classified as intrinsic or extrinsic in nature (Ryan & Deci, 2000). *Intrinsic motivation* is present when individuals feel an inherent enjoyment from participating in an activity. In contrast, when behaviours are extrinsically motivated, the behaviour is engaged in for a separable outcome. Extrinsic motivation ranges in the degree to which it is internalised. Specifically, *integrated regulation* is the most optimal type of extrinsic motivation whereby people engage in the behaviour because it aligns with their values or identity. *Identified regulation* is evident when the individual engages in the behaviour because (s)he values its outcomes (e.g., improved health). Intrinsic, integrated and identified types of regulation represent high quality motivation because they are self-determined. When people have high levels of *introjected regulation,* they engage in the behaviour due to internal pressure, such as feelings of guilt. When behaviours are *externally regulated,* the individual is pressured by others, for example through the threat of punishment. Introjected and external regulation represents low quality of motivation, because they are low in self-determination. In addition to intrinsic and extrinsic motivation, there is also amotivation, which refers to lack of motivation, or an unwillingness to engage in the target behaviour (Ryan & Deci, 2000). Research evidence indicates that high quality types of motivation are positively related to greater participation in PA and exercise across all ages (Teixeira et al. 2012).

Support from Important Others

Significant others (e.g., health-care providers, family members) can help satisfy the three basic psychological needs, and in turn, promote higher quality motivation via the level of autonomy support they provide to the individual. A meta-analysis documented empirical support for the sequence involving autonomy support (despite the use of the term 'autonomy support', the construct taps the support of all three needs), psychological need satisfaction, more self-determined motivation and health outcomes (Ng et al., 2012). However, while SDT addresses the roles of individual and social-contextual factors (Ryan & Deci, 2006; Zhang & Solmon, 2013), it does not explain how human behaviours and experiences can be partly guided by the physical environment.

The Role of the Physical Environment

Older adults are more likely than younger individuals to be influenced by the physical environments since mobility and independence can be greatly limited by a poorly designed community. For example, older adults are more physically active when their neighbourhood environments have a number of walking paths, good street connectivity, high traffic and crime safety (Hall & McAuley, 2010; Van Cauwenberg et al., 2011). Sallis et al. (2008) acknowledged that an important weakness of the literature on such environmental influences on PA was the lack of consideration of the social-psychological processes underpinning PA behaviours. Indeed, Merom et al. (2009) found that motivational aids could overcome the negative effects of low neighbourhood aesthetic appeal (i.e., a physical environment factor). To this end, Zhang and Solmon (2013) proposed a model integrating the physical environment with SDT-based variables to better explain PA behaviours, although to our knowledge, this model has remained untested. Thus, assessing aspects of the physical environments and interpersonal/situational factors proposed by SDT (autonomy support by others, motivation for PA, psychological need satisfaction via PA), may be very informative to enhance our understanding of the correlates of PA behaviours in older adults. Traditionally such type of research has been conducted using variable-based approaches (e.g., regression analysis). In this study, we advocate the merits of a person-centred approach.

Person-Centred Approach

In contrast to a variable-centred approach in which the main interest is to investigate the association between variables (Dyer et al., 2012), a person-centred approach is useful because it shows how variables are combined within people to form distinct profiles/classes (Laursen & Hoff, 2006).

In light of the above, the aim of the study was to identify distinct profiles within individuals representing individual (motivation and psychological needs), social (autonomy support from significant others), and physical environmental (neighbourhood) correlates of PA, and to examine differences between these profiles in terms of objective levels of light PA and MVPA. Unfortunately, few studies have objectively measured PA among residents in ALFs (Haselwandter & Corcoran, 2015; Lobo et al. 2008). We hypothesize that individuals who were most supported by significant others, had higher levels of self-determined motivation and need satisfaction via PA, and who also perceived the environments to be more facilitative of PA, would report the highest levels of both light PA and MVPA.

Methods

Participants

One hundred older adults were recruited from 13 ALFs in the West Midlands, England. However, 13 participants were excluded either because they provided no questionnaire data (*n*= 2); incomplete accelerometer data (no weekend day, *n*= 9; less than 3 valid days, *n*= 2). Therefore, the final pool of participants consisted of 87 residents (58 females, mean age

77.57 years, SD = 8.11; range= 65-99 years). Researchers contacted either the facility manager or the wellbeing manager of each centre, who confirmed that the centre was qualified as an ALF. Subsequently, residents were approached by researchers to participate in the study through monthly resident meetings or coffee mornings. The coffee morning is a tea time. Residents are free to chat with other residents in the cafe of ALFs. Participants were randomly recruited and no physical rewards were given for their participation.

Inclusion criteria were: having lived in ALFs for at least 4 months, ability to speak English, and ability to walk without assistance or using either a cane or walker.

Procedures

Ethical approval for this study was awarded by the Ethical Review Committee of a UK university. Participants were first informed of the purpose and procedures of the study, questions were answered, and then participants gave written informed consent. The participants were given a questionnaire pack to complete by the second visit, which took place one week later. They were also requested to wear an accelerometer for 7 days to measure habitual PA engagement, and were supplied with a daily diary in which they were asked to report periods of non-wear (i.e., the time when they removed the accelerometer each day). Places where they visited were not used because participants rarely recorded. During the second testing visit, the participants returned the questionnaires and accelerometers.

Measures

Perceived autonomy support

Autonomy support from important others was measured using Williams et al.`s (2006) scale. Participants were first asked to identify the person they viewed to be most influential with regards to their PA behaviour (e.g., friend, family member). Subsequently, they were asked to answer questions related to the support they perceived from this important other. The scale consists of 6 items (e.g., “My important other encourages me to ask questions about my physical activity to improve my health"; Ω = .96), each of which were rated on a 7 – point scale (*1 = strongly disagree; 7 = strongly agree*). A high coefficient alpha (α = 0.91) has been reported in a previous exercise study in adults (Ng et al., 2014).

Basic psychological need

Psychological need satisfaction was measured using the Psychological Need Satisfaction in Exercise Scale (PNSE; Wilson et al. 2006). The 18 items were modified to represent with the word 'exercise' being replaced with 'physical activity'. The scale contains three subscales; autonomy (6 items; e.g., "I feel free to be physically active in my own way"; Ω = 0.85), relatedness (6 items; e.g., "I feel attached to those who participate in physical activities with me because they accept me for who I am"; Ω = 0.95), competence (6 items; e.g., "I feel that I am able to participate in physical activities that are personally challenging"; Ω = 0.96). Items were answered on a 6-point scale ranging from (1) *false* to (6) *true.* High coefficient alphas have been reported (autonomy α = 0.95, relatedness α = 0.96, competence α = 0.95) in previous research with older adults (Peddle et al. 2008). For the purposes of the latent profile analysis (LPA), an overall need satisfaction score was computed by averaging.

Behavioural regulations

A Behavioural Regulation in Exercise Questionnaire-2 (BREQ-2; Markland & Tobin, 2004) was used to measure intrinsic (4 items, e.g., "I engage in physical activity because it's fun"; Ω = 0.90), identified (4 items, e.g., "I value the benefits of physical activity"; Ω = 0.82), introjected (3 items, e.g., "I feel guilty when I don't engage in physical activity"; Ω = 0.77), and external regulation (4 items, e.g., "I engage in physical activity because other people say I should"; Ω = 0.73), as well as amotivation (4 items, e.g., "I don't see why I should have to be physically active"; Ω = 0.78). The scale was adapted to refer to 'physical activity' rather than 'exercise'. All 19 items were scored on a scale ranging from (1) *Not at all true* to (5) *Very true*. Previous research on older adults have reported coefficient alphas ranging from

0.64 (introjected regulation) to 0.93 (amotivation;Russell & Bray, 2009). For the purposes of the LPA, the scales were combined into a relative autonomy index (RAI) by weighting and summing each scale with higher scores reflecting higher quality of motivation.

Perceived neighbourhood environment

Perception of the neighbourhood environment was measured using the 'Instruments for Assessing Levels of Physical Activity and Fitness (ALPHA)' scale (Spittaels et al., 2009, 2010). The scale comprises 38 items and is scored using varying anchors and dichotomous scales. Questions about workplace and cycling environments were excluded as they were not relevant to our sample. The questionnaire contains 8 domains, including types of residences (3 items), distance to local facilities (8 items), walking and cycling infrastructure (4 items), maintenance of walking and cycling infrastructure (3 items), neighbourhood safety (6 items), pleasant for walking or cycling (4 items), walking and cycling network (4 items), and home environment (6 items). Fourteen items were excluded as they were not particularly relevant to this population, for example, questions related to cycle paths. Thus, 24 items were used to calculate the total mean: density (3 items: a, b, c; $\Omega = .93$), distance (8 items: a, b, c, d, e, f, g, h; $\Omega = .80$), sidewalk availability (2 items: a, b; $\Omega = .50$), total safety (4 items: b, c, e, f; $\Omega = .73$), pleasure (4 items: a, b, c, d; $\Omega = .53$), and network (3 items: a, c, d; $\Omega = .59$). The ALPHA demonstrated moderate to good test-retest reliability intraclass coefficients ranging from 0.66 to 0.86 across all subscales in Spittaels et al.'s (2010) work in adults. For the purposes of the LPA, a total sum score was computed with higher scores indicating perceptions of a PA-friendly physical environment (Duncan et al., 2012).

Physical activity

Objective PA was measured using an accelerometer (model: GT3X+ and WGT3X-BT; ActiGraph, Pensacola, FL, USA) for 7 consecutive days. The models have been shown to have high intra-monitor reliability (Miller, 2015). The accelerometer was worn on the right hip during all waking hours. Participants were asked to record times they removed/replaced the accelerometer during the 7 day monitoring period in a PA diary log. The accelerometer measured PA in 60-second epochs. Non-wear time was defined as 90 minutes of consecutive zeros in the movement counts recorded by the accelerometer, allowing for 2 minutes of counts <100 (Choi et al., 2012). Accelerometer data were considered valid when participants had worn the accelerometer for ≥10 hours on ≥ 3 days (including a weekend day). A time filter was set to extract data representative of waking hours. Waking hours were determined by examination of wear times as reported by participants in PA diaries. In this study, participants reported largely homogenous waking hours, between 7 am and 10:30 pm. Data recorded within this time period on each day were therefore extracted and used in subsequent analyses. Cut-points developed by Troiano et al., (2008) were used to classify PA as follows: light PA [100-2019 cpm], moderate PA [2020-5998 cpm], and vigorous PA [≥5999 cpm]. Moderate and vigorous PA were combined to represent MVPA. These cut-points have been used in previous studies of older adults (Hagströmer et al. 2010). Total time spent in light and moderate-to-vigorous PA across valid monitoring days were determined, and average daily time spent in each intensity of PA was calculated (min/day). To adjust for inter-participant variability in accelerometer wear time, average daily time spent engaged in light PA and MVPA intensity were expressed as percentage of daily wear time (e.g., [average light PA (min/day) ÷ average valid wear time (min/day)] x100) for use in subsequent correlation and latent profile analyses (Booth et al., 2014).

Statistical Analysis

Descriptive statistics were calculated using IBM SPSS version 22. Subsequently, bivariate correlations and LPA were conducted with Mplus version 7.31. For LPA, the full information robust maximum likelihood estimator was used, which handles missing data and yields unbiased estimates when data are missing at random (FIML; Enders & Bandalos, 2001). In this study, models with 1 to 4 classes were examined. A number of statistical criteria were used to assess model fit. The Akaike information criterion (AIC; Akaike, 1987), the Bayesian information criterion (BIC; Nylund et al. 2007), and the sample-size adjusted BIC (SSA-BIC; Yang, 2006) are relative measures of fit where a lower value indicates a better fit. We also used entropy (ranges between 0 and 1), and the bootstrapped likelihood ratio test (BLRT; Nylund et al., 2007; Peel & MacLahlan, 2000) as criteria when choosing the final model. Higher entropy indicates better precision in the latent class categorization. The BLRT was used to compare the *k*-1 with the *k* class models and a statistically significant BLRT of the *k* class model indicates a better model fit. Finally, we considered proportion of cases within each class, as smaller numbers can result in low power and precision (Berlin et al., 2014). In Step 2, the BCH method (Asparouhov & Muthén, 2014) was applied to examine the association between the latent classes and light PA and MVPA.

Results

Descriptive statistics and correlations

Descriptive statistics are displayed in Table 3.1. Participants were mainly married/co-habitating (40.2%) or widowed (46.0%). Approximately, one third of participants (29.9%) had finished secondary school and 58.6% of them reported their annual income when they had a job as less than £20,000 per annum. The majority was white British (94.3%); more than half drank alcohol (59.8%) and had smoked previously (50.6%). Major current diseases reported were cardiovascular diseases (35.5%) and musculoskeletal disorders (30.3%). As seen in Table 3.2 the percentage of time spent daily in light PA was substantially higher (27.73%, 198.49 mins) than time spent in MVPA (1.35%, 9.54 mins). Of the proposed PA determinants, basic psychological need satisfaction for PA correlated most strongly with daily light PA and MVPA.

Table 3.1

Characteristics of Participants

Variables		
n (%)	87 (female 58, 66.7 %)	
Age (*M*, *SD*)	77.57	8.11
BMI (*M*, *SD*)	28.10	4.89
Marital		
Married/co habituated (*n*, %)	35	40.2
Widowed (*n*, %)	40	46.0
Single (never married) (*n*, %)	2	2.3
Separate/divorced (*n*, %)	10	11.5
Education (missing 12.6 %)		
Secondary	26	29.9
Higher	8	9.2
Post Graduate	1	1.1
Other	8	9.2
None of above	33	37.9
Annual income (missing 14.9 %)		
< £20,000	51	58.6
£20,000 – £35,000	19	21.8
£35,000 – £45,000	2	2.3
> 45,000	2	2.3
Race		
White British (*n*, %)	82	94.3
Irish (*n*, %)	2	2.3
Other white (*n*, %)	1	1.1

Black Caribbean (*n*, %)	1	1.1
Other Asian (*n*, %)	1	1.1
Drink (missing 2.3 %)		
Currently (*n*, %)	52	59.8
Previously (*n*, %)	17	19.5
Never (*n*, %)	16	18.4
Smoke (missing 1.1 %)		
Currently (*n*, %)	4	4.6
Previously (*n*, %)	44	50.6
Never (*n*, %)	38	43.7
Disease indicators (missing 2.3 % in diabetes)		
Diabetes (*n*, %)	10	6.6
CV (*n*, %)	54	35.5
MS (*n*, %)	46	30.3
Kid-liver (*n*, %)	4	2.6
Lung (*n*, %)	12	7.9
Cancer (*n*, %)	8	1.3
Parkinsons (*n*, %)	2	1.3
Other (*n*, %)	16	10.5
Source of Support (%)		
Family	43. 7	
Village staff	19.5	
Medical staff	8.0	
Others	8.0	
Missing	16.1	

Note. CV = Cardiovascular diseases, MS = Musculoskeletal disorders, Kid-liver = Kidney-Liver disease.

