Perceived Neighbourhood Environment and Health-Related Outcomes among Older Adults

By

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A Thesis submitted to the Faculty of Graduate Studies of The University of Manitoba in partial fulfilment of the requirements of the degree of

DOCTOR OF PHILOSOPHY

APPLIED HEALTH SCIENCES
PhD PROGRAM

University of Manitoba
Winnipeg

ABSTRACT

The purpose of this study was to examine whether perceived neighbourhood characteristics and personal characteristics in 2007/2008 predicted health-related outcomes: steps taken per day, life-space mobility, physical function, body mass index (BMI), and body composition-related health benefits in 2010/2011 among community-dwelling older adults. The total sample consisted of 341 men and women above the age of 62 years. Steps per day were measured using pedometers for a 3-day period and the change score was reported as a binary outcome: increased steps and decreased steps. Life-space mobility was assessed using the Life-Space Assessment and the outcome was the life-space score as a continuous variable. Physical function was assessed using the Late Life Function and Disability Instrument. The outcome was the total score as a continuous variable. BMI was assessed using the index of the participants' self-reported weight divided by the height squared. Body composition-related health benefits were assessed using the participants' BMI refined by the participants' self-assessed waist circumference. The independent variable was the perception of the neighbourhood environment assessed using select items of the Neighbourhood Environment Walkability Scale in four categories: presence and maintenance of sidewalks; aesthetics; walkability safety; and traffic safety. Demographic and health information (sex, age, self-rated health, physical function limitations, number of chronic conditions and body mass index) were also collected. Regression analysis showed that although more positive perceptions of neighbourhood characteristics such as walkability safety, traffic safety and sidewalks were associated with health-related outcomes, overall, the perceived neighbourhood environment was not a strong predictor of health-related outcomes among community-dwelling older adults. These outcomes were mostly predicted by demographic and health status variables (i.e. chronic conditions, self-rated health, body mass index, physical function limitations). Initiatives targeted at the neighbourhood environment should consider the health-related outcome of interest (i.e. walking, mobility, physical function or obesity), the specific age group (i.e. old age or very old age and oldest old age), and the importance of demographic and health variables in shaping the relationship between the neighbourhood environment and these outcomes.

ACKNOWLEDGMENTS

I would like to thank God for his guidance, to Him all glory and praise.

To my family, for their love, and supporting me in my academic endeavors in a foreign country that also became my home.

To my husband, for constant love, care, and companionship on every step of the way—in good times and worrisome times.

Special thank you to my co-advisors, Dr. V. Menec and Dr. E. Ready, for your patience, your guidance, constant support and encouragement. You are wonderful mentors and I would not have concluded my program without your help. I also would like to thank my committee members, Dr. B. Shay, Dr. R. Milgrom, and Dr. L. Gauvin. Your inputs, comments, and critique helped me in my research you provided me with a great experience as a graduate student.

I also would like to thank my counselors, Dr. G. Geller and Dr. M. Chohan for helping me to overcome barriers that seemed impossible to remove. I finally did it!

I would like to thank the Faculty of Kinesiology and Recreation Management and for the Age-Friendly Communities (CURA) funded by the Social Sciences and Humanities Research Council of Canada for funding support.

To my special Center on Aging team. The journey would not have been the same without your support, friendship, and positivism. I will always keep fond memories.

Special thank you to my dear University of Manitoba, whom I am so proud to be part of. I will always cherished special and unforgettable moments in my heart.

To all my friends. These wonderful angels of God certainly become family when one is away from home land.

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CHAPTER 1 – INTRODUCTION

1.1 Overview

Population aging is one of the most important demographic outcomes since the twentieth century and has reached utmost significance in the twenty-first century. The number of older adults worldwide has more than tripled since 1950, from 205 million to 737 million, and projections indicate that by 2050 the number of older adults in the world will reach 2 billion. The rate of growth of this population is 2.6 per cent a year, which is more than double the growth of the overall population (1.2 percent a year). As a result, for the first time in history, the number of older adults is estimated to surpass the number of children by the year of 2045. The aging trend is particularly noticeable in the oldest-old age group which has the fastest growth rate of 4% a year with an estimated 13-fold increase, from 287,000 in 2006 to 3.7 million in 2050 (United Nations, 2009).

Canada is also experiencing an aging demographic shift, particularly in the twenty-first century. Factors contributing to this change include low fertility rates, longer life expectancy and the aging of the Baby Boomer generation (comprised by those who were born between the years of 1946 and 1964). Between 1981 and 2005, the percentage of older adults in Canada increased from 9.6% to 13.1% (from 2.4 to 4.2 million). The proportion of older adults is projected to increase at a faster rate between 2005 and 2036, representing 24.5% of the total population (9.8 million). Between the years of 2036 and 2056, it is projected to increase at a slower rate, from 24.5% to 27.2% and going from 9.8 to 11.5 million, which will represent nearly a third of the total population in the country (Statistics Canada, 2007). In Manitoba, between 2006 and 2026, the population at the age of 65 and above will increase from 14.1% to 19.9%, and the number of children and older adults in the province is estimated to be equivalent (Statistics Canada, 2010).

The world is also experiencing a trend towards urbanization. The proportion of the urban population worldwide increased by 16% from 1900 to 1950, and according to the United Nations it reached 49% in 2005. By 2030, approximately 60% of the global population is expected to live in urban areas (United Nations, 2009). In 2006, 80% of the population in Canada lived in urban areas. Factors that contribute to urbanization in the country are the economic development in major cities, the internal migration of younger adults to cities for studies and employment, and international immigration to Canada (Statistics Canada, 2009).

The urbanization trend is also generally observed among the older adult population. According to the United Nations, in 2005, approximately half of the older adult population worldwide lived in urban areas (United Nations, 2009). In Canada, between 2001 and 2006, the proportion of older adults living in cities increased by 12.6 %, and the proportion of those living in rural areas increased by 14.4%. In Winnipeg, a large percentage of older adults reside in the north and west parts of the city compared to younger adults (Statistics Canada, 2009).

Urbanization in combination with population aging should require cities to redesign services, initiatives, and programs in order to accommodate older adults' needs and promote well-being. In 2006, in recognition of the role of the physical and social environments for active, healthy aging, the World Health Organization (WHO) launched the "Age-Friendly Cities" initiative. According to the WHO, communities should adapt their services and structures to be inclusive of older adults, thus optimizing opportunities for health, independence, and participation (World Health Organization, 2006). The objective of the initiative was to inform government sectors about “age-friendly” characteristics of each city, as well as challenges and difficulties that older adults encounter in their environments.

Eight emerging themes were identified: transportation, housing, outdoor spaces and buildings, social participation, respect and social inclusion, civic participation and employment, communication and information, community support and health services (World Health Organization, 2006). The focus on age-friendly cities stimulated research interest on how the environment can foster healthy behaviours such as a physically activity lifestyle, decreased obesity levels, and increased mobility.

The physiological and cognitive changes that happen with aging may increase the susceptibility of older adults to negative health outcomes such as chronic diseases, mobility problems, and disability. Approximately 80% of Canadians 65 years and older reported having at least one chronic disease (Gilmour & Park, 2006). Rheumatism, including arthritis, is the most common condition, reported by 51% of older adults, particularly women. Hypertension is the second most prevalent chronic disease in Canada (Statistics Canada, 2007).

Mobility is an important health-related outcome among older adults because it is associated with independence and quality of life (World Health Organization, 2011b). Mobility problems are common in advancing age, are more prevalent among women compared to men (Statistics Canada, 2006) and are a strong predictor of disability (Guralnik et al., 1994). According to Statistics Canada, 43.4% of older adults reported having some form of disability. The three most common forms of disability reported by the older age group were the ones related to mobility, agility and pain respectively (Statistics Canada, 2006).

Obesity is another chronic disease that represents a serious public health concern. The prevalence of overweight and obesity among adults and older adults in North America reached noteworthy proportions in the last decade and trends over the past 16 years show a possible increase in prevalence, particularly among men (Flegal, Carroll, Ogden, & Curtin, 2010). Obesity is associated with several negative health outcomes such as hypertension, type 2 diabetes, coronary heart disease, stroke (Field et al., 2001), and mobility disability (Vincent, Vincent, & Lamb, 2010) which have a considerable impact on one's overall quality of life.

A physically active lifestyle that includes walking can improve quality of life to a great extent in later years through various health benefits (Murtagh, Murphy, & Boone-Heinonen, 2010). These include prevention and management of chronic diseases (Warburton, Nicol, & Bredin, 2006) and improvements in physical function (Manini & Pahor, 2009). Nevertheless, despite the substantial evidence of health benefits associated with activity engagement, only 30% of older Canadians reported meeting minimum guidelines for leisure time physical activity and this proportion is even lower (23%) when chronic diseases are present (Ashe, Miller, Eng, Noreau, & Physical Activity and Chronic Conditions Research Team, 2009).

According to ecological models, an individual's health depends on a dynamic interaction of biological, psychological, social, and environmental factors as well as policy (Stokols, 1992). Considering physical activity, one's choice to be physically active may be influenced by supportive environments with a variety of accessible, affordable, and inclusive services, safe and pleasant areas to walk in, the presence of supportive and friendly neighbours, and appropriate policies that encourage this behaviour. Therefore, provisions towards supportive neighbourhoods could promote active lifestyles at a population level and facilitate people's interaction with their surrounding environment.

