

**AN EXAMINATION OF HOW PHYSICAL ACTIVITY AND  
SEDENTARY BEHAVIOUR IN OLDER ADULTS IN  
ASSISTED LIVING ASSOCIATE WITH PHYSICAL,  
COGNITIVE AND PSYCHOSOCIAL FUNCTION**

by

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Thesis submitted in partial fulfillment of  
the requirements for the degree of

Master of Science

in the

Department of Biomedical Physiology and Kinesiology

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SIMON FRASER UNIVERSITY

Summer, 2011

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## Abstract

Physical activity and sedentary behaviour are important markers of health and quality of life, and predictors of functional decline. However, the factors that influence movement patterns in older adults, especially for those residing in the growing assisted living (AL) setting, are poorly understood. I acquired measures from 114 AL tenants of movement patterns from waist-mounted accelerometers worn for at least 3 days. On average, participants spent 86% of their waking hours in sedentary behaviour and 13.84% in light physical activity. The time spent sedentary was higher in males than females, and correlated with scores on the Timed-Up-and-Go and Modified Fall Efficacy Scale, but not with the Montreal Cognitive Assessment or Geriatric Depression Scale. These results indicate that both physical function and psychological factors influence sedentary behaviour in AL tenants. Future research should examine whether interventions targeted at intrinsic or environmental factors decrease sedentary behaviours.

**Keywords:** Sedentary behaviour; Physical activity; Movement patterns; Older adults, Assisted Living; Accelerometry

# Dedication

To my late father, Mr. Ka Yik Chan who passed away on April 27, 2010  
and his love for knowledge.

## Acknowledgements

This thesis was made possible with God's help and the help of numerous people.

First, I would like to express my gratitude to my supervisor, Dr. Stephen Robinovitch for his guidance, patience and belief in me by providing me uncountable advice and comments during the writing of this thesis.

Second, I would like to express my appreciation to Dr. Fabio Feldman for his unyielding enthusiasm for this research and his support at work and Dr. Maureen Ashe for her expertise in the field of accelerometry.

I am grateful to the members of the Injury Prevention and Mobility Laboratory at Simon Fraser University and staff of Fraser Health Authority, especially thanks to Mona Jalili, Yijian Yang, Thiago Sarraf, Omar Aziz and Ashley Collins who provided assistance in this research. I wish to express my gratitude to Susie Nugent, Graduate Program Assistant for her guidance and support. Thank you to all the wonderful tenants and staff of the 13 Assisted Living sites who participated in this research.

I would like to thank my family and friends for praying for me and supporting me in my Masters study journey. Finally, I would like to thank my husband, Francis; and my children, Jessica, Amanda, Deanna and Daniel. Without your unwavering support and belief in me Francis, this thesis would not be possible.

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# Chapter 1.

## Introduction

Seniors aged 65 years and older are the fastest growing group in British Columbia (BC), and are expected to increase from the current 550,000 to approximately 1.35 million by 2031 [1]. A large portion of this aging population will need assistance in areas of shopping, food preparation, and housekeeping chores to remain living independently in the community. This need is being addressed through the rapid growth of registered Assisted Living sites in BC. As of June 2010, there were 190 Assisted Living facilities registered in BC, collectively providing 6,647 living units. This represents a 32% increase over the 143 facilities registered in October 2006 [2]. Due to seniors' need for assistance, Assisted Living sites are constructed so that all amenities, such as a hairdresser and general store, are located within the building, and tenants do not have to go outside of the facilities for exercise, social activities and entertainment. On the one hand, Assisted Living sites may facilitate mobility and physical activity, for example, exercise classes are nearby; on the other hand, it may reduce physical activity since all one's need are immediately "at hand." An improved understanding of physical activity patterns and sedentary behaviour of tenants living in Assisted Living should lead to improvement in the design of facilities and strategies to enhance physical activity and health.

## **1.1. Assisted Living in British Columbia, Canada**

Assisted Living sites in BC are independent housing units, a middle option between home support and residential care for those requiring some degree of assistance in carrying out essential activities of daily living. Assisted Living sites typically consist of unfurnished apartment-style residencies including private self-contained bachelor, one-bedroom or two-bedroom suites with full or modified kitchens. All Assisted Living sites include common dining and recreational space where tenants can eat together and socialize. Many Assisted Living units are funded under the Government of BC's Independent Living BC Program. Tenants in Assisted Living do not require the full range of professional nursing services that are available 24 hour in residential care (nursing home) settings. Independent Living BC [2] emphasizes the principles of individuality, choice, dignity, privacy and independence for individuals.

Assisted Living sites provide certain hospitality and personal care services that facilitate people to remain independent for as long as they are able to self direct their own care. Hospitality services include the availability of 3 meals (2 of which are included in the cost of rent), social and recreational programs, laundry and housekeeping services (linens and towels) on a weekly basis. Personal care services include a plan to manage health and well-being, medication reminders and assistance if needed and 24-hour emergency response. The personal assistance plan is an agreement negotiated between an individual tenant and the Assisted Living operator that includes the nature of the tenant's needs and service requests, the risks the tenant is facing and a plan for delivery of services. The plan is developed when the tenant first moves in and is updated regularly to address any ongoing health or safety concerns. Since Assisted Living sites are built to

provide these services, there are admission criteria to ensure that seniors' needs are met and the sites are able to meet those needs.

### **1.1.1. Admission Criteria for Assisted Living**

Seniors admitted to government funded Assisted Living sites are identified and selected by the Health Authority's case managers as being better managed by support and care within a community setting rather than a residential care setting. The criterion for admission to Assisted Living sites is that seniors must require assistance with their personal care or assistance with their medication management or both of these services. Under the BC Assisted Living Act, seniors can receive not more than two prescribed services, such as assistance with medication and personal care. There must be evidence that they cannot manage to look after themselves if these services are provided to them in their own home.

Tenants must be able to live in the community, eat in a common dining room, and be seen to benefit from the hospitality and recreation services available in Assisted Living. They must have the ability to make informed voluntary decisions, participate in the development of their care plan, and make their needs known to the person they are living with who then participates in the development of that person's care plan. They must also be able to use an emergency response system and take direction in an emergency situation.

### **1.1.2. Characteristics of the Assisted Living Population**

A numbers of studies have characterized the physiological, cognitive and mood status of Assisted Living populations using different assessments. In a recent cross-

sectional study of community and assisted living facilities, Avery and colleagues (2010) [3] found that Assisted Living dwelling seniors had lower serum 25-OH vitamin D levels, lower Mini Mental Status Examination (MMSE) scores [4], higher CES-depression scale scores [5], and shorter walking distances in the 6-minute walk [6]. Taylor et al. (2003) [7], reported their participants had a Functional Reach Score (an index of balance) of 4 inches as compared to mean score of 10.47 inches in seniors 70 to 87 years [8]. In the same study, the participants' mean score on the Barthel Index [9] was 71.8, reflecting moderate dependence, and a mean score of 12.2 on the Tinetti Performance-oriented Assessment of Mobility Problems in Elderly Patients [10] indicating a high falls risk. Resnick et al. (2010a) [11], used the 5-item Geriatric Depression Scale [12] and reported that 47% of 171 participants screened positively for depression. Resnick et al. (2010b) [13] also measured the physical activity level of tenants in Assisted Living communities over a period of 24-hour period using an ActiGraph accelerometer. They concluded that Assisted Living tenants engaged in very limited daily physical activity (mean of 8.5 minutes of moderate physical activity/day). A study by Guiliani et al. (2008) [14] examined the ability of performance based measures (grip strength, walking speed, chair rise, and balance test) to predict adverse events, including death, nursing home placement, fracture and functional decline among the study participants. Their findings suggested that tenants who are at risk for adverse events may be identified using a simple test of physical performance. The study further suggested that interventions that improve physical performance may decrease the incidences of fracture and disability in this population. However, few studies in this population have examined how physical activity

levels, a true measure of mobility, associates with clinical measures of physical activity, cognitive performance and mood.

In a report to the BC Ministry of Healthy Living and Sports entitled “Best Practice Guidelines for Fall Prevention in Assisted Living”, Scott et al. (2006) [15] described the characteristics of 101 tenants of average age of 85 years in two Assisted Living sites in British Columbia. Forty eight percent of tenants used walkers. For Timed Up and Go (TUG) scores (a global measure of mobility), 33% of tenants were between 10 to 14 seconds (moderate mobility impairment), 22% scored between 15 to 19 seconds and 14% scored 20 to 24 seconds (reflecting severe impairment). These scores fall in between community dwelling and institutional seniors as reported by Bischoff et al. (2003) [16] who found that the TUG score for a sample of community-dwelling seniors was 8.3 (SD=1.9) seconds and for residential care seniors was 28.2 (SD=23.0) seconds.

## **1.2. Physical Activity and Sedentary Behaviour**

### **1.2.1. Definitions**

Physical activity is considered “any bodily movement produced by skeletal muscles that result in energy expenditure” [17], while sedentary behaviour is defined as “any prolonged periods of inactivity and absence of whole body movement” [18]. There are multiple terms to describe types of activity and/or sedentary time. These may include physical activity, activity patterns, physical inactivity and sedentary behaviours. Currently, the most common technique for monitoring activity is accelerometry, which involves measurement of whole-body acceleration over periods of minutes, hours or days from an accelerometer sensor, usually worn at the waist. Typically, the intensity of



physical activity measured from accelerometry is divided into three levels: “sedentary behaviour,” “light physical activity” and “moderate to vigorous physical activity” (MVPA). Sedentary behaviour is typically defined as behaviour producing a metabolic equivalent (MET) of less than or equal to 1.5, including periods of quiet standing [19, 20], while light activities typically have a MET range between 1.6 to 2.9, and MVPA has a MET above 3.0. Examples of light physical activity patterns include housework, light gardening, and washing dishes [21] while examples of MVPA include brisk walking, running and skiing. Some controversy exists in accepted definitions of sedentary behaviour [22], with some researchers defining sedentary behaviour as not simply the absence of activity, but rather the purposeful use of time to engage in activities that are sedentary in nature, such as watching TV, working on the computer or reading [23].

### **1.2.2. Health Benefits of Physical Activity**

It is well accepted that regular physical activity has a positive influence on fitness and a variety of positive health outcomes, whereas sedentary lifestyle and poor fitness are risk factors for a number of diseases [24]. The documented positive benefits of physical activity on seniors’ health are numerous, and include preventing disease [25], reducing disability [26], improving well-being [25], lowering mortality rates, improving conditions such as hypertension, diabetes and obesity, reducing fall risk, improving mood and well-being, and lessening of functional decline [24, 27-29]. Physical activity is also particularly beneficial in preventing or forestalling disability in people with osteoarthritis [30-32], a leading cause of disability among seniors[33]. However activity patterns may decrease in intensity due to age-related declines in flexibility, bone and muscle mass, and

cardiac and respiratory capacity [34]. Along with this, chronic conditions such as arthritis, lung diseases (COPD), and diabetes increase in prevalence with ageing and can affect activity patterns. This is supported by Westerterp, 2008 [35] who found that when compared to younger adults, seniors spend a higher percentage of their day performing low intensity activities and a lower percentage performing high intensity activities. It is important to remember that despite the barriers to physical activity, even participation in low intensity activities has been found to maintain independence in activities in daily living such as stair climbing, walking and bathing over a 2 year period [31].

To date, clinical practice, community programs, and mass-media campaigns such as ACT NOW [36] have focused mainly on encouraging and supporting individuals to be more active, and doing more moderate exercises to meet the guidelines. Health Canada recommends that seniors accumulate 30 to 60 minutes of moderate exercises most days, building up the activities in 10-minute segments [37]. While these approaches have been met with some success, 62% of women over the age of 65 still remains inactive[38], unable to meet Health Canada recommendations of being active. Along with physical activity, studies have identified sedentary behaviour (time spent sitting) as a important risk factor for the development of chronic disease [39]. Owen et al. (2009) [39] suggested that even if people meet the current recommendation of 30 minutes of physical activity on most days each week, there may be significant adverse metabolic and health effects from prolonged sitting – the activity that dominates most people’s remaining “non-exercise” waking hours. Furthermore, Health Canada suggests that sitting or lying for long periods is as serious a health risk as smoking.

