The Impact of a Walking Intervention in Older Adults: Examining Factors Related to Physical Activity, Cognitive Functioning, and Quality of Life

by

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ABSTRACT

With increasing life expectancies, being physically and mentally fit is important, especially in later years of life. The purpose of this study was to investigate factors related to a walking intervention in older adults. Eighteen older adults (ages 65 to 79) were recruited to complete a six-month walking intervention while tracking changes in cognition and quality of life (QoL) with bi-monthly questionnaires. Subjects also identified an informant to provide information regarding cognition and QoL at the same time intervals. An informal interview was completed with subjects at post-testing. Physical activity was recorded in a daily logbook, and an activity tracker was used for three one-week periods over the duration of the study. Three questions were explored. First, what effects does a walking intervention have on elderly individuals' cognition and QoL? Second, are objective or subjective methods of recording activity more feasible for older adults? Finally, are both subject and informant measures reliable ways of capturing data? Results indicated that both informant and subject measures were highly correlated, indicating both provide similar information. It was found that objective methods of tracking physical activity were more effective and feasible with older adults. Finally, by maintaining a sufficient level of physical activity, participants experienced an overall increase in cognition and QoL.

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"Whether you think you can, or you think you can't – you're right."

"Anyone who stops learning is old, whether at twenty or eighty. Anyone who keeps learning stays young."

- *Quotes by Henry Ford*

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CHAPTER 1: INTRODUCTION

1.1 INTRODUCTION

Due to recent technological and medical advancements, people have been living longer than at any point in history. However, as one ages, declines in both physical and mental capabilities are experienced. While this is a normal progression, in some cases the decline can go beyond expected levels resulting in physical and mental impairments and a reduced quality of life (QoL). As the Gerontology Society of America states, "adding life to years, not just years to life" is important. If people are living to be older, it is essential that those years are fulfilling by retaining functionality for as long as possible. Living a good life is incumbent on a number of factors, one of which is cognitive functioning. The ability to interact with the world around us (Ball et al., 2002) is crucial to our survival and having a positive QoL (Yu, Nelson, Savik, Wyman, Dysken, & Bronas, 2013). Staying physically and mentally healthy can help improve these factors. Research has shown that being physically active can improve not only physical health, but also cognition and QoL (Yu et al., 2013). Being physically active can have a number of benefits, such as reducing obesity and chronic disease (Ross et al., 2000), improving fitness and strength (Barnes, Yaffle, Satariano & Tager, 2003; Busse, Gil, Santarem & Filho, 2009; Heyn, Abreu & Ottenbacher, 2004), as well as promoting a general healthy lifestyle (Abbott et al., 2004; Colcombe & Kramer, 2003; Etgen et al., 2010; Fox, 1999). Additionally, research has indicated that being physically active can positively impact cognitive functioning and help delay or prevent cognitive impairments (Abbott et al., 2004; Barnes, Yaffle, Satariano & Tager, 2003; Fratiglioni, Paillard-Borg & Winblad, 2004; Hillman et al., 2006).

Physical activity benefits more than just cognitive functioning; physical activity is important for people of all ages in order to stay mentally and physically fit throughout their lifespan (Ball et al., 2002; Etgen et al., 2010; Ross et al., 2000). Additionally, good cognitive and physical functioning is associated with positive QoL, which is an important construct that generally determines how satisfied one is with life (Rejeski & Mihalko, 2001). A good QoL, referring to one's physical, mental, and emotional well-being (Wilson & Cleary, 1995), is important for people of all ages. Health related quality of life (HRQoL), which refers to the impact of diseases, disabilities, and disorders on overall health and functioning (Rejeski & Mihalko, 2001), is also important for maintaining independence. Individuals with chronic diseases, including reduced cognitive functioning and/or dementia, can experience a decreased QoL (Ozturk, Simsek, Yumin, Sertel & Yumin, 2011). In order to live the best life possible, emerging research is exploring the relationship between physical activity and cognitive function, and effects on QoL, suggesting that physical activity can reduce cognitive decline and dementia (Fratiglioni, Paillard-Borg, & Winblad, 2004).

1.2 PHYSICAL ACTIVITY AND COGNITION

Physical activity can take many forms. It is important for individuals of all ages to be physically active, to that effect the Canadian Society for Exercise Physiology (CSEP) provides physical activity guidelines for optimal health (Tremblay et al., 2011). It is suggested that "to achieve health benefits, and improve functional abilities, adults aged 65 and older should accumulate at least 150 minutes of moderate- to vigorous-intensity aerobic physical activity per week, in bouts of 10 minutes or more" and "it is also beneficial to add muscle and bone strengthening activities using major muscle groups, at least 2 days per week” (Tremblay et al., 2011, p. 41). Although recommendations are made for specific types of activities, in general, greater levels of activity lead to better health (Tremblay et al., 2011).

The physical activity guidelines also mention a number of benefits that can be obtained through physical activity, including maintaining functional independence, mobility, fitness, improving body weight, and bone health (Tremblay et al., 2011). Often neglected however is the benefits of physical activity on cognitive functioning. A study conducted by Barnes, Yaffle, Satariano and Tager (2003) examined the impact of physical activity on cardiorespiratory fitness, and its associated impact on cognitive function. The sample was drawn from individuals already participating in a longitudinal study that began in 1993, with reassessments every two years. The authors studied 349 adults over the age of 55 and used a treadmill protocol to control for duration and intensity, and measured peak oxygen consumption (peak $\dot{V}O2$) as an indicator of cardiorespiratory fitness. They used the Mini Mental State Exam (MMSE) as well as tests of attention/executive function, verbal memory, and verbal fluency to measure cognitive function. Participants who had no indication of cognitive impairment at baseline were analyzed to determine the impact of cardiorespiratory fitness (CRF) on cognitive functioning over time. The participants underwent a treadmill exercise at baseline to determine their CRF, and then again six years later at the completion of the study. It was found that individuals with poorer levels of cardiorespiratory fitness at the baseline analysis had greater decline in terms of their cognitive performance six years later (Barnes, Yaffle, Satariano & Tager, 2003). This suggests that physical activity is important not just for cardiorespiratory fitness, but also for cognitive functioning.

Encouraging individuals to be physically active is important in the maintenance of physical and mental health (Busse et al., 2009), particularly for older adults with some form of cognitive impairment. While improved cardiovascular fitness is associated with better cognitive performance (Barnes, Yaffle, Satariano & Tager, 2003), the evidence is still insufficient to determine if increasing aerobic activity is the only factor that impacts cognition, or if any type of physical activity influences cognition (Busse et al., 2009). A review of physical activity research shows that aerobic activity is successful in producing benefits in cognitive functioning, and the effects are enhanced if strength training is added to the regime (Busse et al., 2009). While more research in this area is required, it is likely that improvements will be greater for individuals who participate in more than just cardiovascular activities.

A meta-analysis, conducted by Heyn, Abreu, and Ottenbacher (2004) reviewed the effect of physical exercise for people with cognitive impairments and dementia. They analyzed 30 studies that utilized randomized trials for adults over 65 years with some type of cognitive impairment. The studies used a variety of physical activity interventions including aerobic training ('cardio fit'), strengthening, flexibility, and intense calisthenics ('boot camp'). Overall, the researchers found that being physically active improved participants' physical function, as well as their cognitive function, suggesting that physical activity is beneficial for individuals with cognitive impairments. Many of the studies included in the review tested short term (less than six months) physical activity interventions, which even sedentary adults were able to adhere to; however, longer interventions produce greater changes in participant's behaviour (Heyn, Abreu & Ottenbacher, 2004). For individuals who took part in flexibility training, there was a robust effect with participants showing significant improvements in cognitive, behavioural, and functional categories over controls. For individuals in strength training programs, significant increases were found in both cardiovascular fitness, and cognitive tasks. The training regimes analyzed varied from 2 to 112 weeks, with 1 to 6 sessions per week, each for a duration of 20 to 150 minutes. There was an overall trend suggesting that participants engaging in more sessions per week had greater improvements (Heyn, Abreu & Ottenbacher, 2004).

Although limited research suggests that it may be important to include some strength training exercises to improve cognitive function, most studies focused on investigating the effects of cardiovascular activities. Abbott and colleagues (2004) explored the effects of walking among elderly men. The longitudinal study followed men aged 71 to 93 over a period of two years and found that men who walked more decreased their risk of dementia diagnosis. Additionally, men who walked the least had a 1.8-fold excess risk of developing dementia; whereas men who walked more than 2 miles per day significantly reduced their risk of developing dementia (Abbott et al., 2004). Those who walked (>2.0 miles per day) the most had a dementia incidence of 9.0/1000 person-years, compared to those who walked the least (<0.25 miles per day), where the rate was 18.7/1000 person-years.

As the number of adults who suffer from reduced cognitive functioning increases, it is important to have innovative approaches to help delay cognitive decline. Despite the physical and cognitive benefits of engaging in physical activity, an alarming number of people do not meet the physical activity guidelines and instead lead sedentary lives (Booth, Owen, Bauman, Clavisi & Leslie, 2000). There are often several barriers that prevent individuals from being active, such as socio-cognitive and environmental factors. Booth and colleagues (2000) identified some of the major variables that influence activity. Specifically, active family and friends, access to facilities or walking paths, as well as levels of self-efficacy were deemed significant. It is important to overcome barriers as inactivity impacts both physical health and cognitive functioning. Individuals in later stages of dementia often lose the ability to care for themselves and in addition to cognitive deficits also experience impairments in their mobility, and physical capabilities (Ball et al., 2002; Reisberg, Ferris, DeLeon & Crook, 1982). Engaging in physical activity can help improve their overall well-being (Rejeski & Mihalko, 2001). Although it is better to be active through the entire lifespan, it is never too late to start being active.

Cognitive functioning includes a wide range of mental capabilities that moderate how we perceive and interact with the world around us. Cognitive impairment occurs when these mental capabilities become altered and their effectiveness is reduced. Mild cognitive impairment can eventually become a clinical disorder known as dementia, which is a marked reduction in cognitive functioning (Lautenschlager, Cox & Kurz, 2010). It was estimated that in 2006 there were 26.6 million people living with dementia globally, and with an aging population it is expected to rise to over 100 million by the year 2050, resulting in 1 in 85 people suffering from dementia (Lautenschlager, Cox & Kurz, 2010). Decreased cognitive functioning is commonly associated with aging, but there are ways to stimulate cognition to delay the onset of dementia. While dementia cannot currently be cured, various physical activity interventions are successful in delaying the onset of dementia. It is estimated that delaying the onset by 12 months could lead to 9.2 million less cases of dementia (Lautenschlager, Cox & Kurz, 2010; Weijenberg, Lobbezoo, Knol & Tomassen, 2013).

Response time is a key cognitive ability that declines with age, and slower response times are an indicator of impaired cognitive function (Hillman et al., 2006). A study was conducted using a total of 674 participants from 301 families including a younger (ages 15 to 39) and an older (ages 40 to 71) cohort with groups of participants from families (Hillman et al., 2006). Participants were asked how often per week they engaged in types of activities that were of a sufficient intensity to make them sweat. Overall, controlling for age, sex, and intelligence quotient (IQ) score, it was found that the younger cohort had better response times, better accuracy, and higher scores on the Eriksen flanker task; however, individuals that were more active had better response times regardless of age (Hillman et al., 2006). The researchers concluded that, particularly for older adults, having an active lifestyle provides significant benefits on various aspects of cognitive functioning (Hillman et al., 2006).

A meta-analysis conducted by Colcombe & Kramer (2003) reviewed the effect of aerobic fitness training on the cognitive functioning in sedentary older adults. The authors reviewed 18 studies that prescribed an intervention and found selective benefits in relation to cognition based on fitness training, with some of the best effects evident for executive control. The effectiveness of the intervention was mediated based upon the type, duration, and the gender of the participants. The authors noted if study samples were over half female ($\eta = .604$), as opposed to over half male ($\eta = .150$), the overall effectiveness of the intervention had a greater effect size (Colcombe & Kramer, 2003). This suggests that women may be more likely to benefit from physical activity interventions. In terms of participant's age, the effect sizes for older adults aged 66-70 and 71-80 were much greater than for older adults aged 55-65. While aerobic activity interventions were effective, the effect size was greater for interventions that had a combined training type, such as those that included both cardiovascular and strength training. As well it was observed that longer-duration (over six months), were the most effective; as for each individual session, the most effective intervention had a moderate to long duration (Colcombe & Kramer, 2003).

Van Gelder et al. (2004) explored the relationship between physical activity and cognitive function among elderly men born between 1900 and 1920 (van Gelder et al., 2004). Cognitive function was measured with the Mini Mental State Exam (MMSE) at baseline and at the end of the study. At the end of the 10-year longitudinal study, a linear regression revealed that cognitive decline in men with low activity levels was 3.6 times greater than those who maintained sufficient levels of activity (van Gelder et al., 2004). For the men who increased their activity levels, there was no significant cognitive decline. This suggests physical activity can prevent age-related declines in cognitive functioning. Furthermore, the rate of cognitive decline was strongly and negatively associated with duration and intensity of physical activities (van Gelder et al., 2004). While further research is still required, it is likely that although physical activity may not restore lost cognitive functions, it may protect against the loss of functionality over time.

1.2.1 Assessments of Cognition

There are a wide variety of tests available to assess different aspects of cognition. The most sophisticated and sensitive measures are usually administered by a psychologist or other health professional, however there are other screening tools that can be employed by a trained user. Some of these screening questionnaires can be administered directly to the subject, whereas other tests are administered with an informant (any individual who is able to provide information about the subject, typically a friend, family member, or caregiver). For example, subjects complete the Montreal Cognitive Assessment (MoCA; Nasreddine et al., 2005) and Mini Mental State Exam (MMSE; Folstein, Folstein, & McHugh, 1975), whereas informants can complete the Informant Questionnaire on Cognitive Decline in the Elderly (IQCODE; Jorm & Jacomb, 1989). Some cognitive screening tools are designed to be administered to both subjects and informants, such as the Psychogeriatric Assessment Scale (PAS; Jorm & Mackinnon, 1995).

Over the years, as research progresses, more accurate measures are developed, and considered a 'gold standard' in their time. While the MMSE has been widely used, a more comprehensive measure has been recently developed and validated (Toglia et al., 2011). The MoCA (Nasreddine et al., 2005), is more sensitive to cognitive deficits, is better at detecting impairment, and covers a wider array of cognitive functions. Additionally, when compared with the MMSE, the MoCA has a reduced ceiling effect, a higher internal reliability (Cronbach alpha = .78) than the MMSE (Cronbach alpha = .60), and is a stronger predictor of cognitive dysfunction (Toglia et al., 2011).

For a variety of reasons, it is sometimes not possible to collect information directly from an individual with extensive cognitive or physical impairments. To compensate for this, collecting information from an informant can be useful. The IQCODE (Jorm & Jacomb, 1989) was designed to screen for dementia by collecting information from an informant when the subject is unable to undergo direct cognitive testing. The IQCODE has an ICC of 0.95 (strong internal consistency), which has been confirmed by seven different studies ranging from 0.93-0.97 (Jorm, 2004). When compared to other clinical measures assessing dementia, the IQCODE is strongly correlated (-0.61; Jorm, 2004) to the MMSE (Folstein, Folstein & McHugh, 1975). Although the IQCODE (Jorm & Jacomb, 1989) is effective, when combined with other scales it has been shown to provide a more accurate assessment of individuals' present state (Mackinnon & Mulligan, 1998). The authors note that when combined with the MMSE it provides a more accurate diagnostic of an individual's mental capabilities than either test does alone.

Due to the benefits of combining information collected from informants with information directly from subjects, some scales collect both types of information. The PAS contains three informant scales (stroke, cognitive decline, and behaviour change) and three subject scales (stroke, depression, and cognitive impairment). This allows for a comprehensive assessment of an individual's state and can assess change in a number of areas. Two of the scales directly assess cognition, the subject scale cognitive impairment (PAS-CI) and the informant scale cognitive decline (PAS-CD). While all scales demonstrate good reliability, the informant scales are higher than the subject scales; the Cronbach alphas for the PAS-CI was 0.58, and for the PAS-CD 0.84 (Jorm & Mackinnon, 1997; Jorm et al., 1997). The PAS-CI and PAS-CD scales are significantly correlated with each other (r = 0.46) (Jorm et al., 1997). As well, both scales are positively and significantly correlated with the MMSE (PAS-CI -0.77 and PAS-CD -0.42) and the IQCODE (PAS-CI 0.49 and PAS-CD 0.83) (Jorm & Mackinnon, 1995).

1.3 PHYSICAL ACTIVITY AND QUALITY OF LIFE

Having a positive QoL is important for all individuals, particularly older adults, to make the most out of the later years of life. Quality of life has been defined in a variety of ways, and varies between studies (Rejeski & Mihalko, 2001). Some definitions of QoL include references to one's physical, mental, and emotional well-being (Wilson & Cleary, 1995); as a conscious cognitive judgment of the satisfaction level one has with their life (Rejeski & Mihalko, 2001); and related to health, mobility, and functional independence (Ozturk et al., 2011). Quality of life has become an umbrella term to describe a variety of outcomes for older adults in clinical settings, with little focus (Rejeski & Mihalko, 2001). The variety of definitions of QoL means that outcome measures lack standardization and can vary between studies. This has led some researchers to create a more narrow definition that focuses specifically on health, referred to as health status or health related quality of life (HRQoL). This term focuses on patient illness and functional effects. Health related QoL can include various factors such as cognitive function, productivity, perceived and actual symptoms of illness, energy and vitality, pain, self-esteem, body image, and sleep and rest (Rejeski & Mihalko, 2001). Health related QoL also includes the status of one's disease, one's ability to function, and one's overall health (Guyatt, Feeny & Patrick, 1993).

It is important to maintain QoL for all individuals across the lifespan. One of the ways that QoL can be increased is through physical activity (Ozturk et al., 2011; McAuley et al., 2006; Rejeski & Mihalko, 2001; Weijenberg, Lobbezoo, Knol & Tomassen, 2013). When it comes to physical activity guidelines, there is little mention about benefits that are not directly related to physical health; however, a review of the literature indicates there is a positive relationship between physical activity and life satisfaction, measured as a part of QoL (Rejeski & Mihalko, 2001). Although many studies were not statistically significant due primarily to a low intensity level for activities, there was a trend towards a positive relationship (Rejeski & Mihalko, 2001). McAuley and colleagues (2006) also found a positive link between physical activity and QoL in older adults. There was an indirect relationship between physical activity and overall global QoL, which was moderated by mental and health status. The researchers tested a total of 249 older women and found positive support for the social cognitive model relating physical activity and QoL (McAuley et al., 2006).

Similarly, aerobic exercise is an effective QoL intervention for older adults with Alzheimer's disease (Yu et al., 2013). Following a 6-month cardiovascular intervention (10 to 45 minutes of cycling three times per week), there was a trend towards improving cognitive function and QoL, as well as depression. However, due to a small sample size (n = 11) the effects were not significant. Authors agree that small sample sizes and lack of randomization are problematic in clinical trials of aerobic exercise (Yu et al., 2013). Previous research has indicated that the mechanisms underlying the beneficial effects of aerobic activity are likely structural modification of brain networks (Adlard, Perreau, Pop & Cotman, 2005). Physical activity serves to increase the ability of the brain to grow new synapses and modify dendritic branches (Adlard, Perreau, Pop & Cotman, 2005; Cotman & Berchtold, 2007; Yu et al., 2013).

1.3.1 Assessments of Quality of Life

Similarly to assessing cognition, questionnaires for both subjects and informants are used for assessing QoL. The Assessment of Quality of Life (AQoL-8D; Richardson et al., 2011) collects information directly from the subject. The AQoL-8D is one of the instruments designed by researchers at Monash University to test QoL; other tests include the AQoL-4D, AQoL-6D, and AQoL-7D (Richardson, Sinah, Iezzi & Khan, 2011). Each test differs in terms of the dimensions that it assesses, with the AQoL-8D covering the greatest number of dimensions. Additionally, the tests differ in the aspects of physical and mental quality of life that they cover. For example, the AQoL-7D has the greatest coverage of physical QoL, whereas the AQoL-8D has the most comprehensive coverage of mental QoL. Due to the variety of definitions of QoL proposed over the years, the different tests allow for variation in the aspects of QoL to be analyzed. The AQoL-8D has a high internal consistency and test-retest reliability, Cronbach's alpha = 0.95 and ICC = .91 (Richardson & Iezzi, 2011; Richardson, Sinah, Iezzi & Khan, 2011).

The Qualidem (Ettema et al., 2007a) is another questionnaire that assesses QoL, with information gathered from the informant only. This scale was designed particularly for individuals with dementia in residential settings; although ratings by the patient themselves are typically more accurate (professionals underestimate the QoL of residents), a proxy rating is still good at measuring changes in QoL over time (Ettema et al., 2007b). The Qualidem contains a number of subscales to cover different aspects of QoL. The test has good reliability and validity, with each scale rated separately in terms of reliability, with Spearman rho values ranging from .60 to .90, and Cronbach's alpha values above 0.64 (Ettema et al., 2007a). Unlike cognitive tests, which have informant questionnaires that can be used in any setting (residential or community dwelling), informant QoL measures are typically designed to be administered to professional caregivers in residential settings. By not developing questionnaires specifically for informants of community dwelling individuals it leaves a gap in the type of information that can be collected.

1.4 TRACKING PHYSICAL ACTIVITY

There are various methods to keeping track of physical activity, each with its own benefits and downfalls. Tracking activities an individual completes can help encourage compliance (Caildini & Goldstein, 2004). The methods of tracking activity can be generally divided into two main categories; self-report measures and direct measures. In self-report measures, the individual must manually record what type of activity they completed, and any other information (such as duration, intensity, and so on). In direct measures, a physical device (such as a pedometer or accelerometer) is used to objectively measure what types of movements have been completed. Each of these methods can be beneficial, but there can also be some associated limitations (Prince, Adamo, Hamel, Hardt, Gorber, & Tremblay, 2008).

1.4.1 Subjective Measures of Physical Activity

Self-report methods have been used for years; they can take many forms and are relatively easy to use. One common method is to record daily activities in an activity journal or diary. Daily recordings can be completed online through the use of various sites such as MyFitnessPal (2015) and FitDay (2014). Regardless of recording style, self-report methods are open to some interpretation. Individuals need to find time to be able to record their activities. As well, they need an understanding of the activities they are doing to produce an accurate record. If a participant does not understand how to accurately judge intensity, they could be over or underestimating the effect of their workout (Dishman, Washburn, & Schoeller, 2012). As well, participants need to remember how long they engaged in the activity and what types of activities they performed. The longer one waits to record activity, the more likely a recall bias can occur; participants may not remember what exactly they did and again over or underestimate their activity (Tudor-Locke & Myers, 2012). Individuals may forget some activities completed, thus underestimating their actual activity level. However, it is also possible to overestimate the amount of activity done, especially when considering intensity (Tudor-Locke & Myers, 2012).

Another limitation is that participants may be influenced by social desirability bias (Adams, Matthews, Ebbeling, Moore, Cunningham, Fulton, & Hebert, 2005; Caildini & Goldstein, 2004; Motl, McAuley & DiStefano, 2005). Being physically active is typically viewed as a desirable trait, especially for individuals who want to appear to be strong and healthy. If participants are sharing their log with others, as is possible with many of the online tracking communities, they may overestimate activity levels to make themselves appear to be better or more active than in reality. Additionally, another bias may be introduced through the presence of another person. Social facilitation theory states that when others are present, task compliance increases (Zanbaka, Ulinski, Goolkasian, & Hodges, 2004). Through the use of activity logs, especially those that are monitored by other individuals or posted as part of an online community, the presence of others can influence how an individual tracks their activities. Although the presence of another individual may motivate someone to be more active, alternatively, it may motivate them to falsely report their activities. Despite these limitations, manual activity tracking has several benefits, including the ability of participants to view feedback in real time and see what they completed during a specific period of time. This feedback fosters personal reflection and promotes activity modification if deemed necessary.

Activity Logs: Although potentially biased, one of the benefits of activity logs is that users can tailor their use to track information that provides the greatest benefit to them. For example, if an individual wants to increase their running time, they can time their activity and record the information, providing easily accessible information. A review of the studies comparing self-report and direct measures of physical activity was conducted by Prince and colleagues (2008). After analyzing 293 articles, they found that there was low-to-moderate correlation between self-reported and direct measures of physical activity. Correlations ranged from -0.71 to 0.96, without any clear patterns or trends (Prince et al., 2008). There are both benefits and drawbacks to self-report measures of physical activity, and it is important to be aware of these effects on the data.

1.4.2 Objective Measures of Physical Activity

Recording activity through more objective measures has recently become much easier. Through advanced technology the growth of wearable activity trackers has increased dramatically over the last few years. The two main types of activity trackers are pedometers and accelerometers. Pedometers have an axis that measures movement in only one direction (up and down), and generally tracks the amount of steps taken. Accelerometers, however, have multiple axes that can measure acceleration in multiple directions. In addition to counting steps accelerometers also measure activity intensity and speed. This improves upon some of the limitations of pedometers, which often falsely record steps due to excessive vibrations. Although there are still some limitations, accelerometers are now available for use by the public. Accelerometers can be worn on the wrist or waist, or carried in a pocket while pedometers are limited to being worn only at the waist. A limitation of accelerometers are that certain movements may not be strong enough to register as having occurred (such as excessively slow or small steps), and other actions (such as rapidly shaking the hand while using a wrist worn accelerometer) may overestimate the amount of action/steps taken. Accelerometers typically need to be synchronized with an external device (such as a computer), meaning that the information is not always readily available to the user.

Accelerometer Based Activity Trackers: With the advances in technology, activity trackers, in particular those that use accelerometers, have become quite popular and are readily available for individual purchase. This means that while these devices are still used in research, they are also available to a wider population for use in everyday life (Miller, 2013). Wearable computing devices are any device that is worn on the body and uses technology in some way (Mekky, 2014). In the past activity trackers were expensive and thus inaccessible to the general population. Over the last two years however, affordable activity trackers have been highly marketed to the general population. As such, there are a number of devices that can now track ones physical activity; the Jawbone Up, Nike+ Fuelband SE, Withings Plus, Fitbit, Garmin Vivofit, Polar Loop, and so on. Generally these devices work on similar principles to track activities. There are some features that certain companies have added to their devices that others have not, such as being able to connect with a heart rate sensor, tracking elevation, or being able to track movement during sleep.

One of the benefits of various activity trackers is that they can be worn on the wrist. This feature requires the entire body to be in motion for successful movement recording (e.g. steps) however activity overestimations can occur, particularly for activities that require significant hand movement (such as brushing ones teeth or doing dishes). Unlike waist worn pedometers, wrist worn activity trackers are beneficial as individuals are able to wear the devices for longer time periods and not have to worry about putting it on or taking it off. As well, many activity trackers are waterproof, meaning they can be worn in the shower or when swimming. As a result, activity trackers can be worn continuously, allowing for full day activity tracking. Depending on the specific device, they often need to be taken off to recharge the battery, which typically lasts anywhere from 3 to 7 days.

One popular device is the Fitbit (Mackinlay, 2013). This device has similar capabilities to the majority of activity trackers on the market, such as tracking steps, calories, distance, and sleep. Research into the Fitbit activity tracker confirms it is a reliable and valid measure for tracking step counts while walking, jogging, and climbing stairs (Noah, Spierer, Gu, & Bronner, 2013). However, Noah and colleagues (2013) found an underestimation of energy expenditure as compared to indirect calorimetry for inclined activities (such as walking uphill). Inaccuracies such as this are a common problem with activity trackers (Dannecker et al., 2011; Mackinlay, 2013; Noah et al., 2013; Stackpool, 2013; Takacs et al., 2013). Although energy expenditure is relatively accurate with flat motion activities (walking or running on a flat surface), with an increase in incline activity trackers often underestimates the amount of energy expended (Dannecker et al., 2011; Stackpool, 2013). Despite the lack of accuracy in energy expenditure at inclines, studies have found that when the trackers are used primarily for counting steps, their overall accuracy is satisfactory (Noah et al., 2013; Stackpool, 2013; Takacs et al., 2013).