Features of the neighbourhood environment such as land use, transportation, and urban design are associated with positive health outcomes. These outcomes include increased physical activity (Duncan & Mummery, 2005; Duncan, Spence, & Mummery, 2005; Saelens & Handy, 2008; Wendel-Vos, Droomers, Kremers, Brug, & van Lenthe, 2007) and greater physical function and mobility (Rosso, Auchincloss, & Michael, 2011). Certain neighbourhood characteristics have also been linked with obesity (Feng, Glass, Curriero, Stewart, & Schwartz, 2010; Papas et al., 2007). Characteristics of the neighbourhood environment such as greater mixed land use (Eisenstein et al., 2011; Frank, Kerr, Rosenberg & King 2010; Li et al., 2009; King et al., 2011), density measures such as residential units (Frank, Kerr, Rosenberg & King 2010; King et al., 2011) and population density (Hanibuchi et al., 2011) were associated with lower levels of obesity among older adults. Other characteristics such as street connectivity (Frank, Kerr, Rosenberg & King 2010; Li et al., 2009; King et al., 2011) and safety were also associated with lower levels of obesity (Eisenstein et al., 2011).

Despite the growing body of research examining features of the neighbourhood environment and health-related outcomes, studies have focused primarily on younger adults (Duncan et al., 2005; Saelens & Handy, 2008; Wendel-Vos et al., 2007). There is limited evidence of this association among older adults, particularly the group 65 years of age and older. In addition there is limited evidence when outcomes such as life-space mobility and obesity are considered in comparison to outcomes such as physical activity.

Another major limitation of the literature is the lack of studies with a longitudinal design. Since the majority of studies in this area are cross-sectional, it is not evident whether the relationship between supportive neighbourhood environments and health-related outcomes is held over time or if other factors (e.g., health status) are mediating this relationship (Saelens & Handy, 2008; Yen, Michael, & Perdue, 2009). This study will attempt to overcome some of the limitations in the literature and provide novel findings that may strengthen evidence of the importance of specific neighbourhood characteristics in relation to health-related outcomes among older adults.

1.2 An Ecological Perspective on Health Outcomes

Ecology refers to the interaction between organisms and their surrounding environment (Merrian-Webster Dictionary, 2010), which includes the relationship between human beings and the environments in which they live. Ecological approaches have been widely used in health research; they acknowledge that the environment and its multiple features may exert an influence in human development, health, and behaviours. The *'environment'* comprises a multitude of facets such as physical, social, and cultural factors, each of which may be studied from different perspectives. For instance the physical environment may be defined as the natural environment or built environment (Hutchison, 2011). Under the built environment, several geographical boundaries may be considered in a continuum from home, to institutional, to neighbourhoods, to cities. The environment may also be studied from a physical perspective or from a social perspective, or as a continuum from individuals, to groups, to organizations, to systems such as political and economical (Stokols, 1992; Wahl & Weisman, 2003).

The *environment* has also been the focus of gerontological science since the late seventies, with a focus on the adaptation or optimization of the environment for the older person. According to Lawton (1977), the environment has an array of functions that ensures constancy and predictability, but also fosters stimulation and independence, and promotes compensation and support for those with reduced or lost competencies. Therefore, older adults at all levels of physical and cognitive capabilities may maximize their interaction with the surrounding environment (Lawton, 1977). Environmental gerontology rapidly evolved as a consequence of the many sciences that contributed to its roots such as psychology, sociology, and architecture making it a *"pluralistic"* science (Wahl & Weisman, 2003).

Bronfenbrenner (1977) proposed the Ecological Systems Theory which focuses on the inter-relation between human beings and the environments with which they interact. A particular emphasis was given on human development where there is a *"progressive, mutual accommodation, throughout the life span, between a growing human organism and the changing immediate environments in which it lives..."* (p.514). The environment is described at multiple levels where each level is contained within the next. Therefore, the microsystem represents the interrelation between the person and his/her immediate setting (e.g., home, school), the mesosystem represents the interrelations between the various settings where the person may interact at a given point in time (e.g., home, work, church, family). The exosystem is characterized by an expansion of the mesoystem that does not hold the person directly, but exerts an influence on the person. This may be represented by the neighbourhood where one lives, the transportation system, and social networks. Finally, the macrosystem is comprised of the most external surroundings and contains all the other systems above. It is represented by the cultural, political, economical systems in the society as shown in Figure 1 (Bronfenbrenner, 1977).

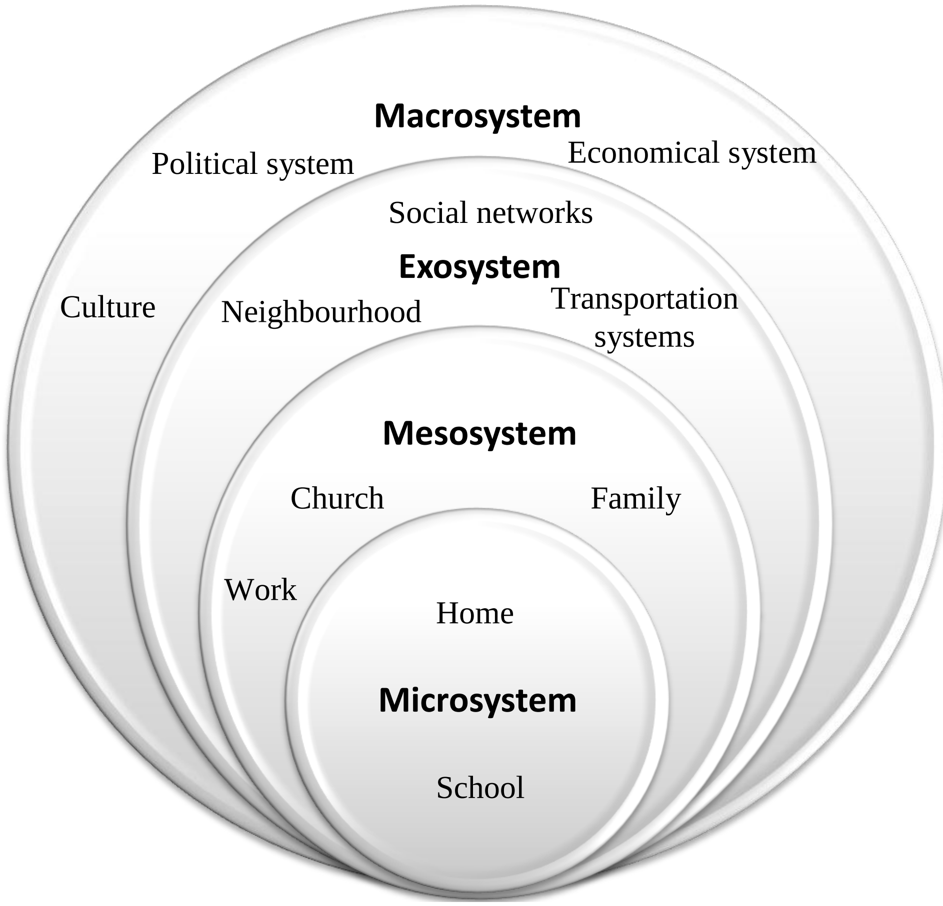


Figure 1. The Ecological Systems Theory (adapted from Bronfenbrenner (1977))

The ecological approach has some core characteristics that explain the dynamic interaction between the multiple environmental influences on people's health. First, individuals exert an influence on the surrounding environment but are also influenced by the environment. This is the principle of reciprocity. Second, the impact of the environment on individuals' health and well-being may be direct (natural catastrophes such as high amount of ash produced from volcanic activity damaging the respiratory system) or indirect (a neighbourhood with dark streets, broken windows and litter may hinder social interaction among residents). Third, the ecological approach takes into consideration the possible interactions of the individual in different settings (e.g., home, work, school). Fourth, as Bronfenbrenner (1977) notes, constant changes may happen in the different settings and/or in people's roles as part of human development and should be taken into consideration (Bronfenbrenner, 1977).

The ecological perspective has also become a guiding framework in health promotion. Stokols (1992) proposed the Socio-Ecological Model of Health that focused on heath-promotive environments. The ecological perspective on health promotion shifted the focus from individual interventions to population-level interventions, where the objective is to identify characteristics or features in the community/cities that are health-promotive and may consequently benefit populations. Therefore the social, cultural, institutional, and economical contexts at a broader scale play a fundamental role in people's health. Furthermore, personal attributes such as biological, genetic, behavioural, and psychological factors that also influence health status need to be taken into account (Stokols, 1992).

Thus, the Socio-Ecological Model allows the study of groups nested in their surrounding environment rather than focusing on individual observations only (Stokols, 1992). For instance, an ergonomically designed environment at the workplace may reduce the risk of injury and therefore increase productivity and satisfaction. In addition, ergonomically designed workplaces do not affect individuals only, but organizations and corporations, thus their influence expands to population levels. When applied to physical activity, people may engage in regular physical activity if services such as recreation facilities are available, accessible, tailored according to age or cultural groups, and affordable. Other factors that may facilitate physical activity are the availability of public features such as parks and trails, the presence of physically active friends or neighbours who offer peer support, or the existence of effective health policies towards a physically active lifestyle. In contrast, some features of the environment, such as poorly maintained recreational areas and unsafe neighbourhoods may discourage physical activity behaviour.