Profile analysis

Model fit statistics are displayed in Table 3.3. The fit indices for the 3 class model had lower values for the AIC, BIC, and SSA-BIC, indicating a better model fit than the 2 class and 1 class model. Moreover, the higher entropy and significant BLRT as well as the reasonable proportion of participants in each class supported the selection of the 3 class model as the final model (see Table 3.4 for a description of the 3 class model). Class 1 (24% of participants) was labeled "Low self-determined and minimally supported" (24%), and consisted of participants who perceived the physical environment to be not conducive to PA, and who reported low levels of autonomy support from important others, psychological satisfaction, and self-determined motivation. Class 2 was labeled "Moderately self-determined and supported" (49%), and contained individuals who reported moderate scores on all variables. Class 3 was labeled "Highly self-determined and supported" (26%) and was characterized by people reporting the environment as being highly facilitative of PA, and who reported high levels of autonomy support from important others, need satisfaction, and self-determined motivation. Participants were younger in Class 3 (76.02 years) and Class 2 (76.21 years) compared to Class 1 (81.99 years). Participants were also predominantly female (Class 3: 60.0%, Class 2: 69.6%, Class 1: 66.7%) and individuals in Class 3 (n = 1.15) and Class 2 (n = 1.80) had a less number of chronic diseases than individuals in Class 1 (n = 2.20).

Profile classification and PA

Chi-square tests revealed statistically significant differences in MVPA and light PA among the three latent classes (Table 3.5). Class 3 ('Highly self-determined and supported') had the highest MVPA and light PA than in the other two classes. The mean percentage of daily MVPA in the 'Highly self-determined and supported' cluster was approximately three times larger than in the 'Low self-determined and minimally supported' class, and twice as large as in the 'Moderately self-determined and supported' group. No statistically significant differences were found between the ‘Low self-determined and minimal support’ and the ‘Moderately self-determined and supported’ classes in light PA and MVPA.

Discussion

The purpose of the current study was to identify typologies/profiles of older ALF residents based on their perceptions of autonomy support by significant others to engage in PA, their psychological need satisfaction and self-determined motivation associated with PA engagement, and their perceptions of their neighbourhood environment. Further, we examined whether individuals across these profiles differed in terms of their daily engagement in light PA and MVPA.

Three distinct profiles/classes emerged from the LPA. Latent profile analysis showed that individuals who perceived greater autonomy support, had higher levels of self-determined motivation and psychological need satisfaction, and perceived their neighbourhood environment as more facilitative for PA, were also more physically active. These findings are consistent with previous research demonstrating that when individuals feel that significant others offer them autonomy support for PA engagement, engage in PA for self-determined reasons and experience psychological need satisfaction from that engagement, they will be physically active (Ng et al., 2014). Our findings are also in line with previous work showing that perceptions of PA-conducive physical environment were positively related to step counts in older women (Hall & McAuley, 2010) and self-reported PA in older adults (Chad & Reeder, 2005).

Another interesting finding was the significant differences in levels of light PA engagement across the three classes. Specifically, more light PA was observed in class 3, relative to class 1 and class 2. Light PA (e.g., walking) is characteristic of most activities of

Table 3.2

Estimated Sample Statistics and Bivariate Correlations

	M	*SD*	Skew	Kur	2.	3.	4.	5.	6.	7.
1. Wear time (min)	723.07	67.95	0.44	-0.83	-0.29**	-0.21	0.02	-0.05	-0.08	0.11
2. Light PA (%)	27.73	10.42	-0.00	-0.12	-	0.56**	0.31**	0.31**	0.41**	0.24*
3. MVPA (%)	1.35	1.37	1.51	3.66		-	0.22*	0.22*	0.41**	0.35**
4. Physical environment	2.97	0.49	-0.87	1.97			-	0.21	0.36**	0.31**
5. Autonomy support	5.40	1.63	-0.93	-0.02				-	0.53**	0.50**
6. Psychological needs satisfaction	4.53	1.07	-0.66	-0.19					-	0.75**
7. Self-Determination Index	9.45	6.93	-1.03	1.36						-

Note. *p < .05, **p <.001, Light PA = Light physical activity, MVPA = Moderate-to-vigorous physical activity.

Table 3.3

Model Fit of the Latent Profile Analyses (n = 87)

Fit statistics	1 Class	2 Classes	3 Classes	4 Classes
AIC	961.013	866.692	839.780	831.244
BIC	980.740	908.613	903.894	917.551
SSA-BIC	955.498	854.972	821.855	807.115
Entropy	-	0.807	0.839	0.827
BLRT (*p*-value)	-	0.000	0.000	0.105
Percent (%)	100	37, 63	24, 53, 23	10, 30, 40, 20

Note. AIC = Akaike information criterion, BIC = Bayesian information criterion, SSA-BIC = sample-size adjusted BIC, BLRT = bootstrapped likelihood ratio test.

Table 3.4

Profile Characteristics

	Class 1: Low self-determined and minimally supported (*n* = 21, 24%)		Class 2: Moderately self-determined and supported (*n* = 46, 53%)		Class 3: Highly self-determined and supported (*n* = 20, 23%)				
	M	*SD*	*M*	*SD*	*M*	*SD*	d_{2-1}	d_{3-1}	d_{3-2}
Physical environment	2.723	0.646	2.911	0.549	3.345	0.429	0.324	1.129	0.841
Autonomy support	3.756	2.795	5.823	2.387	6.204	1.547	0.820	1.076	0.175
Psychological needs satisfaction	3.114	1.402	4.743	1.560	5.586	0.344	1.077	2.395	0.638
Self-Determination Index	0.762	10.494	10.102	8.926	16.492	4.137	0.990	1.954	0.818
Age	81.99	10.22	76.21	6.65	76.02	7.35	0.670	0.670	0.027
Gender (*n*, %)									

Male	7 (33.3)		14 (30.4)		8 (40.0)				
Female	14 (66.7)		32 (69.6)		12 (60.0)				
Number of diseases	2.20	1.17	1.80	1.11	1.15	0.81	0.351	1.043	0.669

Note. *d* = Cohen`s *d* effect size statistic.

Table 3.5

Chi Square Difference Tests

	Light PA (%)					MVPA (%)				
	M	*SD*				*M*	*SD*			
Class 1	22.594	11.841				0.776	1.017			
Class 2	27.965	10.085				1.170	1.153			
Class 3	32.735	10.586				2.349	1.941			
Class comparisons	χ^2	*p*	$d_{2\text{-}1}$	$d_{3\text{-}1}$	$d_{3\text{-}2}$	χ^2	*p*	$d_{2\text{-}1}$	$d_{3\text{-}1}$	$d_{3\text{-}2}$
Overall test	8.443	0.015	0.504	0.902	0.466	10.564	0.005	0.354	1.023	0.823
1 vs. 2	2.917	0.088				1.779	0.182			
1 vs. 3	8.427	0.004				10.463	0.001			
2 vs. 3	2.702	0.100				5.993	0.014			

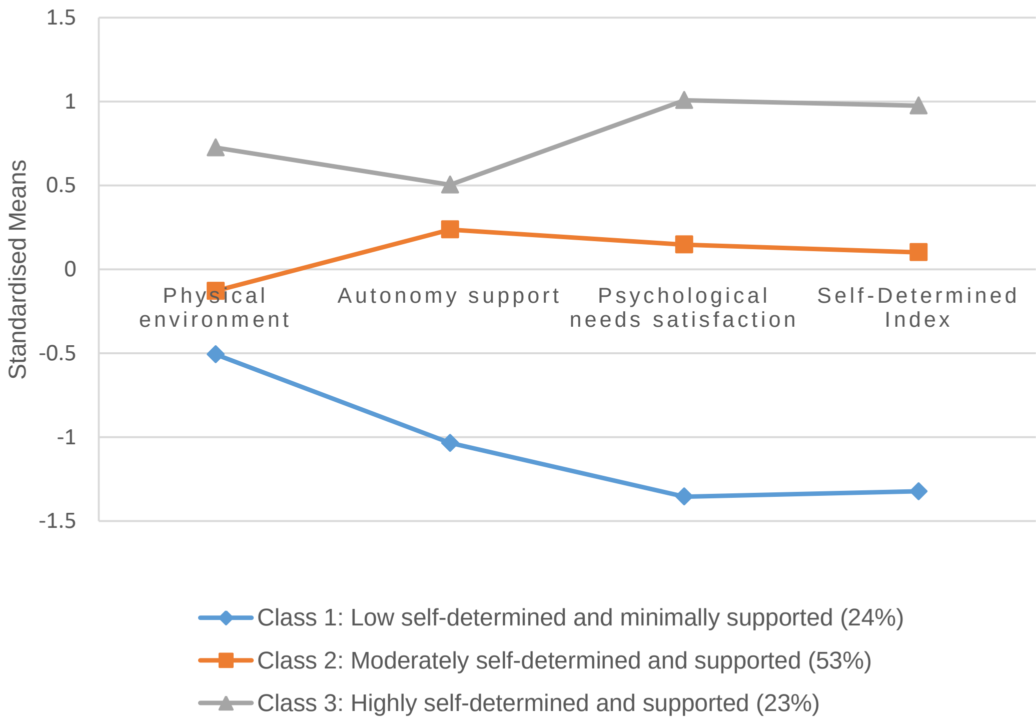
Note. *d* = Cohen`s *d* effect size statistic, Class 1: Low self-determined and minimally supported (*n* = 21, 24%), Class 2: Moderately self-determined and supported (*n* = 46, 53%), Class 3: Highly self-determined and supported (*n* = 20, 23%).

daily living in older adults (Ainsworth et al., 2000), and accumulation of light PA is associated with several beneficial physical and psychological health outcomes (Buman et al., 2010).

The identified classes can be useful when considering the development of

Figure 3.1

Profiles Identified via Latent Profile Analyses



interventions aimed at encouraging higher engagement in PA amongst older residents in ALFs. Interestingly, the personal motivational variables (self-determined motivation and psychological need satisfaction) differentiated more strongly between the three classes than the contextual variables (perceptions of others' autonomy support and perceptions of neighbourhood environment). It is possible to enhance personal motivation for PA (via SDT-based interventions; cf. Hancox et al., 2015), which can increase need satisfaction and self-determined motivation towards PA. It is possible that motivational factors may override the impact of perceived environmental constraints (Merom et al., 2009). However, this hypothesis has not yet been tested with older adults. Results from studies testing this hypothesis could have implications for public health and planning policy.

One limitation of this study is that it analyzed overall scores for motivation and psychological need satisfaction and neighbourhood environment, as opposed to individual subscale scores. This was a pragmatic decision on the basis of the number of variables that were included in the profiles. Whilst individual scores provide valuable sources of information, overall scores for these variables have been shown to predict PA and other related outcomes in older adults (Duncan et al., 2012; Russell & Bray, 2009). A further limitation of the study was that it did not obtain objective ratings of neighbourhood environment. However, perceptions of physical environment are important components and play a key role in examining determinants of PA promotion (Carnegie et al., 2002).

Some items of ALPHA were not used because those items were related to activities thought to be irrelevant for frail older adults (e.g., cycling). ALPHA was developed to capture a range of different concepts that explain the variability of perception of the physical environment on human behaviours. The questionnaire offers two scoring methods: individual means of 8 domains or one total composite score. The detailed evaluation of the reported use of this questionnaire revealed that excluding a few items based on the particular population or environment is not uncommon. However, ALPHA is used for older age groups (Oppert et al., 2016) and is a valid tool for those who live in European housing/living settings (Meusel et al., 2007). In addition, moderate to high reliability coefficients (Ω = 0.50 – 0.93) were found and large effect sizes ($d_{3\text{-}1}$: 1.129, $d_{3\text{-}2}$: 0.841) were observed which may support the sensitivity of capturing perceptions of physical environment in ALFs in this study. However, further scale development is encouraged to better capture perception of the physical environment of residents in ALFs. Another limitation of the study was its crosssectional nature; it would be interesting to examine the stability of the identified classes over time, particularly after individuals engage in a PA program. Therefore, further research into the combination of SDT and perceived physical environment should use each variable of behavioural regulation and objectively-measured physical environment (i.e., GIS) with larger sample sizes. As stated, older adults might recognize their physical environment differently, therefore future research should incorporate both perceived and objective physical environments. In addition, structural equation modelling would be useful to examine how much variance predicts each component across the contexts in SDT, physical environment, and PA. The additional LPA performed with the covariates of age and number of diseases included showed near identical values in Class classifications compared to the original results.

Notwithstanding these limitations, the study makes several unique contributions to current psychosocial research on PA in older adults. Specifically, it represents the first attempt to incorporate determinants from both motivational and the physical environment literatures to predict objective levels of PA in older adults in ALFs. In doing so, it extends self-determination theory research in PA by considering aspects of the physical environmental in conjunction with pertinent psychosocial motivational correlates of PA engagement. In this regard, it offers a complementary view of the theoretically integrated model of SDT and the physical environment, proposed by Zhang and Solmon (2013). The use of objective measures of PA addresses issues with over-reporting of PA and common method variance in previous studies that relied on self-reports. Further, the use of a person-centred analysis takes into account inter-individual differences and examines how intrapersonal, interpersonal and contextual correlates of PA relate within people as opposed to across people. Hence, this person-focused approach provides an alternative view to the traditional variable-centred approach utilized in the literature that examines correlates of PA in older adults. Lastly, this research investigates older adults in ALFs, an under-researched group of older adults. Findings from our study could be utilized to help these individuals remain independent and avoid or prolong move to full care facilities.

Chapter 4

Disentangling Daily Associations from Individual Differences in Studying the Interplay Between Physical Activity, Sedentary Behaviour, Bodily Pain and Fatigue in Older Adults: An Ecological Momentary Assessment

Abstract

Little attention has been paid to within-person associations amongst light physical activity (PA), moderate-to-vigorous physical activity (MVPA), sedentary behaviour (SB), and subsequent bodily pain and fatigue in older adults. The purpose of the study was to examine associations between these variables and how they are partly determined by between-person differences in pain, fatigue, and physical health. Participants were 63 community-living older adults (female *n* = 43, mean age = 70.98 years). Questionnaires measured typical levels of PA, SB, bodily pain, fatigue and physical health. Subsequently, on a daily basis over a 1-week period, participants' levels of light PA, MVPA and SB were measured using accelerometers. Participants completed a questionnaire rating their pain and fatigue at the end of each day. Multilevel modelling revealed positive (negative) within-person associations between daily light PA, daily MVPA, (daily SB), and pain. For individuals with higher typical levels of fatigue, there was a negative association between daily light PA, MVPA, and fatigue. For individuals with better levels of physical health, there was also a negative association between daily MVPA and fatigue. For those with higher typical levels of fatigue and better levels of physical health, there was a positive association between daily SB and fatigue. This research extends knowledge on the links between levels of activity, fatigue and bodily pain in older adults, by testing the daily associations amongst these variables and by showing how some of these associations are partly determined by between-person differences in fatigue and physical health.

Introduction

According to the United Nations (2015a), the number of older adults (≥ 60 years) worldwide is expected to increase from 901 million in 2015 to 1.4 billion by 2030. As adults age, they are more likely to experience negative health outcomes (e.g., heart disease, back pain; World Health Organization, 2016a). For example, evidence shows that many older adults in community settings suffer from bodily pain (63% in men, 91% in women; Bergh et al., 2003) and fatigue (15% in men, 29% in women; Vestergaard et al., 2009). Bodily pain has been found to be negatively related to walking speed, balance and physical functioning in older women in community settings (Sampaio et al., 2015). With regard to fatigue, positive associations have been reported between fatigue and negative health conditions (e.g., arthritis) in older adults (Williamson et al., 2005).