Tracking activity using an electronic device removes subjectivity. The device itself is not subject to any social biases, and only records what activities are actually done (within limitations mentioned above). This allows the user to have accurate feedback to address their level of activity without having to try and remember and interpret the intensity of their activities, ultimately motivating individuals to reach their goals by seeing their accomplishments (Mekky, 2014). With these devices growing in popularity and the increasing competition on the market, it will be important for companies to promote devices that are able to accurately track a variety of activities and to promote the 'quantified self' (Mekky, 2014). Although it is possible that the motivation effect of the activity tracker may wear off after time, it can still provide a benefit to users.

One major limitation of activity trackers is that they can be considered an 'invisible system,' with the devices structures and processes protected by the manufacturer (Mackinlay, 2013). While these devices may successfully track the users' activity, the user has little to no knowledge of the inner workings of the device. For example, manufacturers rarely disclose the formulas used to classify an activity as either low or high intensity, therefore researchers are unable to validate the devices' calculations (Mackinlay, 2013). Some manufacturers indicate that they keep their methodology secure so that the technology and formulas can be modified in the future (DC Rainmaker, 2014); creating another potential source of device variability for the researcher.

1.4.3 Garmin Vivofit

The Garmin Vivofit, released March 2014, is one of the activity trackers that is popular with the general population. One of the benefits of the waterproof Vivofit is its long battery life. The manufacturer omitted energy consuming options such as a backlit screen and automatic notifications (commonly seen in other devices), to extend the battery life to about one year. Although some users have stated that there are limitations with the company's website and connecting the device to the computer (DC Rainmaker, 2014), the online interface does provide a variety of useful information. The Vivofit has the capability of tracking steps, setting a daily step goal, tracking distance, calories, movement during sleep, and connecting with a heart rate sensor (Shin, Cheon, & Jarrahi, 2015). Preliminary analyses of the Vivofit have demonstrated similar limitations as other activity trackers; while energy expenditure for treadmill walking was underestimated, the device did respond to changes in inclinations (Alsubheen, George, Baker, Rohr & Basset, 2016). Greater inclines did produce more energy expenditure than lower inclines. Additionally, it is relatively accurate when calculating BMR (basal metabolic rate) as compared to indirect calorimetry (Alsubheen et al., 2016). When validated for level and stair walking, compared to other devices the Vivofit was one of the most accurate devices for stair climbing, with an error rate of less than 4% (Huang, Xu, Yu & Shull, 2016).

Garmin has stated on their website that their device is designed as a way to encourage activity and that it is not a medical device. The statement from their legal disclaimer is

> "Garmin activity trackers are intended to be tools to provide you with information to encourage an active and healthy lifestyle. Garmin activity trackers rely on sensors that track your movement. The data and information provided by these devices is intended to be a close estimation of your activity, but may not be completely accurate, including step, sleep, distance and calorie data. Garmin activity trackers are not medical devices, and the data provided by them is not

intended to be utilized for medical purposes and is not intended to diagnose, treat, cure, or prevent any disease. Garmin recommends that you consult your doctor before engaging in any exercise routine" (Garmin, n.d.).

1.5 STUDY RATIONALE

The purpose of the series of articles presented in this thesis is to examine the impact of a walking program on cognition and QoL among older people with self-reported memory impairments. Due to increased life expectancy, individuals are living longer than before making it important that these added years are spent in good health. Particularly in Newfoundland and Labrador there is an aging population, with seniors (adults aged 65 and over) accounting for a greater proportion of the population. It is estimated that by 2026 seniors will account for approximately 27% of the population, compared with approximately 17% in 2013 (Statistics Canada, 2013; Government of Newfoundland and Labrador, 2006). Thus it is important that physically activity extends into the later years of life, to promote both physical and cognitive health, and a good QoL. The present study will address several questions relating to these concepts.

The first question that will be addressed is whether a walking program will be associated with improved cognition and QoL. With the implementation of a 6-month walking intervention, it is expected that older adults who walk more, meeting the CSEP guidelines for recommended levels of physical activity (Tremblay et al., 2011) will have less cognitive decline than individuals who walk less and do not meet the CSEP guidelines for physical activity. Based on previous research (i.e. van Gelder et al., 2004) individuals who are more active have a reduced risk of dementia. The present study uses the CSEP guidelines to classify physical activity to determine what level of activity is required to reduce the risk of cognitive impairment. All subjects will be encouraged to adhere to the CSEP guidelines for physical activity, and differences will be examined based on compliance. Based upon previous research (Colcombe & Kramer, 2003), it is also expected that there will be differential benefits based on the sex of the subject, with women experiencing greater benefits than men.

Both self-report and automated measures will be used to track activity, however their accuracies are expected to differ. The second question that will be addressed is the differences between self-report and direct measures of physical activity. By comparing data recorded in a physical activity log and through the use of a Vivofit activity tracker, the relation between the two measures will be assessed. Furthermore, the acceptability of the methods from the users' perspective, especially users who are older, has not been thoroughly examined. Previous research suggests there are barriers to technology adoption by older adults (Selwyn, 2004) and whether this holds true for electronic activity trackers is not known. In this study, through interviews with subjects, the benefits and drawbacks of each type of method will be considered. It is hypothesized that there will be a low correlation between the amount of activity tracked in the logbooks and through the Vivofit activity tracker. It is also hypothesized that subjects will have a preference for the use of the Vivofit over the logbook in terms of being feasibility for recording activity.

Older persons with mild memory impairments require special considerations when designing a walking program and assessing outcomes. In some cases there is a supportive caregiver or other informant who may provide alternate insights into the intervention itself or the impact of the intervention. Other researchers have found that when designing physical activity programs, the informants' points of view are important (Mackinnon &

Mulligan, 1998). This study examines the physical activity program from both the subjects' and informants' perspectives. Using this data we intend to determine the relationship between the two. It is hypothesized that there will be a strong correlation between information collected from the subjects and their informants regarding QoL and cognition. Additionally, the MoCA test of cognition has not been as thoroughly investigated as some other tests (Toglia et al., 2011). The reliability of the MoCA in comparison with other measures will be examined to further validate the test.

The remainder of this thesis is presented in manuscript format. In order to divide the findings into 'stand-alone' manuscripts for future publication, the project data was divided into three chapters. Chapter 2 determines the effects of the physical activity intervention on cognition and QoL, Chapter 3 compares subjective and objective measures of physical activity, while Chapter 4 examines the relationship between subjects' and informants' outcome measures. In this style of thesis there is some repetition of content in the introduction, methods, and references. Chapter 5 provides a discussion of how the findings of the study fit into the field of physical activity interventions for older adults and opportunities for future research.

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CHAPTER 2: EFFECTS OF PHYSICAL ACTIVITY ON COGNITION AND QUALITY OF LIFE

2.1 INTRODUCTION

It is common knowledge that staying physically active is important for maintaining overall health. The health industry reports many benefits of physical activity, from maintaining a healthy weight to reducing the risk or impact of chronic diseases. However, one benefit of physical activity that historically has not received the same consideration is the impact on cognition. Studies have demonstrated that physical activity has benefits for the cardiovascular system (Barnes, Yaffle, Satariano & Tager, 2003), but there is limited research regarding improvements in cognitive functioning. Although the benefits of physical activity on cognition have been examined, their results are not frequently acknowledged. Cognition can include various aspects such as memory, attention, language, and executive functioning (Barnes, Yaffle, Satariano & Tager, 2003). Maintaining a high level of executive functioning is important as it directly affects how an individual interacts with the world around them, and includes aspects such as attentional control, working memory, problem solving, reasoning, and planning and executing actions. Increasing one's level of physical activity can lead to improvements in crucial cognitive functions that allow an individual to navigate the world around them. Improving cognition also improves quality of life (QoL). Quality of life generally refers to the level of satisfaction that an individual has with their life, and is positively correlated with cognition (Rejeski & Mihalko, 2001; Wilson & Cleary, 1995).

2.1.1 Cognition

As individuals get older they usually experience some level of cognitive decline due to a variety of factors associated with typical aging. However, excessive cognitive decline can result in significant impairment. Mild cognitive impairment can become a clinical disorder known as dementia, a marked reduction in cognitive functioning (Lautenschlager, Cox & Kurz, 2010). It was estimated that in 2006 there were 26.6 million people living with dementia globally, and with an aging population it is expected to rise to over 100 million by the year 2050; this would result 1 in 85 people suffering from dementia (Lautenschlager, Cox & Kurz, 2010).

Although age is strongly associated with cognitive abilities, physical activity can also have a significant influence. In a study comparing a younger (ages 15 to 39) and an older (ages 40 to 71) cohort, researchers investigated response time on a flanker task as an indication of cognitive functioning (Hillman et al., 2006). When controlling for age, sex, and intelligence quotient (IQ) scores, it was found that the younger cohort had better response times, better accuracy, and overall better scores on the Weschler Adult Intelligence Scale (WAIS-III). Despite this finding, individuals who were more active had better scores, regardless of age, thus concluding that being physically active does provide benefits to cognition, particularly for older adults (Hillman et al., 2006). Greater levels of activity can have protective effects against the damaging effects of aging on cognitio n.

2.1.2 Quality of Life

While cognitive functioning on its own is important for navigating the world, cognition is also related to QoL. Although there are a number of definitions for QoL, it can often be seen as one's mental, physical, and emotional well-being (Wilson & Cleary, 1995); a conscious cognitive judgment of the satisfaction level one has with their life (Rejeski & Mihalko, 2001); and being related to health, mobility, and functional independence (Ozturk et al., 2011). Additionally health related quality of life (HRQoL), which is related to one's health status and life satisfaction, includes cognitive functioning, productivity, perceived and actual symptoms of illness, energy and vitality, pain, and self-esteem (Rejeski & Mihalko, 2001).

Quality of life is an important factor to consider for healthy aging as it is based on how one perceives their life; the more satisfied an individual is with their life, the happier and more productive they are likely to be (McAuley et al., 2006). One way of increasing QoL is through physical activity. Researchers found positive support for the social cognitive model relating physical activity and QoL, as moderated by mental and health status, which influenced overall global QoL (McAuley et al., 2006). Cognition and QoL are related to one another, and both are important factors in helping individuals live fulfilling and productive lives.

2.1.3 Physical Activity

One potential way to increase QoL is through a physical activity intervention. Studies have shown that aerobic exercise is an effective intervention for older adults with Alzheimer's disease (Yu et al., 2013). Through a 6-month intervention, there was a trend towards improving cognitive function and QoL, as well as reducing depression (Yu et al., 2013). However, due to a small sample size, and lack of randomized controlled trials, the effects were not significant. These are common problems in studies with aerobic activities that need to be addressed in future research (Yu et al., 2013). Previous research has indicated that the reason aerobic activity, such as cycling, displays a trend towards increasing cognition is due to the impacts on the cerebral structure of the brain (Adlard, Perreau, Pop & Cotman, 2005). Physical activity serves to increase the ability of the brain to grow and change (Adlard, Perreau, Pop & Cotman, 2005; Cotman & Berchtold, 2007; Yu et al., 2013). Increase physical activity, especially exercises that work the cardiovascular system (such as running, cycling, swimming, etc.) help to increase blood flow and oxygenation to the brain, which aids in maintaining and improving its functions.

The Canadian Society for Exercise Physiology (CSEP) has guidelines for each age group to follow to remain healthy and active (Tremblay et al., 2011). For older adults (age 65 and over), it is suggested that "to achieve health benefits, and improve functional abilities, adults aged 65 and older should accumulate at least 150 minutes of moderate- to vigorous-intensity aerobic physical activity per week, in bouts of 10 minutes or more" and "it is also beneficial to add muscle and bone strengthening activities using major muscle groups, at least 2 days per week" (Tremblay et al., 2011, p. 41).

Although recommendations are made for specific types of activities, in general, greater levels of overall activity are associated with better health outcomes. One factor that has an impact on individuals' level of physical activity is socioeconomic status and, in particular, education level (Crespo, Smit, Anderson, Carter-Pokras & Ainsworth, 2000; Powell, Slater, Chaloupka & Harper, 2006). The amount and type of activities that one typically engages in differ between levels of education; individuals at lower levels of income and education are less likely to be active (Crespo et al., 2000). Additionally, individuals with lower education levels reported experiencing more barriers to being physically active (Powell et al., 2006).

In a meta-analysis conducted by Heyn, Abreu and Ottenbacher (2004), the effects of physical activity for people with cognitive impairments were explored. After analyzing 30 studies involving a total of 2020 participants over the age of 65, they found that being physically active helped improve physical fitness as well as cognitive functioning. Importantly, although longer interventions were required to create long lasting changes in behaviour patterns, even short-term interventions positively influenced activity levels. As well, they also found an overall trend suggesting that the more activity individuals participated in, the greater benefit to participants (Heyn, Abreu & Ottenbacher, 2004).

A meta-analysis conducted by Colcombe & Kramer (2003) reviewed the effect of aerobic exercise on the cognitive functioning in older adults. The authors reviewed 18 studies that prescribed an intervention to sedentary older adults. It was found that there are selective benefits in relation to cognition based on aerobic activities, with some of the best effects being seen for executive control, such as working memory, coordination, inhibition, and planning and executing actions (Colcombe & Kramer, 2003; Shallice, 1994). The effectiveness of the intervention was mediated by type and duration, as well as by participant's gender. One of the effects noticed by the authors was that when the study sample was over half female, the overall effectiveness of the intervention had a greater effect size than if the sample was primarily male participants (Colcombe & Kramer, 2003). The reason for the difference is still under investigation by researchers, but there may be some biological mechanisms that make women more likely to benefit from physical activity.

2.2 STUDY RATIONALE

The objective of the present study is to build on previous literature regarding the positive effects of physical activity on cognitive functioning and QoL among older people. There are several areas of interest that will be addressed. Firstly, it will be investigated whether there are any differences in the baseline measures of cognition and QoL based on sex, education, or self-reported activity. Previous research has indicated that individuals who have a greater level of education are more active (Crespo et al., 2000; Powell et al., 2006). It is hypothesized that greater levels of education and greater levels of physical activity will be related to better cognition and QoL scores. Secondly, it is hypothesized that adherence to the CSEP guidelines for physical activity will have a positive relationship with cognition and QoL. Since the intervention involves community-based walking advice, there may be variation in subject adherence to the CSEP guidelines. Based upon previous research (Colcombe & Kramer, 2003), it is also expected that there will be differences based on the sex of the subject, with women experiencing greater benefits than men.

2.3 METHODS

2.3.1 Participants

This study was approved by the institutional health research ethics board. The Seniors Physical Activity and Cognition (SPAC) study recruited adults over the age of 65 with self-reported mild memory impairments. Subjects were recruited to the study through posters displayed at Memorial University (MUN), the provincial rehabilitation center (Miller Center), the Seniors Resource Center, and through an email sent out to the MUN Pensioners Association. In order to be eligible, subjects needed to be at least 65 years old, without any falls in the last six months, self-identify mild memory problems, and be able to walk 200 meters unassisted by another person. Subjects who met these requirements completed the Physical Activity Readiness Questionnaire (PAR-Q+; Warburton et al., 2011) to ensure it was safe for them to be active. Subjects were provided with a consent form to read and sign, and were offered a verbal explanation and clarification on any information as needed. At this time the subject identified an individual who would be willing to act as their informant during the study. The requirements were that the informant be willing to provide information about the subject, that they have known each other for at least a couple years, and see each other on a regular basis.

2.3.2 Materials

A total of six questionnaires were used, in addition to an activity log and an activity tracker. The subject was provided with an activity log to use for the duration of the study (26 weeks) to keep track of their daily physical activities. They were instructed to record any walking (or other activities) that they did, as long as it occurred in bouts of 10 minutes or more at a time, consistent with CSEP recommendations. The activity log consisted of letter size pages, with two weeks per page. Each day had a box for subjects to record their activities. The activity tracker, a Garmin Vivofit, was used for a total of three weeks during the study (week 1, 14, and 26). The Vivofit is a wrist-worn, accelerometer based activity tracker that can be worn continuously (all day and night for a total of seven days). It tracks the number of steps an individual takes, as well as how much time is spent being sedentary, active, and sleeping.

The participants completed a total of six questionnaires; four related to cognitive functioning and two related to QoL. The subject filled out one QoL questionnaire, the other was completed by the informant. The subject QoL questionnaire was the Assessment of Quality of Life – 8 Dimension (AQoL-8D; Richardson et al., 2011). This contained a total of 35 questions that were separated into eight categories, with each category having between three and eight items. The eight categories were divided into two super dimensions; *physical* QoL and *mental* QoL. *Physical* QoL included the categories independent living, pain, and senses; the *mental* QoL included mental health, happiness, self-worth, coping, and relationships. The AQoL-8D is one of the instruments designed by the researchers at Monash University to test QoL; other tests include the AQoL-4D, AQoL-6D, and AQoL-7D (Richardson et al., 2011). Each test differs in terms of the dimensions that it assesses related to QoL, with the AQoL-8D covering the greatest number of dimensions. For all questions, subjects were given a choice of five to seven options, and checked which box is most applicable to the way they felt. The AQoL-8D has a high test-retest reliability, Cronbach's alpha = 0.954 and ICC = .907 (Richardson & Iezzi, 2011; Richardson et al., 2011).

The informant QoL questionnaire was the Qualidem (Ettema et al., 2007a). This test included a total of 40 items, divided into nine categories, with each category containing between two and seven items. The nine categories were care relationship, positive affect, negative affect, restless tense behaviour, positive self-image, social relations, social isolation, feeling at home, and having something to do. This scale was designed particularly for individuals with dementia in residential settings; although ratings by the patient themselves are typically more accurate (professionals underestimate the QoL of residents), a proxy rating is still good at measuring changes in QoL over time (Ettema et al., 2007b). The test has good reliability and validity, with each scale rated separately in terms of internal reliability, with Spearman's rho values ranging from .60 to .90, and Cronbach's alpha values above 0.64 (Ettema et al., 2007a).

There are a number of tests that can be used to test cognition, one of the most prevalent being the Mini Mental State Exam (Folstein, Folstein & McHugh, 1975). The MMSE contained 11 questions with good validity and reliability (Folstein, Folstein, & McHugh, 1975), however there were limitations in the aspects of cognition covered. Another test, the Montreal Cognitive Assessment (MoCA; Nasreddine et al., 2005) is more sensitive to deficits and is better at detecting impairment (Dong et al., 2010), providing a more thorough and comprehensive assessment of an individual's cognitive state. Additionally, when compared with the MMSE, the MoCA had a reduced ceiling effect, a higher internal reliability (Cronbach alpha = .78) than the MMSE (Cronbach alpha = .60), and was a stronger predictor of cognitive dysfunction (Toglia et al., 2011). The MoCA includes eleven items with subsections including visuospatial, naming, memory, delayed recall, language, abstraction, orientation, and attention. Together these provide a score out of 30, with scores of 26 or above considered normal, and scores of 22 or below considered severely impaired (Nasreddine, 2003). There are three validated versions of the MoCA; the version of the test used was randomized between subjects.

The second test of cognition was the Informant Questionnaire on Cognitive Decline in the Elderly (IQCODE; Jorm & Jacomb, 1989). The IQCODE was designed to screen for dementia in situations where the subject is unable to undergo direct cognitive testing by relying on information from an informant. This consisted of 26 questions that were asked to the informant regarding changes in the subjects' memory over time. These questions were answered on a scale from "much improved" to "much worse", with a middle score being "no change." This included questions regarding recalling conversations, personal information, belongings, day-to-day routines, navigating familiar surroundings, learning new information, and understanding information. On this test lower scores indicate better recollection and improvement, and higher scores indicate greater levels of impairment. A cut-off of 3.3-3.6 (out of 5) is used to classify an individual with dementia. It has been stated that although the IQCODE is effective, its performance is improved when combined with other tests (Mackinnon & Mulligan, 1998). The authors note that when combined with the MMSE it provides a more accurate diagnostic of an individual's mental capabilities than either test does alone.

The final two questionnaires relating to cognition were taken from the Psychogeriatric Assessment Scale (Jorm & Mackinnon, 1995); the Cognitive Decline (PAS-CD) and Cognitive Impairment (PAS-CI) subscales. This test was designed to assess dementia and depression by interpreting information gathered from the 'subject' and 'informant' scales (Jorm & Mackinnon, 1995). The PAS-CI was administered directly to the subject and included nine items that assessed concentration and memory. Items included remembering words/names, recalling historical figures, repeating a sentence, and following instructions. The PAS-CD was administered to the informant, and involved asking ten questions about the subjects' memory. Questions included memories of recent events, belongings, recalling conversations, meetings, and concentration.

There was high reliability for all scales on the Psychogeriatric Assessment Scale, although reliability was higher for the informant scales than the subject scales (Jorm & Mackinnon, 1997). The Cronbach alpha for the PAS-CI was 0.58, and for the PAS-CD was 0.84 (Jorm et al., 1997). The PAS-CI and PAS-CD scales are significantly correlated at 0.46 with one another (Jorm et al., 1997). As well, both scales are positively and significantly correlated with the MMSE and the IQCODE. The PAS-CI was -0.77 correlated with MMSE and 0.49 with IQCODE, and the PAS-CD was -0.42 correlated with MMSE and 0.83 correlated with the IQCODE (Jorm & Mackinnon, 1995). The IQCODE has an alpha of 0.95 (Jorm, 2004). When compared to other clinical measures the IQCODE has a correlation of -0.61 with the MMSE (Folstein, Folstein & McHugh, 1975; Jorm, 2004). Due to the MoCA being a much newer test, reliability between tests has not been validated to the same extent as with the MMSE; however, the MoCA has been shown to have greater internal reliability than the MMSE (Toglia et al., 2011).

2.3.3 Procedures

The intervention took place over a 26-week period (six months). At the first meeting participants signed the consent form, completed the PAR-Q+, and selected an informant. Participants were informed that there would be a total of four meetings over the six-month period to complete questionnaires, tracking any changes in cognition. All of the meetings were one-on-one between the participant and the researcher. Each participant was assigned an identification code, and names were not attached to data to ensure anonymity and confidentiality. Informants were assured that all information they provided regarding the subject would be kept private and not be shared with the subject or anyone else.

For the duration of the project, subjects were encouraged to be active. They were instructed to try and reach a goal of 150 minutes or more of walking per week, as per CSEP guidelines for older adults (Tremblay et al., 2011). Subjects kept an activity log for the duration of the study (26 weeks), and wore a Vivofit activity tracker during weeks 1, 14, and 26. At each of the meetings, subjects were informally asked about their physical activity levels and habits. If requested, they were provided with encouragement and ideas for increasing their level of activity. For example, park further away from the door when going to the mall, or when going out and the distance is reasonable, walk rather than driving. Subjects were also occasionally (approximately 1-2 times per month) contacted through email to remind them to stay active. To encourage subjects to achieve at least 150 minutes of walking per week, they were provided free access to The Works walking track at Memorial University. Passes were provided for the subjects to use the track, and they were encouraged to bring a friend/spouse to walk with them if they so desired.

At baseline, and every two months until the completion of the study, subjects and their informants completed the six questionnaires regarding QoL and cognitive functioning. The subjects and informants completed the questionnaires at the same intervals, but did so at separate meetings to ensure privacy of information. Subject meetings took approximately 20 to 30 minutes depending on response time, and informant meetings took approximately 10 to 15 minutes. The order in which the questionnaires were presented was kept consistent throughout the testing. In *Figure 2.1*, a list of the questionnaires used at each time point is presented. Upon completion of the study, the subjects participated in a semi-structured interview to get feedback regarding various aspects of the study including the use of the logbook, the activity tracker, access

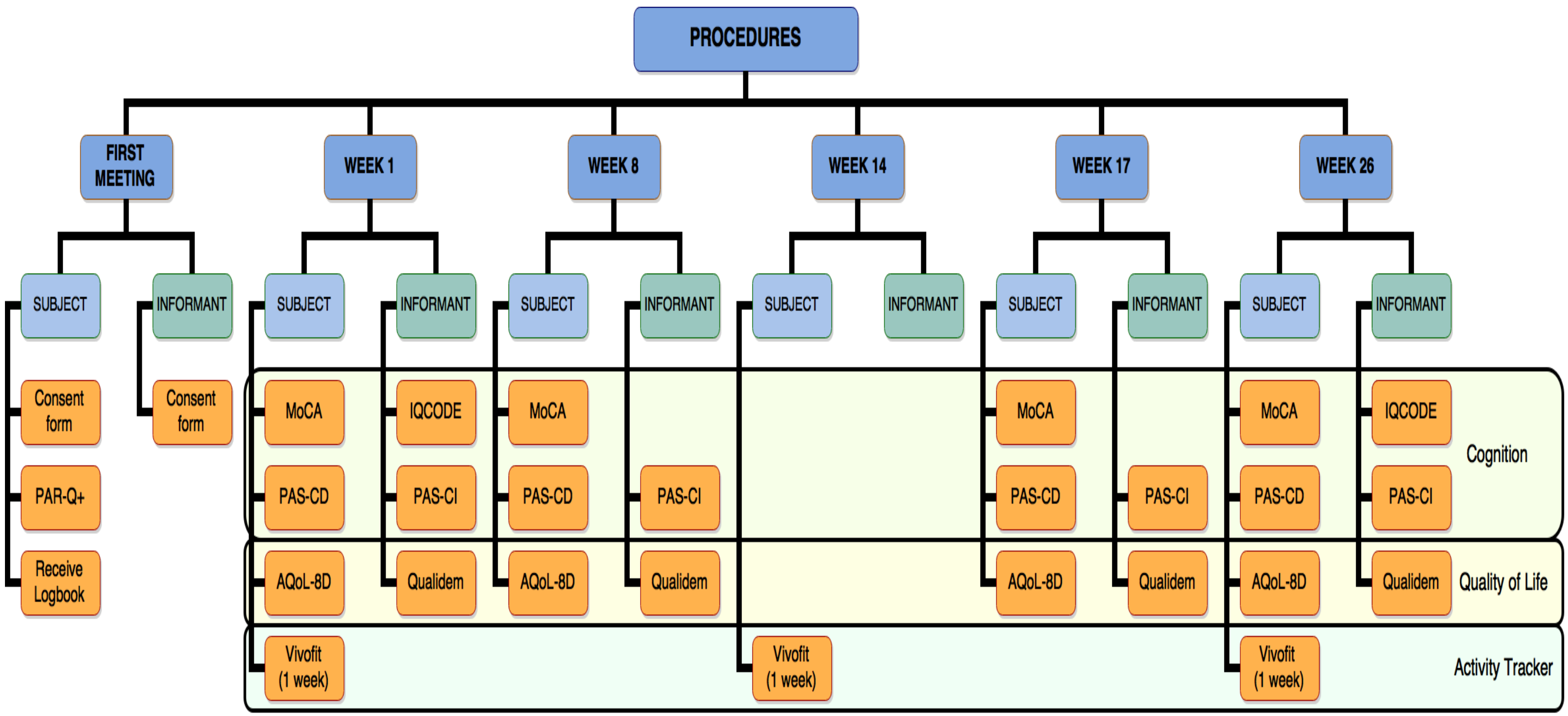

Figure 2.1 Study procedures.
Participants (subjects and informants) completed questionnaires at four time points regarding cognition and quality of life. Subjects wore an activity tracker for three one-week periods.

to walking facilities, and their own performance.