The Socio-Ecological Model of Health has been used as a guide to explain health-related outcomes in urban settings. Physical activity in particular has received extensive attention. The model received contributions from a variety of sciences including public health, urban planning, leisure and recreation studies, political science, and economics. As such, this trans-disciplinary approach of the model allows examining physical activity from different perspectives (Sallis et al., 2006).

Physical activity is a complex behaviour that can be explained by a variety of factors such as a person's physiological, psychological, social and economic characteristics. In view of this complexity, Sallis and colleagues stated that in order for interventions to be effective and to reach populations, a multilevel approach must be taken. Thus, the focus is not only the individual, but the physical and social environments, policy planning, and the cultural and socio-economic aspects surrounding the individual (Sallis et al., 2006).

Health-promotive environments may encourage health and well-being through initiatives that promote physically active lifestyles. Enhancements in land use, improvements in transportation systems including initiatives to promote active modes of transportation (e.g., walking and biking), and decrease in air pollution have a noteworthy impact on physical activity participation (Frank & Engelke, 2001) and other health-related outcomes such as physical function, mobility (Clarke & Nieuwenhuijsen 2009) and obesity (Black & Macinko, 2008).

1.3 Statement of Purpose and Hypotheses

The overall purpose of this study was to examine the relationship between the perceived neighbourhood environment and health-related outcomes (physical activity (walking), physical function, obesity and life-space mobility) over a three-year period (2007/2008 and 2010/2011) among community-dwelling older adults living in various neighbourhoods in Winnipeg.

The specific purposes varied according to each sub-study:

1.3.1. Study 1: Longitudinal Study of the Influence of the Perceived Neighbourhood Environment on Change in Objectively Measured Walking Among Older Adults

1.a To examine whether the perceived neighbourhood characteristics (walkability safety, sidewalks, aesthetics, traffic safety) predicts change in walking activity over a three-year time period (2007/2008 to 2010/2011).

1.b To examine whether demographic and personal characteristics (e.g., age, sex, health status (self-rated health, number of chronic conditions, body mass index (BMI), physical function limitations)) predict change in walking activity over a 3-year period.

Hypotheses:

1. The decline in walking activity will be attenuated by having a positive perception of the neighbourhood environment; those with positive neighbourhood perceptions will show less decline in walking.
2. There will be a decline in walking activity over a 3-year period that will be mostly explained by advancing age and decreased health status. The decline will be greater in women compared to men.

1.3.2. Study 2: Perceived Neighbourhood Environment and Life-Space Mobility and Physical Function among Community-dwelling Older Adults

2.a To examine whether perceived neighbourhood characteristics (walkability safety, sidewalks, aesthetics, traffic safety) in 2007/2008 predict life-space mobility and physical function in 2010/2011.

2.b To examine whether demographic and personal characteristics in 2007/2008 (e.g., age, sex, health status (self-rated health, number of chronic conditions, BMI, physical function limitations, steps taken per day)) predict life-space mobility and physical function in 2010/2011.

Hypotheses:

1. More positive perceptions of neighbourhood characteristics will be associated with greater life-space mobility and greater physical function three years later.
2. Life-space mobility and physical function will be mostly predicted by demographic and health status variables such as age, female sex, more chronic conditions and higher BMI.

1.3.3. Study 3: The Influence of the Perceived Neighbourhood Environment on Obesity Indicators in Older Age

3.a To examine whether perceived neighbourhood characteristics (walkability safety, sidewalks, aesthetics, traffic safety) in 2007/2008 predict BMI and body composition-related health benefits in 2010/2011.

3.b To examine whether demographic and personal characteristics collected in 2007/2008 (e.g., age, sex, health status (self rated health, number of chronic conditions, BMI at baseline, steps taken)) predict BMI and body composition-related health benefits in 2010/2011.

<u>Hypotheses:</u>

1. More positive perceptions of neighbourhood characteristics will be associated with lower BMI and greater body composition-related health benefits three years later.
2. BMI and body composition-related health benefits will be mostly predicted by demographic and health status variables such as age, female sex, chronic conditions and steps taken per day.

1.4 Significance of the Study

This study will overcome some limitations of the existing literature for the following reasons:

1. A longitudinal design will be employed. Although causality cannot be demonstrated, possible associations that may arise between environmental features and

health-related outcomes (i.e. steps taken per day) can be examined over time. According to Spence and Lee (2003), a temporal component should be considered for studies based on ecological models because significant relationships between the explanatory and the outcome variables may require a long time to manifest (Spence & Lee, 2003). That much of the research in this area has relied on cross-sectional data has been criticised (Clarke & Nieuwenhuijsen 2009).

2. Several health outcomes will be examined in this study in addition to physical activity, which has been the focus of most of the existing research. Outcomes such as physical function, life-space mobility and obesity will also be considered. To date, there are no studies published on life-space mobility and the perceived environment.

3. The focus of the study will be on adults 65 years of age and older only instead of younger adults. Most studies have focused on young adults and limited research is available for older adults.

4. Additionally, there is limited evidence on the relationship between the perceived neighbourhood environment and physical activity when an objective measure of physical activity is used. In this study, objective methods were used to measure physical activity among older adults. This increases the chance of capturing daily physical activity instead of relying on participants' reports of physical activity.

1.5 Study Delimitations

1. This study was conducted with community dwelling older adults aged 65 and older who participated in the third (2007-2008) and fourth (2010-2011) phases of the Wellness Information Survey and Evaluation Research (WISER).
2. Both the third and fourth phases of the study were conducted in the fall and winter (September to January) in specific neighbourhoods of a mid-sized Canadian city.

1.6 Study Limitations

The following methodological factors may have impacted the results of the study:

1. Physical activity was objectively measured using pedometers for a 3-day period, thus it might not reflect a usual activity pattern. Pedometers also do not provide information about the location where people are situated, therefore it cannot be guaranteed that certain locations and services in the neighbourhood absolutely contributed to increase/maintain physical activity, physical function, mobility, and body composition-related health benefits or decrease obesity.
2. The neighbourhood environment was assessed using a subjective measurement, therefore perceptions only were considered. Personal factors may shape the way people perceive their surrounding environment.
3. Physical function and body mass index were assessed using self-reported measurements.
4. Waist circumference, as a measure of central obesity, and life-space mobility were self-assessed.

5. Participants were asked to volunteer for the study; therefore there was a possibility of sample bias.

1.7 Assumptions

1. Pedometers accurately reflect physical activity levels.
2. Volunteer subjects are representative of older adults in the community.
3. The difference between any two successive values in Likert scales (numerical values to reported answers on an ordinal scale) are equivalent in significance; this means that the difference between "strongly disagree" and "disagree" is equivalent to the difference between "agree" and "strongly agree". Thus, measures using Likert scales are treated as interval scales in analyses.

1.8 Definitions

Aging

An intrinsic, progressive and biological process characterized by anatomical, physiological and psychological changes. It is not a consequence of diseases and it is variable among individuals (Freitas et al., 2011).

Age Classification

Middle age extends from age 40 to age 64. Old age extends from 65 to 74 years of age. Very old age extends from age 75 to age 84. Oldest old age comprises individuals over 85 years of age (Shephard, 1997).

Activities of Daily Living (ADL)

Basic activities related to everyday life (Andreotti & Okuma, 1999).

Built Environment

Parts of the physical environment that is human-made or modified/constructed by human activity. It comprises urban design, land use and transportation systems (Handy, Boarnet, Ewing, & Killingsworth, 2002; Saelens & Handy, 2008).

Environmental Factors

The physical, social and attitudinal environment in which people conduct their lives (World Health Organization, 2001).

Exercise

Represents the planned and repetitive body movement for improving or maintaining physical fitness (Brach, VanSwearingen, FitzGerald, Storti, & Kriska, 2004).

Functional Limitation

Reduced ability to complete specific activities (Morey, Pieper, & Cornoni-Huntley, 1998).

Health-related Quality of Life

This concept is derived from behavioural medicine and biomedical sciences and encompasses the general aspects of quality of life that have been shown to affect physical or mental health (Centers for Disease Control and Prevention, 2011; Motl & McAuley, 2010).

Instrumental Activities of Daily Living (IADL)

Complex activities related to one's adaptation to the environment (Andreotti & Okuma, 1999).

Metabolic Equivalent

A measure of energy expenditure where 1 MET is equivalent to the energy expended (in kilocalories) divided by resting energy expenditure (in kilocalories) (Montoye, Kemper, Saris, & Washburn, 1996).

Mobility

"*Moving by changing body position or location or by transferring from one place to another, by carrying moving or manipulating objects, by walking, running or climbing, and by using various forms of transportation*" (World Health Organization, 2012a).

Personal Factors

This refers to the background of an individual's life such as age, gender, race, habits, upbringing, coping styles, social background, past and current experience, character style, as well as other psychological assets (World Health Organization, 2001).

Physical Ability

A general term to encompass muscle strength, endurance, balance, flexibility, and neuromuscular coordination (Carlson et al., 1999).

Physical Activity

Body movement that results in increased energy expenditure (Brach et al., 2004), and is also considered a behavior (Bean, Vora, & Frontera, 2004).

Physical Environment Components (attributes)

This encompasses the natural environment (that is not modified by human hands) and the built environment (Hutchison, 2011).

Physical Fitness

The condition resulting from increased physical activity (Bean et al., 2004).

Physical Fitness Components

Muscle strength, endurance, flexibility, aerobic capacity, anaerobic capacity and body composition (Buchner, Beresford, Larson, LaCroix, & Wagner, 1992).