### **1.2.3. Sedentary Behaviour**

Such concerns are based on an emerging evidence that sedentary behaviours, involving high volumes of time spent sitting or lying [39] are distinctly related to risk for chronic disease [40]. Sedentary behaviour has been defined as a range of human endeavours that result in an energy expenditure of no more than 1.5 times resting energy expenditure [19]. These behaviours are typically associated with time spent sitting, reclining, or lying down during waking hours [19, 41]. Self-reported sedentary time (particularly television-viewing time and total sitting time) is associated with obesity, abnormal glucose metabolism, metabolic syndrome and cardio-vascular mortality [42-48]. Research in this area is looking into “bouts” of sedentary behaviour which are periods of consecutive counts where the activity level remains the same and “breaks” from sedentary behaviour which are considered as an interruption in sedentary time, time spent in light physical activity and moderate-to-vigorous physical activity. In addition to total sedentary time, the manner in which it is accumulated (long or multiple short bouts) may be important in terms of health consequences [18].

### **1.2.4. Methods for Quantifying Physical Activity**

There are at least three methods for monitoring physical activity pattern: direct observation, self reporting and wearable motion sensors. The direct observation technique of assessing physical activity offers a variety of reliable approaches to collecting rich information. Direct observation involves the investigator participating, overtly or covertly, in the observer’s daily lives for an extended period of time, watching what happens, listening to what is said, asking questions – in fact, collecting whatever data is available on physical activity patterns

[49]. While considerable time and effort is required to conduct direct observation, the detailed information provided makes it a highly useful method for characterizing the different dimensions of physical activity. It allows the investigator to describe the mode, intensity and duration of the subjects' activities as well as the interaction with the environmental and other individual. This method has its limitations as it can be costly to implement due to its labour and time intensiveness [50]. The period of physical activity to be observed may be limited to a time period which may not reflect the actual physical activity pattern throughout the duration of the day. Furthermore, the technique is generally limited to observing physical activity patterns in the home environment.

Another method used to quantify physical activity is self-report measures such as questionnaires. Advantages of questionnaires are that they are relatively easy to administer and inexpensive. A disadvantage to using self report measures in seniors is recall bias in which the reports may be influenced by fluctuations in health status and mood, depression, anxiety or cognitive ability [51]. One questionnaire commonly used in the elderly population is the Physical Activity Scale for the Elderly (PASE) [52].

A third method used to quantify physical activity and sedentary behaviour is using wearable motion sensors to obtain an objective measure in home environment during waking hours. Pedometers are an example of one type of wearable motion sensor which are cheap and easy to wear; they measure step-count but not cadence and therefore cannot distinguish walking speed [53]. However, the step counts may be under reported due to slow walking speeds due to age and disability [54-56]. Nevertheless, the technology for motion sensors has improved researchers' ability to collect objective data. Another type of wearable motion sensor is an accelerometer which is currently among the most widely

studied wearable motion sensor for physical activity due to their accuracy in the detection of human body movements, small size, and reasonable power consumption [57].

### **1.2.5. Accelerometry**

The accelerometer is a device that measures the acceleration of a structure. The force generated by acceleration causes a small mass within the sensor to "squeeze" an adjacent piezoelectric material which produces an electrical charge directly proportional to the acceleration of the unit. Accelerometers are ideal for use in populations that typically engage in very light or very brief physical activity such as the elderly [58], and can provide data on the amount, frequency and duration of physical activity. Harris et al. (2008) [53] found that it is feasible to monitor physical activity levels in the community-dwelling older people for one week using accelerometers. The authors reported that physical activity levels were low, with only 2.5% achieving the recommended physical activity levels [59] (at least 150 minutes per week), considerably lower than levels based on self-report questionnaires. However barriers in use of accelerometers may arise due to fluctuation in health status, mood, anxiety and cognitive ability. Remembering to wear the device may cause anxiety and challenges the cognitive ability. Tenants may view the device as a burden. Furthermore, the accelerometer must be secured correctly and remain in place at the waist, wrists or ankles. Despite these barriers, accelerometers are objective means for monitoring physical activity patterns which eliminate the source of bias inherent in other techniques.

### **1.2.6. Accelerometry in Older Adults**

Monitoring of individual's physical activity levels has been of growing interest with increasing recognition of its impact on health outcomes. In PubMed, when the words, accelerometer and physical activity were imputed, there were 13 articles in 2000 as compared to 130 in 2009, a 10-fold increase in 10 years.

Few studies have been using accelerometry to examine physical activity in the Assisted Living population. Most studies have focused on adolescents and young adults or specific disorders such as breast cancer [60], obesity, diabetes [40], multiple sclerosis, chronic obstructive pulmonary disease, cardiovascular diseases [61] and metabolic syndrome[62]. A search on Medline with the words "Assisted Living", "physical activity" and "accelerometer", yielded only one article (Zalewski et al. 2009 [63]) which focused only on step counts. Searching with the words "ageing", "physical function" and "accelerometer" again yielded only one article, Resnick, et al. (2010b) [13] which monitored individuals for one day.

Senior populations tend to have unique patterns of physical activity when compared to younger adults. Murphy, (2009) [64] identified four observations related to such differences. First, seniors differ from younger adults and children in the type and intensity of activities in which they engage. Second, age-related decline in basal metabolic rate and decreased fat free mass may contribute to errors in energy expenditure calculations that were developed using younger adult samples. Third, chronic conditions increase in prevalence with aging and can affect physical activity patterns. Fourth, problems with memory and recall among seniors may affect compliance in wearing monitoring equipment over a series of days.

### **1.2.7. Cutpoints in Defining Physical Activity from Accelerometry**

A key issue in accelerometry is defining the threshold value of acceleration or acceleration derived activity levels, to separate sedentary behaviour, light physical activity and moderate to vigorous physical activity (MVPA). These values are often referred to as cutpoints. Freedson et al. (1998) [65] suggested that an activity count above 1953 per minute which corresponds to a MET  $\geq 3$  should be regarded as MVPA and this has been adopted widely in studies. Matthews et al. (2009) [66] in the National Health and Nutrition Examination Study (NHANES) study with community dwelling seniors defined sedentary behaviour as 100 or less activity counts per minute, and light physical activity is between 101 and 1952 activity counts per minute (less than 2.99 MET). However Copeland et al. (2009) [67] suggested that age influences the relationship between accelerometer counts and activity, thus justifying different cutpoints depending on age. For older adults, Copeland et al, (2009) [67] defined sedentary behaviour as below 49 counts per minute, light physical activity between 50 and 1041 counts per minute and MVPA as above 1042 counts per minute.

While accelerometry cutpoints separate behaviours into levels of exertion (sedentary, light, MVPA), they provide limited insight into the types of activities individuals are engaging in during the course of the day. Light physical activity and MVPA can involve transportation (getting to and from different locations or performing errands), household maintenance (e.g. raking leaves, mowing the lawn) and leisure activities (e.g. exercise, sports). Ainsworth et al. (2000) [20] described light activities as including washing dishes, ironing, and slow walking. Finally, Beyler et al. (2008) [68]

described MVPA as activity that causes at least “light sweating or a slight to moderate increase in heart rate or breathing.”

### **1.3. Determinants of Physical Activity in Older Adults**

To be eligible for admission to Assisted Living, seniors must require assistance with their personal care and/or their medication management. These limitations may associate with decreased physical activity patterns. A study by Giuliani et al. (2008) [14] suggested that the Assisted Living tenants increased risk for adverse events may be identified using simple tests of physical performance. The authors compared grip strength, chair rise ability (part of the Short Physical Performance Battery test), and balance to adverse events such as fracture and death. However, no studies to date have examined how physical, cognitive and psychosocial measures correlate with the physical activity patterns of Assisted Living tenants. A major goal of this thesis is to provide insight on these relations.

### **1.4. Thesis Goals**

The main goal of this thesis is to test the hypothesis that the physical activity patterns of older adults residing in Assisted Living associate with measures of physical, cognitive and psychological function. Participants will have their physical, cognitive, and psychosocial functions measured through a battery of tests, such as Timed-up-and-go Test [69], Short Physical Performance Battery (SPPB) Test [70], and Montreal Cognitive Assessment (MoCA) [71]. Patterns of physical activity and sedentary behaviour will be measured with a self-report questionnaire (PASE) [52] and objective measures of activity



patterns using accelerometers. Various statistical tests (correlation, analysis of variance, and regression) will then be employed to determine whether physical activity patterns, and in particular, sedentary behaviours, associate with demographic characteristics and test scores on measures of physical, cognitive, and psychosocial function. It is expected that the novel information gained from this study will have relevance to the design of interventions to enhance the physical activity levels among older adults living in Assisted Living.

## **Chapter 2.**

### **Methods**

#### **2.1. Study Design**

We conducted a cross sectional study, acquiring data from an activity monitor as well as baseline measures of physical function, cognitive and mood. Data was collected between January 7 and February 18, 2010.

#### **2.2. Participants**

Thirteen Assisted Living sites located in the Fraser Health Authority region in British Columbia were invited to participate in the study. An information session providing details about the research protocol was held for the managers and staff from the participating Assisted Living sites. Managers and staff were also informed about the exclusion criteria: (1) unable to read or understand simple directions in English, (2) did not reside in an Assisted Living site, (3) unable to ambulate without a wheelchair and (4) under 65 years of age. Upon agreement to participate, Assisted Living staff informed the tenants of the study and surveyed them on whether they would like to participate.

Out of the 176 tenants who were initially interested, 158 attended the scheduled testing sessions. The reasons 18 tenants did not attend include illness, being in hospital, being unable to ambulate without a wheelchair, and having other plans (Figure 2.1).

Another 10 individuals were excluded because they did not meet the criteria to participate or had changed their minds. A total of 148 participants completed all physical, cognitive and psychosocial tests and were provided with activity monitors and asked to wear them during all waking hours for a continuous period of 7 days. A group of 7 participants immediately refused to wear the activity monitors due to skin irritation, difficulty in putting them on, and changed their mind about participating in the study. Of the 141 sensors given, 114 sensors had the minimal 3 days of 8 hours of valid wearing data (Figure 2.1).

This study received ethics approval from both Fraser Health Authority and Simon Fraser University, and all participants gave written informed consent prior to participating in the study.

## **2.3. Measures**

Each participant attended an hour-long session to complete a battery of physical, cognitive and psychosocial tests. All the measures were administrated by trained assessors. Participants were also asked to complete a one-page health profile questionnaire to provide information on the gender, length of stay in Assisted Living, age in years, previous falls in the past 6 months, use of mobility aids, highest education received, reported health concerns, and exercise program participation.

### **2.3.1. Measures of Physical Function**

To determine the participants' physical ability, Timed Up and Go (TUG) test [69],

Short Physical Performance Battery (SPPB) test [72], dominant leg strength test, and dominant grip strength test were conducted. The TUG test is a method of assessing mobility and quantifying locomotor performance. In the TUG test, participants are instructed to rise from a standard chair with arms, walk a distance of three meters, turn, walk back to the chair and sit down again. The scoring of this test is the actual time required to accomplish this task, commencing from the verbal instruction of “start” and stopping when the participant returned to the seated position. The TUG has been shown to have high validity and inter-rater reliability [69, 73-76]. A score of 20 seconds and below indicated independence in transfer, while a score of  $\geq 30$  seconds indicated dependence [69]

The SPPB test which examines 3 important aspects of lower extremity function, is comprised of 3 individual components: 1) 4 meters timed walk (4MTW), 2) tests of static balance and 3) five times sit-to-stands. For each component, the score of 0 represented the inability to complete the test and 4 the highest level of performance. Thus, the maximum possible score for this test is 12. From the 4 meters timed walk (4MTW), gait speed [77] was calculated using distance in meters (4 meters) divided by the participant’s recorded time in seconds. SPPB has been shown to be a reliable and valid tool. Studenski et al. (2003) [78] reported inter-rater reliability at  $> 0.9$  and test-retest reliability at 0.723. Guralnik et al. (1995) [79] reported that SPPB score had a significant association with self reported mobility related and ADL related disability. The score of 0 to 3 indicates severe limitation, 4 to 6 moderate and 7 to 9 mild. Between a score of 10 and 12, there is minimal limitation.