2.3.4 Data Reduction and Analysis

Each of the questionnaires was analyzed using SPSS software, and calculated based on the respective test instructions. The AQoL-8D scores were calculated using the algorithm provided by Monash University (http://www.aqol.com.au/index.php/scoring-algorithms). The scores for each of the Qualidem subscales were calculated by taking the average of the items in each category. The MoCA was calculated by adding the total points in each category. The IQCODE was calculated by taking the average of all the items. The PAS-CI and PAS-CD were calculated by adding the points for each question, divided by the total minus the amount of missing responses.

Firstly, descriptive statistics were run to identify the characteristics of the sample. Then, a two sample t-test was used to test the data for baseline differences to determine if there was an initial variation in cognition or QoL based on sex (male vs. female), education (high school/college vs. Master's/PhD), and informant relation (friend vs. family); a correlation was used to test for changes in QoL and cognition based on physical activity level. Due to the differences in administration of the IQCODE at baseline (compared present to 10 years ago) and six-months (compared present to pre-study), the IQCODE was analyzed separately for each time point. A single sample t-test was used to determine if the scores were significant different than 3 (a score of 'no change' on the test). The other tests of cognition (MoCA and PAS) were analyzed using repeated measures ANOVA, with 'a priori' follow-ups, comparing scores at the first and last time points. Both QoL measures (Qualidem and AQoL-8D) were also analyzed using repeated measures ANOVA, and significant results were followed up with 'a priori' comparisons of the first and last time points to detect overall differences. Differences based on sex were tested with a 2 (sex) x 4 (time) repeated measures ANOVA. All 'a priori' follow-up analyses were only run when the corresponding ANOVA was significant.

Physical activity data from the Garmin Vivofit was viewed using the Garmin Connect website (Garmin, n.d.). The "active" and "highly active" categories were automatically calculated by the activity tracker; the "total active" category was manually created by summing the activity levels of the other two categories. Step information was displayed for each 24-hour period. Activity data recorded in the subjective logbook was manually totalled in terms of minutes per day and per week. Subjects were categorized as either high activity or low activity, based on their adherence to the recommended CSEP guidelines. A two sample t-tests were used to ensure there was a difference between the two groups in terms of their activity levels. To determine if there was a dose-response effect of activity level on either cognition or QoL, 2 (activity level) x 4 (time) repeated measures ANOVA were utilized. For analyses where sphericity assumptions were violated, Greenhouse-Geisser corrections were employed. Data was entered into SPSS v22 with significance set at $p < .05$.

2.4 RESULTS

2.4.1 Participant Characteristics

A total of 18 older adults aged 65 to 79 ($M = 70.11$, $SD = 4.16$; 66.7% female) with self-reported memory impairments participated in the study; however, one participant was unavailable during the final time point. The majority of the sample was born in Canada (72.2%), along with other countries including the United Kingdom

(16.7%), United States (5.6%), and South Africa (5.6%). The sample was highly educated, with 77.7% of subjects having a PhD or Master's degree. Each subject had identified one informant to provide information during the study; 50% of the informants were the subject's spouse, 16.7% were a child, and 33.3% were a friend. The mean amount of time that the subject and informant had known each other was 37.56 years (*SD* = 14.79). Informants reported how many times per week they saw the subject, with most reporting that they saw the subject daily (55.6%), or once or more per week (38.9%), and only 5.6% reported they saw the subject less than once a week. Compliance was measured based on reported minutes of weekly activity in the logbook; 70% of subjects reported at least 150 minutes of activity each week.

2.4.2 Physical Activity

Objective physical activity was measured with the Garmin Vivofit for three one-week periods in both minutes of activity per day and steps per day (*Figure 2.2*). Minutes of activity per day was automatically divided into four categories; highly active, active, sedentary, and sleeping by the activity tracker and the percent of time spent in each category was reported. In terms of step count, a repeated measures ANOVA indicated that there was a significant decline in steps taken from the first to the last measure, $f(2, 32)$, = 6.11, $p = .006$. The greatest amount of steps were taken at the beginning (M = 8596, SD = 2595), the least amount of steps were taken at the midpoint (M = 6927, SD = 2728). The drop in step counts were partially regained at the last time point. In terms of total minutes of activity per day, there was no significant difference between the time points, $f(2, 32) = 2.507$, $p = .097$; however as with step counts, subjects still had the most

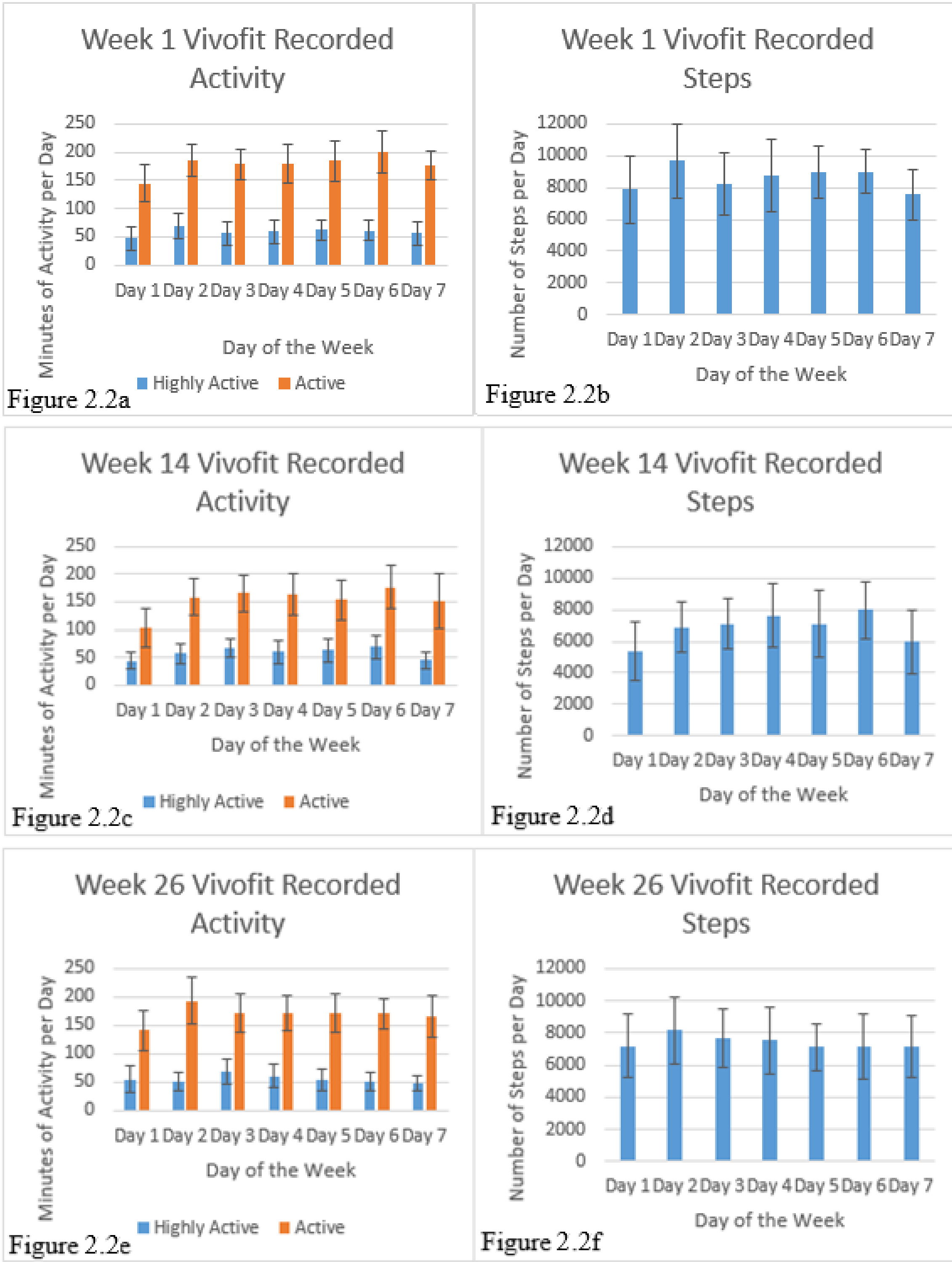

Figure 2.2a-f *Vivofit minutes of activity and daily steps at baseline (a and b), midpoint (c and d), and post-test (e and f).*

minutes of activity at baseline (*M* = 239, *SD* = 65) and the least at the second time point (*M* = 214, *SD* = 67).

In order to determine if there was a dose-response effect based on levels of physical activity, subjects were divided into two groups based on their overall compliance with the CSEP guidelines for physical activity during the weeks the subjects wore the Garmin Vivofit activity trackers. If they achieved at least 150 minutes of total activity they were classified as "high compliance", and subjects who did not achieve at least 150 minutes of total activity each week were classified as "low compliance." Unsurprisingly, there was a significant difference between the two groups at each time point for both the "total active" and "active" categories, both $p < .05$. The only difference between the groups for "highly active" was at the second time point. All means are presented in *Table 2.1*. While the difference in the "active" category was not significant at each time point, it is likely that the amount of high activity drove the changes between the groups.

Table 2.1
Activity based on compliance

		High Compliance (n=12)	Low Compliance (n=5)
Active	Base	203.5 (34.5)	130.8 (31.6)
	Mid	185.3 (51.4)	91.3 (23.8)*
	Post	187.5 (50.2)	124.7 (38.4)
Highly Active	Base	62.2 (37.9)	44.4 (26.8)**
	Mid	66.0 (28.5)	34.6 (14.2)**
	Post	63.2 (29.7)	35.4 (12.4)*
Total Active	Base	265.7 (53.6)	175.3 (43.2)**
	Mid	251.3 (38.5)	125.9 (18.6)**
	Post	250.8 (59.2)	160.0 (29.5)**

Note: Means and standard deviations of activity levels, presented in minutes, at each time point divided by overall compliance level.
* indicates significant difference between the groups at .05
** indicates significant difference between the groups at .01

Table 2.2

Differences based on compliance

	Baseline		2 Month		4 Month		6 Month	
	Low	High	Low	High	Low	High	Low	High
MoCA	26.60 (2.07)	25.25 (2.30)	26.20 (2.28)	26.33 (1.97)	28.00 (1.58)	26.92 (2.11)	27.75 (1.71)	27.42 (2.06)
PAS-CD	1.85 (1.27)	2.11 (1.75)	2.25 (3.20)	0.85 (1.31)	1.80 (1.79)	0.76 (1.09)	0.50 (1.00)	0.64 (0.92)
PAS-CI	1.20 (1.30)	2.22 (1.32)	1.20 (1.09)	1.50 (1.51)	0.60 (0.55)	1.25 (1.91)	0.50 (1.00)	1.17 (1.27)
IQCODE	3.11 (0.14)	3.15 (0.18)	---	---	---	---	3.00 (0.00)	2.89 (0.20)
Qualidem								
Care Relation	2.34 (0.30)	2.39 (0.36)	2.11 (0.32)	2.51 (0.38)	2.17 (0.44)	2.49 (0.38)	2.28 (0.28)	2.45 (0.32)
Positive Affect	2.67 (0.31)	2.68 (0.39)	2.67 (0.47)	2.83 (0.21)	2.77 (0.34)	2.79 (0.24)	2.92 (0.17)	2.82 (0.23)
Negative Affect	2.20 (0.56)	2.14 (0.54)	2.33 (0.61)	2.18 (0.50)	2.27 (0.64)	2.60 (0.50)	2.33 (0.27)	2.26 (0.34)
Tense Behavior	2.00 (0.82)	2.19 (0.50)	1.67 (0.82)	2.33 (0.39)	2.07 (0.72)	2.00 (0.86)	2.25 (0.57)	2.36 (0.48)
Self-Image	2.13 (0.87)	2.36 (0.50)	1.75 (0.50)	2.21 (0.37)	1.60 (0.49)	2.12 (0.62)	1.92 (0.74)	2.18 (0.62)
Social Relations	2.83 (0.20)	2.93 (0.15)	2.83 (0.19)	2.89 (0.15)	2.70 (0.40)	2.94 (0.08)	2.96 (0.08)	2.91 (0.11)
Social Isolation	2.53 (0.38)	2.83 (0.22)	2.25 (0.32)	2.82 (0.23)	2.33 (0.62)	2.73 (0.20)	2.67 (0.27)	2.73 (0.42)
Feeling at Home	1.80 (0.84)	2.14 (0.39)	1.92 (0.79)	2.21 (0.45)	2.00 (0.67)	2.21 (0.43)	1.92 (0.79)	2.06 (0.39)
Something to Do	2.90 (0.22)	2.92 (0.19)	2.75 (0.29)	2.91 (0.20)	2.30 (0.76)	2.91 (0.20)	2.75 (0.29)	2.82 (0.46)
AQoL-8D	0.83 (0.09)	0.86 (0.10)	0.80 (0.12)	0.87 (0.10)	0.82 (0.14)	0.87 90.14)	0.84 (0.13)	0.89 (0.11)
Mental	0.52 (0.17)	0.54 (0.13)	0.51 (0.17)	0.58 (0.16)	0.53 (0.22)	0.57 (0.15)	0.54 (0.25)	0.60 (0.15)
Happiness	0.84 (0.08)	0.86 (0.08)	0.87 (0.07)	0.87 (0.09)	0.87 (0.08)	0.86 (0.09)	0.85 (0.05)	0.86 (0.07)
Mental Health	0.68 (0.15)	0.68 (0.10)	0.66 (0.15)	0.72 (0.12)	0.73 (0.13)	0.75 (0.13)	0.76 (0.21)	0.75 (0.11)
Coping	0.86 (0.07)	0.88 (0.07)	0.82 (0.11)	0.87 (0.07)	0.79 (0.14)	0.86 (0.09)	0.80 (0.15)	0.90 (0.06)
Relationships	0.82 (0.08)	0.84 (0.11)	0.82 (0.09)	0.86 (0.10)	0.81 (0.14)	0.84 (0.09)	0.82 (0.13)	0.87 (0.10)
Self-Worth	0.92 (0.10)	0.92 (0.06)	0.92 (0.10)	0.94 (0.07)	0.91 (0.09)	0.92 (0.08)	0.89 (0.12)	0.92 (0.06)
Physical	0.71 (0.20)	0.54 (0.13)	0.66 (0.22)	0.79 (0.16)	0.71 (0.23)	0.84 (0.18)	0.79 (0.05)	0.82 (0.14)
Independence	0.92 (0.19)	0.94 (0.06)	0.86 (0.20)	0.93 (0.08)	0.89 (0.18)	0.94 (0.12)	0.99 (0.02)	0.94 (0.11)
Pain	0.69 (0.19)	0.89 (0.12)	0.68 (0.22)	0.84 (0.17)	0.72 (0.27)	0.90 (0.17)	0.78 (0.07)	0.88 (0.12)
Senses	0.93 (0.14)	0.87 (0.10)	0.89 (0.11)	0.89 (0.08)	0.92 (0.08)	0.89 (0.10)	0.92 (0.08)	0.90 (0.10)

MoCA, Montreal Cognitive Assessment; PAS-CD, Psychogeriatric Assessment Scale – Cognitive Decline; PAS-CI, Psychogeriatric Assessment Scale – Cognitive Impairment; IQCODE, Informant Questionnaire on Cognitive Decline in the Elderly; AQoL-8D, Assessment of Quality of Life – 8 Dimension

Level of compliance was used as a factor to determine differences in cognition and QoL. A 2x4 repeated measures ANOVA was conducted to determine if there were changes over time based on compliance for cognition or QoL. There were no significant differences in subjects' outcomes based on their physical activity level. The high compliance group did not score significantly better than the low compliance group on any of the tests (*Table 2.2*). Differences based on compliance were also tested using change over time. A difference score was calculated between the first and last time point and used as a predictor for degree of change in cognition and QoL over time. Change in physical activity level was not a significant predictor of cognition or QoL.

2.4.3 Physical activity, Cognition, and Quality of Life at Baseline

First, the data was tested for differences in the baseline measures of cognition and QoL based on sex, education, and informant relation using a two sample t-test. There were no baseline QoL differences based on education, and there were no baseline differences for cognition. A significant difference was found in the mental health subscale of the AQoL-8D, $t(16) = 2.322$, $p = .033$, with males ($n = 6$, $M = .755$, $SD = .121$), reporting higher levels of mental QoL than females ($n = 12$, $M = .637$, $SD = .090$). Significant differences were found in the Qualidem subscales negative affect, $t(16) = -2.382$, $p = .030$, and restless tense behaviour, $t(16) = -3.361$, $p = .004$. For negative affect family members, a spouse or child, ($n = 12$, $M = 1.917$, $SD = .515$), reported lower scores than friends ($n = 6$, $M = 2.722$, $SD = .390$). For restless tense behaviour, family members ($n = 12$, $M = 2.056$, $SD = .547$) also reported lower scores than friends ($n = 6$, $M = 2.778$, $SD = .344$).

Previous research has suggested that there is a relationship between physical activity levels and cognition and QoL. Correlations between levels of physical activity (average steps per day), and cognition and QoL were investigated. Physical activity was significantly correlated with two subscales of the Qualidem, social relations, $r = .48$, $p = .046$, and social isolation, $r = .49$, $p = .038$. In both correlations, higher levels of activity were associated with better scores on QoL.

2.4.4 Effects of a walking program on cognition and QoL

Since cognitive health can change over time, we examined to what extent there were subjective changes in cognition from the informants' point of view before beginning and after finishing the walking program using the IQCODE. During the baseline administration, informants were asked to compare the subject's current cognition to ten years ago; during the post-testing, informants were asked to compare the subject's current cognition to before the start of the intervention (six months ago). Scores above three indicate decline, while scores below three indicate improvement, and a score of exactly three indicates no change. A single sample *t*-test was conducted comparing subjects' scores to a test value of 3 to determine if there was a significant change in either direction. At baseline, scores were significantly greater than 3, $t(17) = 3.745$, $p = .002$). At post-testing, overall scores were below 3, but were not significantly different. Means and standard deviations can be seen in *Table 2.3*.

Subjects experienced an improvement on cognition, objectively measured using the MoCA, over the course of the six-month physical activity intervention. The different validated versions of the MoCA were utilized to reduce learning effects. A repeated measures ANOVA was conducted on MoCA scores to determine if there was a significant difference over time. Sphericity was not assumed, Mauchly's *W*(5) = .38, *p* = .020, and so a Greenhouse-Geisser correction was used. A significant difference was found in the four MoCA assessments over time, *f*(2.01, 30.09) = 6.79, *p* = .004. A linear contrast was significant, *f*(1, 15) = 13.31, *p* = .002, indicating that there was a positive linear trend in the scores. An 'a priori' test was conducted to compare the baseline and post-test scores, and was significant, *t*(15) = -4.04, *p* = .001. This indicated that subjects scored significantly better on the post-test than at baseline, mean difference = -2.09 (*SD* = 1.80). Means and standard deviations for each time point are presented in *Table 2.3*.

Cognition, measured subjectively, improved over time from both the subject's (PAS-CI) and the informant's (PAS-CD) points-of-view. There was a significant difference in subjects' scores over time for the PAS-CI, *f*(3, 45) = 2.87, *p* = .047. There was also a significant linear contrast, *f*(1, 15) = 6.90, *p* = .019, indicating a linear trend in the scores. An 'a priori' test was conducted to compare the baseline and post-test scores,

Table 2.3
Cognition scores

	Baseline	2 Month	4 Month	6 Month
IQCODE	3.15 (0.17)**	----	-----	2.92 (0.17)
MoCA	25.44 (2.36)	26.38 (1.97)	27.27 (1.93)	27.53 (2.10)*
PAS-CD	1.92 (1.61)	1.22 (1.96)	1.02 (1.36)	0.65 (0.93)*
PAS-CI	1.93 (1.32)	1.33 (1.37)	1.06 (1.60)	1.07 (1.22)*

Note: Participants' scores on each of the four cognitive assessments at each time point, presented in means and standard deviations. For the MoCA, higher scores indicate better performance. For all other scales in this table, lower scores indicate better performance.
* indicates significant change from baseline at $\alpha = .05$.
** indicates significantly different than test value at $\alpha = .05$.
IQCODE, Informant Questionnaire on Cognitive Decline in the Elderly; MoCA, Montreal Cognitive Assessment; PAS-CD, Psychogeriatric Assessment Scale – Cognitive Decline; PAS-CI, Psychogeriatric Assessment Scale – Cognitive Impairment

and was significant $t(15) = 2.72$, $p = .016$, with a mean difference of 1.04 ($SD = 1.53$). With lower totals indicating a better score, subjects improved over the six months.

For the informants' assessment of cognition measured using PAS-CD, sphericity was not assumed, $W(5) = .300$, $p = .040$, and a Greenhouse-Geisser correction was used. There was a significant difference over time, $f(1.799, 19.794) = 7.192$, $p = .006$, and a linear contrast, $f(1, 11) = 7.99$, $p = .016$, indicating a linear trend over time. There was a significant difference between the baseline and post-test scores, $t(14) = 4.072$, $p = .001$, with a mean difference of 1.283 ($SD = 1.221$). This indicates that subjects improved over six months from the perspective of their informants (*Table 2.3*).

The physical activity program was associated with improvements in QoL from the subject's perspective (AQoL-8D) but not from the informant's (Qualidem). Repeated measures ANOVA were conducted on each of the Qualidem subscales. There were no significant changes in the informant reported QoL scores. The means and standard deviations of all the Qualidem subscales can be seen in *Table 2.4*. Each subscale of the AQoL was analyzed individually, as well as the *physical*, *mental*, and overall scores. The means and standard deviations of all the AQoL-8D subscale and total scores can be seen in *Table 2.5*. For all AQoL-8D categories, scores closer to 1.00 indicate a better result. Sphericity was assumed for all categories. The total score for the *mental* category was significant, $f(3, 42) = .99$, $p = .014$, with a positive linear contrast, $f(1, 14) = 6.34$, $p = .025$, indicating significant improvement over time. An 'a priori' test to compare the baseline and six-month time points was conducted and indicated a significant result, $t(14) = -2.73$, $p = .016$, mean difference = -.06 ($SD = .08$). The overall total was significant, $f(3, 42) = 2.94$, $p = .044$, with a positive linear contrast, $f(1, 14) = 7.84$, $p = .014$. This indicates that over time there was a significant linear change in the total scores. There was a significant difference between the baseline and six-month time points, $t(14) = -3.36$, $p = .005$, mean difference = -.03 ($SD = .04$). There was no significant difference in the *physical* category. The only subscale with a significant effect was mental health, $f(3, 42) = 9.59$, $p < .001$, with a significant linear contrast, $f(1, 14) = 19.02$, $p = .001$, indicating scores changed in a linear fashion over time. There was a significant improvement in

Table 2.4
Qualidem scores

	Baseline	2 Month	4 Month	6 Month
Care Relationship	2.39 (0.33)	2.40 (0.40)	2.40 (0.40)	2.41 (0.32)
Positive Affect	2.68 (0.33)	2.79 (0.29)	2.77 (0.26)	2.86 (0.22)
Negative Affect	2.19 (0.53)	2.22 (0.51)	2.31 (0.52)	2.27 (0.33)
Restless Behaviour	2.19 (0.61)	2.16 (0.59)	2.06 (0.78)	2.36 (0.50)
Positive Self-Image	2.30 (0.59)	2.09 (0.44)	1.98 (0.61)	2.14 (0.65)
Social Relations	2.90 (0.16)	2.88 (0.16)	2.86 (0.24)	2.92 (0.11)
Social Isolation	2.73 (0.30)	2.67 (0.36)	2.63 (0.41)	2.71 (0.39)
Feeling at Home	2.07 (0.55)	2.13 (0.55)	2.16 (0.49)	2.02 (0.51)
Having Something to Do	2.89 (0.21)	2.87 (0.23)	2.74 (0.50)	2.82 (0.42)

Note: Subjects' scores on the Qualidem, informant quality of life questionnaire, presented in means and standard deviations. Higher scores indicate better performance.

Table 2.5
Assessment of Quality of Life – 8 Dimension scores

	Baseline	2 Month	4 Month	6 Month
TOTAL	.83 (.12)	.84 (.13)	.83 (.17)	.88 (.11)*
MENTAL	.52 (.15)	.56 (.17)	.54 (.19)	.59 (.16)*
Happiness	.85 (.08)	.87 (.08)	.86 (.08)	.86 (.06)
Mental Health	.68 (.11)	.70 (.13)	.73 (.13)	.75 (.13)*
Coping	.85 (.12)	.84 (.10)	.81 (.15)	.88 (.09)
Relationships	.82 (.11)	.83 (.11)	.82 (.12)	.86 (.10)
Self-Worth	.91 (.08)	.93 (.08)	.90 (.10)	.91 (.07)
PHYSICAL	.77 (.16)	.74 (.19)	.78 (.21)	.82 (.13)
Independent Living	.92 (.12)	.89 (.13)	.91 (.15)	.95 (.10)
Pain	.84 (.17)	.81 (.20)	.85 (.21)	.86 (.12)
Senses	.87 (.13)	.87 (.13)	.87 (.14)	.91 (.10)

Note: Subjects' responses to the AQoL-8D, subject quality of life questionnaire, presented in means and standard deviations. Higher scores indicate better performance.
* indicates a significant change from baseline at $\alpha = .05$.

scores between the baseline and six-month time points, $t(14) = -4.33$, $p = .001$, mean difference = -.07 ($SD = .06$).

2.4.5 Gender Differences for Physical Activity

To test the hypothesis that there would be differences based on sex, a 2 (sex) x 4 (time) repeated measures ANOVA was conducted. Cognition (MoCA) was significantly different based on sex, $f(3, 42) = 3.100$, $p = .037$, with a significant linear contrast, $f(1, 14) = 6.822$, $p = .020$. The means and standard deviations can be seen in *Table 2.6*. The improvement for females is much larger than for males, who did not demonstrate the same difference. It was found that there was no significant change in cognition measured using MOCA in males over time, $f(3, 12) = .27$, $p = .848$, but there was a significant change for women over time, $f(3, 27) = 17.23$, $p < .001$. No significant difference based on sex was found in the PAS-CI (subject-reported cognitive status), $f(3, 39) = 2.60$, $p = .066$, however a significant difference based on sex was found in the PAS-CD (informant-reported cognitive status), $f(3, 30) = 6.51$, $p = .002$. Informants of male subjects reported no significant change over time was found for the men, $f(3, 12) = 2.38$, $p = .120$ whereas informants for the female subjects reported a significant change over time, $f(3, 18) = 5.64$, $p = .007$.

In terms of sex difference in the cognitive component of QoL (AQoL-8D *mental* super dimension) was significantly different between men and women, $f(3, 39) = 4.46$, $p = .009$. There was a significant improvement in overall mental QoL for men over time, $f(3, 12) = 9.30$, $p = .002$, but no significant change for women over time, $f(3, 27) = 1.13$, $p = .353$. Sex differences were also seen in the total score for the AQoL-8D $f(3, 39) = 3.49$, $p = .025$. Men improved significantly over time, $f(3, 12) = 5.10$, $p = .017$, whereas there was no significant difference for women over time, *f*(3, 27) = .94, *p* = .435. When compared based on sex, the mental health subscale was significant, *f*(3, 39) = 8.78, *p* < .001, with a linear contrast, *f*(1, 13) = 17.52, *p* = .001. A follow-up repeated measures ANOVA found no significant change in mental health in males over time, *f*(3, 12) = 3.27, *p* = .059, but there was a significant change for women over time, *f*(3, 27) = 5.81, *p* = .003.