Physical Function

The integration of physiological capacity and physical performance mediated by psychosocial factors (Cress et al., 1996).

Physically Active Lifestyle

A way of life that integrates physical activity into daily routines (Sisson, 2005).

Quality of Life

This refers to “subjective well-being or judgments regarding overall satisfaction with life” (Motl & McAuley, 2010, pg. 304).

Sedentary

A person whose lifestyle is marked by much physical inactivity and relatively little physical activity (Tudor-Locke, 2003).

Social Activity

This represents activities such as attending church, clubs, local organizations, social entertainment (cinema, theatre) with family and friends, and doing voluntary work (Jette, 2006; White et al., 2010).

Social Environment

Generally defined by the communities and groups to which people belong. For instance it may be represented by neighbourhoods where people live in, work place environments, or policies that are created to enhance health status (Wagemakers, Vaandrager, Koelen, Saan, & Leeuwis, 2010).

Walkability

Features of the neighbourhood that promote active transportation physical activity (e.g. walking, biking) such as mixed land use, highly connected streets, and high residential density (Brownson, Hoehner, Day, Forsyth, & Sallis, 2009; Sallis, King, Sirard, & Albright, 2007).

CHAPTER 2 – LITERATURE REVIEW

2.1 Physical Activity and Older Adults

Physical inactivity is a fundamental health risk factor because it is associated with a large number of negative health-related outcomes. Conversely, the maintenance of a physically active lifestyle brings enormous health benefits to various aspects of life. This section will present the key benefits of physical activity in relation to important clinical health outcomes (chronic diseases, physical function and disability, mortality, quality of life, and cognition).

A physically active lifestyle significantly reduces the risk for, or the severity of, many chronic diseases (van der Bij, Laurant, & Wensing, 2002). The strongest evidence in the literature is regarding physical activity or exercise and cardiovascular disease. A large number of studies have shown significant reduction in the risk of cardiovascular diseases (from 20% to 50%) if a person is physically fit or physically active (Sattelmair, Pertman, & Forman, 2009; Warburton et al., 2006). The risk reduction is even greater among those who are physically fit compared to those who are generally active only (Warburton et al., 2006). The mechanism that explains this reduction is the moderating effect of exercise enhancing lipid profile and circulating glucose as well as reducing blood pressure (Sattelmair et al., 2009). Physical activity also plays a fundamental role in secondary prevention, therefore facilitating the management of cardiovascular disease (Vogel et al., 2009; Warburton et al., 2006).

Considering the higher prevalence of diabetes among older adults compared to younger adults, physical activity is essential in the prevention or management of this disease (Cigolle, Blaum, & Halter, 2009). Regular physical activity and exercise, particularly aerobic and resistance training, are associated with reduced incidence of diabetes type II. Even moderate intensity physical activity, such as walking, is beneficial to reduce the risk for developing diabetes (Sattelmair et al., 2009). Overall reductions in the incidence have been reported for the general population from 6% (Warburton et al., 2006) to 45% (Sattelmair et al., 2009) and reductions from 40% to 60% have been reported among those considered at high risk for diabetes type II (Warburton et al., 2006). As for secondary prevention, aerobic and/or resistance modalities are beneficial in the management of diabetes (Warburton et al., 2006), as they help to improve glucose tolerance and reduce the risk of physical complications from diabetes (neuropathy, macro and micro vascular complications, lipid profile) (Sattelmair et al., 2009).

Cancer is more prevalent among older adults compared to younger adults (Canada Cancer Society, 2012; Courneya & Karvinen, 2007) and an estimated 187,600 new cases are estimated in Canada in the year of 2013 with 75,500 cancer deaths (Canadian Cancer Society, 2013). Cancer is currently the leading cause of death followed by heart disease, accounting for 51% of the total deaths in the country (Statistics Canada, 2011b). Moderate intensity physical activity is also beneficial in the prevention of some types of cancers, particularly colon and breast cancers. Risk reduction in incidence between 30% and 40% has been reported for colon cancer (Vogel et al., 2009; Warburton et al., 2006), and between 20% to 30% for breast cancer (Warburton et al., 2006). Regarding secondary prevention, studies have shown that engagement in physical activity was associated with a decreased reoccurrence of cancer as well as decreased risk of death from the disease (Warburton et al., 2006). Despite the promising risk reductions in incidence, only few studies focused on the benefits of physical activity in cancer survivors and most studies focused on middle age survivors. It is unknown whether or not the benefits of physical activity may be applicable to the older survivors (Courneya & Karvinen, 2007).

Regular physical activity, especially activities performed against a certain load such as weight bearing and overall resistance training, has shown important benefits for bone health (Sattelmair et al., 2009; Warburton et al., 2006). These activities have been fundamental in primary and secondary prevention of osteoporosis, as they are highly effective in maintaining bone mineral density or preventing bone loss as well as preventing fractures from osteoporosis among middle aged and older adults (Warburton et al., 2006).

Several studies have also shown that being physically active, including occasional and moderate physical activity such as walking, or being physically fit, is associated with decreased risk of all cause mortality (Inoue et al., 2008; Sattelmair et al., 2009; Warburton et al., 2006), cardiovascular related mortality (Sattelmair et al., 2009; Warburton et al., 2006), mortality from cancer (Vogel et al., 2009) and mortality from obesity (Orsini et al., 2008).

Among older adults, regular physical activity has been associated with 40% (Vogel et al., 2009) to 45% (Sattelmair et al., 2009) lower risk of deaths compared to those who are not regularly active. Evidence from younger adults shows that those who have other risk factors for cardiovascular disease but are physically fit have lower risk of premature mortality compared to those who do not have cardiovascular risk factors and are sedentary (Warburton et al., 2006).

In addition to prevention of chronic diseases, physical activity is closely related to physical function and several studies demonstrated that increased levels of physical activity among older adults are associated with lower risk of functional limitations (Manini & Pahor, 2009), particularly related to the lower body (McAuley et al., 2007). Any type of physical activity, including habitual walking, performed on a regular basis helps to improve functional performance and maintain mobility. However, greater benefits on physical function are observed among those with higher levels of activity (Wong, Wong, Pang, Azizah, & Dass, 2003). Visser and colleagues (2005) showed that older adults who were exercisers, and those who had an active lifestyle, were significantly less likely to develop mobility limitations over a period of 4.5 years compared to those who were inactive. However, exercisers had greater protection against incident mobility limitation compared to those who had an active lifestyle only (Visser et al., 2005). Greater benefits on physical function have been observed among exercisers compared to those who are occasionally active throughout the day, but these two groups had higher functional scores compared to inactive older adults (Brach et al., 2004; Hillsdon, Brunner, Guralnik, & Marmot, 2005).

The benefits of physical activity on physical function accrue over the decades of life. Adults who are physically active at recommended levels during middle age years are more likely to maintain higher physical function compared to those who are not active at recommended levels, indicating a protective role of physical activity on physical function (Hillsdon et al., 2005). Among frail older adults physical activity has been essential to maintain physical function. Activities such as walking, gardening, and housekeeping have shown considerable benefits on physical function (Landi et al., 2010).

Although positive strong evidence exists of a relationship between physical activity and physical function, the evidence of an association between physical activity and disability is less clear. The available evidence does not strongly support the statement that exercise effectively prevents or minimizes disability (Keysor & Jette, 2001; Keysor, 2003; Motl & McAuley, 2010). A number of studies have shown that older adults who engage in regular physical activity have better quality of life. However the evidence is stronger for health-related quality of life than quality of life itself. Possible reasons include the variability in measures of quality of life and physical activity.

Lastly, physical activity has an important role related to cognitive function among older adults. Studies have shown that a 60-minute exercise program, three times a week for a minimum of 24 weeks was associated with improvement in cognitive function (Tseng, Gau, & Lou, 2011). Aerobic exercise has been effective in improving cognitive capacity among older adults without cognitive impairment (Angevaren, Aufdemkampe, Verhaar, Aleman, & Vanhees, 2008; Littbrand et al., 2011). However, among those with dementia it is still unclear whether or not exercise can maintain cognitive function (Littbrand et al., 2011). Tseng and colleagues found that multiple-component exercise was more beneficial among those without cognitive impairment whereas single-component exercise was more effective among those with cognitive impairment. However, more studies including larger trials should be done in order to substantiate these findings (Tseng et al., 2011).

2.1.1 Benefits of Walking Among Older Adults

Walking is the most common physical activity engaged in by older adults (Berke, Koepsell, Moudon, Hoskins, & Larson, 2007; Michael, Beard, Choi, Farquhar, & Carlson, 2006) and older adults walk for a variety of purposes such as transportation, leisure (Shigematsu et al., 2009) or health maintenance (de Melo, Menec, Porter, & Ready, 2010; Wong et al., 2003). Walking is convenient, safe, sociable, and does not involve financial costs, thus being appropriate for community settings (Ekkekakis, Backhouse, Gray, & Lind, 2008). It is also associated with higher adherence than more vigorous activities (Lamb, Bartlett, Ashley, & Bird, 2002) and accounts for a significant portion of total daily physical activity (Statistics Canada, 2012a).