Leg strength was measured with a spring gauge attached to velcro with a webbing

strap. The velcro was attached around the leg 10 cm above the ankle joint, with the participant sitting on a chair with the hip and knee joint angles positioned at 90 degrees. The participants were asked to straighten the knee, pushing against the webbing strap. The measurement was recorded in kilograms. For the grip strength, participants were asked to squeeze a hand dynamometer (Jamar 5030 J1, Michigan) with his/her dominant hand three times with no rest period between trials. The highest grip strength score was recorded in kilograms.

### **2.3.2. Measures of Cognitive Function**

Global cognitive function was assessed with the Montreal Cognitive Assessment (MoCA) [71]. The MoCA is a one-page test that takes 10 minutes to administer and includes the following domains:

- i. Short-term memory: recall of five nouns after 5 minutes (5 points)
- ii. Visuospatial clock-drawing (3 points) and cube copying (1 point)
- iii. Executive modified trail making B task (1 point), phonemic fluency (1 point) and 2 item verbal abstractions (2 point)
- iv. Attention, concentration, and working memory: target detection using tapping (1 point), serial subtraction (3 points), and digits forward and backward (2 points)
- v. Language: animal naming of low-familiarity animals (lion, camel, rhinoceros; 3 points) and sentence repetition (2 points)
- vi. Orientation to time and place (6 points)

MoCA has been shown to have excellent reliability and validity [71, 80]. The MoCA is

scored by adding the points from each section, with a maximum possible score being 30. A cut-off of 26 or below indicates cognitive impairment [81].

### **2.3.3. Measures of Psychosocial Function**

Psychosocial function was assessed with the Short Geriatric Depression Scale (Short GDS) [82] and the Modified Falls Efficacy Scale (MFES) [83, 84]. The Short GDS consists of 15 questions related to mood, requiring "yes" or "no" answers and was developed as a basic screening measure for depression in older adults. The GDS was found to have 92% sensitivity and 89% specificity when evaluated against diagnostic criteria and has high validity and reliability [85-87]. A score of 0 to 4 indicates normal, 6-8 indicates mild depression, 9-11 indicates moderate depression and 12-15 indicates severe depression.[86]

The MFES is a one page form, consisting of 14 questions each related to a particular activity (e.g. getting dressed, taking a bath, crossing roads, etc). The questions aim to determine how confidently seniors feel they are able to undertake each activity on a scale of 0 (not confident at all) to 10 (completely confident). The total score is then divided by the number of questions (14) resulting in a final score between 0 and 10, with cutoff points of 0 as not confident/not sure at all, 5 as fairly confident/fairly sure and 10 as completely confident/completely sure. The average score of 9.8 (range 9.2 – 10) from a sample of healthy women (mean age 74.1 years, SD = 4.0) indicated no fear of falling [88]. The MFES has been shown to have high retest reliability in older samples of fallers and non-fallers (ICC=0.95) [83].

## **2.3.4. Measures of Physical Activity**

### **2.3.4.1. Self Reported Activity**

The Physical Activity Scale for the Elderly (PASE) [52] was used to determine participants' self reported activity level. The PASE is designed to assess activities commonly engaged by elderly persons in the past 7 days. The PASE questionnaire contains 10 questions with different weight. The first six items are assessed in terms of hours per day over a 7-day period; the last 3 items are given a score of 2 if the person engaged in that activity and a score of 1 if they did not engage in the activity in the previous 7-days. The last question asks about volunteer work. The maximum score possible is 58 with higher points indicating higher activity levels. The PASE questionnaire was completed by the participants at the time the activity monitors were returned. Therefore, the PASE scoring reflects activities from the same time period as the activity monitors. In healthy elderly the PASE has been shown to have high test retest reliability ( $r = 0.84$ ) [52] and good validity [52, 89].

### **2.3.4.2. Accelerometry**

Participants were asked to wear an activity monitor, ActiGraph (Pensacola, FL) model GT1M (Figure 2.2), during all waking hours for a continuous period of 7 days. The device was initialized according to manufacturer specification prior to being provided to participants. During this initialization, the sampling "epoch" (or independent sampling interval) was set to 10 seconds. The device measures changes in acceleration 30 times per second. Therefore for each 10 seconds epoch, 300 measurements are summed into a single activity count, which is stored in onboard memory. A series of consecutive activity

counts represents a quantitative measure of the intensity of the participant's physical activity over time (Figure 2.3).

## **2.4. Data Analysis**

### **2.4.1. Accelerometry Data Analysis**

For each participant, I analyzed accelerometer data using MeterPlus software (Santech, Inc.) and programs developed in-house using the MATLAB computing language (The Mathworks, Inc.) to identify time intervals spent in sedentary behaviour, light physical activity and moderate-to-vigorous physical activity based on previously established cutpoints (Table 2.1). Only participants with three or more valid days were included in the final analysis, where a valid day was defined as having 8 or more hours where the participant wore the accelerometer. Non-wear time was defined by an interval of at least 360 consecutive 10-second epochs (or one hour) of zero activity counts, and was not included in the analysis. In order to reduce signal noise and ability to compare to other studies, every six 10-second epochs were converted into a 1 minute epoch.

The NHANES cutpoints were used for analysis as they are the most reported cutpoints in accelerometry studies, calculating the percent of time (while the individual was awake and wearing the accelerometer) spent (1) in sedentary behaviour, (2) in light physical activity, and (3) in moderate-to-vigorous physical activity. For each of these behaviours, I also calculated the average duration of each bout (consecutive period) of sedentary behaviour, light physical activity, and moderate-to-vigorous physical activity.



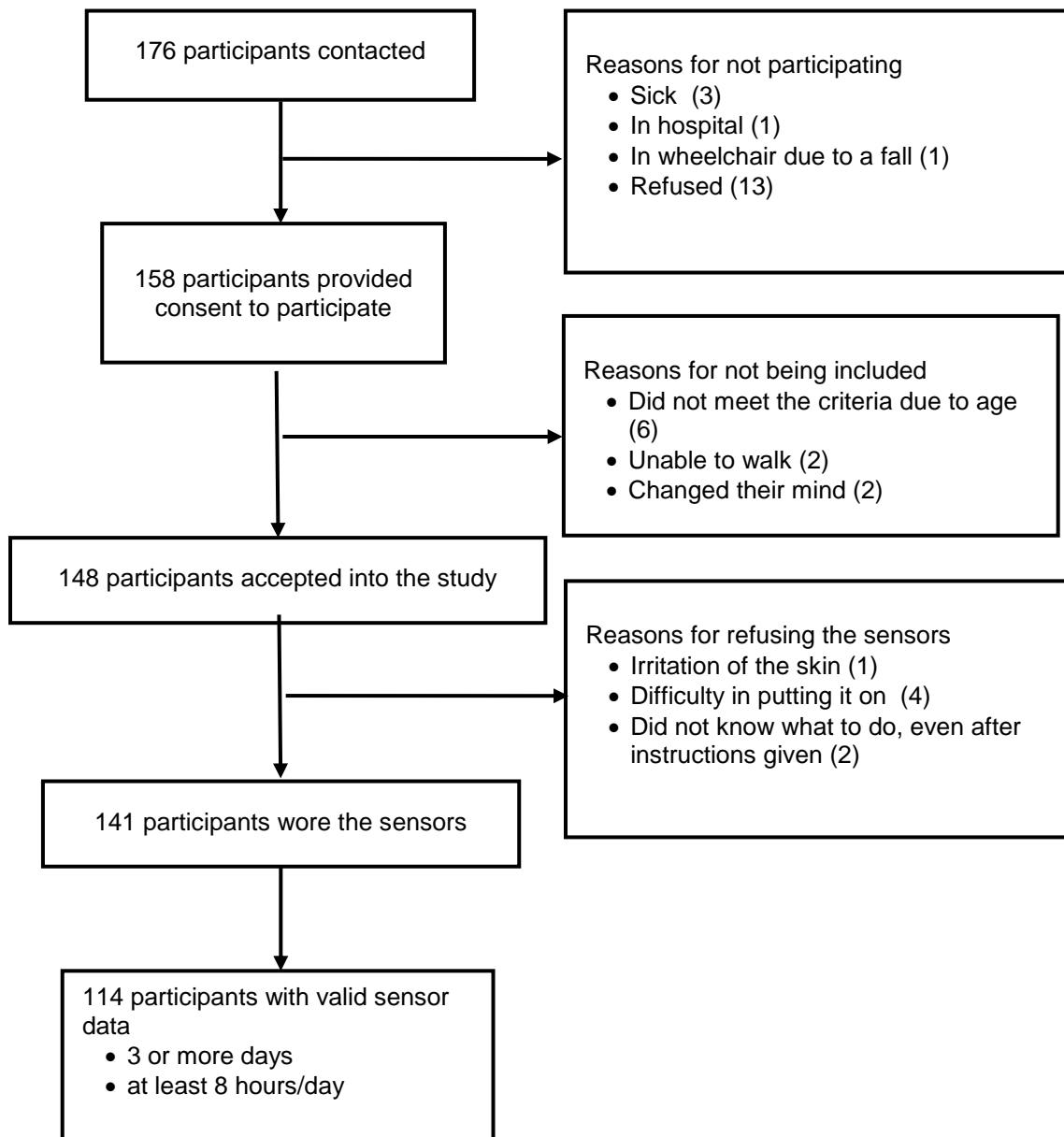
## 2.4.2. Statistical Analysis

To facilitate comparison of my results with published data, my statistical analysis was based on 1 minute epochs and cutpoints for physical activity defined by NHANES [66]. Furthermore, the dependant variables I examined in my statistical analysis were the percentage of light physical activity and sedentary behaviour, the average duration of sedentary bouts, and the average duration of breaks from sedentary behaviour. I used independent sample t-tests to determine whether these accelerometry variables associated with sex (male versus female), mobility aid use (yes versus no) and current involvement in an exercise class (yes versus no). I used one-way analysis of variance (ANOVA) to examine the association between accelerometry variables and Assisted Living site.

I used Pearson correlation to explore how accelerometry variables associated with length of time in Assisted Living, age, number of reported health concerns, and scores on the TUG, SPPB, grip strength, leg strength, gait speed, MoCA, GDS and MFES tests. Bonferroni test was applied to adjust for the significant level.

Finally, I used multiple linear regression models to examine how the variability in accelerometry parameters was explained collectively by sex, age, use of a mobility aid, number of health concerns and scores on the TUG, leg strength, MoCA, GDS and MFES tests. These independent variables were determined based on the significance in the univariate tests (i.e  $p \leq 0.05$ ) and assumed biological relevance such as age, number of health concerns, leg strength, MoCA, and GDS. All statistical analyses were conducted using PAWS version 18 (SPSS, Inc. Chicago, IL), and statistical significance was set at  $p \leq 0.05$ .

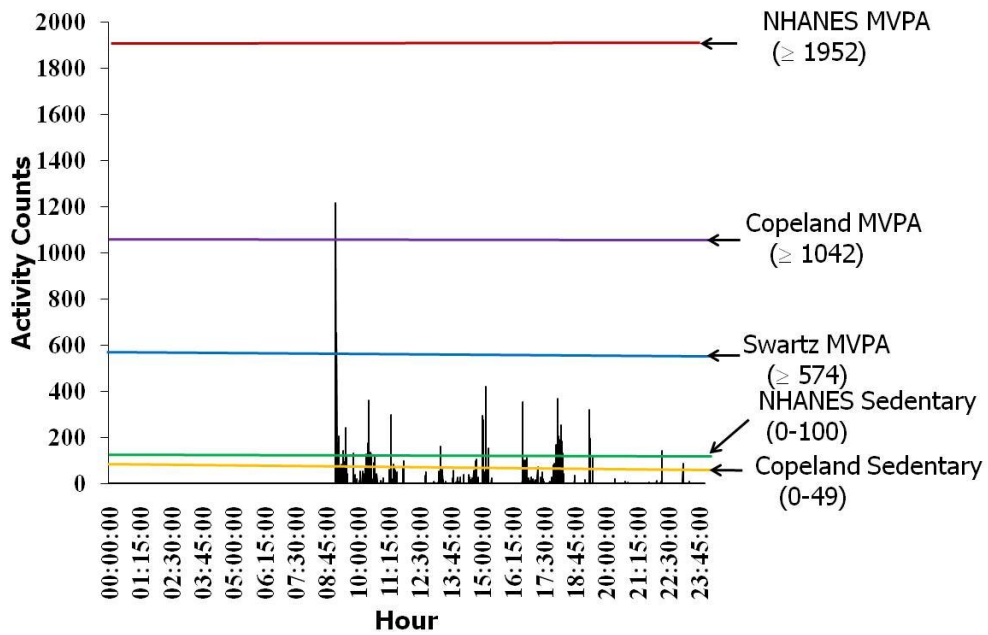
**Figure 2.1 Participant Recruitment**



**Figure 2.2 Activity monitor with waistband (Actigraph GT1M)**



**Figure 2.3** Example of output from Actigraph GT1M sensor, showing activity counts per minute, and cutpoints separating sedentary behaviour, light physical activity, and moderate-to-vigorous activity.