It is well documented that lifestyle factors such as physical activity (PA) and sedentary behaviour (SB) can play an important role in determining health-related quality of life in older adults (Vogel et al., 2009). Evidence shows a positive association between engaging in moderate-to-vigorous PA (MVPA) and improved physical health (e.g., decreased risk of mortality, stroke, type 2 diabetes; World Health Organization, 2016b) and mental health (e.g., fewer depression symptoms) in older adults (Loprinzi, 2013). In light of recent literature that has identified a high prevalence of light PA in the general public (Owen et al., 2010), particularly in older adults, research has also examined the role of light PA in improved physical health. Previous studies have reported positive associations between engagement in light PA and the reduction of coronary heart disease in adults and older men (Sesso, Paffenbarger, & Lee, 2000), as well as fewer depression symptoms in older adults (Loprinzi, 2013).

In contrast, spending a large proportion of the day in SB among older adults (age 70-85; men 67.8%, women: 66.3%; Matthews et al., 2008) impacts negatively on health. For example, Stamatakis et al. (2012) found that engagement in self-reported SB was associated with a higher cholesterol ratio, BMI, and waist circumference in older adults. Taken together, this evidence indicates that lifestyle factors such as light PA, MVPA, and lower SB are important predictors of health. Evidence has also accumulated regarding the role of light PA, MVPA, and SB in predicting two important indices of health, namely, bodily pain and fatigue.

Physical Activity, Sedentary Behaviour and Bodily Pain

Engagement in self-reported PA has been related to less back pain in older adults (Cecchi et al., 2006). Additionally, higher levels of sitting time have been associated with worse bodily pain in community-living older adults (Balboa-Castillo et al., 2011). However, the evidence is inconsistent. For example, a previous study indicated that engagement in self-reported "overactivity behaviour", defined as engaging in more PA than average, was related to pain prevalence in adults (age range= 25-73 years; Andrews et al., 2015). Also, self-reported PA was significantly and positively correlated with pain frequency in older adults (Silva et al., 2016). Such results are in line with evidence which suggests that older adults who spent most of their time sitting (upper quartile) had lower levels of bodily pain than those who sat less (i.e., lower quartile; Balboa-Castillo et al., 2011). However, the associations between PA and pain in older adults have been typically examined at the between-person level (i.e., how typical levels of PA predict typical levels of pain) and predominantly in chronic disease groups (Murphy & Smith, 2010). Nevertheless, chronic pain has been found to fluctuate on a daily basis in older adults (Ravesloot et al., 2016). Studies that have examined within-person associations have found a positive relation between higher engagement in objectively-assessed daily MVPA and higher levels of evening pain in older adults (Ho et al., 2016). However, this study did not include assessments of light PA and SB, which are reflective of the majority of activities performed by older adults (Gando et al., 2010; Matthews et al., 2008). Therefore, more research is needed to provide detailed insight into PA and SB in relation to subsequent pain at the within-person (i.e., daily) level. Currently, there is limited research investigating the within-person association of light PA, MVPA, and SB with subsequent bodily pain in community samples of older adults (Ho et al., 2016) and usually such studies have examined how pain predicts subsequent PA (Litcher-Kelly, Stone, Broderick, & Schwartz, 2004; Murphy, Kratz, Williams, & Geisser, 2012). Daily self-reports are less likely to be affected by recall bias and to conflate days of high and low pain into one overall score of pain. Further, by separating within-person from between-person associations, it is possible to ascertain the degree to which variables correlate with each other within the same individual over time, without such correlations been influenced by between-person differences in the levels of these variables (Raudenbush & Bryk, 2002).

Physical Activity, Sedentary Behaviour and Fatigue

Several studies have shown that fatigue is associated with restricted activities (Gill et al., 2001), lower levels of self-reported PA and more dependency in activities of daily living (Moreh et al., 2010). With regard to SB, Ellingson, Kuffel, Vack, and Cook (2014) found that highly sedentary adult women (mean age= 37 years) reported higher levels of fatigue, compared to those who were less sedentary. Similar to the research on pain, the relation between fatigue and PA has been mainly examined at the between-person level. However, feelings of fatigue can vary at the within-person (i.e., daily) level (Ravesloot et al., 2016). To the best of our knowledge this is the first attempt to examine the within-person association of PA and SB on subsequent fatigue in community samples of older adults (although some studies have examined how fatigue predicts subsequent PA in adults; e.g., Conroy, Elavsky, Doerksen, and Maher., 2013). Therefore, more research is needed to understand the association of light PA, MVPA, and SB in relation to subsequent fatigue at the within/daily level.

Purpose of the Study

Our aim was to examine the relation between daily (over a 7-day period) light PA, MVPA, and SB, and subsequent bodily pain and fatigue. We also investigated whether such associations were moderated by individuals' typical levels of bodily pain, fatigue and physical health. This is the first attempt to examine within-and between person associations of light PA, MVPA, and SB with subsequent bodily pain and fatigue in older adults. It was hypothesized that daily light PA and MVPA would predict lower levels of fatigue, particularly in individuals with lower typical levels of fatigue and better physical health. It was also hypothesized that daily SB would predict higher levels of fatigue, particularly in individuals with higher typical levels of fatigue and better physical health. No hypotheses were put forward for pain due to the mixed results in the literature.

Method

Participants

Older community-dwelling adults (*n* = 67) in the UK were recruited. Inclusion criteria were that they did not use a walker or a wheelchair and were above the age of 60 years. Simulation studies (e.g., McNeish & Stapleton, 2016) indicate that *N*> 50 at level 2 (participants in our case) of a multilevel model, provides adequate power for variance and fixed effects estimates. A list of contacts was provided from a database of approximately 1000 volunteers who were registered with a UK. Research staff sent invitation letters and/or emails and when the potential participants indicated interest, the participant was contacted via email or phone to discuss the study in more detail. There were no rewards for participation and participants were selected randomly from the database.

In total, 63 participants (*n* = 63, M_{age} = 70.98, *SD* = 6.92, female = 68.3%) were included in the analysis, after four participants were excluded (not sufficient accelerometer wear time = 2, using a walker = 2). The participants' average body mass index (BMI) was 25.14 (*SD* = 3.47). The educational background of the participants was mixed with some having completed a post-graduate degree (28.6%) and the remainder had completed an undergraduate degree (23.8%), secondary education (15.9%), primary education (11.1%), or other education (14.3%). Their annual income was reported as: ≥ £45,000 = 12.7%, £35,000-£45,000 = 17.5%, £20,000-£35,000 = 34.9%, < £20,000 = 34.9%. The participants were mostly white and British (79.4%; other white 3.2%; black Caribbean 1.6; Indian 11.1%; other 4.8%). Many participants (57.1%) reported having been diagnosed with a cardiovascular condition. More than one-third of the participants were co-habitating with their partner. More than half of the participants had university education and a cardiovascular disease, a reasonably good income, were of healthy weight for their age, and were co-habitating.

Procedures

Ethical approval for this study was granted by the Ethical Review Committee at a UK university. An introductory session about the study took place in an initial session in a lab or in a convenient place for the participant. The participants signed written consent forms. Their weight and height were then measured to calculate BMI (kg/m^2) using a portable scale (TANITA BC-545N). Two participants refused to be measured, and their self-reported weight and height were recorded. At the beginning of the study, a set of questionnaires was distributed to the participants, to provide pre-diary typical measures of the study variables, including demographics. Further, either a palmtop computer (Scroll Pocket Tablet PC) or a smartphone (ZTE Blade Q Mini Android Smartphone), depending on equipment availability, was given to the participants for the daily assessments. The devices were programmed to prompt a set of daily questions between 4 pm and 9 pm every day on a random basis. The devices had touch-screens which participants had to tap to record an answer. If the participants did not respond to the first alarm, a second alarm was provided 2 minutes later. If there were no answers, the question was treated as missing (*n*= 45). Answers that were outside of the alarm range due to system errors were treated as missing (*n*= 1). The participants' responses were stored within each participant's device. At the end of the data collection period, research staff downloaded the data from the devices to a lab-based desktop computer. In addition, to the touchscreen devices, an accelerometer was distributed to the participants to wear over seven days during waking hours. Participants were instructed to wear the monitor on their right hip, to avoid wearing the accelerometer during any water activities, and to record in a diary each time point when they started and stopped wearing the accelerometer.

Measures

Demographics

We asked participants to tick whether they were diagnosed with any cardiovascular disease over the past 12 months. We assessed the occurrence of high cholesterol, heart disease, vascular disease, high blood pressure and circulatory problems. Their answer was dichotomized as *have* (1) if they had been diagnosed with at least one cardiovascular disease; otherwise, a *do not have* (0) rating was given by the researchers. Gender was coded as male (0) and female (1). Also, we measured participants' marital status as follows: *married/co-habitated*, *widowed*, *never married*, *and separated/divorced.* The answer was dichotomized as *living alone* (0) and *living with someone else* (1).

Typical and daily bodily pain

For typical pain, participants were asked to complete the two pain items from the RAND 36-Item Health Survey (Hays et al., 1993) [i.e., "How much bodily pain have you had during the past 4 weeks?" ranging from 1 (*none*) to 6 (*very severe*), and " During the past 4 weeks, how much did pain interfere with your normal work (including both work outside the home and housework)?", ranging from 1 (*not at all*) to 5 (*extremely*)]. The coefficient alpha (α) was 0.78 in a previous study (Hays et al., 1993) and $\alpha = 0.79$ in the present study. Items were averaged for our analysis. To measure daily bodily pain, the first item above was used and rated on a scale ranging from 1 (*no pain*) to 4 (*severe pain*; i.e., "How much bodily pain do you have right now?") when prompted.

Typical and daily fatigue

The Multi-Dimensional Fatigue Index (MFI-20; Smets et al., 1995) was utilized to assess fatigue over the previous 4 weeks with a total of 20 items. The scale tapped five dimensions of fatigue: general fatigue (e.g., "I feel tired"), physical fatigue (e.g., "Physically, I feel able to only do a little"), reduced activity (e.g., "I think I do very little in a day), mental fatigue (e.g., "My thoughts easily wander"), and reduced motivation (e.g., "I don`t feel like doing anything). Answers were rated on a 5-point scale from 1 (*yes, that is true*) to 5 (*no, that is not true*). Good internal reliability coefficients were found in a previous study (α range: 0.75-0.94; Falk et al., 2007) and in the present study (α range: 0.67-0.83). Subscales were summed to calculate a total fatigue score. To assess daily fatigue, one item ("How much fatigue do you feel right now?") was used from the MFI and was answered at each beep. Participants provided a rating from 1 (*no fatigue*) to 4 (*severe fatigue*).

Daily physical activity and sedentary behaviour

Accelerometers were used to monitor PA and SB levels (models: GT3X+ and WGT3X-BT; ActiGraph, Pensacola, FL, USA). The two models have been shown to produce very similar results (Miller, 2015). Participants who wore the accelerometer a minimum of 10 hours a day for 5 days, including 1 weekend day over 7 days, were included in the analysis (2 participants were excluded). Data were extracted using the ActiGraph software. The researcher programmed the monitor to accumulate movement data every 60 seconds. Non-wear time was classified as 90 minutes of consecutive non-activity counts (< 100 counts) with 2 minutes of tolerance allowance (Choi, Ward, Schnelle, Buchowski., 2012). Based on the diary the participants recorded, we set a time filter to standardise wearing time (7:30 am to 10:30 pm). For the purposes of our analysis, for each day and for each participant, we utilized the movement data accumulated from the morning until the time they answered the daily questions on bodily pain and fatigue. Hence, in our analysis daily PA and SB were used as predictors of daily bodily pain and fatigue.

Counts per minute were processed to categorize the thresholds of activities [i.e., SB: 0-99 counts per minute (cpm; Matthews et al., 2008), light PA: 100-2019 cpm, moderate PA: 2,020-5,998 cpm, and vigorous PA: ≥5,999 cpm (Troiano et al., 2008)]. Moderate and vigorous intensities were summed to represent MVPA. Finally, each activity category (light PA, MVPA, and SB) was divided by the total wear days and then multiplied by 100 to represent the proportion of each activity category, in order to reduce inter-participant variability (Bélanger, Townsend, & Foster, 2011; Owen et al., 2010). These proportion scores were used in the main analysis.

Typical health status

The RAND 36-Item Health Survey was administered to measure physical health (we used the subscales of physical functioning, role functioning/physical, pain, and general health; Hays et al., 1993). Participants were told: "The following questions are about activities you might do during a typical day. During the past 4 weeks, has your health limited you in these activities? If so, how much?" Rating scales varied depending on items (e.g., carrying groceries). Answers were reversed and weighted where appropriate, so that higher scores on the four subscales represented better physical health (Hays et al., 1993). Good internal consistency coefficients have been found in adults (mean age = 30.54, $\alpha = 0.89$; Padden, Connors, & Agazio, 2011) and this was also the case in the current study ($\alpha = 0.75$).

Typical physical activity

Typical PA was assessed using the Physical Activity Scale for the Elderly (PASE; Washburn, McAuley, Katula, Mihalko, & Boileau, 1999). In total, 18 items were rated using 4-point scales (hours/week; e.g., "How much time was spent on the activity over the last 7 days?")

and yes/no questions (e.g., “Have you performed ‘light housework’ over the last 7 days?”). The items captured 7 dimensions of PA: walking, light sport/recreation, moderate sport/recreation, strenuous sport/recreation, muscle strength/endurance PA, household PA, work-related PA. Items were multiplied by the number of hours the participants spent and were weighted and summed to obtain an overall score of PA (Washburn et al., 1993). People with higher scores were more physically active. Acceptable test-retest reliability was reported in a previous study ($r = 0.75$) with older adults (Washburn et al., 1993).

Typical sedentary behaviour

Typical sedentary time was assessed with seven items from the Measure of Older adults` Sedentary Time (MOST; Gardiner et al., 2011). The survey asked the participants to record their total sedentary time (hours and minutes) over the previous seven days (e.g., watching television, using computer, reading, socializing, driving, and doing various hobbies or other activities). Items were summed with higher scores representing higher levels of SB. Test-retest reliability was found to be acceptable ($\rho = 0.52$) in older adults (Gardiner et al., 2011).

Data Analysis

Linear mixed models (IBM SPSS, version 22) were tested to examine within- and between-person associations between light PA, MVPA, and SB with bodily pain and fatigue. We ran four models in total. In the first two, light PA and MVPA predicted bodily pain and fatigue respectively, and in the other two models SB predicted pain and fatigue respectively. We ran separate models for light PA and SB because these variables are typically highly correlated (in our study, daily light PA and SB were correlated $r= -0.83$, $p< 0.01$). Within-person predictors (level 1; daily light PA, daily MVPA, and daily SB) were person-mean centred. At level 2, the average of daily light PA, daily MVPA and daily SB over the 7 days were entered as predictors. By including the predictor average scores over the 7-day period at level 2, the level 1 within-person associations were not conflated by between-person differences

(Raudenbush & Bryk, 2002). In addition, we tested the cross-level interactions between each of the level 1 predictors with typical pain (when predicting daily pain), with typical fatigue (when predicting daily fatigue), and with physical health (when predicting daily pain and fatigue). BMI, age, presence/absence of cardiovascular disease, gender, and co-habitating were also entered at level 2 as covariates. Level 2 predictors were uncentred (Bolger & Laurenceau, 2013). All level 1 and 2 predictors, apart from the categorical ones, were converted into Z scores to obtain β coefficients from the analysis. R_1^2 was estimated as an effect size, representing the amount of variance at level 1 explained by the predictors, compared to the variance explained by a model with only the intercept (Hox, Moerbeek, & Schoot, 2010).