Table 2.6
Differences based on sex

	Baseline		2 Month		4 Month		6 Month	
	Male	Female	Male	Female	Male	Female	Male	Female
MoCA	26.17 (1.94)	25.08 (2.54)	26.50 (1.52)	26.33 (2.23)	26.33 (1.37)	27.50 (2.05)	26.40 (.89)	28.10 (2.33)
PAS-CD	1.50 (1.38)	2.13 (1.74)	.20 (.45)	1.73 (2.24)	1.17 (1.60)	.94 (1.28)	.40 (.89)	.78 (.97)
PAS-CI	2.17 (1.47)	1.81 (1.30)	.67 (.82)	1.67 (1.50)	.83 (1.17)	1.17 (1.80)	.80 (1.30)	1.20 (1.23)
AQoL-8D								
Total	.89 (.04)	.80 (.14)	.90 (.04)	.80 (.15)	.93 (.04)	.78 (.19)	.95 (.04)	.84 (.13)
Mental	.59 (.10)	.49 (.17)	.63 (.12)	.51 (.18)	.67 (.12)	.48 (.19)	.74 (.11)	.52 (.14)
Mental Health	.76 (.12)	.64 (.09)	.78 (.13)	.65 (.10)	.83 (.10)	.68 (.12)	.86 (.12)	.70 (.10)

Note: Data presented in means and standard deviations.
MoCA, Montreal Cognitive Assessment; PAS-CI, Psychogeriatric Assessment Scale – Cognitive Impairment; PAS-CD, Psychogeriatric Assessment Scale – Cognitive Decline; AQoL-8D, Assessment of Quality of Life – 8 Dimension

2.5 DISCUSSION

There are various benefits to maintaining a physically active lifestyle. While the research on the topic of physical activity and cognition has been somewhat varied, it can generally be stated that being physically active is beneficial (Barnes, Yaffle, Satariano & Tager, 2003; Booth et al., 2000; Busse et al., 2009; Heyn, Abreu & Ottenbacher, 2004), and the more active one is the more benefits they will obtain (Heyn, Abreu & Ottenbacher, 2004). In this study we saw an improvement in objective (measured) and subjective (reported) measures of cognition and QoL over a six month period among older adults who self-reported memory problems despite the fact that physical activity levels fluctuated during the 6 month intervention. While there are a number of extraneous variables that could be responsible for this improvement, such as simply being aware of their cognition and trying to improve it, it is likely that being physical active had an influence. Many subjects had a high level of physical activity to start with, and although activity levels typically drop during the winter, it is possible that their activity was still at a sufficient level. Although there was no dose-response effect of physical activity (low vs. high compliance), the overall improvement could suggest that at least some activity is beneficial. Interestingly, differences were found between men and women, with women experiencing greater improvements in cognition and men experiencing greater improvements in QoL.

Our findings are in agreement with other studies that demonstrate physical activity, at any level, is beneficial for individuals. While research has indicated that more activity is better (Heyn, Abreu & Ottenbacher, 2004), it has also been shown that being active at any level can reduce the level of cognitive impairment, and potentially reduce the prevalence of dementia (Busse et al., 2009).

2.5.1 Physical Activity

It was expected that there would be differences in the level of physical activity based on education (Parks et al., 2003). However, no differences were found in the present sample. It is possible that because there was very little variation in the amount of education subjects had, with most having advanced degrees, there was not enough variability to detect an effect. Overall, the sample was highly active, which would be expected given the high level of education (Crespo et al., 2000).

Although there was no dose-response effect of the intervention, there were still positive benefits from participation in the physical activity intervention. Interestingly, according to the activity counts, activity levels actually slightly decreased over the 6-month period. We noted that lower activity counts coincided with the winter months. A review of several studies found that bad weather was a major factor in reducing levels of physical activity, particularly in older adults, as they had significantly lower levels of activity in the winter (Tucker & Gilliland, 2007). Older adults are at greater risk for falls, and experience more severe and long lasting impacts of injury; thus they are likely to reduce their activity in poor weather conditions to mitigate this risk. If the project had taken place over the summer, it is likely that physical activity levels may have been higher, as it is easier to be active outdoors in the summer than in the winter. Despite having access to an indoor track, leaving the house during the winter can be difficult for older adults who are at a greater risk of slips and falls due to snow and ice.

While previous research indicates that more physical activity produces greater benefits (Heyn, Abreu & Ottenbacher, 2004), this was not supported in the present study. It is possible that due to the small sample size, high compliance, and the limited variability, it may have limited the power to detect a significant difference. Additionally, many subjects were active prior to the start of the study, and continued or increased their activity. Research indicates that maintaining an adequate level of physical activity can assist in producing a long term protective effect on cognition (Colcombe & Kramer, 2003). Despite not finding a difference based on level of activity, it should be noted that the majority of subjects achieved the recommended amount of physical activity at all three time points, over the six-month period. In addition to achieving high levels of activity, subjects also gained significant improvements in QoL and cognition.

2.5.2 Improvements in Cognition

The main purpose of the study was to determine whether providing advice to increase physical activity levels would improve activity and cognition. In fact we found that although physical activity did not improve over the 6 month intervention, cognition did. Direct measures of cognition, with the MoCA and the PAS-CI, did show significant change over time. Furthermore, there was no dose-response effect based on level of activity suggesting “more” was not necessarily “better”; overall cognition increased with both low and high levels of activity. Part of the improvement in cognition could be explained by practice effects and relatively high scores of subjects. However, we used two cognitive measures (MoCA and PAS-CI) and learning is minimized when using the MoCA because it has three validated versions which were randomized between trials. At baseline subjects scored on average 25, and two subjects were considered significantly impaired (scores below 22); at post-test the average score was 27 (considered unimpaired), and no subjects were significantly impaired. The PAS-CI only has one validated version, which could allow practice effects however the gap between administrations was 2 months which likely minimized that possibility.

A review of the literature conducted by Lautenschlager and colleagues (2012) regarding the effect of physical activity on cognition in older adults found a positive effect. Through comparing the hazard ratios of cognitive decline for high levels of activity (hazard ratio = 0.62) and low-to-moderate levels of activity (hazard ratio = 0.65), there was little difference (Lautenschlager, Cox, & Cyarto, 2012). As compared to being sedentary, both levels of activity have a significant reduction in the risk of developing a cognitive impairment. This suggests that leading an active lifestyle, regardless of the level, may improve cognition as compared to a sedentary lifestyle.

Informants, who were close and interacted regularly with the study subjects also reported that subject's cognition showed significant improvement over time (a decrease in PAS-CD). Furthermore, when informants were asked to assess changes in cognition over time, using the IQCODE, they reported that although they felt their cognition had declined before the intervention, its remained stable during the intervention. This suggests that although informant reported cognition did not significantly improve during the intervention, it may be possible that the rate of decline slowed.

Differences based on sex were found for the cognitive scores, with women demonstrating greater improvement than men. In both the MoCA and the PAS-CD, when analyzed independently, women demonstrated a significant improvement, but men did not. Some research regarding physical activity interventions has found greater changes when the majority of the sample is women (Colcombe & Kramer, 2003). Research into the associated neurological factors indicated that estrogen may provide a protective effect (Garcia-Segura, Cardona-Gomez, Chowen & Azcoitia, 2000). The interaction of estrogen receptors with insulin-like growth factor-I receptors may aid in neuroprotection and help neurons to survive, thereby preventing cognitive processes from declining. However, there has not been a great deal of research on the impact of the estrogen receptors, and further research is required to determine if other biological differences also have a significant impact.

2.5.3 A Walking Program is Positively Associated with Quality of Life

The final results from the AQoL-8D indicated that the total score, *mental* score, and mental health subscale were significantly different than at baseline. This echoes previous research that indicates being physically active can be beneficial for mental health (Richardson et al., 2005; Roe & Aspinall, 2011). Roe and Aspinall (2011) investigated the effects of walking on mental health in adults and found that increased levels of activity (walking) were associated with improvements in mental health. They found that individuals who started off with poorer mental health experienced greater benefits than individuals who started off with good mental health. The current results fit with previous research, indicating that incorporating physical activity into one's life can positively benefit their mental health (Richardson et al., 2005). Previous research has suggested that QoL is indirectly affected by physical activity, which works through physical health and mental health status (McAuley et al., 2006). An important factor in being able to participate in society, as opposed to being isolated, is one's health. If one is unhealthy they will be unable to participate in daily life, but improved health can help to encourage social behaviors.

Despite subjects reporting significantly higher QoL after the program, the informant's perception of the subject's QoL was that there was no change. There could be several explanations for this difference. First of all highly personal factors may be difficult for an informant to judge. Furthermore, the informants reported that subject's QoL scores were high at baseline (2 or above on a scale 0-3) so there was little room for change suggesting a ceiling effect (Terwee et al., 2007). Additionally, informants may be influenced by a social desirability bias and not want to report low QoL for their friend/family member. While social desirability does tend to impact informant scales less than subject scales, it still has a large impact on scale variance (Pavot & Diener, 1993). It has been suggested that rather than viewing social desirability as a confounding factor, it could be indicative of factors such as social conformity. There are also other factors present that could impact information provided by informants, such as relationship quality and informant characteristics, such as their mental state, including depression or anxiety (Jorm, 2004). For individuals who prefer to keep details about their life private or who are not close with family or friends, the reliability of information may be reduced. Informant opinions of a subject's QoL are highly subjective and may be difficult to interpret, as they are typically unaware of everything affecting the subject at any given time.

Differences in QoL based on sex were also found, with men experiencing greater overall improvements than women. Men showed significant improvement in the total AQoL-8D score and *mental* super dimension, whereas women did not. On the mental health subscale, however, women demonstrated greater improvements than men. However, this may be the result of baseline differences, in which men started at a higher level of mental health. Alternatively, previous research has suggested that women obtain more benefits from physical activity interventions than men do (Colcombe & Kramer, 2003). Although research has suggested that the presence of estrogen has benefits for maintaining cognitive performances (Garcia-Sequra et al., 2000), whether the same mechanisms are responsible for improvements in QoL requires further investigation (Colcombe & Kramer, 2003).

2.5.4 Limitations and Future Directions

There are several limitations in this study. One potential confounding factor is the presence of the Hawthorne Effect (McCarney, Warner, Iliffe, van Haselen, Griffin, & Fisher, 2007). This effect states that individuals who participate in either research or clinical trials may alter their behavior in response to being observed. Similar to social desirability, where participants modify their behavior to appear more favorable (Motl, McAuley, & DiStefano, 2005), the Hawthorne effect also suggests that the act of observing a behavior will modify how it is demonstrated. Factors such as contact with the researcher and the level of observation are defining features and make the extent of the effect difficult to quantify (McCarney et al., 2007). Research conducted by McCarney and colleagues (2007) indicates that the more contact researchers have with participants, the greater the intensity of the Hawthorne effect. Their study included four assessment points at two-month intervals, which is less than many other studies. They concluded that this level of contact had a small Hawthorne effect (McCarney et al., 2007). In the present study, the assessment periods were the same intervals as those utilized by McCarney and colleagues. This suggests that the effect of participating in the study may have had some impact on participants increased performance over time, but the extent of the impact cannot be directly determined.

The small sample size and lack of a control group also limits the interpretability of findings. Due to recruitment difficulties with the elderly population, the subjects were a convenience sample. The intention during the initial recruitment was to obtain individuals who had mild to moderate cognitive impairments and early stages of dementia. Additionally, the sample aimed to include individuals who had previously been sedentary.

None of the subjects had significant cognitive impairments (early stages of dementia), and most were relatively active prior to starting the study. Although there was some variation in the rates of which subjects adhered to the study, for the most part they maintained the desired level of activity. Additionally, the subjects were generally well educated, with the majority having obtained an education beyond high school. Some research has suggested that individuals who are more educated are more likely to be active (Parks, Housemann & Brownson, 2003). Finally, due to the small sample size there was no random assignment to groups; all subjects were given the same target level of physical activity.

Another limitation of the project was the scales utilized. Although the scales selected were based on previous research, there were design limitations. The recruited sample was significantly less impaired than anticipated, which may have limited the effectiveness the tests to detect differences as the selected tests are more effective in detecting severe levels of cognitive impairment (Jorm, 2004; Toglia et al., 2011). Finally, the Psychogeriatric Assessment Scales, although good and validated tests, frames the questions in terms of decline. For example questions ask if the subjects' memory has worsened over time, but does not ask if memory has improved. Although this is common in tests for older adults, as memory typically declines and does not improve in old age, it is a limitation for interventions trying to slow or reverse cognitive decline.

Future studies should use a randomized control trial and obtain a larger sample size to ensure there is more variability between participants. Additionally, by using a control group the effects of physical activity can be better observed. Future studies should also involve questionnaires that are non-directional and ask about change in cognition in either direction (improve or worsen).

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CHAPTER 3: A COMPARISON OF OBJECTIVE AND SUBJECTIVE MEASURES OF PHYSICAL ACTIVITY

3.1 INTRODUCTION

Being physically active is an important part of staying fit and healthy. While some individuals find it very easy to stay active, others require motivation to maintain an active lifestyle. By tracking activity levels and providing individuals with feedback regarding their progress, it can encourage them to improve their activity levels (Caildini & Goldstein, 2004). There are two main types of tracking physical activities; self-report measures (subjective) and direct measures (objective). Using self-report measures, the individual manually records what type of activity they completed, and any other pertinent information (such as duration or intensity). In automated measures, a physical device, such as a pedometer or accelerometer, is used to objectively measure the wearer's movements. Each of these methods can be effective, but there can also be some associated limitations (Prince, Adamo, Hamel, Hardt, Gorber, & Tremblay, 2008).

3.1.1 Self-Report Methods

Traditionally, self-report methods have been the most accessible to the general public. Activities can be recorded on paper, in an activity log, in a digital word document, or on an activity tracking website (such as MyFitnessPal, Total Coaching, and FitDay). One of the limitations of self-report methods is that they are dependent upon the individual finding time to record their activity. Users may begin by keeping a thorough log, but lose motivation over time and become less adherent with their record keeping (Tudor-Locke & Myers, 2012). Another limitation is that individuals need to accurately recall the type, duration, and intensity of their activities. If an individual delays a few hours or days before recording activities their data is at risk of a recall bias and time-related over or underestimation (Tudor-Locke & Myers, 2012). Self-report measures often also fall prey to a social-desirability bias (Adams et al., 2005; Caildini & Goldstein, 2004; Motl, McAuley & DiStefano, 2005). If individuals are sharing their log with others, as is possible with many of the online tracking communities, they may overestimate their activity, making themselves appear to be better or more active than what is actually the case. Finally, in order to keep an accurate log of activity, individuals need to accurately recall the amount of energy they exerted. Inexperienced individuals often overestimate their exertion when asked to recall this information (Prince et al., 2008).

Although there are limitations, there are also benefits to self-report methods of tracking physical activity. The most obvious benefit is the accessibility. Pen-and-paper activity logs are portable and can be accessed at any time. This ease-of-use may provide individuals with instant feedback and allow for more comprehensive reflection upon activity levels and goals. Additionally, online and digital activity logs can be stored for long periods of time without fear of losing data. Online tracking methods employ website tools or apps that can be accessed from mobile devices, allowing users to track their activity from anywhere.

3.1.2 Objective Methods

The second method of recording physical activity involves objective (often electronic) activity trackers. Advanced technology has made activity trackers more accessible and available to the general population. The two primary types of activity trackers are pedometers and accelerometers. Pedometers have a single axis that measures movement in only one direction (up and down), and typically counts the number of steps taken. Accelerometers are multiaxial - measuring acceleration in a number of directions, as well as movement intensity and speed. These features improve upon some of the limitations of pedometers, which are more sensitive to vibrations and can falsely track steps (Mekky, 2014). Additionally, pedometers are limited to being worn on the waist, whereas accelerometers can be worn on the waist, the wrist, or elsewhere.

In order to successfully track physical activity both pedometers and accelerometers need to be worn constantly, or else data gaps will occur in the activity log. While some devices are intended to be worn only during scheduled bouts of exercise, others are designed to track total daily steps and movement. Additionally, since the activity tracker usually requires synchronization with an external device (such as a computer, tablet, or mobile phone), information may not always be readily available to the user.

Despite advancing technology there are still limitations to the devices hardware. Particularly for wrist-worn activity trackers, slight movements may not be sufficient to register as having occurred (such as extremely short or slow steps), and other actions (such as rapidly shaking the hand) may cause overestimation the amount of action/steps taken. The whole body typically needs to be in motion in order to register activity (DC Rainmaker, 2014). Finally, because activity trackers are electronic, the battery will eventually need to be recharged or changed. Some devices can last for up to one year, and then require a new battery, while others only last a few days to weeks, but are rechargeable (DC Rainmaker, 2014).

Despite the drawbacks, there are a number of positive aspects about activity trackers. Many recent wrist-worn activity trackers are designed to be water resistant and can be worn for an extended period of time. The data that these devices collect typically include steps, distance, and calories; some devices also track sleep data and can connect to a heart rate monitor. These features allow for objective tracking of physical activity with little room for individual interpretation. As such, trackers are not subject to a social desirability bias, and only record activities that are actually done (within the limitations previously mentioned). This accurate feedback motivates users to reach their goals by showing what they have and have not accomplished (Mekky, 2014). With these devices growing in popularity and the increasing competition on the market, it is important for companies to promote devices that are able to accurately track a variety of activities. With all of the ways to measure daily activities, an individual can examine their 'quantified self' – the numbers (steps taken, calories burned, active minutes, etc.) associated with their activity level (Mekky, 2014).

3.1.3 Validation of Activity Trackers

Due to the increased popularity of activity trackers, both in research and in the general population, it is important to ensure that data captured by the devices is accurate and reliable. To this end several studies have examined the activity trackers currently available on the market. One of the most popular devices examined is the Fitbit activity monitor (Dannecker, Petro, Melanson & Browning, 2011). Some activities, such as walking, can take place either on a flat surface or at an incline, such as up a hill. The energy expenditure during inclined activities is greater than on a flat surface (Noah, Spierer, Gu & Bronner, 2013). While devices such as the Fitbit, Fitbit One, and Fitbit Ultra are good at calculating energy expenditure on flat surfaces, at an incline they tend to underestimate the amount of energy expended (Noah, Spierer, Gu & Bronner, 2013). The

Fitbit devices have the ability to classify activities (such as walking, running, and cycling) or to record general activity. Dannecker and colleagues (2011) found that calculations of energy expenditure were most accurate when activities were classified as a specific type. In terms of tracking step counts, as opposed to energy expended, the Fitbit One has shown good reliability (ICC $\geq$ 0.95) at various speeds (Takacs, Pollock, Guenther, Bahar, Napier & Hunt, 2013).

A study comparing five different activity trackers (Fitbit Ultra, Nike Fuelband, BodyMedia FIT Core, Adidas MiCoach, and Jawbone UP) was conducted by Stackpool (2013). Both energy expenditure and steps were analyzed in a sample of young adults. The researcher used a treadmill (with no incline), an elliptical, and sports-related exercises (agility). Comparing steps calculated by the devices to manual counting of steps found that for treadmill walking, treadmill running, and elliptical use, some devices (Nike and Fitbit) underestimated steps by 6-10% (Stackpool, 2013). Energy expenditure calculated by the devices was compared to a portable metabolic gas analyzer. It was found that activity trackers were the most reliable for treadmill walking, showed decreased reliability during treadmill running and elliptical use, and were unreliable in agility exercises. Energy expenditure was over estimated for treadmill walking and running, whereas for elliptical use and agility exercises energy expenditure was underestimated (Stackpool, 2013).

Companies wishing to tap into this market are constantly releasing new devices, and as such there are many devices that have been untested. While it is reasonable to assume that new versions of devices released by companies that have previously been tested will have similar or improved capabilities to previous devices (Noah, Spierer, Gu

& Bronner, 2013), the validity of new companies and their devices should be analyzed. Additionally, the majority of these studies have been conducted with healthy, young adults, and have not been explored in other populations (Stackpool, 2013; Takacs et al., 2013).

3.1.4 Garmin Vivofit Activity Trackers

One of the devices currently on the market is the Garmin Vivofit activity tracker. In March 2014 Garmin joined many other companies such as Fitbit and Nike in producing activity trackers available to the general population. Garmin has produced a line of activity trackers and smart watches, each with varying features. One device in particular that can be used for long term tracking is the Vivofit. One of the benefits of the waterproof Vivofit is its long battery life. The manufacturer omitted energy consuming options such as a backlit screen and automatic notifications (commonly seen in other devices), to extend the battery life to about one year. Although some users have stated that there are limitations with the company's website and connecting the device to the computer (DC Rainmaker, 2014), the online interface does provide a variety of useful information. The Vivofit has the capability of tracking steps, setting a daily step goal, tracking distance, calories, movement during sleep, and connecting with a heart rate sensor (Shin, Cheon, & Jarrahi, 2015). The Vivofit has shown to have similar limitations as other activity trackers; while energy expenditure for treadmill walking was underestimated, the device did respond to changes in inclinations (Alsubheen, George, Baker, Rohr & Basset, 2016), with greater inclines requiring increased energy expenditure than lower inclines. Additionally, it is relatively accurate when calculating BMR as compared to indirect calorimetry (Alsubheen et al., 2016). When validated for level and stair walking, compared to other devices, the Vivofit was one of the most accurate devices for stair climbing, with an error rate of less than 4% (Huang, Xu, Yu & Shull, 2016). This suggests that the Vivofit can be a good way to track physical activity levels.

3.2 STUDY RATIONALE

As a part of a six-month physical activity intervention, both objective and subjective measures of physical activity were gathered from the subjects. The purpose of this aspect of the study was to compare the two methods of data collection to determine if there are differences in the activities recorded and to examine the data collected from the Garmin Vivofit activity tracker (Prince et al., 2008). Throughout the study, subjects recorded their daily physical activity in a logbook. For three one-week periods an activity monitor was also worn. The question of interest here was the correlation between the activity tracker and the logbook to determine if individuals' subjective record of physical activity corresponded to the objective device. Changes in activity levels over time were also examined. While the validity of other devices have been more extensively tested (Dannecker, Petro, Melanson & Browning, 2011; Noah, Spierer, Gu & Bronner, 2013; Stackpool, 2013; Takacs et al., 2013), the Vivofit has not been as extensively examined, but has been shown to be on par with other devices (Alsubheen et al., 2016; Huang et al., 2016). Finally, the correlation between various factors that influence physical activity (previous use of a logbook, previous use of an activity tracker, etc.) will be examined to determine their relative impact.

3.3 METHODS

3.3.1 Participants

The study was approved by the institutional Health Research Ethics board. We aimed to recruit a convenience sample of 30 subjects for this study with an even proportion of women and men. Eligibility criteria included being age 65 or older and being able to walk 200 meters unassisted by another person. Posters and flyers were distributed to the local Seniors Resource Centre and Memorial University (MUN), and an email advertisement was sent out to the MUN Pensioners Association.

3.3.2 Materials

The study utilized two methods of tracking physical activity; a pen-and-paper logbook (subjective) and a Garmin Vivofit activity tracker (objective). The logbook was maintained by subjects for 26 weeks (six months), and consisted of double-sided letter size pages (see *Figure 3.1* for a sample page), with two recording boxes for each day. Subjects completed an "Activities" box and a "Notes" box. They were asked to list daily

Week of February 1–7 .

Date	Activities	Notes
Sunday 1		
Monday 2		
Tuesday 3		
Wednesday 4		
Thursday 5		
Friday 6		
Saturday 7		

Week of February 8–14 .

Date	Activities	Notes
Sunday 8		
Monday 9		
Tuesday 10		
Wednesday 11		
Thursday 12		
Friday 13		
Saturday 14		

Figure 3.1 *Sample activity log page*

physical activities in minutes and note any other pertinent information (such as illness or travel) that would affect their activity levels. The watch-like face of the activity tracker allows subjects to access information for the current day (steps, distance, and calories), which is reset automatically every day at midnight. As an incentive to keep active, at the top of the watch screen an 'activity bar' appeared red when activity was not detected in the previous hour or more (*Figure 3.2)*.

Figure 3.2 Garmin Vivofit activity tracker.

3.3.3 Procedures

This study was a subcomponent of the Seniors Physical Activity and Cognition (SPAC) study that involved a six-month intervention where subjects were encouraged to achieve 150 minutes of walking or other physical activities per week, as per Canadian Society for Exercise Physiology (CSEP) guidelines for physical activity for older adults (Tremblay et al., 2011). To encourage activity, all participants were given free access to the university track for the duration of the study. A full description of the methods can be found in Chapter 2. Subjects were instructed to keep a logbook of their daily physical activity, particularly walking, but also activities such as water fitness, going to the gym, sports, and household activities such as gardening, yard work, or cleaning. Due to limited availability of the devices, during weeks 1, 14, and 26 subjects also wore the Garmin Vivofit activity tracker for seven consecutive days, 24 hours a day (including during sleeping and water activities). In order to ascertain subjects' experiences using the logbook and the activity monitor, subjects underwent a semi-structured interview containing open ended questions at the completion of the intervention. Subjects were asked to describe their pre-study exercise experiences and use of activity monitoring, their perceptions of their activity levels, and to provide feedback on their experience during the study with the physical activity and tracking methods.

3.3.4 Data Analysis

Firstly, data was downloaded from the Garmin Vivofit devices via the Garmin Express app installed on a laptop. Data downloaded through the app is visible on the Garmin Connect website. Information is displayed in 24-hour segments (midnight to midnight). The day is broken down into four categories; sleeping, sedentary, active, and highly active. Amount of time spent in each category is presented in terms of percentages, and was manually converted to minutes for analysis. The classification of activity level is completed automatically by the device. Due to the lack of information regarding the distinction between "active" and "highly active" a third category was manually created; "total active" was computed by adding the amount of time spent in "active" and "highly active" categories. Step information is displayed as steps per 15-minute period and as a total for 24-hours. Activity data recorded in the logbook by subjects was manually totaled in terms of minutes per day and minutes per week.

After checking for normality, the relationship between physical activity derived from the Vivofit and the logbook was analyzed using Pearson's correlation (significance set at $p < .05$). To assess change in physical activity over time, a 2 measure (logbook and Vivofit) by 3 week (1, 14, 26) repeated-measures ANOVA was conducted. Follow-up analyses were conducted between the logbook and Vivofit at each time point with paired-samples t-tests. Pearson correlations were completed to determine the relationship between the information derived using the two methods. Correlations were also computed for the factors related to physical activity behaviours to determine if they were significantly related. For analyses where sphericity assumptions were violated, Greenhouse-Geisser corrections were employed. Data was entered into SPSS v22 with significance set at $p < .05$.

The qualitative interviews at the final meetings were audio recorded by the experimenter. The interviews were transcribed using a standardized format for the punctuation. Responses were organized by theme, and ordered from most to least frequently mentioned. Key quotes that embodied the theme were chosen to present.

3.4 RESULTS

3.4.1 Participant Characteristics

Of our initial goal of 30 subjects, 23 individuals responded to the recruitment ads. Eighteen of the individuals consented to participate in the study, but one was unavailable for the final testing session, and was excluded from the analyses. The final sample (women $n = 11$; men $n = 6$) was ages 65 to 79 ($M = 70.11$, $SD = 4.157$), and was highly educated, with 88% having obtained an education beyond high school. Subjects self-reported whether they had used any type of activity tracker or kept an activity log before participating in this study. Eight subjects (50%) reported that they had never previously used an activity tracker, seven subjects (43.8%) reported that they had used a pedometer before, and one subject (6.3%) reported using a ‘shoe chip’ (a measuring device worn in the shoe). In regards to previously tracked physical activity in a logbook, eleven subjects (68.8%) reported no experience, and five subjects (31.3%) reported they have used this subjective measure in the past.