**Table 2.1 Cutpoints from accelerometry for sedentary, light physical activity, and moderate to vigorous physical activity (MVPA), based on activity counts for one minute epoch**

<b>Behaviour</b>	<b>METS<sup>1</sup></b>	<b>NHANES cutpoints<sup>2</sup></b>	<b>Copeland cutpoints<sup>3</sup></b>	<b>Swartz cutpoints<sup>4</sup></b>
Sedentary	< 1.5	0 – 100	0 – 49	...
Light physical activity	1.5 – 3.0	101 – 1951	50 – 1041	0 – 573
MVPA	> 3.0	≥ 1952	≥ 1042	≥ 574

<sup>1</sup> METS (Metabolic Equivalent of Tasks) is defined as the ratio of the metabolic rate during exercise to the metabolic rate at rest. .

<sup>2</sup> Freedson et al. (1998) [65], Matthew et al. (2008) [66]

<sup>3</sup> Copeland et al. (2009) [67]

<sup>4</sup> Strath et al. (2003) [90]

## **Chapter 3.**

### **Results**

#### **3.1. Participant Characteristics**

The demographic data findings are shown in Table 3.1. 114 participants were included from 13 Assisted Living sites, ranging from 4 to 20 participants per site. The number of suites per AL sites range from 28 to 120 (Table 3.2). The room size varies from AL sites, ranging from the smallest size at 27.87 square meters to the largest size at 59.49 square meters. There is a difference between AL sites in the distance from the farthest room to the dining room, ranging from 30.7 meters to 76.2 meters. The distance from the closest room to the dining room ranges from 5.5 meters to 49.68 meters. The mean age of participants was 86.7 years (SD = 7.5 years) with a range from 66 to 100 years. The vast majority (85.5%) of participants were female with 14.5% of them being male. Their average time since entry into Assisted Living was 25 months (SD = 17.6 months) with a range of 1 to 97 months. Eighty four percent of the participants reported using a mobility aid with a 4-wheeled walker being the most common type.

The mean number of health concerns reported was 2.5 with the median at 2.0. The most frequent reported health concerns are high blood pressure, arthritis and heart disease. Seventy percent of the participants stated that they attend some type of exercise class within the past 6 months.

### **3.2. Physical, Cognitive, Psychosocial Measures**

Descriptive statistics on physical, cognitive and psychosocial measures are presented in Table 3.1. The mean TUG score was 20.67 seconds (SD=9.96) with only 6% scoring below 10 seconds and 24% scoring between 10 and 14 seconds. Graphs representing a fast and slow TUG score are presented in Figure 3.1(C) and (D). The mean SPPB test score was 5.23 (SD = 2.25) out of 12, with 98.2% of the participants scoring 9 and below. Nine percent of the participants were unable to stand unassisted with their feet in a semi-tandem (side by side) stance for 10 seconds, and 80% were unable to stand in full tandem position for 10 seconds. Average walking speed was 0.75 meter/seconds with only 31% walking at a speed greater than 0.6 meters/seconds. As for the five times sit-to-stand subtest, 67% of the participants were unable to complete this task in less than 16.7 seconds. The mean gait speed score was 0.746 (SD=0.238) meters per seconds. As the standard time required to travel across the road is 1.2 meters per second [91], none of the participants would be able to walk across the road in this time.

Based on the MoCA test, the majority of the participants displayed some degree of cognitive impairment (Table 3.1). Only 15% of the participants scored 26 and above, a score considered to indicate normal cognition. The mean MoCA score out of a possible 30 was 19.85 (SD=5.33) with a range of 7 to 30. The majority of participants (61%) were able to name 3 of the animals (lion, camel, rhinoceros), however only 57% were fully oriented to time and place. Thirty nine percent could not recall any of the words in the delayed recall test. In the visuospatial/executive subtest, 40% of the participants scored 2 out of a possible 5.

The participants' psychosocial measures indicated that the majority of the participants were not depressed, and had some level of fear of falling (Table 3.1). The mean Short GDS score was 3.17 (SD=3.18) with a range of 0 to 14. The majority (81%) of participants scored 5 and below, indicating that they were not depressed. The mean MFES score was 8 (SD=1.81) out of a possible 10, with the majority (80%) of participants scoring below 9.8, indicating that they have some level of fear of falling..

### **3.3. Self Reported Activity Measure**

A total of 67% of participants completed the PASE questionnaire documenting their daily activity. The majority of respondents (87%) spent 4 or more hours in seated activities. The most frequently reported seated activities were watching TV and reading. Other activities mentioned were knitting, doing puzzles, computer work, and visiting families and friends.

### **3.4. Accelerometry Activity Patterns**

Descriptive statistics for accelerometry data are presented in Table 3.1. Activity was monitored over a period of 3-7 days, with 83% of the participants having 6-7 valid days. The accelerometer data indicated that the participants wore the sensors for an average of 6 days, 12.67 hours per day. The average percentage of the day spent in sedentary behaviour was 86.01%, in light physical activity was 13.85% and in MVPA was 0.14%. When transforming these percentages into minutes in a 12.76-hour day, the average participant spent 658 minutes (10.97 hour) in sedentary behaviour, 106 minutes (1.77 hours) in light physical activity and 1.06 minutes (0.02 hour) in MVPA. Males



spent a higher percent of their waking hours in sedentary behaviour than females (90.25%, SD = 6.47 versus 85.27%, SD = 7.89; Table 3.1). The average number of sedentary bouts in a day was 50.25 with males having a lower number of sedentary bouts at 37.61. The average duration of sedentary bouts was 19 minutes. Graphs depicting two participants with the similar percentage of sedentary behaviour but a different number of sedentary bouts (i.e., a “prolonger” versus “breaker” as defined by Owen et al. 2010 [92] are presented in Figure 3.1(E) and (F).

### **3.5. Correlation between Test Measures**

Bivariate (Pearson) correlations between the test measures are shown on Table 3.3. There was moderate positive correlation between leg strength and grip strength ( $r = 0.424, p < 0.0005$ ). Leg strength correlated significantly with gait speed ( $r = 0.273, p = 0.003$ ), SPPB ( $r = 0.274, p = 0.003$ ) and TUG ( $r = -0.218, p = 0.020$ ). As expected, there were strong associations between gait speed, TUG and SPPB ( $r > 0.65, p < 0.001$ ). Interestingly, there were no associations between cognitive function (as measured by the MoCA) and any of the tests of physical function and mood ( $p > 0.052$ ). GDS correlated negatively with gait speed ( $r = -0.212, p = 0.023$ ) and SPPB ( $r = -0.219, p = 0.019$ ), and positively with TUG ( $r = 0.186, p = 0.048$ ). Finally, MFES correlated negatively with GDS ( $r = -0.417, p = 0.001$ ) and TUG ( $r = -0.298, p = 0.001$ ) and positively with gait speed ( $r = 0.275, p = 0.003$ ) and SPPB ( $r = 0.387, p < 0.0005$ ).

### 3.6. Determinants of Physical Activity and Sedentary Behaviour

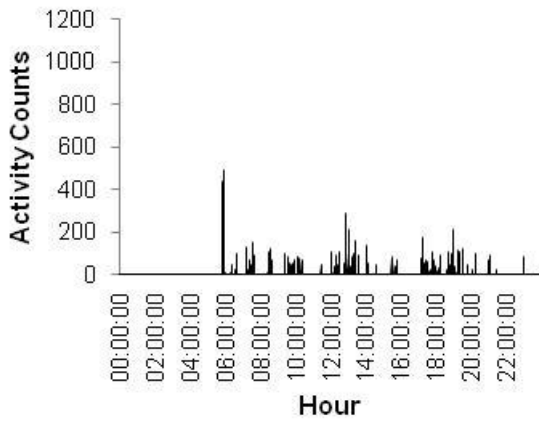
Based on ANOVA, there was no significant difference between Assisted Living sites in percentage of waking time spent in light physical activity, sedentary behaviour, number of sedentary bouts per day and average duration of sedentary bouts. Based on independent sample *t*-tests, percentage of sedentary behaviour associated with sex ( $t = -2.456, p = 0.016$ ) and use of mobility aid ( $t = -3.331, p = 0.001$ ), but not attendance in exercise class ( $t = 1.949, p = 0.54$ ). Similar associations were observed for the percentage of light physical activity, the number of sedentary bouts and average duration of sedentary bouts (Table 3.4). Based on Pearson's correlation, the percentage of time spent in sedentary behaviour associated with TUG ( $r = 0.350, p < 0.0005$ ), SPPB ( $r = -0.221, p = 0.018$ ), gait speed ( $r = -0.206, p = 0.028$ ) and MFES ( $r = -0.234, p < 0.012$ ), but not length of stay in Assisted Living, age, number of reported health concerns, grip strength, leg strength, MoCA, and GDS. Similar trends were observed for the percentage of light physical activity, number of sedentary bouts and average duration of sedentary bouts, with one exception: the number of sedentary bouts per day also associated with GDS ( $r = -0.232, p = 0.013$ ). Scatter plot graphs between sedentary behaviour data and Timed-Up-and-Go (TUG) scores are presented on Figure 3.2. Because there are 56 multiple comparisons tests performed, the Bonferroni correction is used to consider the risk of Type 1 error with the adjusted significant *p* value to be 0.0009. With the adjusted significant *p* value, TUG is the only variable that associated with percentage of light physical activity, percentage of sedentary behaviour, number of sedentary bouts per day and average duration of sedentary bouts ( $p < 0.0005$ ). MFES and SPPB associated with

number of sedentary bouts per day ( $p < 0.0005$ ). Sex associated with average duration of sedentary bouts ( $p < 0.0005$ ). Independent variables that did not significantly associated with any of the dependent variables are use of mobility aid, gait speed and GDS.

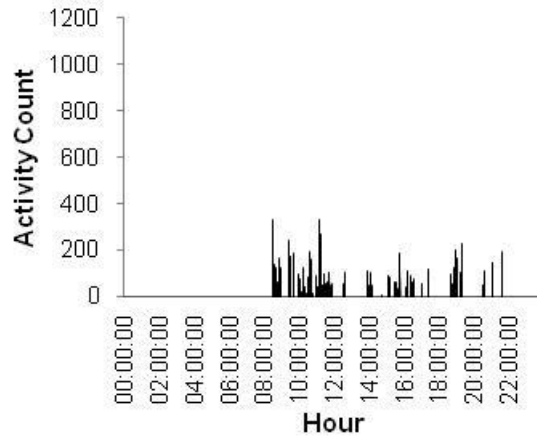
Variables included in the multiple linear regression model included sex, age, use of a mobility aid, attendance in exercise class, reported health concerns and scores on the TUG, Leg strength, MFES, MoCA, and GDS tests. TUG was the only physical function variable entered into the model. SPPB and gait speed were not included in the model due to the high correlation between these variables and TUG. All variables were entered simultaneously into the model. Significant models emerged for each of the four dependent variables examined, with adjusted  $R^2$  values ranging from 0.21 to 0.32 (Table 3.5). TUG scores and sex were significant associated variables for four dependent variables and age was also a significant associated variable for time spent in light physical activity ( $p = .038$ ) and sedentary behaviour ( $p = .035$ ). Number of health concerns was significant associated with number of sedentary bouts ( $p = .049$ ) and average duration of sedentary bouts ( $p = .032$ ) and MFES was significant associated with number of sedentary bouts ( $p = .014$ ). These variables entered into the multiple linear regression had high tolerance levels (.718 to .925), indicating the relationships between the variables are weak.