Results

Participants completed 341 (77.3%) out of 441 (over seven days) daily questions on bodily pain and fatigue. The percentage of missing cases for the pre-diary survey was around 3.2%. The skewness scores for the dependent variables of bodily pain (1.89) and fatigue (0.93) were within an acceptable range (skewness ±2; Gravetter & Wallnau, 2016).

Table 4.1

Participant Characteristics

Variable	
Sex, *n* (%)	63; female = 43 (68.3)
Age, mean (SD)	70.98 (6.92)
Education completed, *n* (%)	Missing 4 (6.3)
Primary	7 (11.1)
Secondary	10 (15.9)
Higher	15 (23.8)
Post graduate	18 (28.6)

Other	9 (14.3)
Annual income, *n* (%)	
Below £20,000	22 (34.9)
£20,000 -35,000	22 (34.9)
£35,000 – 45,000	11 (17.5)
Above 45,000	8 (12.7)
Ethnicity, *n* (%)	
White British	50 (79.37)
Other White	2 (3.17)
Black Caribbean	1 (1.59)
Indian	7 (11.11)
Other	3 (4.76)
BMI (kg/m^2), mean (SD)	25.14 (3.47)
Cardiovascular disorder (%)	0 = have (57.1), 1 = do not have (42.9)
Cohabiting with partner (%)	0 = no (34.9), 1 = yes (65.1)

Table 4.1 presents participant characteristics. The participants wore accelerometers for almost 10 hours (594.13 minutes) before they answered the daily questions. The participants spent most of their time in SB (58.58%) and light PA (35.80%), with a lower proportion of MVPA (5.62%). According to R_1^2, models 1 and 2 (Table 4.3) predicted 52.8% (bodily pain) and 21.0% (fatigue) of the variance at level 1. Also, models 3 and 4 (Table 4.4) accounted for 54.8% (bodily pain) and 19.1% (fatigue) of the variance.

Table 4.2

Descriptive Statistics and Intraclass Correlation Coefficients for Study Variables

	M	*SD*	ICC	*Min*	*Max*
1. Daily accelerometer wear time (min/day)	594.13	115.27	-	-	-

2. Daily SB (% waking time)	58.58	13.44	0.93	-	-
3. Person-mean SB (%)	59.15	10.70	-	-	-
3. Daily light PA (% waking time)	35.80	11.61	0.90	-	-
4. Person-mean light PA (%)	35.43	8.79	-	-	-
5. Daily MVPA (% waking time)	5.62	5.92	0.78	-	-
6. Person-mean MVPA (%)	5.42	3.72	-	-	-
7. Daily bodily pain (scale range = 1-4)	1.24	0.47	0.87	1	4
8. Daily fatigue (scale range = 1-4)	1.59	0.71	0.87	1	4
9. Typical physical health (scale range = 0-100)	80.95	17.59	-	21.67	100
10. Typical PA	140.57	58.11	-	43.21	330
11. Typical SB (min/day)	470.37	216.20	-	570	8,340
11. Typical pain (scale range = 1-5.5)	1.79	0.83	-	1	4.50
12. Typical fatigue (scale range = 20-100)	39.21	13.57	-	20	81
14. BMI (kg/m^2)	25.14	3.44	-	-	-
15. Age (years)	70.98	6.87	-	-	-

Note. Unstandardised estimates were used to calculate descriptive statistics.

Daily light PA, MVPA, and daily SB Predicting Bodily Pain

Table 4.3 shows the standardised coefficients (*β)* and standard errors for level 1 and level 2 predictors of bodily pain. Engagement in daily light PA (*β*= 0.151, *p*= 0.009), daily MVPA (*β*= 0.110, *p*= 0.023), and higher levels of typical pain (*β*= 0.543, *p*<0.001) positively predicted bodily pain experienced at the daily level. No other significant associations were found. Typical bodily pain and physical health did not significantly moderate the associations between daily light PA, MVPA, and bodily pain. Table 4.4 shows that typical pain (*β*= 0.515, *p*<0.001) and daily SB (*β*= -0.182, *p*= 0.003) over the 7 days predicted bodily pain at the daily level. No other associations were significant.

Table 4.3

Multilevel Modelling Coefficients of Light PA and MVPA Predicting Daily Pain and Fatigue

Predictor Variable	Parameter Estimate (SE)	
Fixed Effects	Model 1 bodily pain β (SE)	Model 2 fatigue β (SE)
Intercept	-0.136 (0.285)	-0.437 (0.309)
Daily light PA	0.151** (0.058)	0.029 (0.061)
Person-mean light PA	-0.064 (0.136)	0.080 (0.144)
Daily MVPA	0.110* (0.048)	0.044 (0.053)
Person-mean MVPA	-0.202 (0.156)	-0.005 (0.171)
Daily light PA x typical bodily pain	0.100 (0.075)	-
Daily MVPA x typical bodily pain	-0.090 (0.051)	-
Daily light PA x typical fatigue	-	-0.240** (0.072)
Daily MVPA x typical fatigue	-	-0.254*** (0.061)
Daily light PA x typical physical health	-0.014 (0.074)	-0.154 (0.084)
Daily MVPA x typical physical health	-0.030 (0.058)	-0.164* (0.076)
Typical PA	0.012 (0.083)	-0.122 (0.091)
Typical pain	0.543*** (0.113)	-
Typical fatigue	-	0.263* (0.119)
Typical physical health	-0.070 (0.105)	0.006 (0.131)
BMI	-0.097 (0.089)	0.151 (0.097)
Age	-0.155 (0.102)	0.132 (0.113)
Cardiovascular disease	0.040 (0.178)	0.483* (0.190)
Gender	0.063 (0.240)	0.308 (0.248)
Cohabiting	0.139 (0.193)	-0.076 (0.211)
Random Effects		

Intercept	0.283*** (0.079)	0.369*** (0.093)
Residual (AR1 diagonal)	0.434*** (0.041)	0.492*** (0.043)
-2 restricted log likelihood	798. 796	857.948
Akaike information criterion	804.796	863.948
R_1^2	0.528	0.210

Note. *$p < .05$, ** $p < .01$, *** $p < .000$

Daily light PA, MVPA, and SB Predicting Fatigue

Daily light PA and MVPA did not significantly predict fatigue. However, a number of significant interactions emerged. Those interactions were further probed via simple slope analyses, for which we report unstandardized coefficients. Specifically, for individuals with lower levels of typical fatigue, there was a positive association between daily light PA and daily fatigue (B= 3.28, *p*< 0.001), whereas for those with higher levels of typical fatigue, this association was negative (B= -3.22, *p*= 0.001). For those with lower levels of typical fatigue, there was also a positive association between daily MVPA and daily fatigue (B= 3.49, *p*< 0.001), whereas for those with higher levels of typical fatigue, this association was negative (B= -3.41, *p*< 0.001). For individuals with lower typical levels of physical health, there was a positive association between daily MVPA and fatigue (B= 2.93, *p*= 0.027), whereas for those with higher levels of typical physical health, this association was negative (B= -2.85, *p*= 0.034). Typical levels of physical health did not significantly interact with light PA to predict daily fatigue. In summary, for individuals with higher typical levels of fatigue, there was a positive association between daily light PA and fatigue and between daily MVPA and fatigue. Typical fatigue (β= 0.263, *p*= 0.031) and cardiovascular disorder (β= 0.483, *p*= 0.014) were also significantly associated with daily fatigue.

Table 4.4

Multilevel Modelling Coefficients of SB Predicting Daily Pain and Fatigue

Predictor Variable	Parameter Estimate (SE)

Fixed Effects	Model 3 bodily pain	Model 4 fatigue
	β (SE)	β (SE)
Intercept	-0.121 (0.281)	-0.373 (0.315)
Daily SB	-0.182** (0.061)	-0.050 (0.065)
Person-mean SB	0.171 (0.130)	-0.047 (0.143)
Daily SB x typical bodily pain	-0.015 (0.076)	-
Daily SB x typical fatigue	-	0.336*** (0.080)
Daily SB x typical physical health	0.052 (0.077)	0.212* (0.096)
Typical sedentary time	-0.102 (0.086)	-0.035 (0.096)
Typical pain	0.515*** (0.109)	-
Typical fatigue	-	0.274* (0.120)
Typical physical health	-0.063 (0.102)	0.009 (0.133)
BMI	-0.064 (0.084)	0.142 (0.094)
Age	-0.128 (0.095)	0.136 (0.107)
Cardiovascular disease	0.029 (0.174)	0.489* (0.191)
Gender	0.110 (0.229)	0.299 (0.246)
Cohabiting	0.083 (0.196)	-0.174 (0.221)
Random Effects		
Intercept	0.271*** (0.075)	0.378*** (0.093)
Residual (AR1 diagonal)	0.436*** (0.040)	0.494*** (0.043)
-2 restricted log likelihood	789.974	850.538
Akaike information criterion	795.974	856.538
R_1^2	0.548	0.191

Note. **p* < .05, ** *p* < .01, *** *p* < .0

According to Table 4.4, for individuals with lower typical levels fatigue, there was a negative association between daily SB and fatigue (B= -4.612, *p*< 0.000), whereas for those with higher levels of typical fatigue, this association was positive (B= 4.513, *p*<0.000). For individuals with lower typical levels of physical health, there was a negative association between daily SB and fatigue (B= -3.779, p= 0.019), whereas for those with higher levels of typical physical health, this association was positive (B= 3.680, p= 0.022). Typical fatigue (β= 0.274, p= 0.026) and the presence of cardiovascular diseases (β= 0.489, p= 0.013) also predicted daily fatigue. Taken together, the results indicate that for those with higher typical levels of fatigue, there was a positive association between daily SB and fatigue.

Discussion

In this study we examined daily associations between objectively-assessed light PA, MVPA, and SB, and subsequent bodily pain and fatigue in a sample of older adults. Further, we explored whether these within-person associations were moderated by between-person differences in typical bodily pain, fatigue, and physical health.

Predictors of Bodily Pain

The within-person associations of daily light PA and MVPA with daily bodily pain were positive, in that more engagement in daily light PA and MVPA predicted more subsequent bodily pain. This findings are in line with previously reported positive between-person associations between self-reported low PA and back pain in older adults (Cecchi et al., 2006; Silva et al., 2016). With respect to daily SB and bodily pain, the analysis showed that more engagement in daily SB was associated with less subsequent bodily pain in older adults. This finding is aligned with our results pertaining to PA and pain.

Interestingly, even though engagement in PA might increase bodily pain in older adults, it is well established that regular PA can maintain and improve health in older adults (World Health Organization, 2011). In fact, there are studies showing a negative as opposed to a positive association between PA and pain (e.g., Cecchi et al., 2006). Given these apparently inconsistent findings regarding the associations between PA and pain, more detailed research is needed to explore the temporal effects of PA on pain. Our findings also seem to go against advice to interrupt bouts of daily sedentary behaviour (Bankoski et al., 2011). Future studies may need to utilize more frequent measurement points (e.g., hourly) because daily pain may be a function of the type of activities of daily life. It is also possible that feelings of pain fluctuate from morning to evening and that PA/SB might predict pain in different ways depending on the time of the day (as well as the type of activity).

Predictors of Fatigue

The results showed no significant within- and between-person associations between light PA, MVPA, SB, and subsequent fatigue. A number of interesting interactions emerged. Specifically, better typical levels of physical health moderated the association between daily MVPA and fatigue, and between SB and fatigue. As expected, those who engaged in more MVPA and less SB reported less fatigue, but this was the case only for individuals with better perceived health. In contrast, for those with worse perceived health, engagement in more MVPA and less SB was detrimental as it resulted in more daily fatigue. This moderation signifies the importance of taking into account typical physical health when considering the association between PA, SB and subsequent daily fatigue. There is evidence to suggest that perceptions of physical health are related to perceived confidence (Prieto-Flores, Moreno-Jiménez, Fernandez-Mayoralas, Rojo-Perez, & Forjaz, 2012). Therefore, increasing people's perception of physical health through interventions focused on increasing confidence may be instrumental in decreasing reported fatigue.

Other interactions also showed that the expected negative (positive) association between daily light PA (SB) and subsequent daily fatigue were evident only for those individuals with high typical fatigue levels. This indicates the need to assess both daily and typical levels of fatigue when examining the daily association of this variable with PA and SB. Our findings also highlight the need to focus PA-promoting interventions in older adults on individuals who report high levels of fatigue and perhaps experience chronic fatigue. It would be interesting to examine whether the provision of daily support to those who experience high levels of fatigue can attenuate the positive relation between daily fatigue and PA observed in this study.

Limitations and Future Research Directions

We must acknowledge limitations of the present study. The standardized coefficients associated with the main effects of daily SB, light PA and MVPA were small. However, such effects are in line with our research in the pain and fatigue literatures utilizing objective assessments of PA [(Egerton, Chastin, Stensvold, & Helbostad, 2016; Mahieu et al., 2016)]. Given that participants in this study were generally inactive, 1 SD increases in daily SB, light PA and MVPA represent substantial deviations from the sample's mean scores on those variables. Due to the duration of the study design (7 days), we are not able to establish the extent to which our findings would generalize over a longer period of time (e.g., two or three months). A measurement burst approach (Sliwinski, 2008) in which diaries are administered on multiple occasions (e.g., 3 weeks over a year) would allow for a test of seasonal effects (e.g., due to the weather). Assessing multiple activities and rates of fatigue and pain throughout the same day can also offer a more comprehensive understanding of the dynamic nature of the relations between these two variables, PA and SB. Another limitation of the study was that the sample was relatively ethnically homogenous, educated, healthy (e.g., low bodily pain and fatigue scores), and wealthy, thus it is not wholly representative of the general population of older adults in the UK. In addition, the construct of pain is viewed as multidimensional and levels of pain can vary depending on the extent of individual differences, such as perception, physical and psychological functioning, and socioeconomic factors (Gatchel & J., 2005; Gatchel, Peng, Peters, Fuchs, & Turk, 2007; Turk & Gatchel, 2013). Future studies should aim to recruit older adults from more diverse backgrounds and consider many aspects of pain. Further, another limitation was that we used self-reported measures of health. In future investigations, it might be informative to replicate our study using objective assessments of physical health (e.g., field- based tests of gait speed or hand grip strength).