Table 3.1
Self-reported (logbook) daily activity minutes when the Vivofit was worn

	Daily Activity Minutes
Base	51.9 (20.4)
Mid	48.0 (37.4)
Post	67.8 (63.4)

Note: Data is presented in means and standard deviations

3.4.3 Detecting activity change over time

The data was analyzed to determine if there was a change over time in levels of activity measured using objective and subjective methods. Activity levels were calculated from the total amount of steps taken, amount of time spent in “active”, in “highly active”, and in minutes of activity recorded in the logbook. Subjectively, when comparing the amount of activity recorded in weeks 1, 14, and 26 in the logbook (*Table 3.1*), there was a significant increase by an average of 16 minutes from baseline to study completion, $f(1.781, 197.728) = 1.779$, $p = .016$, in activity levels over the course of the 6 month intervention. Although subjective reports of activity increased over time, examining overall activity and total steps via objective methods found that subjects actually decreased their level of activity during the 6-month physical activity intervention (*Table 3.2*).

The amount of activity recorded by the Vivofit dropped marginally from baseline to the midpoint, and significantly increased at the post-test. Total steps was also significantly different at the various time points, with the highest amount of steps occurring at baseline, and the lowest amount at the midpoint, $f(1.779, 209.865) = 8.087$, $p < .001$. There was also a significant change in the amount of time subjects spent in the 'active category', $f(2, 236) = 4.570$, $p = .011$. The active category followed the same trend as the total steps, the highest level of activity was recorded at baseline, and the lowest at the midpoint. There was no significant difference over time in the highly active or total active categories.

In order to determine if the data collected by the Vivofit and the logbook aligned with subject's perceptions of their own physical activity, at the end of the study subjects were asked whether they felt their activity over the last six months decreased (three subjects), remained consistent (five subjects), or increased (eight subjects). These perceptions were compared to the activity recorded in the logbook by comparing the significant change in activity level over time based on reported change (decrease, consistent, and increase; *Table 3.3*). We found inconsistencies between subjects' reports and the data collected in the logbook. Significant differences in activity recorded in the logbook was found for the groups that reported no change (consistent) and a decrease in activity. The subjects who reported a decrease in their activity had a significant change over time, $f(2, 4) = 16.557$, $p = .012$, the group that reported no change was marginally significant, $f(2, 8) = 4.239$, $p = .056$, and the group that reported an increase was not significant different over time. For the subjects that reported a decrease in their activity, the data shows a large drop in activity at the midpoint based on their self-reported logbook, but the change from baseline to post-test was not significantly different. For subjects that reported no change, their activity increased from baseline to the midpoint, but there was not a significant difference between the midpoint and post-test. Means and standard deviations can be found in *Table 3.3*. In terms of data collected by the activity tracker, there were no significant differences in the activity tracker data based on reported change. This means that whether the subjects described their physical activity levels as decreased, increased, or consistent, the activity tracker data did not align with those perceptions, potentially indicating a recall bias in the logbook data.

Table 3.2
Amount of activity recorded by the Garmin Vivofit

	Active	Highly Active	Total Active	Total Steps
Base	177.6 (65.6)	59.0 (39.8)	236.6 (81.5)	8905 (5585)
Mid	156.5 (86.3)	58.0 (36.6)	214.6 (97.4)	6846 (3717)
Post	168.3 (69.4)	55.8 (38.1)	224.1 (86.0)	7386 (3784)

Note: Data is presented in minutes per day for active, highly active, and total active, and in amount of daily steps for total Steps. All data is presented in means and standard deviations.

Table 3.3
Amount of activity divided by reported change

Reported Change		Logbook	Activity	Total Steps
Decrease (n=3)	Base	65.7 (7.1)	151.5 (57.6)	7271 (2250)
	Mid	14.3 (24.7)	128.2 (67.0)	4528 (2143)
	Post	68.6 (66.4)	150.8 (36.9)	7183 (2725)
Consistent (n=5)	Base	43.3 (24.7)	202.8 (25.7)	9550 (2870)
	Mid	65.0 (36.2)	160.8 (41.5)	7278 (2177)
	Post	64.7 (58.5)	173.2 (27.1)	7490 (1804)
Increase (n=8)	Base	55.0 (18.8)	186.2 (50.1)	8824 (2479)
	Mid	54.7 (36.5)	183.6 (78.2)	8176 (2368)
	Post	69.5 (73.3)	182.0 (70.3)	7894 (3293)

Note: Data is presented in minutes per day for logbook and activity, and in daily steps for total steps. All data is presented in means and standard deviations.

3.4.4 Comparing subjective and objective methods

In order to determine if the data collected subjectively in the logbook was similar to the data collected using the Vivofit activity tracker, outputs were compared between the two methods at baseline (week 1), midpoint (week 14), and post-test (week 26). Due to the lack of information regarding the distinction between how the "active" and "highly active" categories are calculated by Garmin, logbook data was compared to both categories. There was a significant difference between minutes of activity recorded in the logbook and total 'active' minutes recorded by the Vivofit, with the Vivofit recording about three times more physical activity minutes than recorded in the logbook at baseline ($M_{difference}$ = -128.756, *SD* = 79.936), $t(118) = -18.571$, $p < .001$, at midpoint ($M_{difference}$ = -113.457, *SD* = 86.020), $t(118) = -14.388$, $p < .001$, and at post-test ($M_{difference}$ = -105.630, *SD* = 100.162), $t(111) = -11.161$, $p < .001$. Vivofit data categorized as 'highly active' was more similar to the minutes of activity in the logbook. There was no significant difference between the logbook and highly active category at baseline ($M_{difference}$ = -7.988, *SD* = 66.185), at midpoint ($M_{difference}$ = -11.366, *SD* = 70.612), or at post-test ($M_{difference}$ = 11.498, *SD* = 110.144). This suggests that what subjects consider being physically active is more closely related to the 'highly active' category in the Vivofit. The means and standard deviations can be found in *Tables 3.1 and 3.2*.

The correlations between the subjective (log book) and objectives (Vivofit) measures of physical activity were tested at each time point. Correlations between the measures at baseline can be found in *Table 3.4*, midpoint can be found in *Table 3.5*, and post-test can be found in *Table 3.6*. At baseline there was no significant correlation between the logbook and any of the four categories of the Vivofit activity data. At midpoint, there was a significant correlation between Vivofit data in the active, total active, and steps measures with minutes of activity in the logbook. At the post-test, there were also significant correlations between the Vivofit data in the active and total active measures with the logbook data. The highly active category was not significantly correlated with the minutes in the logbook at any time point.

To determine if previous use of subjective activity tracking methods influences accuracy of subjective reports, correlations between the Garmin Vivofit and the logbook were also tested based on subjects self-reported previous use of a logbook to track

Table 3.4
Baseline correlation coefficients

	Log	Active	Highly Active	Total Active	Steps
Log	—	.075	-.005	.059	.132
Active		—	.144	.876*	.411*
Highly Active			—	.604*	.314*
Total Active				—	.478*
Steps					—

Note: Correlation between the various baseline measures of activity.
* indicates significance at $\alpha = .01$.

Table 3.5
Midpoint correlation coefficients

	Log	Active	Highly Active	Total Active	Steps
Log	—	.356*	.051	.338*	.307*
Active		—	.107	.926*	.728*
Highly Active			—	.474*	.549*
Total Active				—	.853*
Steps					—

Note: Correlation between the various midpoint measures of activity.
* indicates significance at $\alpha = .01$.

Table 3.6
Post-test correlation coefficients

	Log	Active	Highly Active	Total Active	Steps
Log	—	.378*	.014	.307*	.154
Active		—	.214*	.901*	.717*
Highly Active			—	.616*	.565*
Total Active				—	.829*
Steps					—

Note: Correlation between the various post-test measures of activity.
* indicates significance at $\alpha = .01$.

Table 3.7
Logbook and Vivofit correlation coefficients

Previous Logbook		Active	Highly Active	Steps
No	Baseline Log	-.005	.082	.124
	Midpoint Log	.373**	.001	.329**
	Post-test Log	.373**	.044	.122
Yes	Baseline Log	.199	-.213	.168
	Midpoint Log	.168	.291	.374*
	Post-test Log	.309	.061	.423*

Note: Correlations between activity reported in the logbook and the Garmin Vivofit at each time point based on self-reported previous use of a logbook.
** indicates significance at $\alpha = .01$.
* indicates significance at $\alpha = .05$.

activity. Correlations can be found in *Table 3.7*. Objective and subjective data were better correlated at midpoint and post-test than at baseline regardless of previous use of an activity log.

3.4.6 Activity tracking from the subjects' perspective

During the informal interview subjects were asked to comment on the use of the logbook and the activity tracker. Overall, these older subjects felt that using the Vivofit was a positive experience. It was simple to use and preferable to the logbook. For example comments, such as the one by Participant 11 below, were quite common.

> "It's something I would like to keep doing that's why I got this, the Vivofit, as opposed to the logbook because with this you can stick it on your arm and just go on and with the logbook I keep it by the computer so it's pretty obvious to me so I don't forget to fill in time. But if I have a choice I use the Vivofit rather than the logbook" (Participant 11).

Before the start of the study, none of the subjects had used an accelerometer-based activity tracker before, but several subjects had experience using a pedometer. The type of pedometer they used was clipped to the waistband. Subjects commented that they preferred a wrist-worn activity tracker to one that is worn on the waist. In regards to the pedometer, some subjects commented “I had one that clips on and they fall off and they’re a nuisance” (Participant 5) and “I did have one there a few years ago. But I never found that it worked, I had one that you strap on your belt, and I didn’t find that it worked very well” (Participant 3).

In contrast to the pedometer, with which subjects were generally not impressed, they had numerous positive comments regarding the activity tracker. Some of the subjects found it to be motivating, although with some limitations.

> “I thought that it was a real motivator. In fact a lot of people have noticed it on me and asked ‘do you find it motivates you?’ and I said ‘definitely’. And two or three of them have purchased one, including my daughter, she purchased one” (Participant 3).
>
> “It was basically, as I’ve told you before, motivating. Um, I’m sure it made me do a bit more. I even bought one for myself… but um, yea I think they’re a good thing. It seems to me that the motivation effect would tail off” (Participant 2).

Despite the motivation effect possibly wearing off, many subjects enjoyed using it to quantify their activity, which is something they did not report doing regularly on their own. Additionally, subjects said it was “fun watching the steps accumulate through normal activities of the day” (Participant 10).

> “I found it excellent actually, I really, I found myself checking it several times a day and I was really pleased with how much I had already walked, because you’re really not conscious of how many steps you walk a day” (Participant 5).

> "I guess I knew any time I wanted to, I could see how much I walked in that day because I really don't know, and with the house we live in a lot of my walking is up and down the stairs" (Participant 7).
>
> "It surprised me actually the first time you told me the results, that I was walking so much, just on a day to day basis" (Participant 11).
>
> "I thought it really good because it was something you would look at and you would know what you were expected to do" (Participant 15).

There were still some criticisms, such as not knowing how it calculated the activity, and difficulties getting it on and off. Despite this, the comments regarding the Vivofit were generally positive. As previously stated, although some subjects found the activity tracker motivating, it was identified that the motivation effect would wear off after time.

> "I'm a bit curious at the beginning how it work, after that you basically forget you have it on and go on about life as normal" (Participant 16).
>
> "I thought it was good, it was really good, it was a motivator too. And it was interesting to see how much you'd done" (Participant 14).
>
> "I honestly don't think it made any difference, I did what I did for other reasons" (Participant 9).

Another benefit of the activity tracker was that it was a consistent recording of subjects' activities. It wasn't dependent on their memory of what they did, or social influences. As one subject said, "it was a real indicator of what we were doing, and if you weren't doing anything it was a real indicator" (Participant 12). The activity tracker was a way for subjects to see what they have done and what they still need to do to be active.

Many subjects also reported benefits from being physically active, such as weight loss, improved flexibility, endurance, and were more active overall.

> "After I saw the one that we were using in the study, and it kind of encouraged me to put steps into my life, and I bought one, and I will certainly use it. But I won't track my steps on paper, I will do it on the computer, but I will be more conscious especially when that light is ready, I need to move" (Participant 15).

When asked about the logbook, most subjects did not have the same enthusiasm for it as they did for the activity tracker. While one subject said that they did like using the logbook, another admitted that they did not like it and did not use it during the study. For the most part, subjects reported difficulty remembering to complete the logbook. One subject commented, "if I could speak into something and say what I did it would be fine, but to write it down was hard" (Participant 6). Other subjects commented "I kept forgetting the logbook" (Participant 5) and "it's the sort of thing that has a tendency to get lost on my dining table" (Participant 2). Forgetting to fill in the logbook was stressful for some of the subjects, and felt that other methods of recording activity would be easier.

> "Oh I found it difficult… it made me anxious when I forgot to put things in and had to say 'did I go for a walk that day or not?'" (Participant 1).

> "It was something you need to have in a small form and attached to you or your computer or phone, because sometimes I didn't record activity until several days later and you have to remember was it Tuesday or Wednesday. One time when I left the province I forgot to take it with me and I had to write it down when I got back. So if you're not used to doing it it's an inconvenience" (Participant 16).

Finally, some subjects commented on the feasibility of physical activity across seasons in Newfoundland and Labrador. One subject remarked "I find it very difficult to walk in the winter with the ice and the snow and the fear of falling down and breaking something" (Participant 6), and another said that she would be travelling down south next year because of the difficulties with the snow (Participant 9). Being physically active during the winter is difficult and a cause of concern for many individuals.

3.5 DISCUSSION

The use of activity trackers in research is growing (Alsubheen et al., 2016; Dannecker et al., 2011; Dishman, Washburn & Schoeller, 2012; McClain & Tudor-Locke, 2009; Prince et al., 2008). It is important to ensure that trackers used, both in research and by the general population, are providing accurate information to their users. While companies do state that their devices are not medical devices (Garmin, n.d.), they can still be very beneficial in helping individuals to reach their activity goals. In this study we aimed to compare subjective amounts of activity (in a logbook) to activity measured using an objective device (Vivofit). Although there was some correlation between the Vivofit data and the subjective recordings, the overall correlations were weak.

Although the two methods of data collection were not correlated, seasonal activity patterns among subjects were captured using both methods. For example, there was a significant difference in activity over time recorded in the logbook, in the total steps, and in activity recorded by the Garmin Vivofit; the first time point had the highest level of activity, the second time point had the lowest level of activity (corresponding to winter), and the third time point was somewhere in the middle. At the second time point the logbook showed the lowest level of activity, but more activity was recorded at the third time point than at the first time point. A possible explanation for the drop in activity around at the second time point may be due to environmental factors. The study began in October/November, with the midpoint measures being taken around January/February, and the final measures were taken in April/May. Due to extreme amounts of snow during the winter months (January/February) in Newfoundland and Labrador, the mobility of individuals, particularly older adults, could have been curtailed. Previous research by Tucker & Gilliland (2007) found that physical activity is significantly impacted by weather; poor weather or extreme weather conditions were a significant barrier to physical activity among individuals. It is suggested that studies attempting to promote physical activity utilize indoor activities to enhance active behaviors (Tucker & Gilliland, 2007). Although participants were provided unlimited access to the MUN track, the ability to travel to the facilities may have been impaired. Importantly both methods seemed to detect this change in behavior.

There was a low level of correlation when the activity recorded in the logbook was compared to the activity captured by the Garmin Vivofit. This finding is consistent with previous research (Prince et al., 2008) that found a low-to-moderate relationship between direct and self-report measures of physical activity. These findings suggest that subjects were not accurately recording their activity in the logbook in the same way it was recorded by the Garmin Vivofit. It has been documented that there are several limitations in considering self-report methods of physical activity. Based on previous research and the evidence from the current study, it can be assumed that the information provided in the logbook may serve as a general guide to subjects' level of activity, but does not have a high degree of accuracy. In the present study, as well as previous research, there is no clear trend – some studies have found activity recorded exceeded what was completed, whereas other studies have found activities were underreported (Prince et al., 2008). This may be due to competing biases (social desirability bias and recall bias), or to individual differences.

When using any type of device to capture information, it is important to understand how data is categorized. One of the limitations of using a device such as the Garmin Vivofit is that there is no publically available information regarding how levels of activities are calculated by the device. As such, the distinction between the amount of time spent in the "highly active" and "active" categories is unclear. Using paired samples t-tests, the amount of time spent in each category was compared to the amount of time recorded in the logbook. The times in the logbook were not significantly different than the "highly active" time recorded in the Garmin Vivofit. This suggests that the activities subjects considered worthy of recording in an activity log are most closely related to "highly active" in the Garmin Vivofit.

While the Vivofit automatically classifies activities as either "highly active" or "active", the "total active" category was created by summing the other two categories. This way all activity undertaken throughout the day was included in the analysis, as the other two categories not included are "sedentary" and "sleeping", which record when individuals are not active. The "total active" category was significantly correlated with the logbook at two of the three time points. Although the correlation was not as high as the "active" category, it still attained significance. In cases where the distinction between level of activity is not important, or where ensuring that all activity of a particular type is captured, using a combined measure may be useful. The nature of the Vivofit's systems, along with many other activity trackers, are considered ‘invisible’ as the user has little to no knowledge regarding their inner workings (DC Rainmaker, 2014). This suggests that before determining how well an activity tracker records activity, it must first be determined how activities are classified and categorized on a particular device. Presently, the Vivofit category of “active” and “total active” seem to correspond with what individuals consider being active, and the category of “highly active” underestimates what people consider to be active. In the future, activity tracker developers should provide methods to extract raw data to allow greater granularity for research purposes.

The categorization of physical activity by the various activity trackers can present difficulties for researchers. Whereas the Garmin Vivofit classifies activities as time spent being “active” or “highly active”, other devices allow users to classify specific types of activities (Dannecker et al., 2011). With little information regarding how activities are classified by activity trackers, it is difficult to know exactly which types of activities are being captured by the device. To that extent, the analysis of the different activity categories on the Vivofit indicates that what subjects reported as activity in their logbooks were correlated with the “active” and “total active” categories of the Vivofit.

Overall, the lack of correlation between the logbook and the Garmin Vivofit is important to note for future use. Although logbooks may provide general activity information, wearing an activity tracker will provide more accurate information for researchers. Additionally, collectively the subjects preferred to use the Vivofit rather than the logbook. Although there was one subject who enjoyed writing his activity and journaling, he still found the Vivofit to be very convenient; other subjects generally found using the Vivofit much easier. Importantly, the Vivofit was acceptable to this group of older subjects. While many activity trackers are marketed to young and healthy individuals, such as pro and amateur athletes, they can also be important for individuals who are older and less active. The use of activity trackers by older adults to record their activity levels, and possibly try and improve their physical well-being, is an important area to consider. Despite the stereotype that older adults are opposed to new technologies, the use of activity trackers with this group seemed to be an overall positive experience.

3.5.1 Limitations

When it comes to recording physical activity, there will always be limitations. With self-report methods, it is dependent on individuals remembering to fill it out, as well as remembering what activities they did so that the record is accurate. It is also subject to several biases, such as a recall bias and a social desirability bias, which can cause it to be inaccurate (Adams et al., 2005; Motl, McAuley & DiStefano, 2005). With objective measures of physical activity, such as the Vivofit, the fact that there is little information regarding how the activity is actually calculated is somewhat limiting. Additionally, the physical construction of the device may be a limitation factor. Waist-worn clip on pedometers and activity trackers are generally considered to be a nuisance, but sometimes wrist-worn activity trackers can be hard to get on or off, or they may fall off depending on the mechanism used to keep it on. The physical design of an activity tracker can greatly impact the decision of an individual regarding which device to use. Devices that are secure, but also relatively easy to remove (such as a normal watch band) may improve wearers' opinions.

The present study had some specific limitations. One of the main limitations was the small sample size. While this can be a common problem, it does limit the ability to reach statistically significant results and to be able to generalize results to a larger population. Additionally, the objective activity trackers were utilized for only three weeks rather than during the entire study. The continuous use of activity trackers could provide a complete picture of an individuals' activity levels. Finally, the study was not designed as a qualitative study per se, limiting the rigorousness of the analysis of interview data. Future studies should engage older users to gain a deepened perspective on activity tracking technology.

An important factor in tracking activity accurately is compliance. With the logbook, one subject admitted to not using it, while many others commented that they found it difficult or forgot at times, suggesting the accuracy may not be very good. As for the Vivofit, all subjects used the device and noted the ease of use. Due to these factors, as well as the subjects' opinions regarding the methods of tracking physical activity, it is likely that using objective measures, such as the Garmin Vivofit activity tracker, are better than using self-report measures.

3.5.2 Future Recommendations

Based on the results of the present study, including the opinions of the subjects, the Garmin Vivofit activity tracker was the better method to capture physical activity. Some of the subjects did mention that the objective activity tracker helped keep them honest and motivated them to stay active. Additionally, many subjects chose to purchase their own activity tracker for personal use beyond the completion of the study. It is likely that motivation was still a factor in subjects' activity levels, but the present methods were not sensitive enough to detect them.

The logbook was useful as a guide to the subjects' engagement in specific activities, but lacked accuracy compared to the activity tracker. A possible improvement to using self-report methods would be to train subjects in the recording. While some of the issues such as remembering what activities have been done and to write them down are more difficult to address, issues such as determining the intensity of activity can be addressed through participant training. One benefit of the logbook is that it allows individuals to keep track specifically of what is important to them. If the logbook is used for a directed purpose or in combination with an activity tracker, it may have some benefits. As a measure of overall physical activity, it was inaccurate. Despite this, logbooks are not completely meaningless as they can be useful for individuals' personal reflections and tracking general changes over time.

3.5.3 Conclusion

The use of activity trackers by the general population is growing as new devices are regularly released by companies, eager to tap into this market. While some early activity trackers (such as the Fitbit) have been validated, newer devices have not yet undergone the same scrutiny. Although further research regarding the capabilities of the Garmin Vivofit are required, it appears to be on par with similar devices.

In terms of tracking physical activity the activity tracker was the best method. In addition to providing various types of data (minutes of activity, number of steps, distance walked, etc.), subjects also rated it quite favorably. While there is some uncertainty to the formula used to classify different activity levels the Vivofit provides a more comprehensive picture of an individual's activity over time. Future studies should attempt to make use of objective methods of activity trackers whenever possible. These affordable devices provide a wealth of information. Although logbooks may provide some general information, for determining specific levels of activities, objective activity trackers are the best method to use in future research.

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CHAPTER 4: COMPARISON OF SUBJECT AND INFORMANT MEASURES OF COGNITION AND QUALITY OF LIFE

4.1 INTRODUCTION

When measuring factors related to individuals' mental and health status, it is important to have valid and reliable tests that provide accurate information. In many cases subjects can be studied directly, and answer questionnaires regarding their current status. However, this is not always possible. Some individuals, such as those with significant cognitive impairments (i.e. dementia), may be unable to answer questionnaires. Problems may also persist for individuals with language barriers, communication difficulties, or other significant impairments (Ettema et al., 2007a). In situations such as these it is important to still be able to gather information regarding a subject. One solution is to use informant questionnaires; rather than asking questions directly to an individual, the questions are asked to a caregiver, family member, or friend who is able to provide information on their behalf.

Quality of life (QoL) and cognitive functioning are two areas where informant questionnaires can be utilized. Quality of life is defined as one's satisfaction with their life (Rejeski & Mihalko, 2001), and cognitive functioning relates to a range of mental capabilities that moderate how well one is able to interact with the world around them (Lautenschlager, Cox & Kurz, 2010). Cognitive functioning can include a wide range of mental capabilities that moderate how we perceive and interact with the world around us; cognitive impairment occurs when these mental capabilities become damaged and their effectiveness is reduced. When one's faculties are impaired, going about daily life is challenging and can lead to difficulties coping, reducing their overall QoL. There are a variety of tests that assess each of these aspects of an individual's life. It is important that the information gathered from both subject and informant questionnaires is reliable as it could potentially have a large impact on interventions in a subject's life.

4.1.1 Cognitive Assessments

There are a number of tests that assess cognition by either directly testing the subject or asking questions of an informant. Tests such as the Montreal Cognitive Assessment (MoCA; Nasreddine et al., 2005) and the Mini Mental State Exam (MMSE; Folstein, Folstein & McHugh, 1975) are administered directly to a subject, whereas tests such as the Informant Questionnaire on Cognitive Decline in the Elderly (IQCODE; Jorm & Jacomb, 1989) are administered to an informant. Alternatively, some tests such as the Psychogeriatric Assessment Scale (PAS; Jorm & Mackinnon, 1995) contains subscales for both directly assessing a subject and for gathering information from an informant.

The MMSE contains 11 questions (covering areas of cognition such as orientation, memory, and verbal fluency), and has good reliability and validity, but there are limitations regarding the aspects of cognition that are covered (Folstein, Folstein & McHugh, 1975). The MoCA assesses cognition in eight areas (visuospatial, naming, memory, attention, language, abstraction, delayed recall, and orientation). The internal reliability is higher than for the MMSE. The MoCA also has a reduced ceiling effect, and covers more aspects of cognition compared to the MMSE (Toglia et al., 2011).

The IQCODE uses a Likert scale from 1 (much improved) to 5 (much worse) to gather information from an informant regarding a total of 26 activities (Jorm, 1991). This questionnaire, administered to an informant, asks them to compare how the individual currently is to how they were ten years ago in terms of a number of items. For example, a question regarding recalling names would be phrased "compared with ten years ago how is this person at recall names of family and friends"; the informant would them respond on a scale from much worse to much improved. The Psychogeriatric Assessment Scale can be used to assess changes in cognition, as well as stroke and depression. The PAS contains both subject (Cognitive Impairment; PAS-CI) and informant (Cognitive Decline; PAS-CD) subscales that contain 9 and 10 questions, respectively, regarding changes in cognitive functioning (Jorm & Mackinnon, 1995).

4.1.2 Quality of Life Assessments

To assess QoL, the Assessment of Quality of Life – 8 Dimension (AQoL-8D; Richardson et al., 2011) has 35 items divided into two super dimensions, mental and physical, each containing three and five dimensions, respectively, that are asked directly to the subject. The mental super dimension contains questions regarding happiness, self-worth, coping, relationships, and mental health; the physical super dimension contains questions regarding independent living, senses, and pain. There are a number of versions of the AQoL, each with a different number of items and dimensions. The Qualidem (Ettema, 2007a) assesses QoL through 40 questions divided into nine subscales asked to an informant, typically a professional caregiver. The questions cover categories such as relationships (social and caregiver), affect (positive and negative), restless behaviour, self-image, and feeling at home. The Qualidem was initially developed to screen for dementia in a residential care setting. To the best knowledge of the authors, this test has not yet been validated for community dwelling older adults who do not have a professional caregiver working with them.