**Figure 3.1** Graphs of activity counts for typical participants.

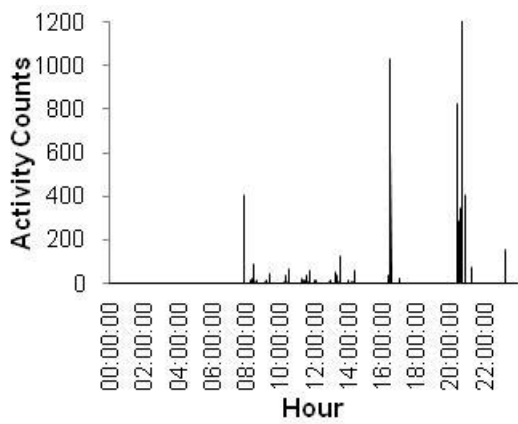
(A) Male with 90% sedentary behaviour



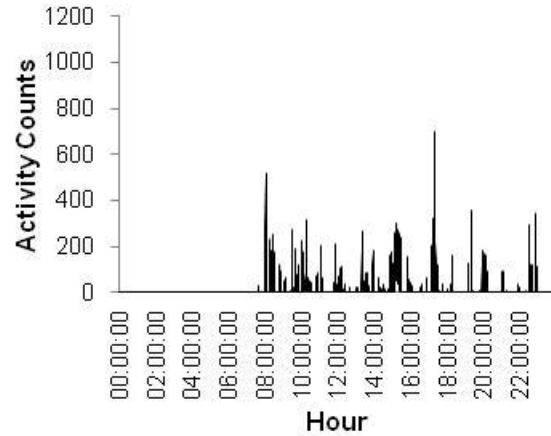
(B) Female with 85% sedentary behaviour



(C) Participant with TUG score 49.5 secs.

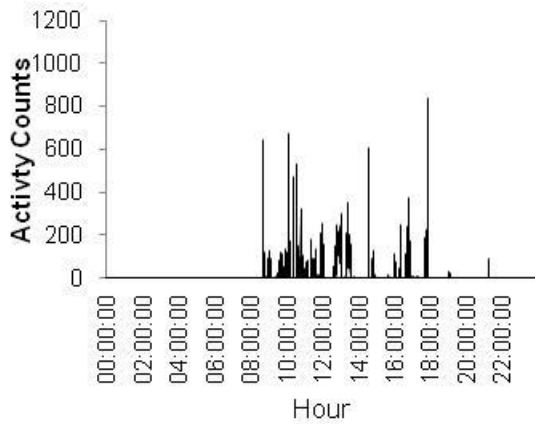


(D) Participants with TUG score 9.5 secs



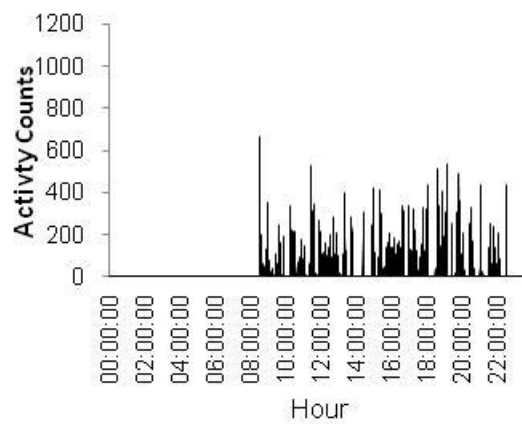
(E) "Prolonger" [92]

74% sedentary, 44 sedentary bouts

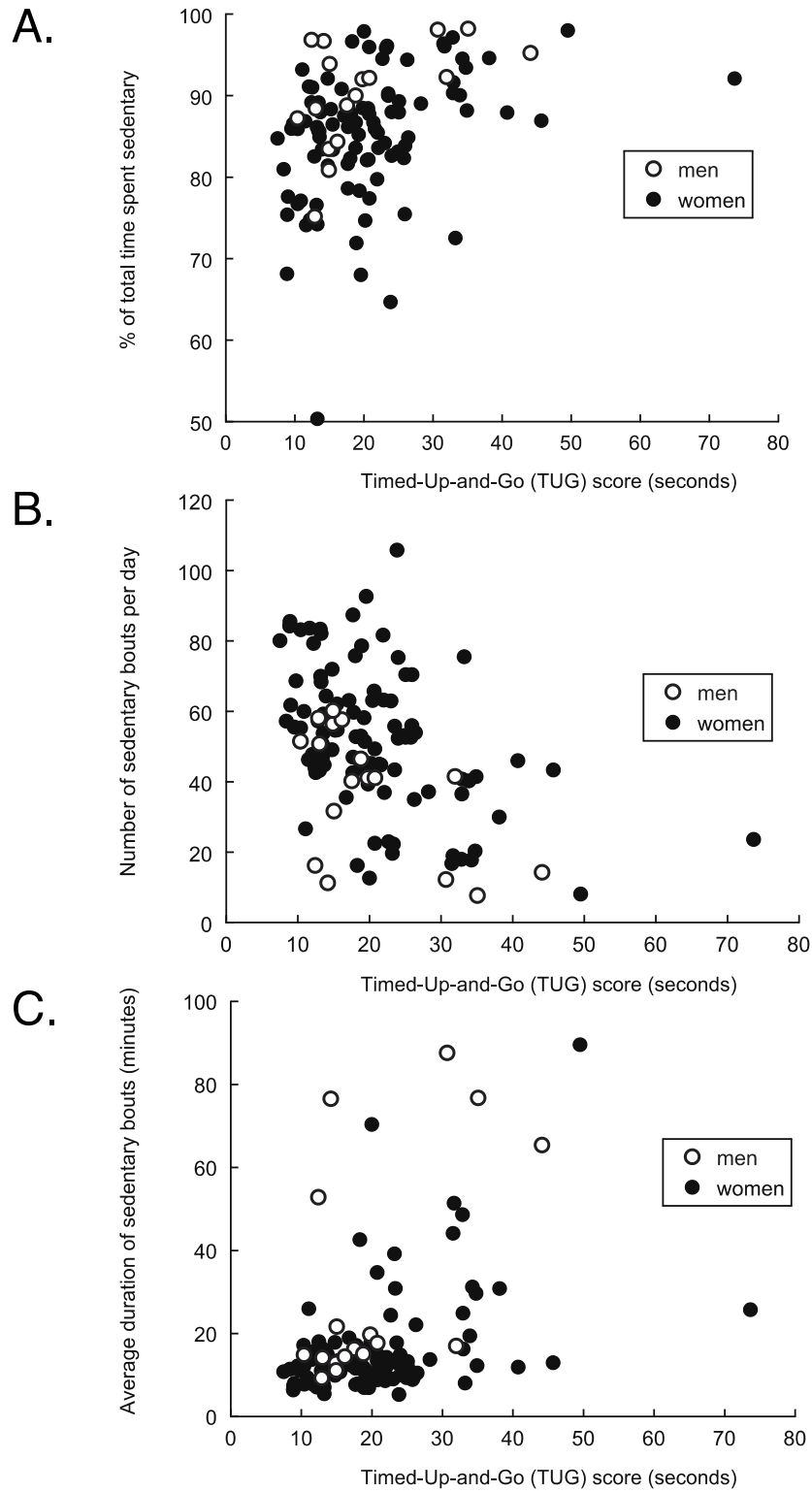


(F). "Breaker" [92]

74% sedentary, 84 sedentary bouts



**Figure 3.2 Scatter plots of Timed-Up-and-Go test and Sex vs (A) percent of time spent sedentary; (B) number of sedentary bouts per day; and (C) average duration of sedentary bouts (minutes)**



**Table 3.1 Demographics, Test Scores, and Accelerometry-Derived Variables for Study Participants**

	<b>Male (N=17)</b>	<b>Female (N=97)</b>	<b>Total (N=114)</b>
<b>Demographic characteristic</b>			
Age (years)	85.66 (7.43)	86.82 (7.50)	86.65 (7.47)
Length of stay in AL (months)	22.88 (15.44)	25.41 (17.98)	25.04 (17.58)
Post Secondary education (%)	31.60	21.70	23.70
Use of mobility aid (%)	88.2	83.5	84.2
Reported health concerns (number)	2.71 (1.36)	2.46 (1.39)	2.50 (1.38)
Exercise program participation within the past 6 months	70.6	70.1	70.2
<b>Test score</b>			
Timed Up and Go (seconds)	20.12 (9.51)	20.76 (10.08)	20.67 (9.96)
Short Physical Performance Battery (score out of 12)	4.94 (1.64)	5.28 (2.34)	5.23 (2.25)
Dominant grip strength (kg)	25.65 (7.81)	16.91 (5.32)	18.21 (6.52)
Dominant leg strength (kg)	17.12 (7.03)	13.82 (5.36)	14.32 (5.72)
Gait speed (meter/second)	0.715 (0.238)	0.751 (0.239)	0.746 (0.238)
Montreal Cognition Assessment (score out of 30)	18.88 (6.44)	20.02 (5.14)	19.85 (5.33)
Short Geriatric Depression Scale (score out of 15)	3.82 (3.66)	3.06 (3.10)	3.17 (3.18)
Modified Falls Efficacy (score out of 10)	7.80 (1.94)	8.05 (1.80)	8.01 (1.81)
<b>Accelerometer-derived variable</b>			
Percent of time in sedentary behaviour (%)	90.25 (6.47)	85.27% (7.89)	86.01 (7.87)
Percent of time in light physical activity (%)	9.65 (9.39)	14.58 (7.74)	13.85 (7.71)
Percent of time in MVPA (%)	0.10 (0.11)	0.15 (0.30)	0.14 (0.28)
Percent of time in light and MVPA (%)	9.75 (6.47)	14.73 (7.89)	13.99 (7.87)
Average number of sedentary bouts per day	37.61 (18.45)	52.46 (20.11)	50.25 (20.50)
Average duration of sedentary bout (minutes)	32.02 (27.49)	16.63 (13.15)	18.93 (16.86)
Average duration of break from sedentary behaviour (minutes)	1.83 (0.48)	2.00 (0.57)	1.98 (0.56)

Note. Cell entries show means, with standard deviations in parentheses. Sedentary behaviour corresponds to < 100 accelerometer counts/minute; light physical activity corresponds to 100 - 1951 accelerometer counts/minute; moderate to vigorous physical activity corresponds to ≥1952 accelerometer counts/minute.