Notwithstanding the limitations above, this study has several strengths. This is the first study to examine within-person associations between light PA, MVPA, SB and subsequent daily pain and fatigue in older adults. We were able to establish support for such within-person associations which were not confounded by individual differences in PA and SB. In addition, advancing past research, we specifically measured light PA because in older adults a high proportion of time is spent engaging in this type of PA (Gando et al., 2010; Owen et al., 2010). Indeed, we found that engagement in daily light PA represented 35.80% of the daily activity up to the measurement of pain and fatigue, a much higher percentage than that for MVPA (5.62%). We measured levels of PA and SB both objectively and via self-reports. In contrast, most of the previous studies have only used self-reports of PA and/or SB in predicting bodily pain and fatigue. By using smart devices for EMA, we were able to obtain real-time reports of pain and fatigue. Future studies in this field could build on our findings to develop targeted PA interventions for individuals with high levels of fatigue and poor health. Such interventions could also offer participants the opportunity to provide real-time assessments of pain and fatigue, and then at appropriate time points, depending on these ratings, prompt customized PA and SB reduction solutions (e.g., via smartphones) that target beliefs, barriers and benefits of being more physically active and less sedentary.

CHAPTER 5

GENERAL DISCUSSION

Overview of Studies

Using person-centred and within-person approaches, the aim of this thesis was to examine associations between motivational factors, perceptions of the physical environment, PA, SB and health in older adults from both ALFs and community settings. The specific aims of this thesis were threefold. First, to identify profiles based on PA (light PA, MVPA), SB and physical function and examine how these differ on mental health outcomes (Chapter 2). A variety of indicators of physical function (grip strength: upper body strength, mobility: leg strength, balance, spirometry: pulmonary function, perceived physical health: perceived physical function) were chosen as physical function is multidimensional (Wright, Hegedus, David Baxter, & Abbott, 2011; Terwee, Mokkink, Steultjens, & Dekker, 2006). It is important to emphasise that the majority of these factors were assessed objectively, thereby improving the quality of the indicators. High quality of indicators is known to be an important aspect in the process of classification of individuals (Wurpts & Geiser, 2014). The second aim was to classify groups of older adults based on motivation constructs from SDT and perceptions of the physical environment and explore the differences between these typologies in terms of light PA and MVPA (Chapter 3). Zhang and Solmon (2013) presented a model which suggested that PA may be better explained when the perception of the physical environment is examined alongside variables from self-determination theory. Therefore, this model was selected for testing and all scales related to self-determination theory selected were widely used in the literature. The ALPHA scale for the assessment of the perceptions of the physical environment has been described above. This tool is highly validated and widely used to assess perceptions of the physical environment in many countries. Finally, the within-person associations between PA (light PA, MVPA), SB, bodily pain and fatigue (Chapter 4) were examined.

Overall, the following conclusions can be drawn from the series of studies presented in this thesis. First, older adults who engage in approximately 4.63 hrs of light PA and 0.31 hrs of MVPA, and who spent 7.11 hrs per day in SB plus have relatively high levels of physical function (subjective health= 51.28, FEV_1= 0.77, Grip strength 25.20 kg, BMI= 26.24 kg/m^2, gait speed= 9.52 sec) are more mentally healthy compared to those who engage in lower levels of these activities and have lower levels of physical function. Specifically, this latter group of older adults with low scores on mental health only engage in approximately 2.10 hrs (17.40%) of light PA, 0.01 hrs (0.09%) of MVPA, 9.82 hrs (81.50%) of SB per day and have low levels of physical function (subjective health= 30.87, FEV_1= 0.54, Grip= 16.11kg, BMI= 30.51kg/m^2, Gait speed= 23.14 sec).

The results from this thesis are consistent with the literature, which found the positive associations between higher levels of PA engagement (Becofsky, Baruth, & Wilcox, 2015; Steinmo, Hagger-Johnson, & Shahab, 2014) and physical function (Vanoh, Shahar, Yahya & Hamid, 2016) but not lower levels of SB (Balboa-Castillo, León-Muñoz, Graciani, Rodríguez-Artalejo, & Guallar-Castillón, 2011) were related to positive mental health outcomes. However, this thesis goes one step further by using the person-centred approach that enables us to identify physically vulnerable older adults who spend less time in SB and more time in light PA and MVPA.

These results demonstrate that PA, SB, physical health and function, and mental health outcomes are closely associated in older adults in ALFs. This suggests that all these factors should be considered in the design of interventions to improve health and well-being in this group. The findings have also provided preliminary insight into potential dose-response issues regarding high levels of PA, low levels of SB, and better levels of physical function relating to positive mental health in this population.

Moreover, according to the results of the person-centred approach, it is interesting to note that light PA and gait speed showed the highest and second highest effect sizes in relation to mental health outcomes. The effect sizes from light PA and gait speed are notable as older adults mainly engaged in light PA, such as slow walking or light household activities (Ainsworth et al., 2000; Brawley et al., 2003; Hansen, Kolle, Dyrstad, Holme, & Anderssen, 2012). Therefore, more specific interventions that target light PA, SB engagement, and increased walking speed are warranted for further research. In addition, research is needed that examines which strategies are most effective for breaking up prolonged SB in this population.

Furthermore, older adults who perceive relatively high levels of autonomy support from significant others in their social environment, have higher levels of self-determined motivation and psychological need satisfaction, perceive the physical environment to be supportive of PA, and are more likely to engage in much higher levels of PA (most supportive class: Light PA= 236.70 min, MVPA= 16.99 min) compared to their counterparts. The current findings have revealed large effect sizes for all variables, which suggest that both perceptions of the physical environment and motivational factors needed to be taken into account to better understand PA engagement in older adults in ALFs.

Another conclusion that can be derived from the thesis is that daily light PA, MVPA, and bodily pain are positively associated at the within-person level, whereas SB is negatively associated with this outcome in community based older adults who report relatively low intensity of pain. However, it is possible that this depends on the types of PA that older adults engage in. The findings from this thesis were interesting insofar as engagement in more SB is widely linked to negative health outcomes and older adults are more likely to be sedentary than other age groups at the between level (Buman et al., 2010; Davis et al., 2014).

In contrast to bodily pain, daily light PA, MVPA, and daily SB were not significant predictors of daily fatigue at the within-person level, but interacted with typical physical health and typical fatigue in relation to daily fatigue. For older community-dwelling adults with better general physical health, engaging in high levels of MVPA and low SB is associated with lower levels of daily fatigue. However, for individuals with a generally poorer health profile, higher levels of MVPA and less SB increased levels of fatigue. This observed moderation effect extends our understanding of the associations between PA and fatigue, and offers potential insight into the design of both PA and SB interventions. The results from this thesis imply that when attempting to increase levels of even light PA in individuals with poor health profiles, it may be important to start slowly, and build up intensity, duration and frequency incrementally to prevent manifestations of fatigue. With regard to SB, fatigue is increased in older adults with better levels of typical fatigue and physical health.

More broadly, the results of this thesis suggest that it is important to consider the interplay of a range of individual, social, and environmental factors to understand mental health, PA, SB, pain and fatigue outcomes in older adults. Although it is well documented that PA and SB are critical to both mental and physical health in older adults (Bauman, Merom, Bull, Buchner, & Fiatarone Singh, 2016; Rosenberg et al., 2016; Teychenne et al., 2010), the series of studies presented in this thesis add to this literature in a number of important ways, which will be outlined in the next section.

Methodological Contributions

Objective Assessment of Behaviours and Function. To date, most research that has examined the associations between PA, function, and mental health has employed self-reported instruments to assess both behaviours and function. The use of objective measures for light PA, MVPA, SB, and physical function (spirometer, grip dynamometer, and gait test) was a key strength of the studies presented in this thesis. This is because objective measures of both behaviours and function eliminate the bias that results from both memory recall and social desirability associated with self-reported assessments (e.g., PA, SB; Aguilar-Farías et al., 2015; Celis-Morales et al., 2012; Chastin et al., 2014; Tudor-Locke & Myers, 2001). It is well known that self-reported PA is overestimated, whereas engagement in SB, such as sitting, is under reported (Celis-Morales et al., 2012). The use of objective assessments provides more accurate and detailed accounts of the patterns and intensities of movement. This is particularly important because many older adults have a greater tendency to struggle with memory recall than do their younger counterparts (Bernstein et al., 1998; Cumming & Klineberg, 1994; Sallis et al., 1985). With regard to physical function, objectively-assessed physical function has been found to be more accurate than self-reported physical function (Brach, VanSwearingen, Newman, & Kriska, 2002).

Beyond Variable-Centred Approaches. Previous literature has demonstrated positive associations between light PA and MVPA, and mental health outcomes, as well as negative associations between SB and mental health outcomes in adults and older adults (Biswas et al., 2015; Camhi, Sisson, Johnson & Katzmarzyk, 2011; Gennuso, Gangnon, Matthews, Thraen-Borowski & Colbert, 2013; Thraen-Borowski, Trentham-Dietz, Edwards, Koltyn & Colbert, 2013). However, this literature has tended to examine these associations by using variable-centred approaches. An important contribution of the research presented in this thesis is that person-centred approaches were adopted to examine the distinct profiles of PA, SB and their associations with mental health outcomes. The person-centred approach enables classification of cut-off scores amongst samples based on key indicators of interest (Marsh et al., 2009). Therefore, the person-centred approach enables a classification of frail older adults in relation to mental health, PA and SB, for example, somewhat different results could be identified (e.g., unobserved patterns of individuals' data; Marsh et al., 2009), which may represent typologies of classes. Therefore, in order to improve individuals' levels of profiles, cut off scores within the classes can be used as targets for changes through further interventions.

Moving from Examinations of Between-Person Differences to Within-Person Associations. This thesis has contributed to previous literature by focusing on the within-person associations in real-settings in terms of engagement in light PA, MVPA, SB and bodily pain, and fatigue. Using momentary assessment makes it possible to examine daily fluctuation within individuals.

As discussed, a plethora of research has shown the positive association between PA and bodily pain. However, there is a limited amount of research that has sought to examine those relations at the within-person level in older adults. Although more evidence is needed to confirm the results of this thesis, this thesis showed that daily bodily pain is positively associated with daily PA and negatively associated with SB in older adults. A previous study has shown that exercise may increase levels of acute pain even though this subsequently decreased over time (Focht, Ewing, Gauvin & Rejeski, 2002). However, in the study by Focht et al. (2002), participants were overweight or obese adults with knee osteoarthritis, which is likely to have a bearing on the results. Other studies have shown that engagement in more PA negatively predicts levels of pain (i.e., back pain) in older adults (Cecchi et al., 2006). Moreover, participants that engaged in above average levels of PA for the group experienced higher levels of acute pain in adults (Andrews, Strong & Meredith, 2015). Similar findings were also shown in relation to SB where some studies found a negative association between SB (i.e., sitting) and bodily pain (Balboa-Castillo et al., 2011), whereas others found no relation between the two variables (Ellingson, Colbert & Cook, 2012). The findings presented in this thesis, using ecological momentary assessment may help to explain some of these inconsistencies, although more research is needed. In future, in relation to bodily pain, it would be interesting to examine the within-person effects of different types (e.g., brisk walking) and intensities of PA, and different types of SB.

Typically, research has been conducted in relation to PA and SB at the between-person level, even though there is an increasing number of studies examining the within-person association (Maher & Conroy, 2015; Marszalek, Morgulec-Adamowicz, Rutkowska, & Kosmol, 2014). This thesis has investigated light PA, MVPA, and SB, as well as simultaneously examining two domains of health (physical health: bodily pain; psychological health: fatigue) because those domains (bodily pain, fatigue) affect a great deal of impact towards ageing population (Blyth et al., 2001; Chen, 1986; Crook et al., 1984; Cullen et al., 2002; Hyyppä et al., 1993; Smith et al., 2001). Furthermore, the findings show that these factors may interact differently with the outcomes examined in this thesis. In future research, investigations of the within-person association would be useful for identifying fluctuations, which may help to identify the most suitable times of the day to engage in PA to avoid exacerbation of daily bodily pain and fatigue.

Conceptual Contributions

Motivation and the Physical Environment. SDT has been widely employed to understand PA engagement (Ng et al., 2012; Teixeira et al., 2012), although less so among older adults than for other population groups. However, although SDT focuses on individual and social contexts, it does not directly consider the influence of the physical environment on behavioural engagement. Therefore, in Chapter 3, the key SDT variables (perceptions of autonomy support, need satisfaction, and behavioural regulations) were examined alongside a consideration of perceptions of the physical environment (Fleig et al., 2016; Zhang & Solmon, 2013). The study was partly informed by a conceptual, but untested, model proposed by Zhang and Solmon (2013). In their model they proposed that variables contained with SDT (i.e., social environment, need satisfaction, motivation) and the physical environment all independently predict PA engagement. In support of their model, which has remained untested until now, the findings from the present thesis showed that individuals who are highly self-determined and who perceived high levels of both social and environmental support for PA engage in greater levels of light PA and MVPA than individuals with low scores on these variables. Thus, the findings suggest that the social environment, personal motivational factors, and the physical environment should be taken into account in the promotion of PA in older adults in ALFs. For example, well-organized environments (e.g., clean streets, good street networks) could optimize motivation for PA in older adults (Fleig et al., 2016). However, in some cases it is unrealistic and costly to change the physical environment. For example, in a year-long study of PA in adolescent girls, the perceptions of the physical environment (i.e., equipment accessibility) were found to be mediated by self-efficacy (Motl et al., 2005), suggesting that improving perceived self-efficacy could be an important factor relating to physically active lifestyles. Therefore, supporting the combined concept of autonomy support and perception of the physical environment might be another way to explore PA promotion. Moreover, interventions based on motivational contexts (i.e., a walking program, pedometer) were effective to override the negative perceptions of the physical environment (i.e., low aesthetics) in adults (Merom et al., 2009), although there are needs examining more specific perceptions of the physical environment (Merom et al., 2009). Therefore, results from this thesis imply that further interventions could be developed on the basis of LPA results, which show large effect sizes within many indicators. However, very limited attention has been paid to the literature, perceptions of the physical environment in conjunction with the motivational contexts should be considered when examining PA and SB outcomes.

Nature of Sample

Much attention has been paid to the growing number of older adults (United Nations, 2015b). Whilst a steadily increasing amount of research has examined PA, SB and related outcomes in older adults in community settings, relatively little attention has been paid to residents of ALFs. This is concerning as residents of ALFs are more sedentary (time spent in SB: ALFs= 665.24 min/day, community= 504.6 min/day) and inactive (time spent in MVPA: ALFs= 1.6 min/day, community= 16.7 in males, 12.4 in females; Corcoran et al., 2016; Troiano et al., 2008) compared to those in community settings (Corcoran et al., 2016; Matthews et al., 2008). Furthermore, residents in ALFs are more functionally vulnerable compared to older adults in community settings. This thesis has contributed important new information about the determinants and outcomes of PA and SB, mental health, and function in older adults in ALFs, and bodily pain and fatigue in older adults in community settings.

Practical Implications.

The use of LPA in this thesis provides some support for the new conceptual premise that identifying groups of older adults at risk can in turn be used to develop appropriate interventions for each group.