4.1.3 Internal and External Reliability

Although tests of cognition are usually effective on their own, research suggests that their effectiveness is increased when combined with other scales (Mackinnon & Mulligan, 1998). To that end, it is important to ensure that scales have a high internal reliability rating, but also that scales which are used together during assessments are significantly correlated with one another. The internal reliability of each of the tests has

Table 4.1
Reliability analyses

Test	Cronbach's Alpha	Reference
MMSE	.60	Toglia et al., 2011
MoCA	.78	Toglia et al., 2011
IQCODE	.95	Jorm 2004
PAS-CI	.58	Jorm et al., 1997
PAS-CD	.84	Jorm et al., 1997
AQoL-8D	.95	Richardson & Iezzi, 2011
Qualidem	.64	Ettema et al., 2007a

Note: Cronbach's Alpha ratings for each of the tests.
MMSE, Mini-Mental State Exam; MoCA, Montreal Cognitive Assessment; IQCODE, Informant Questionnaire on Cognitive Decline in the Elderly; PAS-CI, Psychogeriatric Assessment Scale – Cognitive Impairment; PAS-CD, Psychogeriatric Assessment Scale – Cognitive Decline; AQoL-8D, Assessment of Quality of Life – 8 Dimension

Table 4.2
Tests of cognition correlation coefficients

	MMSE	PAS-CI	PAS-CD	IQCODE
MMSE	---	-.77	-.42	-.61
PAS-CI		---	.46	.49
PAS-CD			---	.83
IQCODE				---

Note: Correlation coefficients between the various tests of cognition.
MMSE, Mini-Mental State Exam; PAS-CI, Psychogeriatric Assessment Scale – Cognitive Impairment; PAS-CD, Psychogeriatric Assessment Scale – Cognitive Decline; IQCODE, Informant Questionnaire on Cognitive Decline in the Elderly

previously been analyzed and is presented in *Table 4.1*. Additionally, correlations between some of the tests have already been conducted. The correlations can be seen in

Table 4.2 (Jorm et al., 1997; Jorm, 2004). The highest correlation is between the IQCODE and the PAS-CD, which is very similar.

Overall, the scales have a high level of internal reliability. The IQCODE and the AQoL-8D have the highest levels of internal reliability, indicating that the items in the test work well together to measure the same general construct, confirming they are very good tests to use. The IQCODE also has a high test-retest reliability over a 3 day period, $\alpha = .96$, and over one year, $\alpha = .75$ (Jorm, 2004). The test-retest reliability of the Psychogeriatric Assessment Scales has also been analyzed over a period of 3.6 years. Two of the subscales, cognitive impairment scale (PAS-CI), $\alpha = .59$, and the cognitive decline scale (PAS-CD), $\alpha = .66$, have adequate test-retest reliability, although not extremely high (Jorm et al., 1997). The author does note that these "are not reliability coefficients because they are affected by real change over the period as well as measurement error" (Jorm et al., 1997, p. 97).

When comparing the MoCA and the MMSE, it can be seen that the internal reliability of the MoCA is much higher than the MMSE (Toglia et al., 2011). Although the MMSE has been used for years to assess cognition, there is some evidence that the MoCA is a better test. However, the correlation of the MoCA with other tests has not been examined as thoroughly. The correlation of the MMSE is strongest with the subject scale of the PAS, although it is also strongly correlated with the IQCODE (*Table 4.2*). The negative correlation is due to the scoring of the tests. On the MMSE higher scores indicate better cognition, whereas for the IQCODE and the PAS lower scores indicate better cognition.

4.2 STUDY RATIONALE

The purpose of the present study is to further build on previous research and test the relationships between the various assessments. Firstly, although the MoCA is a better assessment tool than the MMSE, there has been little research investigating how well it correlates with other measures, such as the IQCODE, and the PAS subscales. Here, the correlation between the MoCA and the other cognition scales will be investigated. Second, the correlation between the subject and informant measures of QoL (the AQoL-8D and the Qualidem) will also be investigated. Additionally, the Qualidem has been primarily used in residential settings and not in community-dwelling populations (Ettema et al., 2007a). The internal reliability of the Qualidem in a sample of community-dwelling older adults will be examined. Although some studies have examined test-retest reliability (Jorm et al., 1997), this will not be investigated presently due to the nature of the intervention and expected change in scores over time.

4.3 METHODS

4.3.1 Participants

The study was approved by the institutional health research ethics board. We aimed to recruit a convenience sample of 30 subjects for this longitudinal observational study with an even proportion of women and men. Eligibility criteria included being age 65 or older, self-reported memory problems, and having an informant also willing to participate. The subject was instructed to identify an individual who knows them well enough to be able to answer questions regarding cognition and QoL, they see each other on a regular basis, and who is willing to participate. Posters and flyers were distributed to the local Seniors Resource Centre and Memorial University (MUN), and an email advertisement was sent out to the MUN Pensioners Association.

4.3.2 Materials

The study utilized a total of four cognitive and two QoL tests. The cognitive tests used were the MoCA (Nasreddine et al., 2005), the IQCODE (Jorm & Jacomb, 1989), and the informant and subject scales of the PAS, cognitive decline and cognitive impairment (Jorm & Mackinnon, 1995). The QoL tests were the AQoL-8D (Richardson et al., 2011) and the Qualidem (Ettema, 2007a). The MoCA, PAS-CD, and the AQoL-8D were administered directly to the subject, whereas the IQCODE, PAS-CI, and the Qualidem were administered to an informant.

4.3.3 Procedures

As part of the Seniors Physical Activity and Cognition (SPAC) study, cognition and QoL were analyzed utilizing informant and subject questionnaires during a physical activity intervention. Full methods for the study can be found in Chapter 2. Participants completed QoL and cognitive assessments at baseline, and every two months until the completion of the study (six months, four assessments total). The subjects and informants attended at the same intervals to fill out questionnaires. Administration of the tests was kept consistent across time points, and participants were reminded of the instructions for each questionnaire at every assessment. The environment was kept consistent across all testing sessions, in a room with adequate lighting and a sturdy table and chairs. All testing sessions were one-on-one with the participant and the researcher. Each participant was assigned a participant code so that responses could be kept anonymous and confidential.

4.3.4 Data Analysis

Scores from each of the questionnaires were calculated based on the respective test instructions, and analyzed using SPSS software. The AQoL-8D scores were calculated using the algorithm provided by Monash University (http://www.aqol.com.au/index.php/scoring-algorithms). The algorithm assigns each item a predefined weight in its respective category, and calculates the total score for each category. The scores for each of the Qualidem subscales were calculated by taking the average of the items in each category. The MoCA was calculated by adding the total points in each category. The IQCODE was calculated by taking the average of all the items. The PAS-CI and PAS-CD were calculated by adding the points for each question, divided by the total minus the amount of missing responses.

Descriptive statistics were calculated to identify the characteristics of the sample. Data from all four time points was combined to conduct the analyses. Internal reliability of each of the scales was tested with Cronbach's Alpha values. The overall alpha level and how each of the subscales impacts it was examined. Next, correlations between each of the measures were conducted. The correlations of the AQoL and Qualidem subscales were analyzed to determine which subscales were associated with one another. Convergent validity was tested with correlations between each of the tests of cognition (to determine if the MoCA is as reliable as the MMSE), and between each of the subscales of the MoCA with the other tests of cognition.

4.4 RESULTS

4.4.1 Participant Characteristics

Twenty three individuals responded to the recruitment ads, and a total of 18 subjects (66.6% female) took part in the study. Subjects were aged 65 to 79 years (*M* = 70.11, *SD* = 4.157), and were highly educated, with 88% having obtained an education beyond high school. Each subject had an informant take part in the study with them. Informants were either a spouse (50%), a child (16.7%), or a friend (33.3%). The mean amount of time that the subject and informant had known each other was 37.56 years (*SD* = 14.79). Informants reported how many times per week they saw the subject, with most reporting that they saw the subject 'daily' (55.6%), or 'once or more per week' (38.9%), and only 5.6% reported they saw the subject 'less than once a week.'

4.4.2 Internal Reliability

The internal reliability, Cronbach's Alpha, was calculated for each of the tests. Data was collapsed across the four time points for the analyses. A list of the Cronbach's Alphas for each of the tests, as well as the scale mean and variance, can be found in *Table 4.3*. Although the internal reliability did not reach the same level as previous research, likely due to the sample size, the pattern of results for the tests of cognition was the same. The IQCODE had the highest internal reliability (α =.888). The PAS-CD had the second highest (α =.689), followed by the MoCA (α =.423), and the PAS-CI (α =.326). In terms of the tests of QoL, the AQol-8D neared previous levels, whereas the Qualidem surpassed previous analyses. The AQoL-8D had an internal reliability of α =.920. The Qualidem had an internal reliability of α =.887.

Table 4.3
Ratings of internal reliability

	Cronbach's Alpha	Scale Mean (Variance)
IQCODE	.888	67.27 (32.36)
PAS-CD	.689	1.15 (2.37)
PAS-CI	.326	1.30 (1.92)
MoCA	.423	48.77 (19.92)
Qualidem	.887	98.23 (94.46)
Care Relationship	.637	16.86 (5.84)
Positive Affect	.732	16.60 (2.78)
Negative Affect	.555	6.85 (1.63)
Restless Tense Behaviour	.766	6.64 (2.87)
Positive Self Image	.640	7.20 (2.10)
Social Relations	.505	17.34 (1.07)
Social Isolation	.311	8.03 (1.07)
Feeling at Home	.188	6.25 (2.29)
Having Something to Do	.318	5.65 (.51)
AQoL-8D	.920	58.04(132.95)
Mental	.916	43.59 (76.48)
Happiness	.719	7.59 (2.65)
Mental Health	.809	15.22 (12.20)
Coping	.732	5.86 (2.70)
Relationships	.711	10.29 (4.90)
Self-Worth	.547	4.67 (1.67)
Physical	.838	15.45 (20.43)
Independent Living	.869	5.71 (5.95)
Pain	.789	4.67 (3.04)
Senses	.663	5.06 (2.64)

Note: IQCODE, Informant Questionnaire on Cognitive Decline in the Elderly; PAS-CD, Psychogeriatric Assessment Scale – Cognitive Decline; PAS-CI, Psychogeriatric Assessment Scale – Cognitive Impairment; MoCA, Montreal Cognitive Assessment; AQoL-8D, Assessment of Quality of Life – 8 Dimension

4.4.3 Correlations between Measures

Measures of Cognition: The focus was on the correlation between the MoCA and the other tests of cognition, as this has not been explored as extensively as the relation between the other tests. The strongest correlation was found between the two objectively-assessed subject-administered measures (the MoCA and the PAS-CI; *Table 4.4*). The

MoCA was also significantly correlated with the informant-administered IQCODE, but was not correlated with the PAS-CD. Although many of the correlations were not significant, the pattern of results followed what would be expected based on previous research.

The subscales of the MoCA were also tested for significant correlations with the other tests of cognition. The correlations can be seen in *Table 4.5*. Of the subscales, only visuospatial, delayed recall, and orientation were significantly correlated. Visuospatial

Table 4.4
Tests of cognition Pearson correlations

	MoCA	PAS-CI	PAS-CD	IQCODE
MoCA	---	-.530**	-.132	-.373*
PAS-CI		---	.241	.306
PAS-CD			---	.350*
IQCODE				---

Note: Correlations between the tests of cognition.
* indicates significance at $\alpha = .05$.
** indicates significance at $\alpha = .01$.
MoCA, Montreal Cognitive Assessment; PAS-CI, Psychogeriatric Assessment Scale – Cognitive Impairment; PAS-CD, Psychogeriatric Assessment Scale – Cognitive Decline; IQCODE, Informant Questionnaire on Cognitive Decline in the Elderly

Table 4.5
MoCA test Pearson correlations

		PAS-CI	PAS-CD	IQCODE
MoCA	Visuospatial	-.275*	-.198	-.214
	Naming	-.019	-.078	.055
	Memory	-.233	-.017	-.229
	Attention	-.189	-.145	-.180
	Language	-.049	.039	.034
	Abstract	.036	.068	-.174
	Delayed Recall	-.672**	-.155	-.429*
	Orientation	.175	.279*	-.051

Note: Correlations between the subscale of the MOCA and the other tests of cognition.
* indicates significance at $\alpha = .05$.
** indicates significance at $\alpha = .01$.

was significantly correlated with the subject scale of the PAS, whereas orientation was significantly correlated with the informant scale of the PAS. Delayed recall was significantly correlated with both the IQCODE and the subject scale of the PAS. No other subscales were significantly correlated with the PAS or IQCODE.

Quality of Life Measures: Correlations among the two measures of QoL, the subject-administered AQoL-8D and the informant-administered Qualidem, were conducted. All of the correlations between the scales of the two tests can be seen in *Table 4.6*. Overall, there was a significant correlation between the two tests. On both tools, higher test scores indicate better QoL. In addition to the overall tests being significantly correlated (r = .283), several subscales were also significantly correlated. The total score for the AQoL-8D (subject scale) was significantly correlated with four of the Qualidem (informant) subscales. Of the two super dimensions of the AQoL-8D, the *mental* dimension was more significantly correlated with the Qualidem than *physical*. The super dimension *mental* was significantly correlated with the Qualidem total, and five of the nine subscales. Of the subscales in the *mental* super dimension, coping was significantly correlated with three of the Qualidem subscales. All of the other subscales were correlated with one Qualidem subscale, except for relationships, which was not significantly correlated (*Table 4.6)*. The super dimension *physical* was significantly correlated with one Qualidem subscale. The subscale senses was not significantly correlated with any Qualidem subscales, but the other two subscales were highly correlated. The independent living subscale was significantly correlated with the Qualidem total and six of the subscales; the pain subscale was significantly correlated with the Qualidem total and eight of the subscales.

Table 4.6

Quality of life Pearson correlations

Assessment of Quality of Life -8D	Qualidem: Total	Care Relationship	Positive Affect	Negative Affect	Restless Behaviour	Positive Self Image	Social Relations	Social Isolation	Feeling at Home	Having Something to Do
Total	.283*	.044	.391**	.308*	.200	.097	.320*	.118	.093	.261*
Mental	.420**	.209	.375**	.231	.348**	.209	.370**	.353**	.236	.401*
Happiness	-.054	-.295*	.204	.232	.037	-.155	.040	-.131	-.090	-.026
Mental Health	.124	.055	.306*	.186	.095	-.040	.102	-.080	-.109	.076
Coping	.165	-.050	.379**	.127	.063	.027	.364**	.123	-.123	.268*
Relationships	.158	.050	.194	.196	.056	-.062	.204	.061	.092	.126
Self-Worth	.200	-.046	.206	.312*	.082	.144	.237	-.004	.223	.133
Physical	.133	-.050	.348**	.222	.070	-.073	.234	-.013	-.075	.141
Independent Living	.424**	.239	.417**	.241	.362**	.310*	.393**	.293*	.213	.434**
Pain	.501**	.205	.408**	.316*	.400**	.266*	.436**	.410**	.264*	.428**
Senses	-.038	-.001	.038	-.038	.044	-.065	-.060	-.025	-.002	.019

Note: Correlations between the subscales of the Quality of Life tests.

* indicates significance at $\alpha = .05$.

** indicates significance at $\alpha = .01$.

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For the Qualidem, the most significantly correlated subscales were the positive affect, negative affect, social relations, and having something to do. Each of the four subscales was correlated with the AQoL-8D total as well as a number of subscales. Negative affect was correlated with two subscales, social relations and having something to do were each correlated with four subscales, and positive affect was correlated with six subscales on the AQoL-8D. Additionally restless tense behaviour and social isolation were each correlated with three AQoL-8D subscales, but not with the total score. All other scales of the Qualidem were significantly correlated with at least one subscale on the AQoL-8D.

4.5 DISCUSSION

The main purpose of the study was to evaluate the questionnaires used to assess cognition and QoL, specifically whether informant scales can be useful to measure cognition and QoL in community-dwelling older people. Not surprisingly, subject administered tools that measured the same construct were correlated with one another (for example MoCA and PAS-CD); however, what is more important is that an informant questionnaire that measured QoL (Qualidem) was significantly correlated with the subjects' self-report (AQol-8D). Additionally, the informant questionnaire of QoL, the Qualidem (Ettema et al., 2007), was analyzed in a new population (community dwelling individuals) and correlated with a subject questionnaire for QoL. Analyses indicated that the general trends found followed the patterns of previous research (Jorm et al., 1997; Jorm, 2004; Richardson & Iezzi, 2011; Toglia et al., 2011). The second purpose was to assess the reliability of the MoCA with other measures that have previously been analyzed. The MoCA was found to follow the same pattern of significant correlations as the MMSE.

Although the MMSE is considered the gold standard to measure cognition, and has been validated with other cognitive measures, it is indicated that newer tests may be more reliable. The MoCA, which improves upon the MMSE, has not previously been validated against other specific questionnaires, such as the IQCODE and PAS. To the best knowledge of the authors, we show for the first time, that like the MMSE, the MoCA correlates with both subject-reported (PAS-CI) and informant-reported (IQCODE) measures. Due to the strength of the association between the PAS-CI and MMSE, it was expected that the MoCA would be most strongly correlated with the PAS-CI (Jorm et al., 1997). The correlation between the MoCA and PAS-CD, was not significant. Previous research (Jorm et al., 1997) has indicated that the relation between those two measures is the weakest association, thus our findings are not unexpected. Both of these tests are derived from the MMSE, and thus should measure the same constructs reliably. However, as one is administered to a subject and the other to an informant, it is possible that they capture different constructs. The significant correlations follow the trends indicated in previous research and confirm the usefulness of the selected tests. This is important as it has been indicated that cognitive assessments work best when combined (Mackinnon & Mulligan, 1998).

The MoCA was further validated by testing the correlations of the individual subscales with the other tests of cognition. The delayed recall subscale, which directly relates to a subject's memory, demonstrated the strongest correlations to the other tests of cognition. Considering the other scales test changes in a subject's memory, it is expected that the delayed recall subscale will have the strongest correlation. This suggests that when utilizing the MoCA to test a subject's change in cognition that in addition to the overall score, the delayed recall subscale may also be a strong indicator of their cognitive decline. There was very little variability in the orientation subscale, as subjects generally performed very well. The orientation subscale asked subjects to give the current date (date, day of week, month, and year) and location (room/building name and city). Given that subjects arranged the meeting (date and location) beforehand, typically via email, it is likely that they had a greater awareness of the date and time in order to be able to attend the meeting. This could pose a limitation on the reliability of this subscale and should be considered when being analyzed.

Internal reliability (Cronbach's alpha) of measurement tools is a key consideration in research, and the pattern of results found further confirms the validity of the tests in question. The IQCODE, having the highest internal reliability, is the most comprehensive test, and likely the best to use to assess cognition from an informant. The trends found in the subscales of the Psychogeriatric Assessment Scale indicate that the informant scale had a higher internal reliability than the subject scale.

The QoL assessments also had good internal reliability. The strength of the AQoL-8D was replicated, with an internal reliability nearing levels achieved in past research, and with all subscales demonstrating moderate to good levels of internal reliability. The Qualidem, however, was found to have a much higher internal reliability than previously indicated (Ettema et al., 2007a). As this is likely the first known assessment in a community-dwelling population, this is important to consider. When collecting information using informant questionnaires, it can be difficult to select an appropriate informant. In residential care settings, informants typically consist of paid caregivers, whereas in community-dwelling samples informants are typically family or friends. The closer relationship between the subject and informant may provide more reliable information (Andersen, Vahle & Lollar, 2001). Research has found that the reliability of informant responses varies depending on the type of informant, with closer informants providing better information; regardless of the type of informant, QoL is typically underestimated and subjective scales should be taken with caution (Andersen, Vahle & Lollar, 2001).

Although guidelines were provided to aid subjects in selecting their informant, there was little regulation to this process. While most subjects chose a spouse or a child, some selected a friend. Even though all of the informants reported seeing the subject at least once per week, some informally stated that they have only known the subject for a few years, or that the subject is a private person and does not share a lot of personal information. This may limit how well informants were able to answer questions, and could be why no differences were found with these questionnaires. Friends are typically unable to observe changes in individuals as closely as a family member would. Internal factors, such as anxiety and depression, can influence an informant's response (Jorm, 2004), but other factors, such as relationships, should be investigated further.

The correlations between the overall QoL tests and subscales were analyzed as this has not been previously explored. The subject and informant measures of QoL were significantly correlated. Many of the subscales were positively correlated with each other, as well as the overall test scores. Interestingly, care relationships from the Qualidem was not significantly correlated with relationships from the AQoL-8D. It was, however, inversely correlated with happiness, thus indicating that higher levels of happiness were associated with lower scores of care relationship. Many of the items in care relationship are related to accepting help from others; therefore it is possible that being more independent, not having to accept help from others, may contribute towards one's happiness (Borg, Hallberg & Blomqvist, 2006). Overall, although the results indicate that the subscales of each test may be divided up differently and have a different focus, taken as a whole, the AQoL-8D and Qualidem pair very well.

In some situations it may be important to utilize information from informants when subjects may be unable to provide a response. The level of correlation between these two measures suggests that when informant information is required, the Qualidem (informant scale) captures similar responses to the AQoL-8D (subject scale). This may indicate that responses for the Qualidem are sufficient to provide a picture of a subject's QoL. This may allow for a reduction in the number of questionnaires a subject has to complete, especially in cases where it is difficult for them to respond. Even in community-dwelling samples, the Qualidem is a good test to use and should be utilized in future research.

4.5.1 Limitations

Within this study there were some limitations. First, a small sample size was investigated. In total 18 subjects were each tested four times over a six-month period. Any outliers or extreme scores would have a much larger impact on the overall results than if the sample was larger. Additionally, the tests were conducted to assess the effects of an intervention, as such, some individuals may have changed more in some areas than others over time. The amount of change over time was not assessed within the validation.

Although it is expected that improvements on one test of cognition should be correlated with improvements on another test, this was not investigated and could limit some of the correlation coefficients.

4.5.2 Conclusion

These analyses further validate the strength of the tests when used in conjunction with one another. Although some of the tests did not reach the same significance as indicated in previous research, similar trends were evident. The MoCA has been previously shown to improve upon the MMSE in terms of internal reliability (Toglia et al., 2011), and present research has indicated that its correlation with other tests of cognition also follows the same patterns. This further supports the decision to use the MoCA during cognitive assessments with older adults.

The QoL assessments were significantly correlated with one another. The strength of the association between the scales indicates that they are both reliable measures that capture similar information. Previous studies have not examined the relationship between the two tests; thus these results indicate that further research into their compatibility may be warranted. Each test has multiple subscales, which do not directly match between the tests. However, because they measure similar constructs, both questionnaires can be used to gather the same type of information regarding the QoL of an individual. The internal reliability of the Qualidem in this study was much higher than in previous research, which may be the result of the type of informant. Although the Qualidem was initially validated for use in residential care facilities, the strong correlations with the AQoL-8D in this analysis indicate that it may also be suitable for community-dwelling individuals.

Overall, the tests that were selected for this study performed as expected. The relationships between the tests followed the same general trends as previous research, and indicated a number of significant correlations. Further validation of these tests can help researchers become more confident in the measures that they are choosing to assess participants' cognition and QoL.

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CHAPTER 5: DISCUSSION

5.1 DISCUSSION

It is important to maintain a sufficient level of physical activity in order to remain healthy. As such, the Canadian Society for Exercise Physiology (CSEP) provides guidelines to aid in this endeavour. The present study utilized these guidelines to encourage participants to maintain a sufficient level of physical activity. The primary aim was determine whether a walking program could improve cognition among a group of older community dwelling individuals with self-reported memory problems. The secondary aim was to compare objective (Garmin Vivofit) and subjective (pen-and-paper logbook) measures of physical activity to determine the usefulness of objective activity trackers. Finally, we tested the validity and reliability of subject-completed and informant-completed questionnaires used to measure cognition and quality of life (QoL).

According to the physical activity guidelines for older adults, participation in 150 or more minutes of moderate- to vigorous-intensity physical activity per week in bouts of 10 minutes or more is recommended (Tremblay et al., 2011). Based on subjects' physical activity, as reported by the Garmin Vivofit activity tracker, on average they obtained the recommended amounts of physical activity. It is also important to choose measures that accurately quantify and detect changes in cognition and QoL. Based on the results, it can be seen that the selected measures accurately captured information about subjects.

5.2 COGNITION AND QUALITY OF LIFE

At the completion of the study, subjects had improved scores for cognition and QoL. This increase may be due to extraneous factors as no dose-response effect was found due to little variation in the subjects' level of activity. Although previous research demonstrates higher levels of activity are associated with greater improvements (Heyn, Abreu & Ottenbacher, 2004), any level of physical activity can be beneficial (Barnes, Yaffle, Satariano & Tager, 2003; Booth et al., 2000; Busse et al., 2009; Heyn, Abreu & Ottenbacher, 2004).

Gender differences were found; women experienced greater improvements in cognition, but men experienced greater improvements in QoL. Based on previous research, changes with physical activity interventions are more significant when the majority of the sample is female, and that women typically experienced greater benefits than men (Colcombe & Kramer, 2003; McAuley et al., 2006). Research has suggested that the interaction of estrogen with insulin-like growth factor-I receptors has benefits for maintaining cognitive performances (Garcia-Sequra et al., 2000), whether the same mechanisms are responsible for improvements in QoL requires further investigation (Colcombe & Kramer, 2003).

As one ages, declines in cognition are expected, however, individuals who are active typically have better accuracy and response times regardless of age (Hillman et al., 2006). A comparison of hazard ratios by Lautenschlager and colleagues (2012) found that both low-to-moderate and high levels of activity demonstrated a significant reduction in the risk of developing cognitive impairment compared to sedentary individuals. This suggests that leading an active lifestyle, regardless of activity level, may improve cognition. Greater levels of physical activity are also related to improved QoL and overall health (McAuley et al., 2006; Yu et al., 2013). Research has indicated that physical activity has positive benefits for mental health (Richardson et al., 2005; Roe & Aspinall, 2011). Individuals who start with poorer mental health generally experience greater benefits than those who start off with better mental health (Roe & Aspinall, 2011). Seasonal barriers may have impacted the results. The activity levels were lowest during the midpoint of the study (January/February), and highest at the start of the study (October/November). Poor or extreme weather is a significant barrier to physical activity among individuals (Tucker & Gilliland, 2007). The winter in St. John's is extremely difficult for pedestrians to manoeuvre; even for individuals who drive, the amount of snow and ice can make it difficult to get to and from a vehicle. It is suggested that studies attempting to promote physical activity utilize indoor activities to enhance active behaviors (Tucker & Gilliland, 2007).

5.3 ACTIVITY TRACKERS ARE RELIABLE AND ACCEPTABLE AMONG OLDER COMMUNITY-DWELLING ADULTS

The present study found that the Garmin Vivofit activity tracker was preferred to the standard pen-and-paper logbook. Objective activity trackers are not subject to recall biases or social desirability biases (Motl, McAuley & DiStefano, 2005; Tudor-Locke & Myers, 2012), which can negatively impact self-report methods. While in the past these may have been inaccurate or expensive, technological improvements have made them much more accessible to researchers and to individuals (Miller, 2013). The low correlation between the activity tracker and the pen-and-paper logbook mirrors the low-to-moderate correlations found in previous research (Prince et al., 2008).

5.4 VIVOFIT ACTIVITY TRACKER

While there are still limitations with the Garmin Vivofit activity tracker, it is generally on par with similar devices available on the market (Mackinlay, 2013).

Information provided through different aspects of the activity tracker (time spent in activity zones and daily steps) had a high correlation with one another. The relationships are not perfect, and this may indicate one of two things. For example, working out in a gym, or on a bicycle may not provide a significant amount of steps, but it is far from being classified as sedentary. Second, it is possible that there is some error in the recording. Since there is little public knowledge regarding the formulas used to calculate the steps taken and determine the level of activity, it is possible that there is some error in the device (Mackinlay, 2013). Garmin does provide a legal disclaimer on their website that their devices may not be completely accurate and should not be used as medical devices to diagnose or treat illnesses (Garmin, n.d.). Typical inaccuracies are likely to not be extreme enough to skew results. For example, if the tracker is over by a few hundred steps, but an individual took more than 10,000 steps in a day, it is unlikely that those couple hundred steps will make a difference in their overall activity level.