Regular walking is associated with a variety of health benefits and the most reported one is improvement in cardiovascular health because of benefits to lipid profile, blood pressure and body mass (Murtagh et al., 2010; Sattelmair et al., 2009). Several observational and intervention studies have shown that walking for longer duration or longer distance is associated with increased cardiovascular health and decreased risk for cardiovascular disease, and is therefore beneficial for both primary and secondary prevention (Sattelmair et al., 2009). Walking has also shown to be beneficial in the management of diabetes (Warburton et al., 2006). Other health-related benefits include improvements in cognitive function (Weuve et al., 2004), prevention of physical disability (Wong et al., 2003), and maintenance of physical fitness in older adults (Aoyagi, Park, Watanabe, Park, & Shephard, 2009).

Depending on the intensity, walking provides a range of physical benefits. When performed at low intensity it is associated with improvements in neuromotor performance

(Rooks, Kiel, Parsons, & Hayes, 1997) and recovery of independence among older adults with disabilities (Hardy & Gill, 2005). At moderate intensity, walking may improve cardio respiratory fitness, and increase levels of energy (Ekkekakis et al., 2008; Wong et al., 2003). Benefits to lower body strength have also been reported as a consequence of walking training (Kubo et al., 2008).

2.1.2 Physical Activity Recommendations for Older Adults and Current Levels of Physical Activity

Additional and important health benefits are clearly observed among older adults who are regularly active at a moderate intensity in comparison to those who are just active through the day (Visser et al., 2005; Wong et al., 2003). Physical activity guidelines have been developed and updated over the years in order to determine the minimum level of activity required for health. According to the current physical activity guidelines of the Canadian Society for Exercise Physiology, older adults must accumulate at least 150 minutes of moderate-to-vigorous intensity aerobic physical activity per week for health and functional benefits. Strength training should be performed at least twice a week. Balance training should be performed by older adults with mobility problems. The updated guidelines also recommend bouts of at least 10 minutes throughout the day as it allows individuals to tailor their physical activity practice according to their daily routine (Canadian Society for Exercise Physiology, 2011).

Despite the many health benefits, Canadians are not meeting the recommended levels of physical activity. When examining activity levels between the years of 2000 and 2007, the percentage of adults who were at least moderately active did not increase significantly. In 2007/2008, 48% of Canadians 20 years of age and older were at least moderately active (≥ 1.5 MET – hours per day) (Canadian Fitness and Lifestyle Research Institute, 2007).

Accelerometry data from the Canadian Health Measures Survey showed that 68% of men and 69% of women are sedentary and only 15% of adults meet the new recommendations for physical activity. Older adults between 60 and 79 years of age spent 594 minutes (men) and 602 minutes (women) of their daily time in sedentary activities (e.g., sitting, standing, car travel), and only 15 minutes (men) and 12 minutes (women) of their daily time in moderate activities. Overall, adults aged 20 to79 averaged 9, 500 steps per day and women aged 20 to79 averaged 8,400 steps per day. The total number of steps accumulated per day among older adults aged 60 to 79 was 7,869 for men and 6,970 for women) (Colley et al., 2011). The results from this nationally representative survey showed that when accelerometry data is used, Canadian adults are less active than what self reported measures indicate. Accelerometry data showed that the majority of older adults are spending time in activities that are considered sedentary. According to ecological models, effective strategies to increase physical activity levels should target an array of levels of influences from the individual to the environment to policy. Therefore, there is a need to better understand which factors beyond the personal level explain activity participation among older adults.

2.2 Physical Function and Mobility among Older Adults

Despite continuous efforts to clarify terms and concepts regarding function, considerable inconsistency still exists in the literature, particularly when different frameworks are used (Jette, 2006). Terms such as functional capacity, physical function, physical ability, and functional independence are often used and some are used interchangeably. Physical function integrates physiological capacity and physical performance. Physiological capacity represents the basic anatomical function such as nerve conduction speed, and strength generated by cross-sectional area of the muscle. Physical performance represents the ability to integrate the physiological functions in effective movements in order to attain physical function (Cress et al., 1996). When a particular movement is performed in purposeful manner it is called functional performance. For example force generated by the cross-sectional area of the quadriceps muscle is considered physiological capacity while lower body strength is considered physical performance. The individual's ability to walk is regarded as functional performance (Cress et al., 1996). Cress and colleagues (1996) also state that physical function is mediated by psychosocial factors such as motivation, perceived ability and social role since these factors shape functional performance.

Another essential outcome under the umbrella of physical function is mobility and its outcome-related parameters. Mobility limitation is a condition where the individual faces limitation in independent physical movement (Shumway-Cook, Ciol, Yorkston, Hoffman, & Chan, 2005). To be able to perform basic activities of daily living (such as preparing meals, cleaning a house and bathing) and activities related to social and civic life (such as buying groceries, volunteering in community services, driving or using public transportation, participating in community walking programs) an individual needs an acceptable level of physical function and mobility (Gandolfi & Skora, 2001). Therefore adequate physical performance (e.g., muscle strength and power, endurance) is essential to cope with these activities. Strength is necessary to perform activities such as walking moderate distances, lifting objects, and climbing stairs, therefore facilitating overall mobility (Nied & Franklin, 2002; Rikli & Jones, 1999). Reductions in strength and endurance may affect quality of life in older adults by contributing to a less active lifestyle (Hunter, McCarthy, & Bamman, 2004). Muscle power positively impacts activities such as stair climbing, lifting heavy objects, and brisk walking (Miszko et al., 2003). Other important components associated with physical function are flexibility and balance because they impact activities such as dressing, reaching objects, stooping, driving and gait ability (Carlson et al., 1999).

When the individual is severely affected and is unable to perform locomotor tasks in a usual manner, the condition is called mobility disability (Syddall, Martin, Harwood, Cooper, & Aihie Sayer, 2009). Mobility is a strong predictor of disability (Guralnik et al., 1994). The term mobility disability was proposed in order to focus on one particular aspect of disability since disability encompasses many aspects from physical (locomotor, sensorial), to intellectual, to psychological aspects, among others (World Health Organization, 2001). When several aspects of disability are considered the prevalence can reach noteworthy proportions.

According to the World Health Organization, 15.6% of the world's population over 18 years of age experience disability (approximately 650 million people) (World Health Organization, 2011a). In Canada, 4.4 million people (14.3% of the population) reported having disability in 2006, an increase of almost 2% compared to the last survey in 2001. Disability was more present in the older age groups, compared to the younger ones, and was more prevalent among women compared to men. Among older adults, the prevalence of disability also followed a trend towards advancing age, as it is noticeably higher among the old-old age group (56.3%) compared to the young-old (33%) (Statistics Canada, 2006).

The three most common forms of disability reported by the older age group were the ones related to mobility (difficulty walking, going up and down a flight of stairs, carrying objects, or standing for long periods), agility (e.g., difficulty bending, dressing and undressing oneself, getting into or out of bed, reaching in any direction), and pain (e.g., limited in the amount or types of activities that one can do because of a long-term pain that is constant or reoccurs from time to time such as recurrent back pain) respectively. The proportion of those having more than three types of disability related to the types previously mentioned is considerably higher (64.8%) compared to those who only have one type of disability (18.4%). Between 2001 and 2006 in Canada, population aging accounted for a 40% increase of disability rate. Manitoba has the fifth highest disability rate (15.7%) among all Canadian provinces (Statistics Canada, 2006).

Mobility is an important aspect of aging because it is closely related to many other health outcomes. Increased mobility is associated with higher quality of life (Olivares, Gusi, Prieto, & Hernandez-Mocholi, 2011), whereas mobility limitation is linked with negative outcomes such as loss of independence (Rubenstein & Josephson, 2002), higher risk of institutionalization (von Bonsdorff, Rantanen, Laukkanen, Suutama, & Heikkinen, 2006), higher risk for mortality (Hirvensalo, Rantanen, & Heikkinen, 2000; Keeler, Guralnik, Tian, Wallace, & Reuben, 2010), and occurrence of falls (Manty et al., 2009). Incident mobility disability is linked with musculoskeletal pain (Shah et al., 2011). As cited by Cress and colleagues (1996), psychosocial factors also have an impact on the prevalence of mobility in older populations (Cress et al., 1996). Factors such as increased social participation and diversity of social network are associated with higher mobility (Nilsson, Avlund, & Lund, 2010) whereas low social economic status is associated with increased mobility disability (Koster et al., 2006).

The cost associated with the management of disability is considerable, particularly among the older adult segment of the population. Direct costs may include health care services, assistive devices, special diets, or personal assistance and, social insurance benefits among others. Indirect costs are mainly represented by the reduced labour force participation that will affect productivity and tax collection. From the individual perspective, the decrease in labour force participation may generate extensive financial issues that may lead to non-economic costs for the individual such as isolation and stress (World Health Organization, 2011b).

Despite the negative impact of mobility limitation and disability on an individual's health, a physically active lifestyle can enhance physical function and mobility. Older adults who are physically active generally have higher levels of physical function and mobility compared to those who are sedentary (Di Francesco et al., 2005; McAuley et al., 2007). Any type and amount of physical activity, including habitual walking, done on a regular basis may help to prevent functional decline and maintain mobility (Boyle, Buchman, Wilson, Bienias, & Bennett, 2007; Visser et al., 2005; Wong et al., 2003). However, when done at the recommended levels, greater achievements in physical function are observed (Brach et al., 2004). The literature reports a consistent and positive relationship between physical activity and physical function. Greater levels of physical function are achieved as a result of increased physical activity among community-dwelling older adults (Brach et al., 2004; Hillsdon et al., 2005; Patel et al., 2006) and among frail older adults (Chou, Hwang, & Wu, 2012).