Given the sedentary lifestyles, very low levels of engagement in MVPA, and the functional vulnerability of residents of ALFs, in terms of PA promotion it may be most realistic to target light PA. Light PA consists of slow walking, household chores, and other low intensity activities of daily living (Ainsworth et al., 2000; Brawley et al., 2003; Hansen et al., 2012). However, staff in ALFs assists residents in the performance of their daily activities, which may indirectly reduce the residents' active engagement in light PA. Therefore, staff could be made aware of light intensity activities that residents are still able to do, and rather than performing all the activities for them, they might encourage them to become actively involved. Moreover, if possible, PA relating to muscular strength (e.g., sitting to standing exercises) should be encouraged for residents because this factor is also closely related to mental health outcomes (e.g., grip strength; Taekema, Gussekloo, Maier, Westendorp, & de Craen, 2010). The results from this series of studies suggest the importance of delivering such messages in a need supportive way.

In addition, staff in ALFs may recommend residents to use a portable exercise tool (e.g., hand grip exerciser) to maintain or improve their grip strength, particularly for those in Class 1 ("low physical function and PA with a highly sedentary lifestyle"). The use of the portable exercise tool might be perceived as a feasible exercise tool for the residents who lead sedentary lifestyles. Increasing exercise, even when seated, can have positive benefits for mental health. In addition, as more than half of the residents live alone (widowed: 45.9%, single: 2.4%, separate: 10.6%), it would also be interesting to explore if a peer-programme could be set up, whereby those who live a more active lifestyle are supporting those who are more sedentary, encouraging them to be more active.

In Chapter 3, perceptions of physical environment were more positive in "highly self-determined and supported" compared to "moderately self-determined and supported" (d = .8) and so were the differences between the two classes in terms of MVPA (d = .8). This finding is important because although older adults are encouraged to engage in regular MVPA to reap health benefits (World Health Organization, 2011), adequate MVPA (150 minutes a week of moderate PA or 75 minutes of vigorous PA) is a difficult aim to accomplish for older adults to achieve (Troiano et al., 2008). In this study, participants spent only approximately 9.53 (1.35%; see Table 5.1) minutes a week in MVPA, which is far less than the recommended guidelines. Further research should examine which specific environmental features (e.g., types of residence, distance to local facilities) are more influential in determining MVPA as the location of footpaths, parks, and running tracks could be related to more levels of MVPA.

Furthermore, smart phones may be cost effective in delivering digital interventions to improve perceptions of the physical environment. Weather conditions change frequently particularly in the UK, therefore weather updates could be provided to older adults to allow them to plan a suitable time to engage in PA. Also, providing regular information on (new) PA facilities in the neighbourhood (e.g., gyms) or events, which take place locally, could be tested to see whether these lead to more physically active lifestyles. This information could be updated using a ‘global positioning system (GPS)’, which is a built-in application in all smart phones. In addition, people tend to have better basic psychological needs when they perceive they are supported by their social contexts (Deci & Ryan, 2000). However, not much is known about how “important others” of residents in ALFs can support physically active lifestyles amongst the residents by satisfying the latter’s psychological needs. This could be explored in future research. In addition, such interventions should consider differences in physical environments. For those who perceive that they reside in deprived areas (e.g., on the basis of the proportion of green spaces or crime rates), more staff lead group walking could be a possible strategy for older residents as they may feel more supported over the period of walking.

In Chapters 2 and 3, participants revealed that staff of ALFs are perceived as important people in terms of encouraging them to be more active. Therefore, education programs for staff should be also developed to understand the importance of active lifestyles of residents and to support residents of ALFs to become more active. These educational programmes should include methods on how to create an autonomous supportive environment to facilitate PA. Given that walking is the main PA (i.e., light PA) for older adults, staff led walking programmes could motivate residents in ALFs. In addition, GPS could be used to measure the objectively-assessed physical environment. Social support, such as family, friends, and staff in ALFs is also an important determinant for evaluation.

According to the results discussed Chapter 4, engaging in PA and sitting on a regular basis should be carefully implemented to manage bodily pain because older adults tend to feel more bodily pain after light PA and MVPA. It is also notable that older adults experience lower levels of bodily pain after SB at the within level. However, according to literature, the results from this thesis were somewhat different because there is a tendency of reporting positive roles of PA and adverse associations between SB and fatigue (Ellingson, Kuffel, Vack & Cook, 2014; Moreh et al., 2010) and physical health (Manini & Pahor, 2009) at the between level in literature. An implication from this thesis can therefore be assumed the importance of examining the within-person association to explain mechanisms between PA, SB, and bodily pain. Moreover, this thesis further adds to the literature showing that managing typical fatigue and typical physical health would be of importance in relation to fatigue to benefit from engaging in light PA and MVPA as well as less SB in relation to fatigue at the within-person level. However, a caution is needed not to take part in light PA and MVPA at the beginning of those activities (light PA, MVPA) due to that bodily pain was increased by engagement in light PA and MVPA. There might be some value in exploring the impact of the type of activity on the association between PA and pain. For example, lifting heavy objects and gardening could have differential effects on the relationship between pain and PA. In addition, typical physical health did not moderate the associations between pain and PA or SB. It should be acknowledged that the overall perceived physical health of the participants was good (i.e. 81 out of 100). Therefore, in order to explore this hypothesis in the future, it is important to include a sample with a greater variation in their perceived physical health. These findings suggest that only those with better physical health should be recommended to engage with more intensive PA, whereas those with lower levels of physical health are less likely to benefit from MVPA. Given that physical health did not influence the associations between light PA and fatigue, perhaps light PA would be the most suitable type of PA to start an intervention to reduce fatigue for older adults. Increasing light PA might not only benefit levels of fatigue and physical health, but it is also a feasible target for older adults who are not active.

Other studies have generally reported small associations between fatigue and PA [(Egerton et al., 2016; Mahieu et al., 2016)]. Such small and/or non-significant associations could be due to the possibility that the relations between PA, SB and fatigue are dependent on individuals' levels of health and their general levels of fatigue. Hence, individuals might benefit more (in terms of their daily fatigue levels) from moving more and sitting less when their health is relatively good and when they report higher levels of typical fatigue (i.e., there is more room for improvement in their fatigue levels).

The current findings also suggest that those with higher typical levels of fatigue might benefit more in terms of their daily fatigue levels from moving more and sitting less than those with lower levels of typical fatigue. Even though exercise interventions have been shown to reduce the levels of fatigue (Puetz, O'Connor, & Dishman, 2006), even in clinical populations with high levels of fatigue such rheumatoid arthritis (Rongen-van Dartel et al., 2015) and multiple sclerosis (Pilutti, Greenlee, Motl, Nickrent, & Petruzzello, 2013), to our knowledge little attention has been paid to the moderating role of typical levels of fatigue on these benefits. Therefore, the possibility that those with higher levels of typical fatigue might benefit more from being physically active in term of their daily fatigue should be investigated in future intervention studies. Our findings also highlight the need to focus PA-promoting interventions in older adults on individuals who report high levels of fatigue and perhaps experience chronic fatigue. Given that higher levels of light PA were associated with lower levels of fatigue in those with higher levels of typical fatigue, perhaps PA-promoting interventions for this particular population should focus on light PA. As mentioned above, this is likely to be a feasible target for people who are not physically active, and such type of activity can help to increased overall health (Manns et al., 2012; Matthews et al., 2015).

In addition, text messages can be an easy intervention to examine the change of engagement in PA, which may lead to positive outcomes. Examples of text messages could be providing information (e.g., "Physical activity is good for your health") or suggesting an aim ("Have you done a brisk walk for 30 minutes today?"). Those messages could be also delivered using mobile phone voice, which may contain a range of information and easy to listen to. Furthermore, GPS could be used to recommend the best places to walk or take part in PA. Showing pictures of the neighbourhood may attract older adults to visit the place of PA and may further motivate them. Another advantage is that it is plausible to adjust the frequency and intensity of interventions compared to typical deliveries of interventions (i.e., face-to-face). Further research should examine how other factors (e.g., perceptions of the physical environment, the presence of other people, or the quality of motivation) may moderate the associations between daily light PA, MVPA, SB, and daily fatigue. For example, being immersed in natural environments may invigorate positive psychological variables such as feelings of well-being (Kinnafick & Thøgersen-Ntoumani, 2014).

Limitations and Future Research Directions

This thesis set out to explore the determinants of mental health, bodily pain and fatigue by examining light PA, MVPA, SB, and physical function using a combination of objective and self-reported measures in older adults. Beyond the strengths of the research already highlighted, its limitations should be acknowledged when interpreting the results.

The sample sizes in studies 1 and 2 were relatively small (Chapters 2 and 3). However, the studies used objective measures for light PA, MVPA, and SB, as well as physical function which may partly outweigh the limitations of the limited sample size (Wurpts &

Geiser, 2014). Furthermore, the results presented in Chapter 2 and Chapter 3, that used LPA, cannot be generalised beyond the samples from the ALFs. Moreover, further investigation should be undertaken with other age groups or older adults in community settings to examine whether the results can be replicated in these settings.

Another possible limitation is that the samples in this thesis were largely ethnically homogeneous as most participants were white English. According to the literature, ethnic disparity may be a possible determinant of lifestyle factors (Li & Wen, 2013). For example, individuals from ethnic minor groups generally participate in lower levels of leisure-time PA compared to Caucasians (Li & Wen, 2013). However, the proportion of white English participants in the studies presented here is similar to the proportion of this ethnic group in England (e.g., White English: 80.5%, Any other White 4.4%, Indian 2.5%, Pakistani: 2.0; Office for National Statistics, 2012). In addition, participants were mainly women (Chapter 2: 68.2%, Chapter 3: 66.7%, Chapter 4: 68.3%), which may limit the generalisability of the results. Therefore, these findings cannot be extrapolated beyond the participants of this study.

Furthermore, due to the cross-sectional nature of the studies (Chapter 2 and Chapter 3), stability of class membership over time cannot be assumed (Chapter 2: mental health; Chapter 3: light PA, MVAP). Therefore, it would be useful to identify the factors that might predict stability versus change in class membership. It is also critical to examine which interventions would be most suitable to change behaviours for each of the classes identified.

In this research, the assessment of the physical environment was limited to self-report (Chapter 3). Previous studies have assessed the physical environment objectively by using GIS and estimated “walkability” (Haselwandter & Corcoran, 2015). However, due to the associated costs and resources required, objectively assessing aspects of the physical environment were not possible in this thesis. Moreover, changing the physical environment can be very costly and in some cases unrealistic. The findings discussed in Chapter 3 suggest that it is important to increase perceptions of the physical environment. Orstad, McDonough, Stapleton, Altincekic, and Troped (2016) have shown that objectively measured environments and self-reports of those environments are unrelated, and that each uniquely predicts PA behaviour. In particular, unlike objectively-assessed physical environments, perceptions of the physical environment vary dependent on individual differences (Clark et al., 2009; Bandura, 1978; Bowling & Stafford, 2007; Nasar, 2008; Wen, Hawkley, & Cacioppo, 2006; Wilson et al., 2004). Therefore, further research should test whether motivationally rooted interventions may change *perceptions* of the physical environment. Moreover, it would be useful to measure the changing perceptions of the physical environment using ecological momentary assessment, possibly in combination with walk and talk interviews (Evans & Jones, 2011), to discover where and when people feel differently.

In addition, although the timed up and test was used for physical function of mobility, it should be acknowledged that the SPPB (Guralnik et al., 1994) has been widely used in older adults (Chen, Blake, Genther, Li, & Lin, 2014). Given the number of assessments undertaken in the studies included in this thesis, it was decided to go for the timed up and go test as it would reduce the assessment burden on the participant. However, it would be interesting to conduct further studies using the more detailed SPPB to assess mobility and lower extremity functional ability.

The study period (seven days) may have been inadequate to gain a true representation of bodily pain and fatigue. Further studies may need to assess the variables over a longer period of time (e.g., two weeks) to gain a more comprehensive assessment of daily PA and SB, as well as bodily pain and fatigue. Given these apparently inconsistent findings regarding the associations between PA and pain, more research is needed to explore the temporal effects of PA on pain in more detail. Future studies may need to utilize more frequent measurement points (e.g., hourly). Although many studies have used a two-week period

(Maher & Conroy, 2015, 2016), the study period has not been standardised, particularly in terms of measuring daily PA and SB (Marszalek, Morgulec-Adamowicz, Rutkowska, & Kosmol, 2014). Moreover, the EMA method involves the collection of a considerable amount of intensive data within a short time period (Bolger & Laurenceau, 2013), and adopting a longer study period may be too great burden for participants (Shiffman, 2009). In addition, participants were only prompted to respond to the surveys once per day (see Chapter 4). In future, researchers could assess the variables several times each day to examine within-day fluctuations. Moreover, this thesis suggests that providing more enjoyable PA programmes may help to relieve daily fatigue, which may lead to feeling in better general health in relation to PA, which is a positive predictor of physical health (Biswas et al., 2015), as well as typical fatigue (Gill et al., 2001; Moreh et al., 2010).

Conclusions

The results of the thesis show that determinants of, and associations between, physically active lifestyles, SB, mental health, fatigue and bodily pain are multifaceted. The evidence in the literature on the determinants of mental health and lifestyle factors has focused on the variable centred approach and examined associations at the between-person level in older adults. This thesis has contributed to the literature by examining the profiles of groups of individuals' in respect of (1) light PA, MVPA, and SB in mental health, (2) both SDT and the physical environment perception towards light PA and MVPA, and (3) the within-person association of light PA, MVPA and SB in relation to bodily pain and fatigue.

Findings from this thesis would suggest that older adults who reside in ALFs could enjoy greater mental health if they engage in more light PA, MVPA, and less SB and improve physical function. This implies that staff in ALFs should implement multidimensional strategies relating to active lifestyles and physical function to improve mental health. Furthermore, staff in ALFs also needs to be aware of the impacts of the physical environment in relation to physically active lifestyles by providing more information to make residents informative in regard to PA-friendly environments. In practice, due to the problems of cost and time, modifying the physical environment may be difficult as a means of changing behaviour (Bungum, Clark, & Aguilar, 2014). Thus, further intervention studies should focus on changing *perceptions* (e.g., via the provision of autonomy support). Providing more information about PA-related environments (e.g., PA facilities, PA programmes, parks) might for example, lead to older adults' greater engagement in PA. Consistent with these results of this thesis, intermittent PA engagement and finding the best day (by examining time variants; Maher & Conroy, 2015) to intervene to change bodily pain and fatigue, may be associated with reductions in typical fatigue and typical physical health.

APPENDICES

Appendix 1: Questionnaires used for chapters 2, 3, and 4

The SF-12 (used for Chapter 2)

The Dartmouth CO-OP Chart (used for Chapter 2)

The Subjective Vitality Scale (used for Chapter 2)

The Hospital Anxiety and Depression Scale (HADS; used for Chapter 2)

The Multi-Dimensional Fatigue Index (MFI-20; used for Chapters 2 and 4)

The Perceived Autonomy Support Scale (used for Chapter 3)

The Instruments for Assessing Levels of Physical Activity and Fitness (ALPHA) scale (used for Chapter 3)

The Psychological Need Satisfaction in Exercise Scale (used for Chapter 3)

The Behavioural Regulations in Exercise Questionnaire-2 (BREQ-2; used for Chapter 3)

The RAND 36 (used for Chapter 4)

The Physical Activity Scale for the Elderly (PASE; used for Chapter 4)

The Measure of Older adults` Sedentary Time (MOST; used for Chapter 4)

Appendix 2: Diary log

Accelerometer Log Diary (used for Chapters 2, 3, and 4)

Appendix 1
The SF-12
The scale was developed by Ware, Kosinski, and Keller, (1996). It was used as a measure for physical and mental health.