5.5 USE OF ASSESSMENTS OF COGNITION AND QUALITY OF LIFE

The selected measures of cognition and QoL have high levels of internal reliability, and are significantly correlated with one another. The MoCA demonstrates a higher internal reliability and a reduced ceiling effect than the MMSE, the previous standard test to use for cognition (Toglia et al., 2011). It was significantly correlated with both subject-reported (PAS-CI) and informant-reported (IQCODE) measures. This indicates that the MoCA may be a suitable replacement for the MMSE in cognitive assessments, especially when combined with other similar measures (Mackinnon & Mulligan, 1998).

The Qualidem was analyzed in a new population (community dwelling individuals) and correlated with a validated subject-based questionnaire (AQoL-8D). It was found to have a higher internal reliability than in residential settings. This may be a result of the closer relationship between the subject and the informant; informants in residential settings are generally paid caregivers, whereas in community-dwelling samples informants are typically family or close friends. Individuals who have closer relationships generally provide more reliable information (Andersen, Vahle & Lollar, 2001). The high correlation with the AQoL-8D indicates that the two tests work well together and measure similar constructs. These results suggest that the Qualidem can be used in either residential or community-dwelling samples, although further research is still required on the latter.

5.6 CLINICAL SIGNIFICANCE

In the present study, although results indicate trends in the right direction, not all of the results were statistically significant. Despite this, there may still be important clinical significance to the findings. In particular, the use of activity trackers presents an important point. While many subjects did not like to use the logbook, they did embrace using the Vivofit. Five subjects purchased an activity tracker during the study, and four more indicated an intention to purchase one in the near future. Subjects reported that using it helped encourage them to be more active. By being able to follow along with their activity level, it helps them to realize what they have and have not done, and what they need to do to maintain an active lifestyle.

Despite previously being active, many subjects reported that they felt more active after participating in the study. By having someone to walk with, at an available facility, individuals were encouraged to maintain an active lifestyle that fit into their schedule and was possible to sustain. At the end of the intervention, the majority of the subjects reported consistent (5 subjects) or positive changes (8 subjects) in their level of physical activity. Additionally, when asked if they felt that their cognition improved over time, half of the subjects reported a positive change. Individuals were given guidelines to follow, but were able to make the choice on their own whether to follow them or not. For subjects who did increase their physical activity level they reported several benefits. Many subjects reported that they had lost weight, improved their flexibility, increased their endurance, got stronger, and were more active overall. While each of these benefits were not directly tested by the assessments, the subjects still found benefits to being physically active. Additionally, by reporting they felt like their cognition improved, whether it has or not, suggests self-confidence and self-worth may have increased, allowing individuals to be happier with themselves.

5.7 LIMITATIONS AND FUTURE DIRECTIONS

Although there are some limitations in the current project, there are also many opportunities for future directions. Common problems with research in this area are small sample sizes and lack of control groups. Future research can work to build on previous methodologies and increase sample sizes to obtain a more representative sample of the population. The majority of the participants in this study were highly educated. Some research has suggested that individuals who are more educated are more likely to be active (Parks, Housemann & Brownson, 2003). To account for this, studies could also target individuals with lower levels of education to determine differences in activity levels, and how physical activity interventions differently impact those individuals.

Another limitation regarding the sampling was that the sample was significantly less impaired than expected. Initially, recruitment targeted individuals with significant cognitive impairment and early stages of dementia. Due to difficulties in recruitment, the majority of subjects only had minor cognitive impairments, and no subjects had early stages of dementia.

There are known limitations with the questionnaires utilized. The tests selected were based on previous research identifying them as valid and reliable measures. Although in the present study the reliability assessment did not reach previous levels, it still indicates that the tests chosen are able to adequately measure the variables of interest. One major limitation is the directionality of the questioning. Some of the assessments, such as the IQCODE, asked about bidirectional change, that is have the variables of interest increased or decreased over time. However, most of the tests used directional questions and only asked about decrease over time. Although for older adults decrease over time is more common, it is somewhat limiting when attempting to slow the decline and possibly improve conditions. By not having questions that assess bidirectional change it is possible that some important information is not captured.

The measures of physical activity that were chosen were also based on previous research, which has shown both benefits and drawbacks for objective and subjective methods of capturing physical activity. Through subject feedback it can be seen that the logbook method of recording physical activity is difficult and can be somewhat ineffective. Future studies can make increased use of activity trackers and other types of accelerometers. With technological advancements, these have become more commonplace and are more accessible to researchers and to individuals. An objective record of a participant's physical activity over a long period of time may provide interesting results. Over an extended period of time it is likely that any motivation effects may wear off and participants' regular physical activity routines will be captured. This could provide important information for researchers planning physical activity interventions and producing long term changes in physical activity behaviour.

5.8 CONCLUSION

Overall, the present study positively contributes to the growing literature regarding the positive effects of physical activity on cognition and QoL. The benefits subjects noted for cognition and QoL may be a result of their activity levels, but it may also be due to an increased awareness of their current state. With increasing technologies and better health care, people are living longer than before. However, it is important to stay active in these later years of life in order to maintain a healthy, happy, productive lifestyle. Many older adults in the study found that they maintained or increased their activity level, and enjoyed being able to keep track of what they were doing. By utilizing methods of tracking physical activity it helped subjects see what they were and were not doing to stay active. Reflecting on their activity was one of the motivating factors that helped them to maintain an active lifestyle. Additionally, using an activity tracker also helped to provide them with instant feedback regarding their level of activity. Although some of the results may not have achieved statistical significance due to lack of power, small sample size, or lack of a comparison group, one should not ignore the clinical significance of the results. Feedback from the subjects indicated that they found many benefits to being physically active, and that constructs put in place to assist them in being active will be utilized. Future research in the area of physical activity should continue to examine what factors impact why people choose to be active, and how they can be encouraged to stay active throughout the lifespan to add life to years and not just years to life.

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APPENDIX

Appendix A – Informant Questionnaire on Cognitive Decline in the Elderly

Informant Questionnaire on Cognitive Decline in the Elderly (IQCODE)

Now we want you to remember what your friend or relative was like 10 years ago and to compare it with what he/she is like now. 10 years ago was in 19__. Below are situations where this person has to use his/her memory or intelligence and we want you to indicate whether this has improved, stayed the same, or got worse in that situation over the past 10 years. Note the importance of comparing his/her present performance *with 10 years ago*. So if 10 years ago this person always forgot where he/she had left things, and he/she still does, then this would be considered 'Hasn't changed much'. Please indicate the changes you have observed by *circling the appropriate answer*.

Compared with 10 years ago how is this person at:

	1	2	3	4	5
1. Recognizing the faces of family and friends	Much improved	A bit improved	Not much change	A bit worse	Much worse
2. Remembering the names of family and friends	Much improved	A bit improved	Not much change	A bit worse	Much worse
3. Remembering things about family and friends e.g. occupations, birthdays, addresses	Much improved	A bit improved	Not much change	A bit worse	Much worse
4. Remembering things that have happened recently	Much improved	A bit improved	Not much change	A bit worse	Much worse
5. Recalling conversations a few days later	Much improved	A bit improved	Not much change	A bit worse	Much worse
6. Forgetting what he/she wanted to say in the middle of a conversation	Much improved	A bit improved	Not much change	A bit worse	Much worse
7. Remembering his/her address and telephone number	Much improved	A bit improved	Not much change	A bit worse	Much worse
8. Remembering what day and month it is	Much improved	A bit improved	Not much change	A bit worse	Much worse
9. Remembering where things are usually kept	Much improved	A bit improved	Not much change	A bit worse	Much worse
10. Remembering where to find things which have been put in a different place from usual	Much improved	A bit improved	Not much change	A bit worse	Much worse

11. Adjusting to any change in his/her day-to-day routine	Much improved	A bit improved	Not much change	A bit worse	Much worse
12. Knowing how to work familiar machines around the house	Much improved	A bit improved	Not much change	A bit worse	Much worse
13. Learning to use a new gadget or machine around the house	Much improved	A bit improved	Not much change	A bit worse	Much worse
14. Learning new things in general	Much improved	A bit improved	Not much change	A bit worse	Much worse
15. Remembering things that happened to him/her when he/she was young	Much improved	A bit improved	Not much change	A bit worse	Much worse
16. Remembering things he/she learned when he/she was young	Much improved	A bit improved	Not much change	A bit worse	Much worse
17. Understanding the meaning of unusual words	Much improved	A bit improved	Not much change	A bit worse	Much worse
18. Understanding magazine or newspaper articles	Much improved	A bit improved	Not much change	A bit worse	Much worse
19. Following a story in a book or on TV	Much improved	A bit improved	Not much change	A bit worse	Much worse
20. Composing a letter to friends or for business purposes	Much improved	A bit improved	Not much change	A bit worse	Much worse
21. Knowing about important historical events of the past	Much improved	A bit improved	Not much change	A bit worse	Much worse
22. Making decisions on everyday matters	Much improved	A bit improved	Not much change	A bit worse	Much worse
23. Handling money for shopping	Much improved	A bit improved	Not much change	A bit worse	Much worse
24. Handling financial matters, e.g. the pension, dealing with the bank	Much improved	A bit improved	Not much change	A bit worse	Much worse

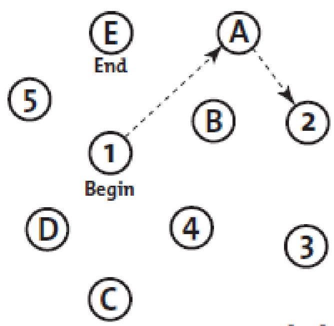
25. Handling other everyday arithmetic problems, e.g. knowing how much food to buy, knowing how long between visits from family or friends	Much improved	A bit improved	Not much change	A bit worse	Much worse
26. Using his/her intelligence to understand what's going on and to reason things through	Much improved	A bit improved	Not much change	A bit worse	Much worse

Appendix B – Montreal Cognitive Assessment

MONTREAL COGNITIVE ASSESSMENT (MOCA)

NAME :
Education :
Sex :
Date of birth :
DATE :

VISUOSPATIAL / EXECUTIVE



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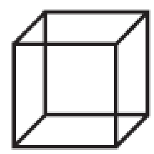


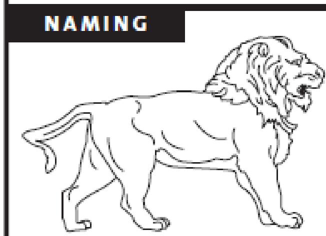
Copy cube [ ]

Draw CLOCK (Ten past eleven) (3 points)

[ ] Contour [ ] Numbers [ ] Hands

POINTS: __/5

NAMING



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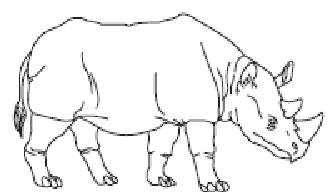

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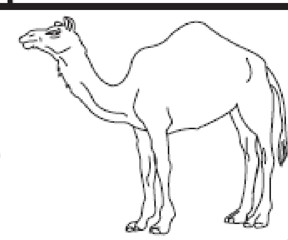


[ ]

__/3

MEMORY

Read list of words, subject must repeat them. Do 2 trials. Do a recall after 5 minutes.

	FACE	VELVET	CHURCH	DAISY	RED
1st trial					
2nd trial					

No points

ATTENTION

Read list of digits (1 digit/ sec.). Subject has to repeat them in the forward order [ ] 2 1 8 5 4
Subject has to repeat them in the backward order [ ] 7 4 2 __/2

Read list of letters. The subject must tap with his hand at each letter A. No points if ≥ 2 errors
[ ] F B A C M N A A J K L B A F A K D E A A A J A M O F A A B __/1

Serial 7 subtraction starting at 100 [ ] 93 [ ] 86 [ ] 79 [ ] 72 [ ] 65 __/3
4 or 5 correct subtractions: **3** pts, 2 or 3 correct: **2** pts, 1 correct: **1** pt, 0 correct: **0** pt

LANGUAGE

Repeat : I only know that John is the one to help today. [ ]
The cat always hid under the couch when dogs were in the room. [ ] __/2

Fluency / Name maximum number of words in one minute that begin with the letter F [ ] ____ (N ≥ 11 words) __/1

ABSTRACTION

Similarity between e.g. banana - orange = fruit [ ] train – bicycle [ ] watch - ruler __/2

DELAYED RECALL

Has to recall words	FACE	VELVET	CHURCH	DAISY	RED	
WITH NO CUE	[ ]	[ ]	[ ]	[ ]	[ ]	Points for UNCUED recall only
Optional: Category cue						
Optional: Multiple choice cue						

__/5

ORIENTATION

[ ] Date [ ] Month [ ] Year [ ] Day [ ] Place [ ] City __/6

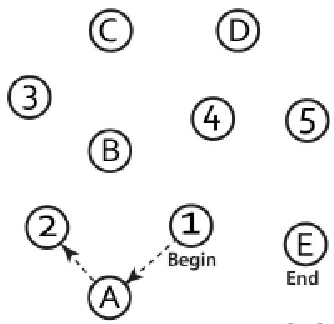
 www.mocatest.org Normal ≥ 26 / 30 **TOTAL** __/30

Administered by: ______________________ Add 1 point if ≤ 12 yr edu

MONTREAL COGNITIVE ASSESSMENT (MOCA)
Version 7.2 Alternative Version

NAME :
Education : **Date of birth :**
Sex : **DATE :**

		POINTS
VISUOSPATIAL / EXECUTIVE		



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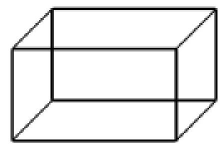
Copy rectangle

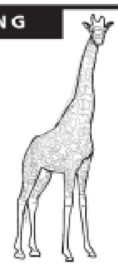


[ ]

Draw CLOCK (Five past four)
(3 points)

[ ] Contour [ ] Numbers [ ] Hands ___/5

NAMING



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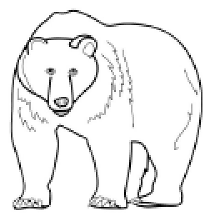

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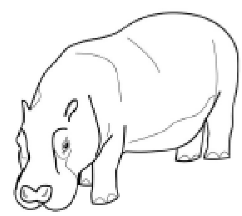


[ ] ___/3

MEMORY Read list of words, subject must repeat them. Do 2 trials, even if 1st trial is successful. Do a recall after 5 minutes.

	TRUCK	BANANA	VIOLIN	DESK	GREEN
1st trial					
2nd trial					

No points

ATTENTION Read list of digits (1 digit/ sec.).
Subject has to repeat them in the forward order [ ] 3 2 9 6 5
Subject has to repeat them in the backward order [ ] 8 5 2 ___/2

Read list of letters. The subject must tap with his hand at each letter A. No points if ≥ 2 errors
[ ] F B A C M N A A J K L B A F A K D E A A A J A M O F A A B ___/1

Serial 7 subtraction starting at 90 [ ] 83 [ ] 76 [ ] 69 [ ] 62 [ ] 55
4 or 5 correct subtractions: **3 pts**, 2 or 3 correct: **2 pts**, 1 correct: **1 pt**, 0 correct: **0 pt** ___/3

LANGUAGE Repeat : A bird can fly into closed windows when it's dark and windy. [ ]
The caring grandmother sent groceries over a week ago. [ ] ___/2

Fluency / Name maximum number of words in one minute that begin with the letter S [ ] _____ (N ≥ 11 words) ___/1

ABSTRACTION Similarity between e.g. carrot - potato = vegetable. [ ] diamond - ruby [ ] cannon - rifle ___/2

DELAYED RECALL	Has to recall words **WITH NO CUE**	TRUCK [ ]	BANANA [ ]	VIOLIN [ ]	DESK [ ]	GREEN [ ]	Points for UNCUED recall only	___/5
Optional	Category cue							
	Multiple choice cue							

ORIENTATION [ ] Date [ ] Month [ ] Year [ ] Day [ ] Place [ ] City ___/6

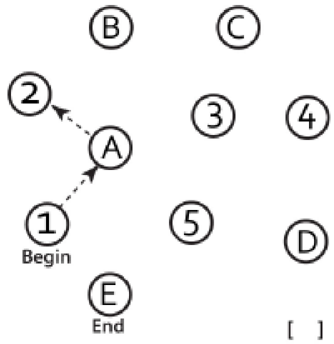
Adapted by : Z. Nasreddine MD, N. Phillips PhD, H. Chertkow MD
 www.mocatest.org
Administered by: ______________________

Normal ≥26 / 30 TOTAL ___/30
Add 1 point if ≤ 12 yr edu

NAME :
Education : Date of birth :
Sex : DATE :

MONTREAL COGNITIVE ASSESSMENT (MOCA)
Version 7.3 Alternative Version

	POINTS
VISUOSPATIAL / EXECUTIVE	



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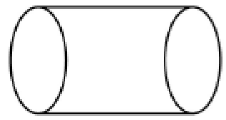


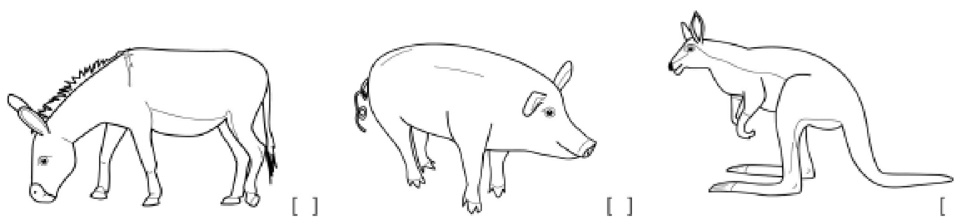
[ ]

Draw CLOCK (Ten past nine)
(3 points)

[ ] Contour [ ] Numbers [ ] Hands

__/5

NAMING



[ ] [ ] [ ]

__/3

MEMORY Read list of words, subject must repeat them. Do 2 trials, even if 1st trial is successful. Do a recall after 5 minutes.

	TRAIN	EGG	HAT	CHAIR	BLUE
1st trial					
2nd trial					

No points

ATTENTION Read list of digits (1 digit/ sec.).
Subject has to repeat them in the forward order [ ] 5 4 1 8 7
Subject has to repeat them in the backward order [ ] 1 7 4
__/2

Read list of letters. The subject must tap with his hand at each letter A. No points if ≥ 2 errors
[ ] F B A C M N A A J K L B A F A K D E A A A J A M O F A A B
__/1

Serial 7 subtraction starting at 80 [ ] 73 [ ] 66 [ ] 59 [ ] 52 [ ] 45
4 or 5 correct subtractions: **3 pts**, 2 or 3 correct: **2 pts**, 1 correct: **1 pt**, 0 correct: **0 pt**
__/3

LANGUAGE Repeat : She heard his lawyer was the one to sue after the accident. [ ]
The little girls who were given too much candy got stomach aches. [ ]
__/2

Fluency / Name maximum number of words in one minute that begin with the letter B [ ] ____ (N ≥ 11 words)
__/1

ABSTRACTION Similarity between e.g. banana - orange = fruit [ ] eye – ear [ ] trumpet – piano
__/2

DELAYED RECALL	Has to recall words **WITH NO CUE**	TRAIN [ ]	EGG [ ]	HAT [ ]	CHAIR [ ]	BLUE [ ]	Points for UNCUED recall only	__/5
Optional	Category cue							
	Multiple choice cue							

ORIENTATION [ ] Date [ ] Month [ ] Year [ ] Day [ ] Place [ ] City __/6

Adapted by : Z. Nasreddine MD, N. Phillips PhD, H. Chertkow MD
 www.mocatest.org
Administered by: ____________________

Normal ≥26 / 30 TOTAL __/30
Add 1 point if ≤ 12 yr edu

Appendix C – Psychogeriatric Assessment Scale – Cognitive Decline

Background Information

1. *What is your relationship to SUBJECT?*

Spouse	1
Sibling	2
Sister/brother in-law	3
Daughter/son	4
Daughter/son in law	5
Friend	6
Nurse/professional carer (other than above)	7
Other	8

2. *How long have you known SUBJECT?*

Length of time in years .... ☐☐

3. *How often do you see SUBJECT?*

Lives with subject	1
Daily	2
More than once a week or weekly	3
Less than once a week	4
Does not know	?

4. *How old is SUBJECT?*

Age in years .... ☐☐☐

5. *How old was SUBJECT when s/he left school?*

Age in years	☐☐
Does not know	?

If subject was less than 12 when s/he left school, ask:

Did s/he have any particular problems learning to read or write?

No	0
Yes	1
Does not know	?

Cognitive Decline Scale

I would now like to ask you about some specific situations and whether SUBJECT's memory has become any worse in these areas compared to earlier in life.

CD1. *Has s/he recently had any difficulty finding her/his way around familiar places when alone? (Where s/he lives, the neighbourhood and shops, the homes of close friends and relatives?)*

No difficulty, or doesn't think so	0
Moderate or occasional difficulty	1
Severe, persistent, frequent difficulty	1
Bedridden, immobile	1
Does not know	?

☐

CD2. *Does SUBJECT have more trouble remembering things that have happened recently?*

No, not much worse	0
A bit worse	1
Yes, a lot worse	1
Does not know	?

☐

CD3. *Is SUBJECT worse at remembering where belongings are kept?*

No, not much worse	0
A bit worse	1
Yes, a lot worse	1
Does not know	?

☐

CD4. *Does s/he have more trouble recalling conversations a few days later?*

No, not much worse	0
A bit worse	1
Yes, a lot worse	1
Does not know	?

☐

CD5. *Does s/he have more trouble remembering appointments and social arrangements?*		
No, not much worse	0	
A bit worse	1	
Yes, a lot worse	1	
Does not know	?	☐

CD6. *Does s/he have more trouble recognising the faces of family and close friends even though s/he has reasonably good vision?*		
No, not much worse	0	
A bit worse	1	
Yes, a lot worse	1	
Does not know	?	☐

CD7. *Does s/he need help to handle her/his money and financial affairs (banking, paying bills, deciding how and where to spend money, or how to invest)?*		
No, no difficulty	0	
Yes, but manages day-to-day purchases	1	
Yes, cannot manage finances or handle money	1	
Has never handled finances except for day-to-day purchases	0	
Does not know	?	☐

CD8. *Has SUBJECT had more trouble concentrating recently?*		
No	0	
Depends on situation	0	
Yes	1	
Does not know	?	☐

CD9. *Recently have her/his thoughts seemed more mixed up so that s/he cannot get them sorted out?*		
No more than usual	0	
Depends on situation	0	
Yes	1	
Does not know	?	☐

CD10. *Recently, has SUBJECT had more difficulty making decisions?*

No more than usual (includes makes no decisions)	0
Depends on situation	0
Yes	1
Does not know	?

☐

Now calculate the PAS Cognitive Decline (CD) Score

Add boxes CD1 to CD10 .... ☐ **CD**

Number of boxes with ? 's .... ☐ **?**

If ? is not zero, score should be pro-rated using formula: 10×CD/(10-?)

$$\frac{10 \times CD}{(10 - ?)}$$

☐ **CD´**

Appendix D – Psychogeriatric Assessment Scale – Cognitive Impairment

Background Information

1. *Please spell your last name (for me). And your first name?*

   Correctly spelled **0**
   Cannot give both names correctly (one minor spelling error allowed), does not know .... **1** → ☐

2. *What year were you born in?*

   Year .... ☐☐☐☐ **0**
   Does not know .... **1** → ☐

3. *So how old are you now?*

   Age in years .... ☐☐ **0**
   Does not know .... **1** → ☐

4. *What country were you born in?*

   Country .... ____________________ **0**
   Does not know .... **1** → ☐

Add boxes → ☐

If total is 1 or more, skip to the Cognitive Impairment scale.

Cognitive Impairment Scale

Now let me ask you a few questions to check your concentration and your memory. Most of them will be easy.

I am going to name three objects. After I have said them I want you to repeat them. Remember what they are, because I am going to ask you to name them again in a few minutes.

"Apple" "Table" "Penny"

Could you repeat the three items for me?

Repeat objects until all three are learned. Stop after five unsuccessful attempts.

C1. *I am going to give you a piece of paper. Would you please write any complete sentence on that piece of paper for me?*

If sentence is illegible, ask *"Could you read it for me?"*, **and copy sentence onto sheet.**

Sentence should have a subject and a verb, and make sense.
Spelling and grammatical errors are acceptable.

Correct	0
Incorrect or refusal	1
Not asked (e.g. sensory or motor impairment)	?

☐

C2. *Now what were the three objects I asked you to remember?*

Score 0 for each object remembered, 1 if an error is made because object is not mentioned or subject refuses. Order of recall is not important.

Apple	0
Object not mentioned or subject refuses	1
Not asked (e.g. sensory or motor impairment)	?

☐

Table	0
Object not mentioned or subject refuses	1
Not asked (e.g. sensory or motor impairment)	?

☐

Penny	0
Object not mentioned or subject refuses	1
Not asked (e.g. sensory or motor impairment)	?

☐

Subject Interview 8

Please listen carefully to the following name and address, then repeat it:

John Brown, 42 West Street, Kensington.

Repeat address until learned. Stop after five unsuccessful attempts.

Please go on remembering this name and address and I will ask you about it later.

C3. *I am now going to say the names of some people who were famous and I would like you to tell me who they were or why they were famous in the past.*

Score 0 for each person correctly identified, 1 if answer is incorrect or subject refuses.

Charlie Chaplin 0
(actor, comedian, film star, comic)
Incorrectly identified or refused 1
Not asked (e.g. sensory or motor impairment) .... ? ☐

Joseph Stalin 0
(Soviet, Russian, WWII leader, Communist leader)
Incorrectly identified or refused 1
Not asked (e.g. sensory or motor impairment) .... ? ☐

Captain Cook 0
(explorer, sailor, navigator, discoverer)
Incorrectly identified or refused 1
Not asked (e.g. sensory or motor impairment) .... ? ☐

Adolf Hitler 0
(German, Nazi, WWII leader)
Incorrectly identified or refused 1
Not asked (e.g. sensory or motor impairment) .... ? ☐

C4. *New Year's day falls on what date?*
First of January/first day of new year 0
A wrong date, does not know, refusal 1
Not asked .... ? ☐

C5. *What is the name and address I asked you to remember a short time ago?*

Score 0 for each component remembered, 1 if a component is not mentioned or subject refuses. Order of recall is not important.

John	0
Component not mentioned or subject refuses	1
Not asked (e.g. sensory or motor impairment)	?
Brown	0
Component not mentioned or subject refuses	1
Not asked (e.g. sensory or motor impairment)	?
42	0
Component not mentioned or subject refuses	1
Not asked (e.g. sensory or motor impairment)	?
West Street	0
Component not mentioned or subject refuses	1
Not asked (e.g. sensory or motor impairment)	?
Kensington	0
Component not mentioned or subject refuses	1
Not asked (e.g. sensory or motor impairment)	?

C6. *Here is a drawing. Please make a copy of it here.*

Hand subject the paper with 2 five-sided figures and point to the space underneath it.

Correct if 2 five-sided figures intersect to make a four-sided figure.

Correct	0
Incorrect or refusal	1
Not asked (e.g. sensory or motor impairment)	?

C7. *Read aloud the words on this page and then do what it says.*

Hand subject the sheet with the words "close your eyes".

Correct (subject closes eyes)	0
Incorrect or refusal	1
Not asked (e.g. sensory or motor impairment)	?

C8. *Now, read aloud the words on this page and then do what it says.*

Hand subject the sheet with the words "cough hard".

Correct (subject coughs)	0
Incorrect or refusal	1
Not asked (e.g. sensory or motor impairment)	?

C9. *Tell me what objects you see in this picture?*

Hand the four-object sheet to the subject.

Score 0 for each object identified, 1 if an object is not mentioned or subject refuses. Order of identification is not important.