**Table 3.2. Number of participants at the various Assisted Living sites**

<b>AL site</b>	<b>N</b>	<b>Total number of suites</b>
1	8	109
2	20	120
3	5	84
4	7	50
5	4	70
6	9	68
7	6	32
8	13	59
9	13	50
10	5	28
11	7	88
12	10	58
13	7	59

**Table 3.3. Correlation between test scores**

	GDS	MoCA	Gait speed	Leg strength	Grip strength	SPPB	TUG
SPPB							-.659**
Grip strength						.136	-.131
Leg strength					.424**	.274**	-.218*
Gait speed				.273**	.131	.653**	-.763**
MoCA			.185	-.013	.118	.153	-.178
GDS		-.097	-.212*	-.179	-.178	-.219*	.186*
MFES	-.417**	.011	.275**	.180	.120	.387**	-.298**

\*p ≤ 0.05 level, \*\* p ≤ 0.01 level

Abbreviations: MFES - Modified Fall Efficacy Scale, GDS - Geriatric Depression Scale, MoCA - Montreal Cognitive Assessment, SPPB - Short Physical Performance Battery, TUG - Timed Up and Go



**Table 3.4. Results from bivariate tests examining the association between independent variables and accelerometry derived variables (light physical activity and sedentary behaviour)**

\*p ≤ 0.05 level, \*\* p ≤ 0.01 level

Test	Independent variable	Dependant variable							
		Percentage of Light physical activity		Percentage of time sedentary		Number of sedentary bouts per day		Average duration of sedentary bouts	
Analysis of variance	AL site	F <sub>1,12</sub>	Sig.	F <sub>1,12</sub>	Sig.	F <sub>1,12</sub>	Sig.	F <sub>1,12</sub>	Sig.
Independent sample t-test (df = 112, equal variances assumed)	Sex	<i>T</i>	<i>P</i>	<i>T</i>	<i>p</i>	<i>T</i>	<i>P</i>	<i>t</i>	<i>p</i>
	Use of mobility aid	-2.477*	.015	-2.456*	.016	2.840**	.005	-3.656**	<.0005
	Exercise class participation	-3.311**	.001	-3.331**	.001	2.875**	.005	-1.985*	.050
Pearson Correlation		<i>R</i>	<i>P</i>	<i>R</i>	<i>p</i>	<i>R</i>	<i>P</i>	<i>r</i>	<i>p</i>
	Length of stay in AL	.094	.323	.093	.323	-.036	.707	.035	.708
	Age	.152	.116	.152	.106	.005	.955	-.043	.651
	Number of reported health concerns	-.073	.440	-.074	.434	.083	.383	-.113	.231
	TUG	-.353**	<.0005	.350**	<.0005	-.446**	<.0005	.395**	<.0005
	SPPB	.223*	.017	-.221*	.018	.348**	<.0005	-.249**	.008
	Grip strength	-.024	.803	.021	.823	-.058	.543	.088	.352
	Leg strength	.062	.513	-.061	.518	.144	.126	-.099	.296
	Gait speed	.204*	.029	-.206*	.028	.259**	.005	-.256**	.006
	MoCA	.097	.304	-.095	.314	.156	.097	-.072	.444
	GDS	.179	.056	.179	.057	-.232*	.013	.121	.201
MFES	.234*	.012	-.234*	.012	.371**	<.0005	-.194*	.039	

Abbreviations: TUG - Timed Up and Go, SPPB - Short Physical Performance Battery, MoCA - Montreal Cognitive Assessment, GDS - Geriatric Depression Scale, MFES - Modified Fall Efficacy Scale

**Table 3.5 Results from multiple linear regression examining the association between independent variables and accelerometry derived variables (light physical activity and sedentary behaviour)**

Dependent variable	Adjusted R <sup>2</sup>	F <sub>10,103</sub>	P	Independent Variable	Beta	P
Percent of Light Physical Activity	0.215	4.095	< 0.0005	Sex	-.260	.004
				Age	-.186	.038
				Use of mobility aid	-.126	.204
				Number of health concerns	.116	.198
				Attendance in exercise program	.155	.082
				TUG	-.264	.007
				Leg strength	.099	.295
				MoCA	-.019	.831
				GDS	-.050	.603
				MFE	.071	.467
Percentage of Sedentary Behaviour	0.214	4.074	< 0.0005	Sex	.258	.004
				Age	.189	.035
				Use of mobility aid	.130	.191
				Number of health concerns	-.117	.196
				Attendance in exercise program	-.153	.086
				TUG	.261	.008
				Leg strength	-.098	.299
				MoCA	.021	.812
				GDS	.051	.596
				MFE	-.071	.473
Number of Sedentary Bouts	0.321	6.331	< 0.0005	Sex	-.293	<.0005
				Age	-.041	.617
				Use of mobility aid	-.018	.844
				Number of health concerns	.167	.049
				Attendance in exercise program	.132	.110
				TUG	-.328	<.0005
				Leg strength	.149	.090
				MoCA	.051	.529
				GDS	-.020	.826
				MFE	.229	.014
Average Duration of Sedentary Bouts	0.244	4.653	< 0.0005	Sex	.371	<.0005
				Age	-.013	.883
				Use of mobility aid	.027	.779
				Number of health concerns	-.192	.032
				Attendance in exercise program	-.020	.819
				TUG	.358	<.0005
				Leg strength	-.123	.184
				MoCA	.038	.660
				GDS	-.010	.915
				MFE	-.065	.500

## Chapter 4.

### Discussion

#### 4.1. Interpretation of results

In this study examining physical activity behaviours among older adults residing in Assisted Living, I found that TUG scores, fear of falling (MFES score), gender, age and number of health concerns were predictors of light physical activity and sedentary behaviour, as quantified through accelerometry. However, at best, these variables explained only 32% of the variability in sedentary behaviour among study participants (as indicated by the adjusted  $R^2$  of 0.32 in the multiple regression for number of sedentary bouts per day). Furthermore, I observed no association between measures of light physical activity and sedentary behaviour and measures of cognitive function (MoCA) and depression (GDS).

By documenting a moderate but significant association between physical ability and physical activity behaviour, our results extend the observations of Zalewski et. al. (2009) [63] who studied a smaller sample of 59 older adults in continuing care retirement communities in Milwaukee, and found no relationship between physical measures (comfortable gait speed, fast gait speed and time on the 6 minute walk test) and physical activity (step counts) measured by accelerometry. The large percent of unexplained

variance in sedentary behaviours points towards situational and environmental factors as a potentially dominant factor in shaping activity behaviours. For example, the AL environment removes the need for tenants to engage in behaviours that involve light physical activity, including housework, cooking and walking to the grocery store. Staff have keys to suites, eliminating the need for tenants to rise up from their chairs and open their suite door.

My results also support the point raised by Zalewski et al. (2009) [63] that the measures commonly used by clinicians to assess physical function, and guide decisions on rehabilitation, have limited explanatory power in reflecting physical activity patterns in older adults residing in Assisted Living. Accordingly, clinicians need to employ more direct techniques (such as accelerometry) to assess physical function, and consider modifications to environmental or situational variables to enhance physical activity, independent of physical abilities.

Our participants generally scored poorer in measures of physical ability (TUG and SPPB) than values documented previously for community dwelling seniors. The mean TUG score for our participants was 22.3 seconds, which is closer to the mean value of 28.2 seconds for residential care seniors, than the 8.3 seconds for community-dwelling seniors, reported by Bischoff et al. (2003) [16]. Podsiadlo et al. (1991) [69] interpreted TUG scores of less than 10 seconds as indicating freely independent, between 10 and 20 seconds as indicating independence in basic tub or shower transfers, and able to climb most stairs and go outside alone, and greater than 30 seconds as indicating dependence in most activities. Accordingly, a mean TUG score of 22.3 seconds should reflect that most of our participants would need some assistance with basic tub or shower transfers, and

would not be able to climb most stairs and go outside alone. The mean SPPB test score for our participants was 5.23 out of 12. Guralnik et al. (1995) [93] reported that a cutoff point of 9 and below indicates moderate limitation in performing daily activities which meant that 98.2% of the participants had moderate limitations. Furthermore, 23.7% of the participants scored 3 and below, indicating that they have severe limitations.

Results from cognitive measurements indicated that only 15% of the participants were cognitively intact (scored 26 and above out of a possible 30) and 49% scored less than 20. This is surprising since one of the criteria for admission to Assisted Living is that the person must be cognitively capable of making informed voluntary decisions. However, tenants with some level of cognitive impairment are able to function in Assisted Living sites due to the simple routine of the day and because of the support from the staff. For example, the staff reminds tenants of mealtimes by knocking on the door or giving them a telephone call. Also, the Assisted Living staff checks on the participants regularly, whether it is the housekeeping staff for cleaning or Assisted Living workers for bathing or dispensing medication.

This study provides novel findings in regards to Assisted Living participants' level of physical activity. I found that participants spent 86% of their waking hours in sedentary behaviours, despite the fact that 70% of the participants stated that they participated in exercise classes. This is higher than what has been found in previous studies [35, 39, 66]. Matthews et al. (2008) [66] indicated that community dwelling seniors (aged 60-85) spent 66.3% of their waking hours in sedentary behaviour. Healy et al. (2006) [94] also reported lower sedentary behaviour than this study at 57% for age 30 to 87. I found on average, the participants spent a lower proportion in light physical

activity (13.85%) and an even lower proportion in MVPA (0.14%) as compared with previous studies [13, 21, 95]. Healy et al. (2007) [21] reported that community dwelling participants aged 51 to 55 spent on average 23.8% of their waking hours engaged in light physical activity and 3.9% in MVPA. Troiano et al. (2007) [95] reported that community dwelling participants over the age of 70 spent on average 7.05 minutes engaged in MVPA. Whereas in the Assisted Living community (mean age of 87.7 years), Resnick, et al. (2010b) [13] reported 8.5 minutes of MVPA per day. In comparison, in my study, the mean time of MVPA was 1 minute. Therefore the participants spent their waking hour time in light physical activity and sedentary behaviour.

The patterns of physical activity in our participants are likely influenced by both physiological and environmental factors. From a physiological perspective, age-related declines in joint flexibility, bone and muscle mass, and cardiac and respiratory capacity cause a decline in physical activity. Furthermore, chronic conditions such as arthritis, lung diseases (Chronic Obstructive Pulmonary Disease), and diabetes increase in prevalence with ageing and can affect physical activity levels. The mean number of health concerns reported from participants in this study was 2.5. The most frequent reported health concerns were high blood pressure, arthritis and heart disease. From an environmental perspective, the time spent in sedentary behaviour may be influenced by the proximity of services available at Assisted Living sites, such as hairdresser, a general store, entertainment, meals, and laundry. .

Finally, I found that men had a higher percentage of time spent in sedentary behaviour compared with women. This is comparable to previous studies [21, 66, 96]. Matthews et al. 2008 [66] reported that the increase in time spent in sedentary behaviour

after age 60 years, particularly among men, may reflect an increase in leisure time following retirement. In Assisted Living sites, it may also be due to the lack of activities targeting men, since most of the activities are geared toward socialization, such as tea time and musical entertainment.

The results of my study provide important information concerning physical activity levels of Assisted Living participants as measured by waist-mounted accelerometers. The results point to the urgent need to limit sedentary behaviour among AL tenants. For tenants who are able, the need should be retained to undertake light physical activity through cleaning, cooking, or shopping. The distance between tenant units and in-house amenities should be considered carefully, with recognition that the optimal distance is not always the shortest. High-intensity activities, such as brief exercise bouts, should be programmed to reduce the duration of sedentary bouts (especially among males, where the average duration was nearly twice as long as for females).

## **4.2. Limitations**

There are some limitations to this study. First, it is possible that only the healthiest and most active people from the Assisted Living sites volunteered for the study, introducing a source of potential bias. Second, the participants were selected from 13 different sites and certain characteristics that may influence activity level, such as size of facility (physical layout), good outside walking pathways, number of social and physical activities available, and motivation from staff, were not take into consideration. Finally, accelerometers can be used to approximate energy expenditure; however, activity levels

might have been underestimated because they do not capture the full energy cost of certain activities, such as resistance exercises, upper body work, walking while carrying a load or walking uphill, because acceleration patterns do not change under these conditions. On the other hand, there may be activity counts recorded from the activity monitor that are not related to the energy expenditure required for that activity, such as counts recorded while putting on and taking off the activity monitor or when sitting down heavily on a chair. Furthermore, despite the fact that I did conduct preliminary tests with the accelerometer simulating the participants' activities such as walking, sitting down, it was uncertain as to the types of activities the participants were performing or the exact energy expenditure that activity required, or whether they actually worn the accelerometer as soon as they get up from the bed or took them off when they went to bed.

### **4.3. Future Studies**

Similar research should be conducted using newer generation accelerometers such as ActivPAL (PAL Technologies Ltd., Glasgow, UK), which classifies an individual's free-living activity into periods spent sitting, standing and walking. Another option is GPS accelerometer which is able to provide travel pattern information. These studies should provide a more accurate picture of the behaviour patterns of Assisted Living tenants.

Healy et al. (2008) [18] suggested that how sedentary time is broken up is significantly associated with health, independent of total sedentary time. Tremblay et al. (2010) [97] had termed the sedentary person as a “prolonger” being a person who would typically remain seated for long periods of time or a “breaker” being a person who



typically would stand up if only to move briefly in between seated activities. Therefore, future studies should evaluate whether Assisted Living tenants are of the “breaker” or “prolonger” type, and the impact on their health outcomes.