INSTRUCTION: The questions below ask for your views about your health. Please answer every question by ticking one box. If you are unsure about how to answer, please give the best answer you can.

1. In general, would you say your health is:

   Excellent ☐ Very good ☐ Good ☐ Fair ☐ Poor ☐

The following items are about activities you might do during a typical day. Does your health now limit you in these activities? If so, how much?

2. Moderate activities, such as moving a table, pushing a vacuum cleaner, bowling, or playing golf

   Yes, limited a lot ☐ Yes, limited a little ☐ No, not limited at all ☐

3. Climbing several flights of stairs

   Yes, limited a lot ☐ Yes, limited a little ☐ No, not limited at all ☐

During the past 4 weeks, have you had any of the following problems with regular daily activities as a result of your physical health?

4. Accomplished less than you would like

   Yes ☐ No ☐

5. Were limited in the kind of activities that you could

   Yes ☐ No ☐

During the past 4 weeks, have you had any of the following problems with regular daily activities as a result of any emotional problems (such as feeling depressed or anxious)?

6. Accomplished less than you would like

   Yes ☐ No ☐

7. Didn`t do activities as carefully as usual

   Yes ☐ No ☐

8. **During the past 4 weeks,** how much did pain interfere with your normal activities?

Not at all	A little bit	Moderately	Quite a bit	Extremely
☐	☐	☐	☐	☐

9. **<u>During the past 4 weeks</u>**, Have you felt calm and peaceful?

All of the Time	
Most of the Time	
A Good Bit of the Time	
Some of the Time	
A Little of the Time	
None of the Time	

10. **<u>During the past 4 weeks</u>**, Did you have a lot of energy?

All of the Time	
Most of the Time	
A Good Bit of the Time	
Some of the Time	
A Little of the Time	
None of the Time	

11. **<u>During the past 4 weeks</u>**, Have you felt downhearted and blue?

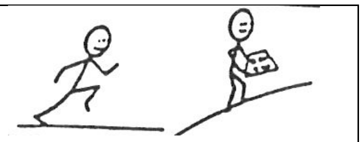
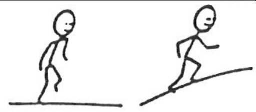
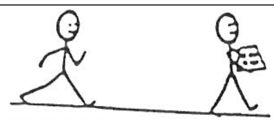
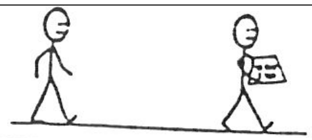
All of the Time	
Most of the Time	
A Good Bit of the Time	
Some of the Time	
A Little of the Time	
None of the Time	

12. **<u>During the past 4 weeks</u>**, how much of the time has your physical health or emotional problems interfered with your social activities (like visiting friends, relatives, etc.)?

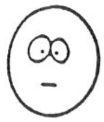
All of the Time	
Most of the Time	
Some of the Time	
A Little of the Time	
None of the Time	

The Dartmouth CO-OP Chart
The scale was developed by Jenkinson, Mayou, Day, Garratt, and Juszczak, (2002). It was used as a measure for quality of life:

1. **<u>During the past 4 weeks</u>**, what was the HARDEST PHYSICAL ACTIVITY you could do FOR AT AT LEAST 2 MINUTES? **Please tick one box only.**

Very heavy e.g. run, fast pace Carry a heavy load upstairs or uphill (25lbs/10kgs)	☐	
Heavy e.g. jog, slow pace climb stairs or a hill, moderate pace	☐	
Moderate e.g., walk, fast pace carry a heavy load on level ground (25lbs/10kgs)	☐	
Light e.g., walk, medium pace carry a light load on level ground (10lbs/5kgs)	☐	
Very light e.g., walk, slow pace wash dishes	☐	

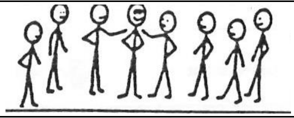
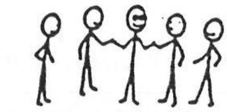
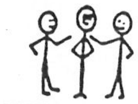
2. **<u>During the past 4 weeks</u>**, how much have you been bothered by emotional problems such as feeling anxious, depressed, irritable or downhearted and sad? Please tick one box only.

Not at all	☐	
Slightly	☐	
Moderately	☐	
Quite a bit	☐	
Extremely	☐	

3. Daily activities
<u>During the past 4 weeks</u>, how much difficulty have you had doing your usual activities because of your physical and emotional health? **Please tick one box only.**

No difficulty at all	☐	
A little bit of difficulty	☐	
Some difficulty	☐	
Much difficulty	☐	
Could not do	☐	

4. Social activities
<u>During the past 4 weeks</u>, how much has your physical and emotional health limited your social activities with family, friends, or groups? **Please tick one box only.**

Not at all	☐	
Slightly	☐	
Moderately	☐	
Quite a bit	☐	
Extremely	☐	

5. Pain
<u>During the past 4 weeks</u>, how much bodily pain have you generally had? **Please tick one box only.**

No pain	☐	
Very mild pain	☐	
Mild pain	☐	
Moderate pain	☐	
Severe pain	☐	

6. Change in Health
How would you rate your overall health now **compared to 4 weeks ago**? **Please tick one box only.**

Much better	☐	↑↑	++
A little better	☐	↑	+
About the same	☐	↔	=
A little worse	☐	↓	−
Much worse	☐	↓↓	−−

7. Overall Health
<u>During the past 4 weeks</u>, how would you rate your health in general? **Please tick one box only.**

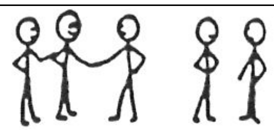
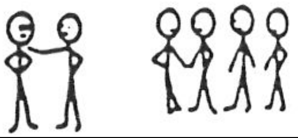
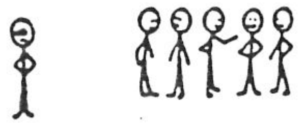
Excellent ☐	
Very good ☐	
Good ☐	
Fair ☐	
Poor ☐	

8. Social Support

<u>During the past 4 weeks</u>, was someone available to help you if you needed and wanted help?

For example if you:

- Felt very nervous, lonely or sad
- Were ill and had to stay in bed

Yes, as much as I wanted	☐	
Yes, quite a bit	☐	
Yes, some	☐	
Yes, a little	☐	
No, not at all	☐	

The Subjective Vitality Scale
The scale was developed by Ryan and Frederick (1997) and It was used as a measure for subjective vitality.

Please respond to each of the following statements by ticking one number representing how you generally felt during the last 4 weeks. Please circle one number only for each question.

In general, over **the last four weeks**…	Not at all True		Somewhat True			Very True	
1. I felt alive and full of vitality.	1	2	3	4	5	6	7
2. I had energy and spirit.	1	2	3	4	5	6	7
3. I looked forward to each day.	1	2	3	4	5	6	7
4. I nearly always felt alert and awake.	1	2	3	4	5	6	7
5. I felt I had a lot of energy.	1	2	3	4	5	6	7

The Hospital Anxiety and Depression Scale (HADS)
The scale was developed by Zigmond and Snaith (1983) and it was used as a measure for depression and anxiety.

Please read each item and place a tick in the box opposite the reply which comes closest to how you have been feeling in the last 4 weeks. Don't take too long thinking about your replies: your immediate reaction to each item will probably be more accurate than a long thought-out response.

TICK only one BOX in each section

1. I feel tense or 'wound up':

Most of the time	A lot of the time	Time to time, Occasionally	Not at all

2. I still enjoy the things I used to enjoy:

Definitely as much	Not quite as much	Only a little	Hardly at all

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

Very definitely and quite badly	Yes, but not too badly	A little, but it doesn't worry me	Not at all

4. I can laugh and see the funny side of things:

As much as I always could	Not quite so much now	Definitely not so much now	Not at all

5. Worrying thoughts go through my mind:

A great deal of the time	A lot of the time	From time to time but not too often	Only occasionally

6. I feel cheerful:

Not at all	Not often	Sometimes	Most of the time

7. I can sit at ease and feel relaxed:

Definitely	Usually	Not often	Not at all

8. I feel as if I am slowed down:

Nearly all the time	Very often	Sometimes	Not at all

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

Not at all	Occasionally	Quite often	Very often

10. I have lost interest in my appearance:

Definitely	I don't take so much care as I should	I may not take quite as much care	I take just as much care as ever

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

Very much indeed	Quite a lot	Not very much	Not at all

12. I look forward with enjoyment to things:

As much as ever I did	Rather less than I used to	Definitely less than I used to	Hardly at all

13. I get sudden feelings of panic:

Very often indeed	Quite often	Not very often	Not at all

14. I can enjoy a good book or radio or TV programme:

Often	Sometimes	Not often	Very seldom

The Multiple Fatigue Index (MFI-20)
The scale was developed by Smets, Garssen, Bonke, De, and Haes (1995) and it was used as a measure for fatigue.

By means of the following statements we would like to get an idea of how you have been feeling lately. The more you disagree with the statement, the more you can tick just one in the direction of "no, that is not true". Please DO NOT miss out a statement.

		Yes, that is true				No, that is not true
1.	I feel fit	1	2	3	4	5
2.	Physically I feel only able to do a little	1	2	3	4	5
3.	I feel very active	1	2	3	4	5
4.	I feel like doing all sorts of nice things	1	2	3	4	5
5.	I feel tired	1	2	3	4	5
6.	I think I do a lot in a day	1	2	3	4	5
7.	When I am doing something, I can keep my thoughts on it	1	2	3	4	5
8.	Physically I can take on a lot	1	2	3	4	5
9.	I dread having to do things	1	2	3	4	5
10.	I think I do very little in a day	1	2	3	4	5
11.	I can concentrate well	1	2	3	4	5
12.	I am rested	1	2	3	4	5
13.	It takes a lot of effort to concentrate on things	1	2	3	4	5
14.	Physically I feel I am in a bad condition	1	2	3	4	5
15.	I have a lot of plans	1	2	3	4	5
16.	I tire easily	1	2	3	4	5
17.	I get little done	1	2	3	4	5
18.	I don't feel like doing anything	1	2	3	4	5
19.	My thoughts easily wander	1	2	3	4	5
20.	Physically I feel I am in excellent condition	1	2	3	4	5

The Perceived Autonomy Support Scale
The scale was developed by Williams et al. (2006) and it was used as a measure for perceived autonomy support.

Who (e.g. partner, best friend, GP, etc) is the *most important person* in your effort to becoming healthier through regular physical activity? Please select the most important other to you (and specify their relationship to you; e.g., partner, GP) and then answer the questions with respect to this individual. Please circle one number only for each question.

With respect to my Physical Activity regime, My important other is:	1.						
	Strongly disagree		Neither agree or disagree			Strongly agree	
1. I feel that my important other provides me with choices and options about physical activity and health.	1	2	3	4	5	6	7
2. I feel my important other understands how I see things with respect to my physical activity and health.	1	2	3	4	5	6	7
3. My important other conveys confidence in my ability to make changes regarding my physical activity and health.	1	2	3	4	5	6	7
4. My important other listens to how I would like to do things regarding my physical activity and health.	1	2	3	4	5	6	7
5. My important other encourages me to ask questions about my physical activity to improve my health.	1	2	3	4	5	6	7
6. My important other tries to understand how I see my health-related physical activity before suggesting changes.	1	2	3	4	5	6	7

The 'Instruments for Assessing Levels of Physical Activity and Fitness (ALPHA)
It was developed by Spittaels et al. (2009) and it was used as a measure for perceived neighbourhood environment.

We would like to find out more information about the way that you think about your neighbourhood, home environment. Please answer as honestly and completely as possible and provide only one answer for each item. There are no rights or wrong answers.

1. Types of residences in your neighbourhood

How common are the following types of residences in your immediate neighbourhood?
By your neighbourhood we mean ALL the area within approximately one kilometer or half a mile of your home or that you could walk to in 10-15 minutes.
Please tick one box (✓) that best applies to your view of your neighbourhood

	None	A few	Some	Most	All
a) Detached houses	☐	☐	☐	☐	☐
b) Semi-detached houses or terraced houses	☐	☐	☐	☐	☐
c) Apartment buildings or blocks of flats	☐	☐	☐	☐	☐

2. Distance to local facilities

About how long would it take to get from your home to the *nearest* businesses or facilities listed below if you WALKED to them?
Please tick one box (✓) for each business or facility.

The nearest…	1-5 min	6-10 min	11-20 min	21-30 min	More than 30 min
a) Local shop: grocery shop, bakery, butcher etc.	☐	☐	☐	☐	☐
b) Supermarket	☐	☐	☐	☐	☐
c) Local services such as a bank, post office or library, …	☐	☐	☐	☐	☐
d) Restaurant, café, pub or bar	☐	☐	☐	☐	☐
e) Fast-food restaurant or takeaway	☐	☐	☐	☐	☐
f) Bus stop, tram, metro or train station	☐	☐	☐	☐	☐
g) Sport and leisure facility such as a swimming pool, sports field or fitness centre	☐	☐	☐	☐	☐
h) Open recreation area such as a park or other open space	☐	☐	☐	☐	☐

3. Walking and cycling infrastructure in your neighbourhood. **Please circle one answer only.**

	Strongly disagree	Somewhat disagree	Somewhat agree	Strongly agree
a) There are sidewalks in my neighbourhood	1	2	3	4
b) There are pedestrian zones or pedestrian trails in my neighbourhood	1	2	3	4
c) There are special lanes, routes or paths for cycling in my neighbourhood	1	2	3	4
d) There are cycle routes in my neighbourhood that are separated from traffic	1	2	3	4

4. Maintenance of walking and cycling infrastructure in your neighbourhood. **Please circle one answer only.**

	Strongly disagree	Somewhat disagree	Somewhat agree	Strongly agree	Not applicable
a) There are sidewalks in my neighbourhood are well maintained	1	2	3	4	5
b) The cycle paths in my neighbourhood are well maintained	1	2	3	4	5
c) The play areas, playgrounds, parks or other open spaces in my neighbourhood are well maintained	1	2	3	4	5

5. Neighbourhood safety. **Please circle one answer only.**

	Strongly disagree	Somewhat disagree	Somewhat agree	Strongly agree
a) It is dangerous to leave a bicycle locked in my neighbourhood	1	2	3	4
b) There are not enough safe places to cross busy streets in my neighbourhood	1	2	3	4
c) Walking is dangerous because of the traffic in my neighbourhood	1	2	3	4
d) Cycling is dangerous because of the traffic in my neighbourhood	1	2	3	4
e) It is dangerous in my neighbourhood during the day because of the level of crime	1	2	3	4
f) It is dangerous in my neighbourhood during the night because of the level of crime	1	2	3	4

6. How pleasant is your neighbourhood for walking or cycling? **Please circle one answer only.**

	Strongly disagree	Somewhat disagree	Somewhat agree	Strongly agree
a) My local neighbourhood is a pleasant environment for walking or cycling	1	2	3	4
	None	A few	Some	Plenty
b) There is litter or graffiti in the streets of my neighbourhood	1	2	3	4
c) There are trees along the streets in my neighbourhood	1	2	3	4
d) In my neighbourhood there are badly maintained, unoccupied or ugly buildings	1	2	3	4

7. Walking and cycling network. **Please circle one answer only.**

	Strongly disagree	Somewhat disagree	Somewhat agree	Strongly agree
a) There are many shortcuts for walking in my neighbourhood	1	2	3	4
b) Cycling is quicker than driving in my neighbourhood during the day	1	2	3	4
c) There are many road junctions in my neighbourhood	1	2	3	4
d) There are many different routes for walking or cycling from place to place in my neighbourhood so I don't have to go the same way every time	1	2	3	4

8. Home Centre Environment. **Please tick one box (✓) only**.

	Please tick **Yes** or **No** [✓]	
	Yes	No
a) Do you have a bicycle for your personal use?	☐	☐
b) Do you have a garden (including a yard, allotment or city garden)?	☐	☐
c) Do you have small sports equipment such as a ball, racquets, …for your personal use?	☐	☐
d) Do you have exercise equipment such as weights, treadmill, stationary cycle, …for your personal use?	☐	☐
e) Do you have access to a car?	☐	☐
f) Do you have a dog ?	☐	☐

The Psychological Need Satisfaction in Exercise Scale
The scale was developed by Wilson et al. (2006) and it was used as a measure for basic psychological need.