2.3 Obesity among Older Adults

Obesity is defined as an abnormal or excessive accumulation of body fat that may threaten overall health (World Health Organization, 2012b). Obesity is a growing epidemic and has been recognized by the World Health Organization as one of the major public health concerns of the century because it affects populations on a large scale and has several health-related consequences (World Health Organization, 2000). Obesity is mostly reported as an index of weight (in kilograms) divided by the square of the height (in meters), or Body Mass Index (BMI). According to the World Health Organization, an individual with a BMI below 18.5 is considered underweight; an individual with a BMI between 19 and 24.9 is considered normal weight; and an individual with a BMI between 25 and 29.9 is considered overweight and above 30 is considered obese. Categories for obesity according to BMI cut off points are also used; therefore obesity class I is defined by a BMI ranging between 30 and 34.9, obesity class II between 35 and 39.9, and obesity class III or extreme obesity when the BMI is above 40 (World Health Organization, 2000).

It is estimated that 1.4 billion adults are considered overweight or obese and of this total, 200 million men and 300 million women are obese (World Health Organization, 2012b). The prevalence of obesity in Canada is on the rise; in 1978/1979 the age-adjusted prevalence of obesity in adults was 13.8% and it increased significantly to 23.1% in 2004, representing a total of 5.5 million people (Tjepkema, 2004). Between 2007 and 2009, the prevalence of obesity increased by 10% among men and by 8% among women

(Statistics Canada, 2011a). The increase was noticeable in each of the three obesity categories, particularly Class II and Class III. The proportion of adults in Class II went from 2.3% to 5.1%. In Class III this proportion went from 0.9% to 2.7% (Tjepkema, 2004).

Despite the largest increase being observed in the middle age groups (between 45 to 64 years of age), the prevalence of obesity has also grown considerably among the older segment of the population. Between 1978/1979 and 2004 the prevalence of obesity among adults 75 years of age and older increased from 10.6% to 23.6 %. Also, in 2004, the obesity rate among men in the 65 to 74 age group was 24% and among those in the 75 years or over group it was 19%. Among women these rates were 25% and 27% in the same age categories respectively. Manitoba had one of the highest prevalence of obesity compared to other provinces in Canada. In 2007/2008, the prevalence of obesity among men was 28.3% and 25.9% among women (Fransoo et al., 2011). The increase in obesity rates represents a public health concern because it is associated with consequences at the individual as well as societal levels.

Obesity also represents a major burden for the health care system because it is associated with several costly co-morbidities including type II diabetes, cardiovascular diseases, cancer (pancreatic), osteoarthritis, chronic back pain among 13 other associated diseases (Anis et al., 2010). In Canada, in 2001, the direct and indirect costs of obesity were $4.3 billion, corresponding to 2.2% of the total health care expenditures (Katzmarzyk & Janssen, 2004). In 2006 the direct costs associated with overweight and obese categories together represented $6 billion, corresponding to 4.1% of the total health expenditures in the country. Researchers urged for effective health policies to target the steady increase in obesity and its associated costs (Anis et al., 2010).

Among older adults obesity is directly linked to poorer health outcomes such as lower levels of physical function (Riebe et al., 2009) and disability (Rejeski, Marsh, Chmelo, & Rejeski, 2010). Those at obesity category II and higher are at greatest risk for disability compared to those at normal weight range. Additionally, those who become obese earlier in life (around the third decade) are at a greater risk to have disability when reaching older adulthood compared to those who become obese later in life (around the fifth decade) (Rejeski et al., 2010). In addition to obesity, other age-related changes may also lead to functional impairments and disability such as sarcopenia (gradual decline in muscle mass) (Janssen, Heymsfield, & Ross, 2002) because it impacts muscle strength and power. However, obesity per se is more associated with reduced physical function than sarcopenia (Bouchard, Dionne, & Brochu, 2009) and several studies have shown BMI as a predictor of onset or worsening of disability among older adults (Vincent et al., 2010). When obesity occurs together with sarcopenia there is more than a 2-fold increased risk for poorer functional outcomes compared to when either obesity or sarcopenia occur alone (Baumgartner et al., 2004; Rolland et al., 2009).

The occurrence of obesity may be explained by a combination of factors including behavioural, environmental, social and economic factors, as well as genetic predisposition. Behavioural factors such as physical activity and diet play a fundamental role in the management of obesity because they are directly related to the balance between energy intake and energy expenditure. Among adults the most effective type of activity is aerobic activity and different modalities have been suggested including walking, cycling, and jogging (Sodlerlund, Fischer, & Johansson, 2009). However it has been shown that higher level of structured aerobic activity is associated with greater benefits against negative health outcomes. Among obese individuals, aerobic activity has been shown a greater protective effect against obesity-related risks, particularly all-cause and cardiovascular mortality, than overall physical activity (Fogelholm, 2010).

Among older adults, aerobic activity has been the main type of activity suggested by the American (US Department of Health and Human Services, 2013) and the Canadian (Canadian Society for Exercise Physiology, 2011) physical activity guidelines with multiple benefits for this population including management of obesity. Strength training has also been shown to be effective in the management of overweight and obesity (Sodlerlund et al., 2009).

Despite the effectiveness in the management of the disease, physical activity levels are normally lower among obese individuals. According to the Canadian Community Health Survey, the energy expenditure from leisure time physical activity was lower among obese men and women compared to their counterparts in a normal weight range. There was also a decrease in energy expenditure with advancing age in obese individuals (Chen & Mao, 2006).

Sedentary behaviours have received increased attention over the years. They involve activities predominantly related to sitting or lying down which requires very low energy expenditure (less than 2 METS) and include activities such as reading, watching television, or using computers (Ainsworth et al., 2011). These types of behaviours are on a rise in the developed world and studies have shown significant associations between sedentary behaviour and increased risk of being overweight or obese.

Canadian data showed that the prevalence of obesity was higher among those who watched television for 21 hours or more per week compared to those who watched television for 5 hours or less per week. The former group of television watchers were 1.8 times more likely to be obese compared to the latter group, independent of physical activity and diet. Among frequent computer users, men and women who used computers for 11 hours or more per week were 1.2 and 1.3 times more likely to be obese compared to those who used them for 5 hours or less per week (Shields & Tremblay, 2008). These findings are primarily related to the adult population. There is a need to address this concern among older adults.

Besides physical activity, interventions related to diet have shown to be effective in the management of obesity (Aditya & Wilding, 2009). However these are primarily individual-level initiatives. Given the significant prevalence of obesity, initiatives that focus on populations rather than individuals have the potential for health benefits (Black & Macinko, 2008). Hence the neighbourhood environment has received increased attention because of the potential to benefit a large number of people. Certain environments are considered “obesogenic” because they provide a combination of opportunities and conditions that promote obesity among individuals (Swinburn et al., 1999). Obesogenic environments exist in several different ways. First, the built environment can facilitate or hinder physical activity among residents. Second, the “food environment” which relates to the availability and types of food stores in the neighbourhood can impact people’s decisions on healthy or unhealthy meal choices. Third, the social environment can contribute to the likelihood of being obese through the association with physical activity. Neighbourhood characteristics such as social nuisances, social support, and neighbourhood socioeconomic status have been shown to influence physical activity levels, which may contribute to the development of obesity (Black & Macinko, 2008).

Regarding the food environment, supermarkets have shown to be the best food option regarding variety, price, and quality of food offered. Those who have easier access to supermarkets in the neighbourhood are more likely to acquire healthier options and are less likely to be obese. In contrast, convenience stores and “fast-food” restaurants normally offer unhealthy options at higher prices (Larson et al., 2009). Evidence has shown that residents of low-income neighbourhoods are also more likely to have “fast-food” stores available (Black & Macinko, 2008; Larson et al., 2009; Lovasi et al., 2009).

Despite the promising results of studies on the relationship between obesogenic environments and overweight/obesity, some methodological problems have been reported. These include the lack of studies using broader and comprehensive models to examine determinants of obesity, the high number of cross-sectional data, the over-reliance on self- reported BMI data, problems with data generalization to older adults and people with mobility limitation (Black & Macinko, 2008), and lack of acceptable psychometric measures of the food environment (Larson et al., 2009). In addition, the fact that studies were mostly done in the United States limits the generalizability of the available evidence.

2.4 The Environment and Health Outcomes

A common way to categorize the environment in the literature is the classification into built and social environments (Ball, 2006; Granner, Sharpe, Hutto, Wilcox, & Addy, 2007; Hall & McAuley, 2010). Although the terms ‘built environment’ and ‘physical environment’ may be used interchangeably in some studies (Brownson et al., 2009; Rodriguez & Joo, 2004), this paper will follow the definition provided by Handy and colleagues (2002) and Saelens and Handy (2008) that the built environment represents the physical environment that is human-made or modified/constructed by human activity (Handy et al., 2002; Saelens & Handy, 2008). It comprises urban design, land use and transportation systems (Frank, Engelke, & Schmid, 2003). This section will describe the built environment as well as the relationship between health-related outcomes such as physical activity, physical function, mobility and obesity and features of the environment.

2.4.1 The Built Environment

The built environment can be classified into three major features: transportation systems, land-use patterns, and urban design (Frank et al., 2003). The following discussion is based on Frank et al.’s (2003) definition of each of these three features.