Future studies should also focus on qualitative studies with direct observation and focus-group techniques. This will provide valuable insights on why Assisted Living tenants are spending longer periods of time in sedentary behaviour and what activities are being performed during sedentary times.

Lastly, more research should focus on evaluating interventions targeted at reducing sedentary behaviour by increasing the amount of “breaks” the participants have during the day and the duration of those “breaks”, thus substituting sedentary behaviour with light physical activities. For example, Tremblay et al. (2010) [97] stated that reducing sedentary behaviours may be achieved through almost limitless micro-intervention opportunities; and therefore may be achievable for most seniors and may have a higher success rate, particularly since 70% of the participants stated that they participated in exercise classes.

## Chapter 5

### Conclusion

The primary aim of this thesis was to determine whether measures of physical, cognitive and psychosocial function associated with physical activity patterns among older adults residing in Assisted Living sites. A waist-mounted accelerometer, the ActiGraph GT1M, was used to collect objective data on physical activity patterns in 114 participants from 13 Assisted Living sites. The accelerometry data were processed using 1 minute epochs and established cutpoints separating sedentary behaviour, light physical activity, and moderate-to-vigorous physical activity (MVPA). I found that, on average, participants spent 86% of their waking hours in sedentary behaviours, 13.86% in light physical activity and only 0.14% in moderate-to-vigorous physical activity. The average duration of sedentary bouts was 18.9 minutes, and was nearly twice as long in males as females (32.0 versus 16.6 minutes).

I found that measures of physical function (TUG scores), fear of falling (MFES score), age, gender, and number of health concerns were independently associated with sedentary behaviour. However, at best, these variables explained only 32% of the variability in sedentary behaviour among study participants. Furthermore, I observed no

association between measures of sedentary behaviour and measures of cognitive function (MoCA) and depression (GDS).

These results extend recent findings by Zalewski et al. (2009) [63] that measures commonly used by clinicians to assess physical function, and guide decisions on rehabilitation, have limited explanatory power in reflecting physical activity patterns in older adults residing in Assisted Living. Accordingly, clinicians need to employ more direct techniques (such as accelerometry) to assess physical function, and consider modifications to environmental or situational variables to enhance physical activity, independent of physical abilities.

It is important to recognize that my results are most applicable to tenants of Assisted Living, who were in general, transitioning to frailty. The average age of my participants was 87 years, 85% were female, and 84% used a mobility aid (mostly a 4-wheeled walker). They scored poorer in measures of physical function (TUG and SPPB) than established means for community-dwelling seniors. Participants' mean TUG score was 22.3 seconds, indicating that the majority would need some assistance with basic tub or shower transfers, and may not be able to climb most stairs and go outside alone. Based on SPPB scores, participants had poor balance, slow walking speed and poor muscle strength. These results are not surprising, given that, in order to be eligible for admission to Assisted Living, individuals must require assistance with personal care or medication management or both.

Even so, when compared to other studies with older adults, the percent of waking time spent by our participants in sedentary behaviours was remarkably high (at 86%) and the percent time spent in moderate-to-vigorous physical activity (0.1%) was remarkably

low. Based on responses to the PASE questionnaire, sedentary behaviours included watching TV, reading, computer work and visiting others. According to Health Canada recommendations, older adults should participate in at least 2.5 hours of moderate-to-vigorous intensity aerobic activity each week (or, on average, 21 minutes per day), divided into sessions of 10 minutes or more. In our study, participants engaged on average in only 1.06 minutes of moderate-to-vigorous physical activity per day, 1/20th of the recommended amount. Furthermore, our participants spent only 13.85% (1.77 hours) of their waking time in light physical activity, nearly half the value of 23.8% reported by Healy et al. (2007) [21] for adults of average age 53 years living in the community.

This study illustrates the feasibility and value of wearable sensors for monitoring activity patterns in older adults who are transitioning to frailty, and points towards important future applications of this technology. Future research should focus on determining the types of activities performed by Assisted Living tenants during periods of sedentary behaviour and light physical activity, using more advanced sensor hardware and data classification schemes, such as that used in the ActivPAL system (PAL Technologies Ltd., Glasgow, UK). The use of global positioning system (GPS) sensors may help with understanding the travel patterns of seniors. Future work should also utilize sensor technology to monitor the effect of interventions in enhancing non-sedentary behaviours. Finally, additional work is required to understand the effect on health outcomes in seniors of decreasing the total time spent sedentary, and the duration of sedentary bouts.

My findings also illustrate the pressing need for collaborative efforts between care providers and researchers to identify feasible and effective methods to decrease sedentary behaviours among tenants in Assisted Living. For tenants who are able, the need should

be retained to undertake light physical activity through cleaning, cooking, or shopping. The distance between tenant units and in-house amenities should be considered carefully, with recognition that the optimal distance is not always the shortest. High-intensity activities, such as brief exercise bouts, should be programmed to reduce the duration of sedentary bouts (especially among males, where the average duration was nearly twice as long as for females).

## References

1. Government of BC. *Promoting Healthy Living Through Lifelong Learning*. 2010 [cited April 1, 2010]; Available from: <http://www.gov.bc.ca/seniors/features/sfu.html>.
2. Government of BC. *Office of the Assisted Living Registrar*. 2010 [cited April 1, 2010]; Available from: <http://www.health.gov.bc.ca/assisted/>.
3. Avery, E., et al., *Determinants of living situation in a population of community-dwelling and assisted living-dwelling elders*. *J Am Med Dir Assoc*. **11**(2): p. 140-4.
4. Folstein, M.F., S.E. Folstein, and P.R. McHugh, "*Mini-mental state*". *A practical method for grading the cognitive state of patients for the clinician*. *J Psychiatr Res*, 1975. **12**(3): p. 189-98.
5. Orme, J.G., J. Reis, and E.J. Herz, *Factorial and discriminant validity of the Center for Epidemiological Studies Depression (CES-D) scale*. *J Clin Psychol*, 1986. **42**(1): p. 28-33.
6. Guyatt, G.H., et al., *The 6-minute walk: a new measure of exercise capacity in patients with chronic heart failure*. *Can Med Assoc J*, 1985. **132**(8): p. 919-23.
7. Taylor, L., et al., *Assessing the effectiveness of a walking program on physical function of residents living in an assisted living facility*. *J Community Health Nurs*, 2003. **20**(1): p. 15-26.
8. Duncan, P.W., et al., *Functional reach: a new clinical measure of balance*. *J Gerontol*, 1990. **45**(6): p. M192-7.
9. Mahoney, F.I. and D.W. Barthel, *Functional Evaluation: The Barthel Index*. *Md State Med J*, 1965. **14**: p. 61-5.
10. Tinetti, M.E., *Performance-oriented assessment of mobility problems in elderly patients*. *J Am Geriatr Soc*, 1986. **34**(2): p. 119-26.

11. Resnick, B., et al., *Satisfaction with assisted living: the unexplored role of physical activity*. *Geriatr Nurs*, 2010a. **31**(3): p. 197-205.
12. Hoyl, M.T., et al., *Development and testing of a five-item version of the Geriatric Depression Scale*. *J Am Geriatr Soc*, 1999. **47**(7): p. 873-8.
13. Resnick, B., et al., *Perceptions and performance of function and physical activity in assisted living communities*. *J Am Med Dir Assoc*, 2010b. **11**(6): p. 406-14.
14. Giuliani, C.A., et al., *Physical performance characteristics of assisted living residents and risk for adverse health outcomes*. *Gerontologist*, 2008. **48**(2): p. 203-12.
15. Scott, V., et al., *Promoting Active Living (PAL): Best practice guidelines for fall prevention in assisted living*. 2008, Ministry of Healthy Living and Sport: Victoria, BC.
16. Bischoff, H.A., et al., *Identifying a cut-off point for normal mobility: a comparison of the timed 'up and go' test in community-dwelling and institutionalised elderly women*. *Age Ageing*, 2003. **32**(3): p. 315-20.
17. Caspersen, C.J., K.E. Powell, and G.M. Christenson, *Physical activity, exercise, and physical fitness: definitions and distinctions for health-related research*. *Public Health Rep*, 1985. **100**(2): p. 126-31.
18. Healy, G.N., et al., *Breaks in sedentary time: beneficial associations with metabolic risk*. *Diabetes Care*, 2008. **31**(4): p. 661-6.
19. Owen, N., et al., *Environmental determinants of physical activity and sedentary behavior*. *Exerc Sport Sci Rev*, 2000. **28**(4): p. 153-8.
20. Ainsworth, B.E., et al., *Compendium of physical activities: an update of activity codes and MET intensities*. *Med Sci Sports Exerc*, 2000. **32**(9 Suppl): p. S498-504.
21. Healy, G.N., et al., *Objectively measured light-intensity physical activity is independently associated with 2-h plasma glucose*. *Diabetes Care*, 2007. **30**(6): p. 1384-9.
22. Bennett, J.A., et al., *Definitions of sedentary in physical-activity-intervention trials: a summary of the literature*. *J Aging Phys Act*, 2006. **14**(4): p. 456-77.
23. Ward, D.S., et al., *Accelerometer use in physical activity: best practices and research recommendations*. *Med Sci Sports Exerc*, 2005. **37**(11 Suppl): p. S582-8.

24. Pate, R.R., et al., *Physical activity and public health. A recommendation from the Centers for Disease Control and Prevention and the American College of Sports Medicine*. JAMA, 1995. **273**(5): p. 402-7.
25. Chief Medical Officer, *At least five a week: evidence on the impact of physical activity and its relationship to health*. 2004.: London: Department of Health.
26. Keysor, J.J., *Does late-life physical activity or exercise prevent or minimize disablement? A critical review of the scientific evidence*. Am J Prev Med, 2003. **25**(3 Suppl 2): p. 129-36.
27. Kahn, E.B., et al., *The effectiveness of interventions to increase physical activity. A systematic review*. Am J Prev Med, 2002. **22**(4 Suppl): p. 73-107.
28. Karmisholt, K., F. Gyntelberg, and P.C. Gotzche, *Physical activity for primary prevention of disease. Systematic reviews of randomised clinical trials*. Dan Med Bull, 2005. **52**(2): p. 86-9.
29. Taylor, A.H., et al., *Physical activity and older adults: a review of health benefits and the effectiveness of interventions*. J Sports Sci, 2004. **22**(8): p. 703-25.
30. Dunlop, D.D., et al., *Risk factors for functional decline in older adults with arthritis*. Arthritis Rheum, 2005. **52**(4): p. 1274-82.
31. Feinglass, J., et al., *Effect of physical activity on functional status among older middle-age adults with arthritis*. Arthritis Rheum, 2005. **53**(6): p. 879-85.
32. Penninx, B.W., et al., *Physical exercise and the prevention of disability in activities of daily living in older persons with osteoarthritis*. Arch Intern Med, 2001. **161**(19): p. 2309-16.
33. Centers for Disease Control and Prevention. *Arthritis Meeting the Challenge: At a glance 2010*. [cited May 28, 2010,]; Available from: <http://www.cdc.gov/arthritis>.
34. Skinner, K., R.M. Hanning, and L.J. Tsuji, *Barriers and supports for healthy eating and physical activity for First Nation youths in northern Canada*. Int J Circumpolar Health, 2006. **65**(2): p. 148-61.
35. Westerterp, K.R., *Physical activity as determinant of daily energy expenditure*. Physiol Behav, 2008. **93**(4-5): p. 1039-43.
36. Public Health Agency of Canada. *ACT NOW*. [cited 16/10/2010]; Available from: <http://www.phac-aspc.gc.ca/hl-vs-strat/pdf/html/showcase-eng.php>.