The following statements represent different experiences people have when they engage in physical activity. Please answer the following questions by considering how you TYPICALLY feel while you are engaging in physical or leisure time activity.

Please circle one number only for each question.

	False	Mostly False	More false than true	More true than false	Mostly True	True
1. I feel that I am able to participate in physical activities that are personally challenging	1	2	3	4	5	6
2. I feel attached to those who participate in physical activities with me because they accept me for who I am	1	2	3	4	5	6
3. I feel like I share a common bond with people who are important to me when we participate in physical activities together	1	2	3	4	5	6
4. I feel confident I can do even the most challenging physical activities	1	2	3	4	5	6
5. I feel a sense of camaraderie with those people I am active with because we engage in physical activity for the same reasons.	1	2	3	4	5	6
6. I feel confident in my ability to perform physical activities that personally challenge me	1	2	3	4	5	6
7. I feel close to those I am physically active with as they appreciate how difficult regular engagement in physical activity can be	1	2	3	4	5	6
8. I feel free to be physically active in my own way	1	2	3	4	5	6
9. I feel free to make my own decisions regarding my participation in physical activity	1	2	3	4	5	6
10. I feel capable of doing physical activities that are challenging to me	1	2	3	4	5	6
11. I feel like I am in charge of my physical activity decisions	1	2	3	4	5	6
12. I feel like I am capable of doing even the most challenging physical activities	1	2	3	4	5	6

	False	Mostly False	More false than true	More true than false	Mostly True	True
13. I feel like I have a say in choosing the physical activities that I do	1	2	3	4	5	6
14. I feel connected to the people who I interact with while we participate in physical activity together	1	2	3	4	5	6
15. I feel good about the way I am able to complete challenging physical activities	1	2	3	4	5	6
16. I feel like I get along well with other people who I interact with while we are physically active together	1	2	3	4	5	6
17. I feel free to choose which physical activities I participate in	1	2	3	4	5	6
18. I feel like I am the one who decides what physical activities I do	1	2	3	4	5	6

The Behavioural Regulation in Exercise Questionnaire-2 (BREQ-2)
The scale was developed by Markland and Tobin (2004) and it was used as a measure for behavioural regulations.

Why do you engage in physical activity?
We are interested in the reasons underlying peoples' decisions to engage or not engage in any current physical or leisure time activity. Using the scale below, please indicate to what extent each of the following items is true for you. Please circle only one number for each item.

	Not at all true	Somewhat true			Very true
1. I engage in physical activity because other people say I should	1	2	3	4	5
2. I feel guilty when I don't engage in physical activity	1	2	3	4	5
3. I value the benefits of physical activity	1	2	3	4	5
4. I engage in physical activity because it's fun	1	2	3	4	5
5. I don't see why I should have to be physically active	1	2	3	4	5
6. I take part in physical activity because my friends/family/partner say I should	1	2	3	4	5
7. I feel ashamed when I miss a chance to be physically active	1	2	3	4	5
8. It's important for me to participate in physical activity regularly	1	2	3	4	5
9. I can't see why I should bother being physically active	1	2	3	4	5
10. I enjoy participating in physical activity	1	2	3	4	5
11. I engage in physical activity because others will not be pleased with me if I don't	1	2	3	4	5
12. I don't see the point in being physically active	1	2	3	4	5
13. I feel like a failure when I haven't been physically active in a while	1	2	3	4	5
14. I think it is important to make the effort to participate in regular physical activity	1	2	3	4	5
15. I find physical activity pleasurable	1	2	3	4	5
16. I feel under pressure from my friends/family to be physically active	1	2	3	4	5

17. I get restless if I don't regularly participate in physical activity	1	2	3	4	5
	Not at all true	Somewhat true			Very true
18. I get pleasure and satisfaction from participating in physical activity	1	2	3	4	5
19. I think engaging in physical activity is a waste of time	1	2	3	4	5

The RAND 36
The scale was developed by Hays et al. (1993) and it was used as a measure for typical physical health and typical and daily bodily pain.

INSTRUCTIONS: This survey asks for your views about your health **in the last 4 weeks**. Answer every question by marking the answer as indicated. If you are unsure about how to answer a question, please give the best answer you can.

1. In general, would you say your health is:

Excellent	Very good	Good	Fair	Poor

2. Compared to one year ago, how would you rate your health in general in the last 4 weeks?

	(tick one)
Much better now than one year ago……….	
Somewhat better now than one year ago…	
About the same as one year ago…………..	
Somewhat worse now than one year ago…	
Much worse now than one year ago……….	

3. The following questions are about activities you might do during a typical day. During the past 4 weeks, has your health limited you in these activities? If so, how much?

(circle one number on each line)

ACTIVITIES	Yes, Limited A Lot	Yes, Limited A Little	No, Not Limited At All
a. **Vigorous activities**, such as running, lifting heavy objects, participating in strenuous sports.	1	2	3
b. **Moderate activities**, such as moving a table, pushing a vacuum cleaner, bowling, or playing golf.	1	2	3
c. Lifting or carrying groceries	1	2	3
d. Climbing **several** flights of stairs.	1	2	3
e. Climbing **one** flight of stairs.	1	2	3
f. Bending, kneeling, or stooping.	1	2	3
g. Walking **more** than a mile.	1	2	3
h. Walking **half** a mile.	1	2	3
i. Walking **one hundred yards.**	1	2	3
j. Bathing or dressing yourself.	1	2	3

4. During the past 4 weeks, have you had any of the following problems with your work or other regular daily activities as a result of your physical health?

(tick one on each line)

	YES	NO
a. Cut down on the amount of time you spend on work or other activities.		
b. **Accomplished less** than you would like.		
c. Were limited in the kind of work or other activities.		
d. Had **difficulty** performing the work or other activities (for example, it took extra effort).		

5. During the past 4 weeks, have you had any of the following problems with your work or other regular daily activities as a result of any emotional problems (such as feeling depressed or anxious)?

(tick one on each line)

	Yes	No
a. Cut down on the amount of time you spent on work or other activities.		
b. **Accomplished less** than you would like.		
c. Didn't do work or other activities as **carefully** as usual.		

6. During the past 4 weeks, to what extent has your physical health or emotional problems interfered with your normal social activities with family, friends, neighbours, or groups?

Not at all	A little bit	Moderately	Quite a bit	Extremely

7. How much bodily pain have you had during the past 4 weeks?

None	Very Mild	Mild	Moderate	Severe	Very severe

During the past 4 weeks, how much did pain interfere with your normal work (including both work outside the home and housework)?

Not at all	A little bit	Moderately	Quite a bit	Extremely

9. These questions are about how you feel and how things have been with you during the past 4 weeks. For each question, please give the one answer that comes closest to the way you have been feeling during the past 4 weeks.

(circle one number on each line)

	All of the Time	Most of the Time	A Good Bit of the Time	Some of the Time	A Little of the Time	None of the Time
a. Did you feel full of life?	1	2	3	4	5	6
b. Have you been a very nervous person?	1	2	3	4	5	6

c. Have you felt so down in the dumps that nothing could cheer you up?	1	2	3	4	5	6
d. Have you felt calm and peaceful?	1	2	3	4	5	6
e. Did you have a lot of energy?	1	2	3	4	5	6
f. Have you felt downhearted and low?	1	2	3	4	5	6
g. Did you feel worn out?	1	2	3	4	5	6
h. Have you been a happy person?	1	2	3	4	5	6
i. Did you feel tired?	1	2	3	4	5	6

10. Please rate how much of the time has your physical health or emotional problems interfered with your social activities over the past 4 weeks (like visiting with friends, relatives, etc)?

All of the time	Most of the time	Some of the time	A little of the time	None of the time

11. How TRUE or FALSE is each of the following statements for you

(circle one number on each line)

	Definitely True	Mostly True	Don't Know	Mostly False	Definitely False
a. I seem to get ill more easily than other people.	1	2	3	4	5
b. I am as healthy as anybody I know.	1	2	3	4	5
c. I expect my health to get worse.	1	2	3	4	5
d. My health is excellent.	1	2	3	4	5

The Physical Activity Scale for the Elderly (PASE)

The scale was developed by Washburn, McAuley, Katula, Mihalko and Boileau (1999) and it was used as a measure for typical physical activity.

I am interested in how much time you have spent doing the following activities over the last 7 days. Please tick as appropriate.

1. Walking outside the home

Never (0 days)	Seldom (1 to 2 days)	Sometimes (3 to 4 days)	Often (5 to 7 days)

How many hours per day did you spend on this activity?

Less than 1hour	1 to 2 hours	2 to 4 hours	More than 4 hours

2. Light sport/recreation

Name the activity/activities___________ (Walking is not applicable in this question)
e.g. golf with a power cart, archery, badminton, bowling, darts, fishing, Frisbee, musical program, swimming: no laps, table tennis.

How much time was spent on the activity over the last 7 days (Please tick as appropriate)

Never (0 days)	Seldom (1 to 2 days)	Sometimes (3 to 4 days)	Often (5 to 7 days)

How many hours per day did you spend on this activity?

Less than 1hour	1 to 2 hours	2 to 4 hours	More than 4 hours

3. Moderate sport/recreation

Name the activity___________ **e.g. dancing, golf without a cart, tennis**

How much time was spent on the activity over the last 7 days (Please tick as appropriate)

Never (0 days)	Seldom (1 to 2 days)	Sometimes (3 to 4 days)	Often (5 to 7 days)

How many hours per day did you spend on this activity?

Less than 1hour	1 to 2 hours	2 to 4 hours	More than 4 hours

4. Strenuous sport/recreation

Name the activity__________

e.g. aerobic dance or water aerobics, bicycling, hiking, mountain climbing, running, stair climbing, swimming laps, tennis (singles)

How much time was spent on the activity over the last 7 days (Please tick as appropriate)

Never (0 days)	Seldom (1 to 2 days)	Sometimes (3 to 4 days)	Often (5 to 7 days)

How many hours per day did you spend on this activity?

Less than 1hour	1 to 2 hours	2 to 4 hours	More than 4 hours

5. Muscle strength/endurance physical activity

Name the activity__________

e.g. calisthenics, hand weights, push-ups, sit-ups, weight-lifting

How much time was spent on the activity over the last 7 days (Please tick as appropriate)

Never (0 days)	Seldom (1 to 2 days)	Sometimes (3 to 4 days)	Often (5 to 7 days)

How many hours per day did you spend on this activity?

Less than 1hour	1 to 2 hours	2 to 4 hours	More than 4 hours

Household Physical Activities

6. Have you performed 'Light housework' over the last 7 days? | No | Yes |

7. Have you performed 'Heavy housework and chores over the last 7 days? | No | Yes |

8. Have you performed 'Home repairs over the last 7 days? | No | Yes |

9. Have you performed 'Lawn work over the last 7 days? | No | Yes |

10. Have you performed 'Outdoor gardening over the last 7 days? | No | Yes |

11. Have you performed 'Caring for another person over the last 7 days? (Including babysitting) | No | Yes |

Work related physical activity

12. In the last 7 days how many hours paid or volunteer work have you done:________hrs/week

Would you describe your work as mainly: **(Please tick appropriate box)**

1) Sitting with slight arm movements	
2) Sitting or standing with some walking	
3) Walking with some handling of materials generally weighing less than 50 pounds	
4) Walking and heavy manual work often requiring handling of materials weighing over 50 pounds.	

The Measure of Older adults` Sedentary Time (MOST)
The scale was developed by Gardiner et al. (2011) and it was used as a measure for typical sedentary behaviour.

I am going to ask you about activities you did **over the *last week whilst sitting or lying down***. Please do not count the time you spent in bed. For each of the activities only count the time when this was your main activity. For example, if you are watching television and doing a crossword, count it as television time or crossword time but not as both.

During the last week **(7-Day period)**, how much time in total did you spend sitting or lying down and……

Weekly Sedentary Activity	Time (weekly)	
1) Watching television or videos/DVDs (weekly)	______ hours/w	______ minutes/w
2) Using the computer/Internet (weekly)	______ hours/w	______ minutes/w
3) Reading (weekly)	______ hours/w	______ minutes/w
4) Socialising with friends or family (weekly)	______ hours/w	______ minutes/w
5) Driving or riding in a car, or time on public Transport (weekly)	______ hours/w	______ minutes/w
6) Doing hobbies, e.g. craft, crosswords (weekly)	______ hours/w	______ minutes/w
7) Doing any other activities (weekly)	______ hours/w	______ minutes/w

Appendix 2
Accelerometer Log Diary
The scale was developed by authors of this thesis and it was used as a measure for recording the accelerometer start and stop time.

Diary

Participant ID:

Please wear the movement meter for 10 hours at least, seven (7) consecutive days. In the table below, write down the each physical activity you did, record the time, date, intensity and the time you engaged in physical activity during each day.

	Day/Date	**Wearing time**	**Description of Physical Activity**	**Intensity (√)**			**Place**
				Light	Moderate	Vigorous	
1	___ /___	Morning	Start time: Example 10:00-10:30 walking	√			corridor
		Afternoon					
		Evening	Stop time:				
2	___ /___	Morning	Start time:				
		Afternoon					
		Evening	Stop time:				

	Day/Date	Wearing time	Description of Physical Activity	Intensity (√)			Place
				Light	Moderate	Vigorous	
3	___ /___	Morning	Start time:				
		Afternoon					
		Evening	Stop time:				
4	___ /___	Morning	Start time:				
		Afternoon					
		Evening	Stop time:				

	Day/Date	Wearing time	Description of Physical Activity	Intensity (√)			Place
				Light	Moderate	Vigorous	
5	___ /___	Morning	Start time:				
		Afternoon					
		Evening	Stop time:				
6	___ /___	Morning	Start time:				
		Afternoon					
		Evening	Stop time:				

	Day/Date	Wearing time	Description of Physical Activity	Intensity (√)			Place
				Light	Moderate	Vigorous	
7	___ /___	Morning	Start time:				
		Afternoon					
		Evening	Stop time:				

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