2.4.1.1 Transportation Systems

Transportation systems represent networks of infrastructure in a certain area. They establish how well destinations are connected by the number of routes present as well as travel distances to reach final destinations. One of the fundamental features of transportation systems are street networks, which promote high or low connectivity within each region (Frank et al., 2003). High street connectivity is represented by a high number of blocks and intersections per unit of area. Conversely, low street connectivity is defined by fewer blocks and intersections per certain unit of area (Frank et al., 2003; Handy et al., 2002). Features such as traffic volume and traffic density are also commonly examined.

Features of transportation systems are associated with health-related outcomes among older adults. Less car traffic has been associated with more walking, although one study showed the opposite effect. Proximity to paths and trails are associated with increased walking (Rosso et al., 2011). However, the evidence has been limited with respect to street connectivity as studies have reported no association or negative association between street connectivity and walking activity. Variations in neighbourhood definition as well as in walking assessment may explain the disagreement between studies (Rosso et al., 2011).

In terms of mobility-disability, older adults with physical disabilities were less likely to walk more than 10 blocks, and avoided busy streets and streets with increased traffic density compared to those without a physical disability (Shumway-Cook et al., 2002; Shumway-Cook et al., 2003). In contrast, among older adults without a physical disability increased traffic volume was associated with increased walking (Nagel, Carlson, Bosworth, & Michael, 2008), suggesting that perhaps certain environmental features from transportation systems may matter for those with increased physical disability but not for those without physical disability. The limited number and the cross-sectional nature of the studies do not allow solid conclusions.

In terms of density of intersections, Beard and colleagues (2009) showed that low density of intersections was also associated with physical disability (Beard et al., 2009). Regarding availability of public transportation in the community, older adults with functional limitations who had public transportation close to their homes were more likely to be physically and socially active compared to those who did not have public transport available (White et al., 2010). Public transport in relation to distance to a bus stop has also been an important issue for those with physical disabilities. Those with bus stops close to their residences were less likely to perceive themselves with a physical disability (Beard et al., 2009). Other issues related to public transport such as driver friendliness, easy entry to and exit from the bus, information practicality have also been highlighted as priorities among this group for mobility maintenance (Broome, Nalder, Worrall, & Boldy, 2010).

Somewhat inconsistent findings have been reported for street connectivity and prevalence of obesity. Higher street connectivity has been associated with less obesity (Frank, Kerr, Rosenberg, & King, 2010; Grafova, Freedman, Kumar, & Rogowski, 2008; King et al., 2011; Li et al., 2009a). However, Berke and colleagues (2007) found no association between street connectivity and obesity (Berke et al., 2007a). Increased number of public transit stations has been associated with lower BMI, however the evidence is limited to one study (Li et al., 2009a).

2.4.1.2 Land Use Patterns

The second major feature of the built environment discussed by Frank (2003) is land use pattern, which corresponds to the overall arrangement of structures within a given area and may be studied as density and mixed land use (Frank et al., 2003). Density describes how compact the environment is, generally in terms of residents, and may be assessed in a variety of ways including *"household density – the total number of households per a given area of land; residential density – total number of residents per* *area; net residential density – total number of residents per amount or residential land in an area; and employment density – the number of employees per land area"* (Frank et al., 2003, pg. 140). Another measure of density normally studied is commercial density which includes the total number of commercial establishments in a given area, including supermarkets, shopping centers, and post offices (Frank et al., 2003).

Higher housing density has been associated with increased walking and lower levels of disability (Rosso et al., 2011). Higher population density has been associated with lower levels of obesity (Hanibuchi et al., 2011). Increased commercial and residential density has also been shown to have significant relationship with increased physical activity and greater function (Clarke & George, 2005; Nagel et al., 2008; Michael et al., 2006; Berke et al., 2007a; Fisher, Li, Michael, & Cleveland, 2004; Shigematsu et al., 2009). Increased residential density has been associated with lower levels of obesity (Frank et al., 2010; King et al., 2011). In contrast, low housing density is associated with higher levels of obesity (Booth, Pinkston, & Poston, 2005; Lovasi et al., 2009). However, Berke and colleagues (2007) found no association between residential density and obesity among older adults (Berke et al., 2007).

Mixed land use corresponds to the overall arrangement of structures (e.g., commercial, retail, recreation, residential, industrial, or residential buildings, parks) within a given area. The greater the mix of uses the greater the proximity to destinations regardless of how well or how poorly connected they are. The premise between greater mixed land use density and non-motorized transportation behaviour (e.g., walking and biking) is that higher land mix may reduce the distance to reach the final destination, therefore reducing the need for motorized transportation and encouraging overall physical activity (Frank et al., 2003).

Empirical evidence has shown that greater land use-mix is associated with increased physical activity. Thus, older adults who have certain services and facilities close by are more likely to walk around the neighbourhood or to accumulate 30 minutes of moderate to vigorous activity 5 days of the week compared to those who do not have facilities and services available. These include select establishments (Nagel et al., 2008), post office, supermarkets (Poortinga, 2006), shopping mall (Michael et al., 2006), grocery stores (Berke et al., 2007a) and recreational facilities (Shigemetsu et al., 2009). The overall consistency in the relationship between land use-mix and physical activity remains regardless of whether objective or subjective measures of the environment are used (Michael et al., 2006).

The availability of parks in the neighbourhood has also been associated with increased physical activity in spite of not being substantially studied among older adults (65 years of age and older). Perceived proximity of parks and trails close to participants' homes is associated with increased physical activity (Kaczynski & Henderson, 2008). Although this review was not primarily done with older adults it points to the multigenerational importance of these features. When parks are available, they have been one of the most off-site routes for walking among older adults and have been associated with other environmental features such as aesthetics and safety (Rosenberg et al., 2009). White and colleagues showed that seniors without parks and walking areas in their neighbourhood were less likely to be physically and socially active and were more likely to report more disability (White et al., 2010).

Results on the impact of land use are somewhat less consistent when physical function and disability are the outcomes. Bowling and colleagues found that neighbourhoods with greater accessibility and quality of services (leisure, health, transport, and rubbish collection services) were associated with greater physical function among residents (Bowling, Barber, Morris, & Ebrahim, 2006). Moreover, Clarke and George (2005) reported that older adults living in neighbourhoods with fewer facilities were more likely to report functional limitations and disability (Clarke & George, 2005). However, Beard and colleagues (2009) found no association between land use-mix and disability (Beard et al., 2009). Satariano and colleagues (2010) found that older adults living in neighbourhoods with greater land use-mix are more likely to walk compared to those who live in more residential areas (Satariano et al., 2010). However, these measures were not associated with lower body function.

Among older adults, there is growing evidence that living in an area of greater land use-mix is associated with lower likelihood of being overweight and obese (Frank et al., 2010; Eisenstein et al., 2011; Li et al., 2008; Li et al., 2009a; King et al., 2011). Measures of the food environment that are related to land use patterns have also been examined. Residents living in neighbourhoods with higher density of fast food (Li et al., 2008; Li, Harmer, Cardinal, Bosworth, & Johnson-Shelton, 2009) as well as with more food outlets available (Hanibuchi et al., 2011) were more likely to be obese or to have larger waist circumferences. However, the evidence for an association between obesity and availability of food outlet was only found among those who live alone (Hanibuchi et al., 2011).

Additionally, in two studies, individuals with higher number of visits to fast food restaurants were also more likely to be obese (Frank et al., 2010) or to have higher waist circumference (Li et al., 2009a). Hanibuchi and colleagues (2011) also reported that those living in neighbourhoods with more supermarkets available were more likely to be obese (Hanibuchi et al., 2011). Accessibility of services in the neighbourhood had inconsistent results in relation to obesity. Greater accessibility of services was significantly associated with lower levels of obesity (Eisenstein et al., 2011). In addition, the number of supermarkets close by was more strongly associated with overweight and obesity than the distance to the nearest supermarket (Hanibuchi et al., 2011). However, Berke and colleagues (2007) found no association between availability or distances to stores and BMI (Berke et al., 2007a).

Lovasi and colleagues (2009) showed that the link between certain types of neighbourhood and ethnicity may play a role in obesity levels. Neighbourhoods with low sprawl (areas with high housing density, high mixed land use, and good street connectivity) and high population density are very characteristic among disadvantaged groups such as low-income, Black and Hispanic populations. However this evidence is limited to studies in the United States (Lovasi et al., 2009).

2.4.1.3 Urban Design

The third major feature of the built environment described by Frank and colleagues (2003) is urban design, which encompasses characteristics such as attractiveness of the environment (presence and diversity of objects around the streets/ sidewalks – planting, benches, telephone booths, designed street lamps, public art, buildings facades) and safety (width, type of pavement for streets and sidewalks, traffic speed, lighting, traffic calming). Street design, which refers to the layout of streets, is an important aspect of urban design because it is the most convenient place for walking activity in the neighbourhood for different purposes. The street layout encompasses several characteristics from the road itself such as street surface and the surrounding area, including lanes for traffic, lanes for parking and biking, medians, sidewalks, and presence of shade trees (Frank et al., 2003). In addition, other characteristics of the neighbourhood such as presence of graffiti on the walls and vandalism have also been considered as part of urban design since it pertains to aesthetics (Rosso et al., 2011).