37. Public Health Agency of Canada. *Physical Activity Guide for Older Adults*. 2007 [cited 16/10/2010]; <http://198.103.98.192/hp-ps/hl-mvs/pag-gap/downloads-eng.php>].
38. Statistics Canada. *Level of leisure-time physical activity, household population aged 12 or older, Canada, 2005* [cited April 13, 2011]; Available from: <http://www.statcan.gc.ca/pub/82-003-x/2006008/article/phys/t/4060707-eng.htm>.
39. Owen, N., A. Bauman, and W. Brown, *Too much sitting: a novel and important predictor of chronic disease risk?* Br J Sports Med, 2009. **43**(2): p. 81-3.
40. Hamilton, M.T., D.G. Hamilton, and T.W. Zderic, *Role of low energy expenditure and sitting in obesity, metabolic syndrome, type 2 diabetes, and cardiovascular disease*. Diabetes, 2007. **56**(11): p. 2655-67.
41. Dietz, W.H., *The role of lifestyle in health: the epidemiology and consequences of inactivity*. Proc Nutr Soc, 1996. **55**(3): p. 829-40.
42. Dunstan, D.W., et al., *Television viewing time and mortality: the Australian Diabetes, Obesity and Lifestyle Study (AusDiab)*. Circulation. **121**(3): p. 384-91.
43. Dunstan, D.W., et al., *Association of television viewing with fasting and 2-h postchallenge plasma glucose levels in adults without diagnosed diabetes*. Diabetes Care, 2007. **30**(3): p. 516-22.
44. Dunstan, D.W., et al., *Physical activity and television viewing in relation to risk of undiagnosed abnormal glucose metabolism in adults*. Diabetes Care, 2004. **27**(11): p. 2603-9.
45. Dunstan, D.W., et al., *Associations of TV viewing and physical activity with the metabolic syndrome in Australian adults*. Diabetologia, 2005. **48**(11): p. 2254-61.
46. Foster, J.A., S.A. Gore, and D.S. West, *Altering TV viewing habits: an unexplored strategy for adult obesity intervention?* Am J Health Behav, 2006. **30**(1): p. 3-14.
47. Hu, F.B., et al., *Television watching and other sedentary behaviors in relation to risk of obesity and type 2 diabetes mellitus in women*. JAMA, 2003. **289**(14): p. 1785-91.
48. Jakes, R.W., et al., *Television viewing and low participation in vigorous recreation are independently associated with obesity and markers of cardiovascular disease risk: EPIC-Norfolk population-based study*. Eur J Clin Nutr, 2003. **57**(9): p. 1089-96.
49. Hammersley, M., Atkinson, P., *Ethnography*. 1993: London and New York.

50. Spruijt-Metz, D., Bergen, D., Kelly, L.A., McConnell, R., Dueker, D., Lindsey, G., Atienza, A.A., Nguyen-Rodriguez, S., Irwin, M.L., Welch, J., Jerrett, M., Tatalovich, Z., Redline, S., *Handbook of Assessment Methods for Eating Behaviors and Weight Related Problems*, D.B. Allison, Baskin, M.L., Editor. 2009, SAGE Publications: United States of America.
51. Rikli, R.E., *Reliability, validity, and methodological issues in assessing physical activity in older adults*. Res Q Exerc Sport, 2000. **71**(2 Suppl): p. S89-96.
52. Washburn, R.A., et al., *The Physical Activity Scale for the Elderly (PASE): development and evaluation*. J Clin Epidemiol, 1993. **46**(2): p. 153-62.
53. Harris, T.J., et al., *What factors are associated with physical activity in older people, assessed objectively by accelerometry?* Br J Sports Med, 2009. **43**(6): p. 442-50.
54. Crouter, S.E., P.L. Schneider, and D.R. Bassett, Jr., *Spring-levered versus piezo-electric pedometer accuracy in overweight and obese adults*. Med Sci Sports Exerc, 2005. **37**(10): p. 1673-9.
55. Cyarto, E.V., A.M. Myers, and C. Tudor-Locke, *Pedometer accuracy in nursing home and community-dwelling older adults*. Med Sci Sports Exerc, 2004. **36**(2): p. 205-9.
56. Le Masurier, G.C., S.M. Lee, and C. Tudor-Locke, *Motion sensor accuracy under controlled and free-living conditions*. Med Sci Sports Exerc, 2004. **36**(5): p. 905-10.
57. Mathie, M.J., et al., *Accelerometry: providing an integrated, practical method for long-term, ambulatory monitoring of human movement*. Physiol Meas, 2004. **25**(2): p. R1-20.
58. Shephard, R.J., *Limits to the measurement of habitual physical activity by questionnaires*. Br J Sports Med, 2003. **37**(3): p. 197-206; discussion 206.
59. Davis, M.G. and K.R. Fox, *Physical activity patterns assessed by accelerometry in older people*. Eur J Appl Physiol, 2007. **100**(5): p. 581-9.
60. Lynch, B.M., et al., *Objectively measured physical activity and sedentary time of breast cancer survivors, and associations with adiposity: findings from NHANES (2003-2006)*. Cancer Causes Control. **21**(2): p. 283-8.
61. Warren, T.Y., et al., *Sedentary behaviors increase risk of cardiovascular disease mortality in men*. Med Sci Sports Exerc. **42**(5): p. 879-85.

62. Metzger, J.S., et al., *Associations between patterns of objectively measured physical activity and risk factors for the metabolic syndrome*. Am J Health Promot. **24**(3): p. 161-9.
63. Zalewski, K.R., et al., *Measures of physical ability are unrelated to objectively measured physical activity behavior in older adults residing in continuing care retirement communities*. Arch Phys Med Rehabil, 2009. **90**(6): p. 982-6.
64. Murphy, S.L., *Review of physical activity measurement using accelerometers in older adults: considerations for research design and conduct*. Prev Med, 2009. **48**(2): p. 108-14.
65. Freedson, P.S., E. Melanson, and J. Sirard, *Calibration of the Computer Science and Applications, Inc. accelerometer*. Med Sci Sports Exerc, 1998. **30**(5): p. 777-81.
66. Matthews, C.E., et al., *Amount of time spent in sedentary behaviors in the United States, 2003-2004*. Am J Epidemiol, 2008. **167**(7): p. 875-81.
67. Copeland, J.L. and D.W. Eslinger, *Accelerometer assessment of physical activity in active, healthy older adults*. J Aging Phys Act, 2009. **17**(1): p. 17-30.
68. Beyler, N., Nusser, S., Fuller, W., Welk, G. *Relating Self report and Accelerometer Physical Activity with Application to NHANES 2003-2004*. 2008 [cited November 18, 2010]; Available from: <http://www.amstat.org/Sections/Srms/Proceedings/y2008/Files/302097.pdf>.
69. Podsiadlo, D. and S. Richardson, *The timed "Up & Go": a test of basic functional mobility for frail elderly persons*. J Am Geriatr Soc, 1991. **39**(2): p. 142-8.
70. Guralnik, J.M., et al., *A short physical performance battery assessing lower extremity function: association with self-reported disability and prediction of mortality and nursing home admission*. J Gerontol, 1994. **49**(2): p. M85-94.
71. Nasreddine, Z.S., et al., *The Montreal Cognitive Assessment, MoCA: a brief screening tool for mild cognitive impairment*. J Am Geriatr Soc, 2005. **53**(4): p. 695-9.
72. Guralnik, J.M., *Understanding the relationship between disease and disability*. J Am Geriatr Soc, 1994. **42**(10): p. 1128-9.
73. Bohannon, R.W., *Reference values for the timed up and go test: a descriptive meta-analysis*. J Geriatr Phys Ther, 2006. **29**(2): p. 64-8.
74. Mathias, S., U.S. Nayak, and B. Isaacs, *Balance in elderly patients: the "get-up and go" test*. Arch Phys Med Rehabil, 1986. **67**(6): p. 387-9.

75. Noren, A.M., et al., *Balance assessment in patients with peripheral arthritis: applicability and reliability of some clinical assessments*. *Physiother Res Int*, 2001. **6**(4): p. 193-204.
76. Rockwood, K., et al., *Feasibility and measurement properties of the functional reach and the timed up and go tests in the Canadian study of health and aging*. *J Gerontol A Biol Sci Med Sci*, 2000. **55**(2): p. M70-3.
77. Studenski, S., et al., *Gait speed and survival in older adults*. *JAMA*. **305**(1): p. 50-8.
78. Studenski, S., et al., *Physical performance measures in the clinical setting*. *J Am Geriatr Soc*, 2003. **51**(3): p. 314-22.
79. Guralnik, J.M. and C.H. Winograd, *Physical performance measures in the assessment of older persons*. *Aging (Milano)*, 1994. **6**(5): p. 303-5.
80. Gill, D.J., Freshman, A., Blender, J. A. and Ravina, B., *The montreal cognitive assessment as a screening tool for cognitive impairment in Parkinson's disease*. *Movement Disorders*, 2008. **23**: p. 1043–1046.
81. Nasreddine, Z.S., et al. *Normative Data MoCA score*. 2005 March 11, 2011 [cited; Available from: [http://www.mocatest.org/validation\\_study.html](http://www.mocatest.org/validation_study.html)].
82. Yesavage, J.A., et al., *Development and validation of a geriatric depression screening scale: a preliminary report*. *J Psychiatr Res*, 1982. **17**(1): p. 37-49.
83. Hill, K.D., et al., *Fear of falling revisited*. *Arch Phys Med Rehabil*, 1996. **77**(10): p. 1025-9.
84. Tinetti, M.E., D. Richman, and L. Powell, *Falls efficacy as a measure of fear of falling*. *J Gerontol*, 1990. **45**(6): p. P239-43.
85. Almeida, O.P. and S.A. Almeida, *Short versions of the geriatric depression scale: a study of their validity for the diagnosis of a major depressive episode according to ICD-10 and DSM-IV*. *Int J Geriatr Psychiatry*, 1999. **14**(10): p. 858-65.
86. Kurlowicz, L.H., *Nursing standard of practice protocol: depression in elderly patients*. *NICHE faculty*. *Geriatr Nurs*, 1997. **18**(5): p. 192-9; quiz 200.
87. Nguyen, H.T. and A.B. Zonderman, *Relationship between age and aspects of depression: consistency and reliability across two longitudinal studies*. *Psychol Aging*, 2006. **21**(1): p. 119-26.
88. Hill, K., et al., *Falls among healthy, community-dwelling, older women: a prospective study of frequency, circumstances, consequences and prediction accuracy*. *Aust N Z J Public Health*, 1999. **23**(1): p. 41-8.

89. Schuit, A.J., et al., *Validity of the Physical Activity Scale for the Elderly (PASE): according to energy expenditure assessed by the doubly labeled water method*. *J Clin Epidemiol*, 1997. **50**(5): p. 541-6.
90. Strath, S.J., D.R. Bassett, Jr., and A.M. Swartz, *Comparison of MTI accelerometer cut-points for predicting time spent in physical activity*. *Int J Sports Med*, 2003. **24**(4): p. 298-303.
91. BC Ministry of Transportation and Infrastructure. *Pedestrian Crossing Control Manual for British Columbia*. [cited April 14, 2011]; Available from: [http://www.th.gov.bc.ca/publications/eng\\_publications/Ped\\_X\\_Manual//1358-ch3.pdf](http://www.th.gov.bc.ca/publications/eng_publications/Ped_X_Manual//1358-ch3.pdf).
92. Owen, N., et al., *Too much sitting: the population health science of sedentary behavior*. *Exerc Sport Sci Rev*. **38**(3): p. 105-13.
93. Guralnik, J.M., et al., *Lower-extremity function in persons over the age of 70 years as a predictor of subsequent disability*. *N Engl J Med*, 1995. **332**(9): p. 556-61.
94. Healy, G.N., et al., *Objectively measured sedentary time, physical activity, and metabolic risk: the Australian Diabetes, Obesity and Lifestyle Study (AusDiab)*. *Diabetes Care*, 2008. **31**(2): p. 369-71.
95. Troiano, R.P., et al., *Physical activity in the United States measured by accelerometer*. *Med Sci Sports Exerc*, 2008. **40**(1): p. 181-8.
96. Buman, M.P., et al., *Objective light-intensity physical activity associations with rated health in older adults*. *Am J Epidemiol*. **172**(10): p. 1155-65.
97. Tremblay, M.S., et al., *Physiological and health implications of a sedentary lifestyle*. *Appl Physiol Nutr Metab*. **35**(6): p. 725-40.