Teapot, kettle	0
Object not mentioned or subject refuses	1
Not asked (e.g. sensory or motor impairment)	?

Telephone (whole object, not just dial)	0
Object not mentioned or subject refuses	1
Not asked (e.g. sensory or motor impairment)	?

Scissors	0
Object not mentioned or subject refuses	1
Not asked (e.g. sensory or motor impairment)	?

Fork	0
Object not mentioned or subject refuses	1
Not asked (e.g. sensory or motor impairment)	?

That brings us to the end of the interview. Thank you very much for your time.

Now calculate PAS Cognitive Impairment Score (C)

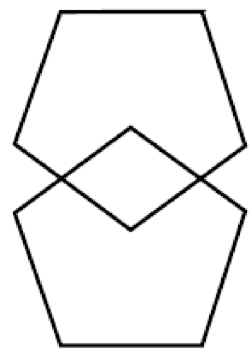
Add response boxes for C1 to C9 ... ☐ C

Number of boxes with ? 's .... ☐ ?

If ? is not zero, score should be pro-rated using formula: 21×C/(21-?)

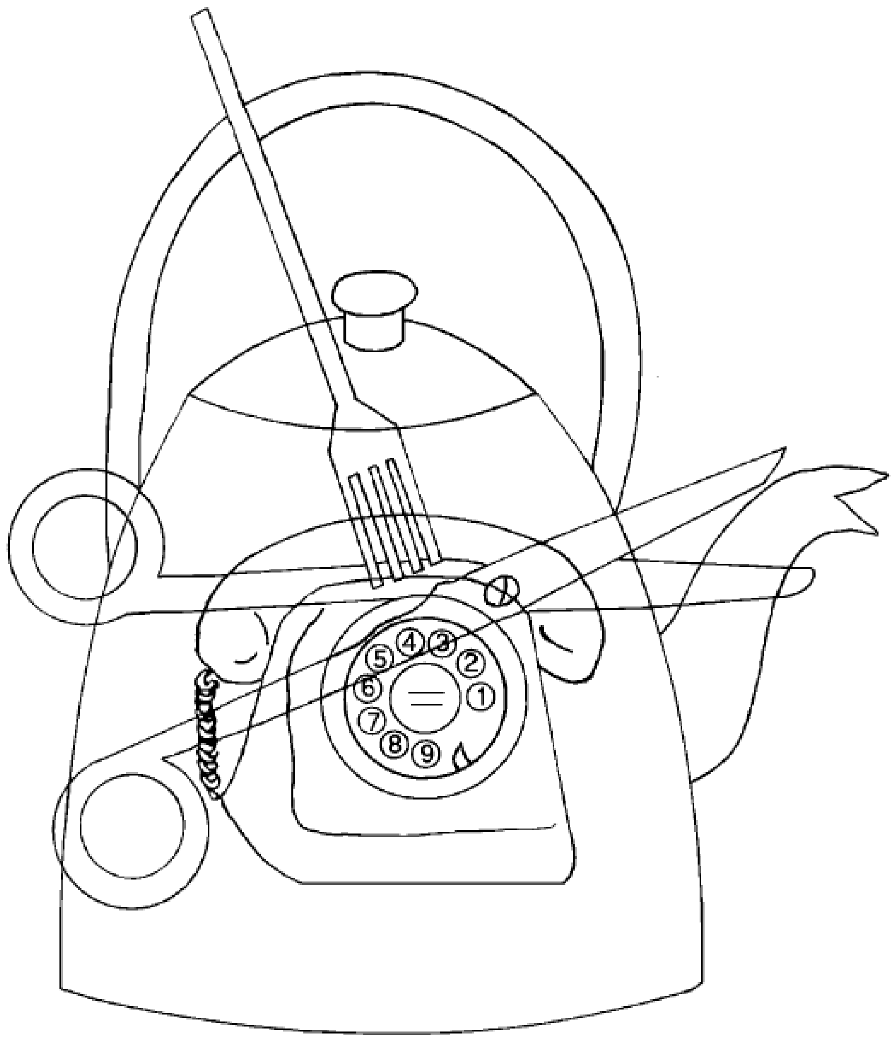
$$\frac{21 \times C}{(21 - ?)}$$

☐ C´



Close your eyes

Cough hard


5
4
3
2
6
1
7
8
9

Appendix E – Assessment of Quality of Life – 8 Dimension

AQOL-8D (Data Collection Copy)

Tick the box that best describes your situation as it has been over the past week

aqol1 Thinking about how much energy you have to do the things you want to do:
I am
- ❑ always full of energy
- ❑ usually full of energy
- ❑ occasionally energetic
- ❑ usually tired and lacking energy
- ❑ always tired and lacking energy

aqol2 How often do you feel socially excluded or left out?
- ❑ never
- ❑ rarely
- ❑ sometimes
- ❑ often
- ❑ always

aqol3 Thinking about how easy or difficult it is for you to get around by yourself outside your house (e.g., shopping, visiting):
- ❑ getting around is enjoyable and easy
- ❑ I have no difficulty getting around outside my house
- ❑ a little difficulty
- ❑ moderate difficulty
- ❑ a lot of difficulty
- ❑ I cannot get around unless somebody is there to help me

aqol4 Thinking about your health and your role in your community (that is to say neighbourhood, sporting, work, church or cultural groups):
- ❑ my role in the community is unaffected by my health
- ❑ there are some parts of my community role I cannot carry out
- ❑ there are many parts of my community role I cannot carry out
- ❑ I cannot carry out any part of my community role

aqol5 How often do you feel sad?
- ❑ never
- ❑ rarely
- ❑ some of the time
- ❑ usually
- ❑ nearly all the time

aqol6 Thinking about how often you experience serious pain:
I experience it
- ❑ very rarely
- ❑ less than once a week
- ❑ three to four times a week
- ❑ most of the time

aqol7 How much confidence do you have in yourself?
- ❑ Complete confidence
- ❑ A lot
- ❑ A moderate amount
- ❑ A little
- ❑ None at all

aqol8 When you think about whether you are calm and tranquil or agitated:
I am
- ❑ always calm and tranquil
- ❑ usually calm and tranquil
- ❑ sometimes calm and tranquil, sometimes agitated
- ❑ usually agitated
- ❑ always agitated

aqol9 Thinking about your health and your relationship with your family:
- ❑ my role in the family is unaffected by my health
- ❑ there are some parts of my family role I cannot carry out
- ❑ there are many parts of my family role I cannot carry out
- ❑ I cannot carry out any part of my family role

aqol10 Your close relationships (family and friends) are:
- ❑ very satisfying
- ❑ satisfying
- ❑ neither satisfying nor dissatisfying
- ❑ dissatisfying
- ❑ unpleasant
- ❑ very unpleasant

aqol11 When you communicate with others, e.g. by talking, listening, writing or signing:
- ❑ I have no trouble speaking to them or understanding what they are saying
- ❑ I have some difficulty being understood by people who do not know me. I have no trouble understanding what others are saying to me
- ❑ I am understood only by people who know me well. I have great trouble understanding what others are saying to me.
- ❑ I cannot adequately communicate with others

Centre for Health Economics, Monash University 1

Tick the box that best describes your situation as it has been over the past week

aqol12 How often do you have trouble sleeping?

- ❑ never
- ❑ almost never
- ❑ sometimes
- ❑ often
- ❑ all the time

aqol13 How often do you feel worthless?

- ❑ never
- ❑ almost never
- ❑ sometimes
- ❑ usually
- ❑ always

aqol14 How often do you feel angry?

- ❑ never
- ❑ almost never
- ❑ sometimes
- ❑ often
- ❑ all the time

aqol15 Thinking about your mobility, including using any aids or equipment such as wheelchairs, frames, sticks:

- ❑ I am very mobile
- ❑ I have no difficulty with mobility
- ❑ I have some difficulty with mobility (for example, going uphill)
- ❑ I have difficulty with mobility. I can go short distances only.
- ❑ I have a lot of difficulty with mobility. I need someone to help me.
- ❑ I am bedridden

aqol16 Do you ever feel like hurting yourself?

- ❑ never
- ❑ rarely
- ❑ sometimes
- ❑ often
- ❑ all the time

aqol17 How enthusiastic do you feel?

- ❑ extremely
- ❑ very
- ❑ somewhat
- ❑ not much
- ❑ not at all

aqol18 And still thinking about the last seven days, how often did you feel worried?

- ❑ never
- ❑ occasionally
- ❑ sometimes
- ❑ often
- ❑ all the time

aqol19 Thinking about washing yourself, toileting, dressing, eating or looking after your appearance:

- ❑ these tasks are very easy for me
- ❑ I have no real difficulty in carrying out these tasks
- ❑ I find some of these tasks difficult, but I manage to do them on my own
- ❑ many of these tasks are difficult, and I need help to do them
- ❑ I cannot do these tasks by myself at all

aqol20 How often do you feel happy?

- ❑ all the time
- ❑ mostly
- ❑ sometimes
- ❑ almost never
- ❑ never

aqol21 How much do you feel you can cope with life's problems?

- ❑ completely
- ❑ mostly
- ❑ partly
- ❑ very little
- ❑ not at all

aqol22 How much pain or discomfort do you experience:

- ❑ none at all
- ❑ I have moderate pain
- ❑ I suffer from severe pain
- ❑ I suffer unbearable pain

aqol23 How much do you enjoy your close relationships (family and friends)?

- ❑ immensely
- ❑ a lot
- ❑ a little
- ❑ not much
- ❑ I hate it

Tick the box that best describes your situation as it has been over the past week

aqol24 How often does pain interfere with your usual activities?

- ❑ never
- ❑ rarely
- ❑ sometimes
- ❑ often
- ❑ always

aqol25 How often do you feel pleasure?

- ❑ always
- ❑ usually
- ❑ sometimes
- ❑ almost never
- ❑ never

aqol26 How much of a burden do you feel you are to other people?

- ❑ Not at all
- ❑ A little
- ❑ A moderate amount
- ❑ A lot
- ❑ totally

aqol27 How content are you with your life?

- ❑ extremely
- ❑ mainly
- ❑ moderately
- ❑ slightly
- ❑ not at all

aqol28 Thinking about your vision (using your glasses or contact lenses if needed):

- ❑ I have excellent sight
- ❑ I see normally
- ❑ I have some difficulty focusing on things, or I do not see them sharply. E.g. small print, a newspaper or seeing objects in the distance.
- ❑ I have a lot of difficulty seeing things. My vision is blurred. I can see just enough to get by with.
- ❑ I only see general shapes. I need a guide to move around.
- ❑ I am completely blind

aqol29 How often do you feel in control of your life?

- ❑ always
- ❑ mostly
- ❑ sometimes
- ❑ only occasionally
- ❑ never

aqol30 How much help do you need with jobs around the house (e.g. preparing food, cleaning the house or gardening):

- ❑ I can do all these tasks very quickly and efficiently without any help
- ❑ I can do these tasks relatively easily without help
- ❑ I can do these tasks only very slowly without help
- ❑ I cannot do most of these tasks unless I have help
- ❑ I can do none of these tasks by myself

aqol31 How often do you feel socially isolated?

- ❑ never
- ❑ rarely
- ❑ sometimes
- ❑ often
- ❑ always

aqol32 Thinking about your hearing (using your hearing aid if needed):

- ❑ I have excellent hearing
- ❑ I hear normally
- ❑ I have some difficulty hearing or I do not hear clearly. I have trouble hearing softly-spoken people or when there is background noise.
- ❑ I have difficulty hearing things clearly. Often I do not understand what is said. I usually do not take part in conversations because I cannot hear what is said.
- ❑ I hear very little indeed. I cannot fully understand loud voices speaking directly to me.
- ❑ I am completely deaf

aqol33 How often do you feel depressed?

- ❑ never
- ❑ almost never
- ❑ sometimes
- ❑ often
- ❑ very often
- ❑ all the time

aqol34 Your close and intimate relationships (including any sexual relationships) make you:

- ❑ very happy
- ❑ generally happy
- ❑ neither happy nor unhappy
- ❑ generally unhappy
- ❑ very unhappy

aqol35 How often did you feel in despair over the last seven days?

- ❑ never
- ❑ occasionally
- ❑ sometimes
- ❑ often
- ❑ all the time

AQoL-8D with Dimension Headings

Physical SuperDimension -1, 2, 3

Psychological SuperDimension 4, 5,6,7,8

1. INDEPENDENT LIVING

Q1 How much help do you need with jobs around the house (e.g., preparing food, cleaning the house or gardening)?

Q2 Thinking about how easy or difficult it is for you to get around by yourself outside your house (e.g., shopping, visiting)

Q3 Thinking about your mobility, including using any aids or equipment such as wheelchairs, frames, sticks:

Q4 Thinking about washing yourself, toileting, dressing, eating or looking after your appearance

2. SENSES

Q5 Thinking about your vision (using your glasses or contact lenses if needed):

Q6 Thinking about your hearing (using your hearing aid if needed):

Q7 When you communicate with others, e.g. by talking, listening, writing or signing:

3. PAIN

Q8 Thinking about how often you experience serious pain:

Q9 How much pain or discomfort do you experience?

Q10 How often does pain interfere with your usual activities?

4. MENTAL HEALTH

Q11 How often do you feel depressed?

Q12 How often do you have trouble sleeping?

Q13 How often do you feel angry?

Q14 Do you ever feel like hurting yourself?

Q15 How often did you feel in despair over the last seven days?

Q16 And still thinking about the last seven days, how often did you feel worried?

Q17 How often do you feel sad?

Q18 When you think about whether you are calm and tranquil or agitated:

5. HAPPINESS

Q19 How content are you with your life?

Q20 How enthusiastic do you feel?

Q21 How often do you feel happy?

Q22 How often do you feel pleasure?

6. SELF WORTH

Q23 How much of a burden do you feel you are to other people?

Q24 How often do you feel worthless?

Q25 How much confidence do you have in yourself?

7. COPING

Q26 Thinking about how much energy you have to do the things you want to do:

Q27 How often do you feel in control of your life?

Q28 How much do you feel you can cope with life's problems?

8. RELATIONSHIPS

Q29 How much do you enjoy your close relationships (family and friends)?

Q30 Your close relationships (family and friends) are:

Q31 How often do you feel socially isolated?

Q32 How often do you feel socially excluded or left out?

Q33 Your close and intimate relationships (including any sexual relationships) make you:

Q34 Thinking about your health and your relationship with your family:

Q 35 Thinking about your health and your role in your community (that is to say neighbourhood, sporting, work, church or cultural groups):

Appendix F - Qualidem

QUALIDEM

First version (May 2005)

Name of resident:……………………………………………………

Ward:………………………………………………………………

The questionnaire contains 40 questions. The objective is that you, together with a colleague, answer the questions about the past week, in which you have observed the resident. Please answer every question. If you hesitate between two possibilities, circle the figure below the answer that is most in line with your observations. An answer is never wrong, but always indicates what you feel comes closest to reality. Do not think too long about an answer; the first answer that comes to mind is usually the best one. Try to reach agreement on the questions on which you and your colleague have different opinions.

Never	=	Never
Rarely	=	No more than once a week
Sometimes	=	A few times per week
Frequently	=	Almost daily

1	Is cheerful	Never 0	Rarely 1	Sometimes 2	Frequently 3	B
2	Makes restless movements	Never 3	Rarely 2	Sometimes 1	Frequently 0	D
3	Has contact with other residents	Never 0	Rarely 1	Sometimes 2	Frequently 3	F
4	Rejects help from nursing assistants	Never 3	Rarely 2	Sometimes 1	Frequently 0	A
5	Radiates satisfaction	Never 0	Rarely 1	Sometimes 2	Frequently 3	B
6	Makes an anxious impression	Never 3	Rarely 2	Sometimes 1	Frequently 0	C
7	Is angry	Never 3	Rarely 2	Sometimes 1	Frequently 0	A
8	Is capable of enjoying things in daily life	Never 0	Rarely 1	Sometimes 2	Frequently 3	B
9	Does not want to eat	Never 3	Rarely 2	Sometimes 1	Frequently 0	J
10	Is in a good mood	Never 0	Rarely 1	Sometimes 2	Frequently 3	B
11	Is sad	Never 3	Rarely 2	Sometimes 1	Frequently 0	C
12	Responds positively when approached	Never 0	Rarely 1	Sometimes 2	Frequently 3	F
13	Indicates that he or she is bored	Never 3	Rarely 2	Sometimes 1	Frequently 0	H
14	Has conflicts with nursing assistants	Never 3	Rarely 2	Sometimes 1	Frequently 0	A
15	Enjoys meals	Never 0	Rarely 1	Sometimes 2	Frequently 3	J
16	Is rejected by other residents	Never 3	Rarely 2	Sometimes 1	Frequently 0	G
17	Accuses others	Never 3	Rarely 2	Sometimes 1	Frequently 0	A
18	Takes care of other residents	Never 0	Rarely 1	Sometimes 2	Frequently 3	F

19	Is restless	Never 3	Rarely 2	Sometimes 1	Frequently 0	D
20	Openly rejects contact with others	Never 3	Rarely 2	Sometimes 1	Frequently 0	G
21	Has a smile around the mouth	Never 0	Rarely 1	Sometimes 2	Frequently 3	B
22	Has tense body language	Never 3	Rarely 2	Sometimes 1	Frequently 0	D
23	Cries	Never 3	Rarely 2	Sometimes 1	Frequently 0	C
24	Appreciates help he or she receives	Never 0	Rarely 1	Sometimes 2	Frequently 3	A
25	Cuts himself/herself off from environment	Never 3	Rarely 2	Sometimes 1	Frequently 0	F
26	Finds things to do without help from others	Never 0	Rarely 1	Sometimes 2	Frequently 3	I
27	Indicates he or she would like more help	Never 3	Rarely 2	Sometimes 1	Frequently 0	E
28	Indicates feeling locked up	Never 3	Rarely 2	Sometimes 1	Frequently 0	H
29	Is on friendly terms with one or more residents	Never 0	Rarely 1	Sometimes 2	Frequently 3	F
30	Likes to lie down (in bed)	Never 3	Rarely 2	Sometimes 1	Frequently 0	J
31	Accepts help	Never 0	Rarely 1	Sometimes 2	Frequently 3	A
32	Calls out	Never 3	Rarely 2	Sometimes 1	Frequently 0	G
33	Criticizes the daily routine	Never 3	Rarely 2	Sometimes 1	Frequently 0	A
34	Feels at ease in the company of others	Never 0	Rarely 1	Sometimes 2	Frequently 3	F
35	Indicates not being able to do anything	Never 3	Rarely 2	Sometimes 1	Frequently 0	E
36	Feels at home on the ward	Never 0	Rarely 1	Sometimes 2	Frequently 3	H
37	Indicates feeling worthless	Never 3	Rarely 2	Sometimes 1	Frequently 0	E
38	Enjoys helping with chores on the ward	Never 0	Rarely 1	Sometimes 2	Frequently 3	I
39	Wants to get off the ward	Never 3	Rarely 2	Sometimes 1	Frequently 0	H
40	Mood can be influenced in positive sense	Never 0	Rarely 1	Sometimes 2	Frequently 3	B

Score calculation: in the last column the subscale is mentioned. Summate the scores for each subscale.

Subscale (number of items)	*Range*		*Score*
A: Care relationship (7)	0 – 21	A	
B: Positivef Affect (6)	0 – 18	B	
C: Negative Affect (3)	0 – 9	C	
D: Restless tense behavior (3)	0 – 9	D	
E: Positive self-image (3)	0 – 9	E	
F: Social Relations (6)	0 – 18	F	
G: Social Isolation (3)	0 – 9	G	
H: Feeling at home (4)	0 – 12	H	
I: Having something to do (2)	0 – 6	I	
J: Remaining items to be used in future research			

Appendix G – Sample Log Book Page

Week of February 1–7 .

Date	Activities	Notes
Sunday 1		
Monday 2		
Tuesday 3		
Wednesday 4		
Thursday 5		
Friday 6		
Saturday 7		

Week of February 8–14 .

Date	Activities	Notes
Sunday 8		
Monday 9		
Tuesday 10		
Wednesday 11		
Thursday 12		
Friday 13		
Saturday 14		

Appendix H – Ethics Approval

NEWFOUNDLAND AND LABRADOR
HREB
HEALTH RESEARCH ETHICS BOARD

Ethics Office
Suite 200, Eastern Trust Building
95 Bonaventure Avenue
St. John's, NL
A1B 2X5

June 5, 2014

Ms Amanda George
School of Human Kinetics and Recreation
Memorial University of Newfoundland

Dear Ms George:

Reference #14.101

RE: **The effect of physical activity on cognitive function and quality of life in older adults**
This will acknowledge receipt of your correspondence.

This correspondence has been reviewed by the Chair under the direction of the Board. ***Full board approval*** of this research study is granted for one year effective **May 29, 2014.**

This is to confirm that the Health Research Ethics Board reviewed and approved or acknowledged the following documents (as indicated):

- Application, approved
- Revised consent form, approved
- Physical Activity Readiness Questionnaire, approved
- Stratify Falls Risk Assessment Tool, approved
- Montreal Cognitive Assessment (MOCA), approved
- Psychogeriatric Assessment Scale – Subject Interview (Cognitive Impairment), approved
- Psychogeriatric Assessment Scale – Informant Interview (Cognitive Decline), approved
- Informant Questionnaire on Cognitive Decline in the Elderly (IQCODE), approved
- Assessment of Quality of Life 8D (AQoL-8D), approved
- Qualidem, approved

MARK THE DATE

This approval will lapse on May 29, 2015. **It is your responsibility to ensure that the Ethics Renewal form is forwarded to the HREB office prior to the renewal date; you may not receive a reminder, therefore the ultimate responsibility is with you as the Principle Investigator.** *The information provided in this form must be current to the time of submission and submitted to HREB not less than 30 nor more than 45 days of the anniversary of your approval date.* The Ethics Renewal form can be downloaded from the HREB website http://www.hrea.ca.

The Health Research Ethics Board advises THAT IF YOU DO NOT return the completed Ethics Renewal form prior to date of renewal:

- *Your ethics approval will lapse*

email: info@hrea.ca Phone: 777-8949 FAX: 777-8776

- *You will be required to stop research activity immediately*
- *You may not be permitted to restart the study until you reapply for and receive approval to undertake the study again*

Lapse in ethics approval may result in interruption or termination of funding

It is **your responsibility to seek the necessary approval from the Regional Health Authority or other organization as appropriate. You are also solely responsible for providing a copy of this letter, along with your application form, to the Office of Research Services should your research depend on funding administered through that office.**

Modifications of the protocol/consent are not permitted without prior approval from the Health Research Ethics Board. Implementing changes in the protocol/consent without HREB approval may result in the approval of your research study being revoked, necessitating cessation of all related research activity. Request for modification to the protocol/consent must be outlined on an amendment form (available on the HREB website) and submitted to the HREB for review.

This research ethics board (the HREB) has reviewed and approved the research protocol and documentation as noted above for the study which is to be conducted by you as the qualified investigator named above at the specified site. This approval and the views of this Research Ethics Board have been documented in writing. In addition, please be advised that the Health Research Ethics Board currently operates according to *Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans*; *ICH Guidance E6: Good Clinical Practice* and applicable laws and regulations. The membership of this research ethics board is constituted in compliance with the membership requirements for research ethics boards as defined by *Health Canada Food and Drug Regulations Division 5; Part C.*

Notwithstanding the approval of the HREB, the primary responsibility for the ethical conduct of the investigation remains with you.

We wish you every success with your study.

Sincerely,

Patricia Grainger

Dr Fern Brunger, PhD (Chair Non-Clinical Trials)
Ms. P. Grainger, (Vice-Chair Non-Clinical Trials)
Health Research Ethics Board

For Office Use Only: June 12, 2014

email: info@hrea.ca Phone: 777-8949 FAX: 777-8776

Version January 2015

Health Research Ethics Board
777-6974 (Phone)
777-8776 (Fax)

Request for Amendment to an Approved Application

HREB #: 14.101

Current Date: March 5, 2015

Title of study: Include protocol number, if any.

The Effect of Physical Activity on Cognitive Function and Quality of Life h Older Adults

Amendment Date: March 5, 2015 | Version # (if applicable):

Are these changes editorial and/or administrative?	Yes	No
Will there be any increase in risk, discomfort or inconvenience to the participants?	Yes (Specify below)	No
Are there changes to inclusion or exclusion criteria?	Yes (Specify below)	No
Are participants enrolled in the study?	Yes	No
Is a modification to the consent form required?	Yes (Attach revised ICF)	No
Is a consent addendum required? (*If participants are enrolled in the study and the proposed changes affect them, a consent addendum must be submitted*)	Yes (Attach consent addendum)	No

Summarize the significant changes being requested. It is not necessary to itemize editorial, administrative and similar changes.

In the final meeting with participants, in addition to the quest bnnaires a lready being conducted, an additional interview will be added. Participants will have the option of having this interview voice recorded.

What is the rationale for the amendment(s)?

Throughout the duration of the study, during informal conversations participants have identified several factors that were not considered in the origina l study. In order to get a better understanding of these factors an interview will be conducted.

Other pertinent information – List ALL documents, including version dates, to be reviewed:

Interview Questions
Consent Addendum March 2015

Amanda George — Printed Name of Principal Investigator
[signature] — Signature of Principal Investigator
March 5, 2015 — Date

1

HREB #:	Amendment Date:	Version:

Health Research Ethics Board
777-6974 (Phone)
777-8776 (Fax)

Version January 2015

This Health Research Ethics Board (the HREB) has reviewed the amendment as noted above for the study which is to be conducted by you as the qualified investigator named above at the specified study site. This approval and the views of this Research Ethics Board have been documented in writing. In addition, please be advised that the Health Research Ethics Board currently operates according to Tri-Council Policy Statement (TCPS2) and applicable laws and regulations. The membership of this research ethics board complies with the membership requirements for research ethics boards defined in TCPS2.

Full Board Review and Approval granted at ______________________ *Meeting*

______________________ ______________________
Signature Chair (Dr. Fern Brunger) *Date*

______________________ ______________________
Signature Vice-Chair (Patricia Grainger) *Date*

OR

Reported to Full Committee at March 19 2015 *Meeting*

Approved by:

APPROVED MAR 0 6 2015

______________________ ______________________
Signature Chair (Dr. Fern Brunger) *Date*

______________________ ______________________
Signature Vice-Chair (Patricia Grainger) *Date*

*Attach additional documentation if necessary

2

HREB #:	Amendment Date:	Version:

Appendix I – Interview Questions

To start, before the study began, how active would you say you were?

Do you think that your activity level has changed throughout the study?

Were you able to make use of the track at MUN?

Did you have another place you were able to walk?

What other types of activities did you engage in on a regular basis?

When you were walking, did you meet up with other people to walk, or did you walk on your own?

Did you prefer having set times to use the track or being able to use it at any time?

Do you have any other comments about your walking or other activities?

Have you ever used an activity tracker or pedometer before the study?

How did you find using the Vivofit activity tracker during the study?

What were some things that you like about it?

What were some things you did not like about it?

Do you currently own an activity tracker?

(If yes to previous question only) If you have purchased one within the last six months, what were your motivations for doing so?

Before the study have you ever tracked your physical activity in a log book, or through any other method?

How did you find using the log book during the study?

What were some things you liked about using it?

What were some things you did not like about using it?

Do you have any other comments about tracking your activity either with the log book or Vivofit?

How do you think you performed on the cognitive questionnaires?

Do you think your performance has changed since the start of the study?

Do you think your informant has noticed any changes since the start of the study?

Do you have any other comments regarding any aspect of the study?

Thank you for your participation.