The quality of sidewalks and paths including coverage (Nagel et al., 2008), overall poor quality (Mendes de Leon et al., 2009) or simply the presence of sidewalks (Michael et al., 2006; Clarke & George, 2005) has been examined in several studies, but few found a significant association between good quality of sidewalks/paths and increased physical activity (Rosso et al., 2011). It seems that when quality of sidewalks is examined in combination with other environmental features such as services and facilities, and safety, this feature becomes less of a concern for older adults. Sugiyama and colleagues showed that among several environmental features, quality of paths was the only predictor of walking activity (Sugiyama, Thompson, & Alves, 2009). Perhaps this feature may be more important among those with limited mobility, as Keysor and colleagues (2010) showed that uneven sidewalks was the most frequently reported barrier among older people with functional limitations (Keysor et al., 2010).

Poor street conditions such as cracks, broken curbs and potholes were also associated with difficulty in walking among those with lower body impairments compared to those who live in neighbourhoods with streets in good condition (Clarke, Ailshire, Bader, Morenoff, & House, 2008). Clarke and colleagues investigated a younger sample of those aged 45 years and older. In addition, Shumway-Cook and colleagues reported that older adults with disability avoided crossing streets even with traffic lights compared to those without disability (Shumway-Cook et al., 2002; Shumway-Cook et al., 2003).

There is very limited evidence to show a relationship between neighbourhood design and obesity among older adults. One study reported that increased access to green spaces was associated with lower obesity levels (Hanibuchi et al., 2011).

In general, increased neighbourhood safety is associated with more exercise (Young, Russell, & Powers, 2004), walking (King, 2008; Rosenberg et al., 2009), or leisure activity (Annear, Cushman, & Gidlow, 2009). Furthermore, unsafe neighbourhoods are associated with less walking (Mendes de Leon et al., 2009) and increased disability (Beard et al., 2009; Clark et al., 2009).

However, safety is a very complex feature to examine because it is studied with different purposes such as safety from crime, from traffic, and sidewalk safety as well as in conjunction with other environmental features. Better safety in conjunction with greater accessibility of services predicted less decline in physical activity among older adults over a 1-year period (Li, Fisher, & Brownson, 2005a). Safety has also been associated with lighting and neighbourhood nuisances (e.g., graffiti, vandalism, garbage accumulated), therefore each dimension may have a different impact on peoples' responses.

Another issue is that safety may not have a direct effect but rather a moderating effect between activity and the other environmental features. Li and colleagues (2005) found an interaction between safety from traffic and street connectivity for walking. Those living in neighbourhoods with higher street connectivity and who also reported safety from traffic were more likely to walk compared to those living in neighbourhood with lower street connections (Li, Fisher, Brownson, & Bosworth, 2005b).

King (2008) found a mediating effect between safety from crime and presence of physical incivilities for physical activity (King, 2008). In an intervention study to increase walking among residents of a retirement community (congregate and assisted living), a nearby park was the most preferred route because it was pleasant and safe (Rosenberg et al., 2009). Perhaps for some older adults certain features of the neighbourhood environment may be secondary to others that promote personal safety. In regards to safety features and obesity, very limited evidence is available among older adults. Eisenstein and colleagues (2011) found a significant association between higher safety from crime and lower levels of obesity, but after accounting for individual covariates no association was found (Eisenstein et al., 2011).

2.5 The Effect of Personal Factors on the Relationship between the Environment and Health Outcomes

Factors such as age, gender, and health status must be taken into consideration when examining the relationship between the environment and health-related outcomes. These factors normally affect the relationship between the environment and health-related outcomes, particularly when subjective measurements of the environment are used.

Age and gender play a fundamental role in physical activity participation. In general, men are more active and mobile (Colley et al., 2011; Poortinga, 2006; Yasunaga et al., 2008) compared to women, whereas older adults are normally less active and mobile compared to younger adults (Colley et al., 2011; McMurdo et al., 2012; Yasunaga et al., 2008). In terms of the perceived environment and supportive neighbourhoods for physical activity, older age groups are more likely to perceive the presence of non-residential facilities around the neighbourhood as being fundamental for physical activity compared to younger adults (Shigematsu et al., 2009).

Wen and colleagues showed that individual factors help to better explain the relationship between the environment and health among older adults. A significant association between neighbourhood socio-economic status (SES) and self-rated health has been demonstrated, however this is moderated by personal SES and perceptions of the neighbourhood environment: older adults living in low SES neighbourhoods tend to be in poor health, however this relationship is partially explained by their low personal SES and their low perception of their neighbourhood environment (Wen, Hawkley, & Cacioppo, 2006). McCurdo and colleagues (2012) showed that age, perceived behavioural control, and physical function were all independently associated with physical activity levels (McMurdo et al., 2012). Another study also demonstrated that personal factors including demographics, functional limitations and personal income accounted for a significant part of the variation between perceived neighbourhood characteristics and physical activity (de Melo et al., 2010).

Health status is another factor that may significantly impact the relationship between the neighbourhood environment and health outcomes. Among older adults, self-rated health had a significant contribution in explaining the relationship between physical activity and the neighbourhood environment (Tucker-Seeley, Subramanian, Li, & Sorensen, 2009). Wen and colleagues (2006) showed a significant association between self-rated health and neighbourhood SES. However, factors such as individual SES, psychosocial status and perceptions of the neighbourhood also played an important role in the relationship (Wen et al., 2006). These findings suggest that studies should examine the role of personal factors as covariates when examining the relationship between the neighbourhood environment and health-related outcomes in order to further explain the relationship between neighbourhood characteristics and health-related outcomes.

2.6 A Review of Measurements

The assessment of health-related outcomes in older populations is highly because it allows researchers to examine health benefits associated with the regular practice of physical activity, as well as negative outcomes that may result from functional or mobility decline. In addition, proper assessment allows one to evaluate programs and measure the effectiveness of interventions, to report trends in activity, obesity and disability levels, to raise awareness about health outcomes, and ultimately to influence public health policy.

Physical activity, physical function, mobility and obesity may be quantified using subjective or objective measures. Subjective measures of physical activity and physical function have a questionnaire format normally requiring participants to report type, frequency, duration, and intensity of activities over a particular time or to report their ability in executing functional tasks. Objective measures assess the participant’s actual capacity to perform certain activities (e.g., walk) or tasks (e.g., chair stands) based on time, distance or intensity of performance. Objective measures also capture physiological parameters that result from variation in intensity of activity. Several instruments to measure physical activity, physical function and mobility have been proposed in the literature. This section will describe the most utilized ones. The selection of instruments was based on higher rates of usability among this population, established psychometric measures, and supporting literature (systematic reviews and meta-analysis). A descriptive table of the measures is provided in Appendix 1.

2.6.1 Measurement of Physical Activity

2.6.1.1 Subjective measures

2.6.1.1.1 Seven Day Recall Physical Activity Questionnaire

In the Seven Day Recall Physical Activity Questionnaire participants are asked to estimate the number of hours spent in light, moderate, hard, and very hard physical activity in the past seven days. Metabolic equivalents (METs), multiples of resting energy expenditure, are assigned to each activity based on energy cost values existing in the literature. Thus, 1 to 2.9 METs represent light activity, 3 to 5 METs moderate activity (e.g., brisk walk), 5.1 to 6.9 METs hard activity (e.g., cycling at 8 miles/hour), and ≥ 7 METs very hard activity (e.g., jogging). MET values are multiplied by the number of hours spent in each of the five categories and the result is summed to give the total caloric expenditure representing the amount of physical activity and may be adjusted to individual body weight. The Seven Day Recall Physical Activity Questionnaire takes approximately 15 minutes to complete (Blair et al., 1985) and is considered a valid instrument to assess physical activity in older adults (doubly labeled water method, r= 0.52) (Bonnefoy et al., 2001).

2.6.1.1.2 *Physical Activity Scale for the Elderly (PASE)*

The Physical Activity Scale for the Elderly is intended to assess physical activity over a one-week period in community-dwelling older adults. It includes 12 types of sport and recreational activities in which older adults commonly participate, classified as light, moderate, and heavy (e.g., walking and biking, gardening, paid/unpaid work, muscle strength and endurance exercises). The score is obtained by multiplying each activity engaged in by a weighting factor, and summing the product for all 12 items. Good test-retest reliability (over a 3 to 7 week interval r=0.75) and construct validity (tested against several physiological and health related measures) were reported (Washburn, Smith, Jette, & Janney, 1993). The PASE was shown to have moderate validity against accelerometers, with correlations of r= 0.49 for total sample and r=0.64 for those over 70 years of age (Washburn & Ficker, 1999), as well as against the doubly labeled water method (r= 0.58); authors recommended weight recalculation for gender specific activities to avoid overvaluation (Schuit, Schouten, Westerterp, & Saris, 1997).

2.6.1.1.3 International Physical Activity Questionnaire (IPAQ)

The International Physical Activity Questionnaire is one of the most recent and globally used instruments to measure physical activity. The long version contains 31 items divided into sections such as household chores, occupational, leisure and sedentary activities. The short version contains 9 items and addresses time spent in walking, vigorous, moderate, and sedentary activities (e.g., sitting). Total weekly physical activity is estimated by weighting the reported minutes per week in each category by a MET value to estimate energy expenditure. Test-retest reliability of all items had an average of 0.80. Concurrent validity between the two versions had a pooled correlation of 0.67. Criterion validity using accelerometers had a pooled correlation of 0.33 and 0.30 for the long and short versions respectively (Craig et al., 2003). Efforts to validate this measure among older adults have been made since the original questionnaire is designed for adults between 18 and 65 years. Although this instrument was shown to be practical among older adults, issues with low reliability have been reported in both long and short versions of the questionnaire (Kolbe-Alexander, Lambert, Harkins, & Ekelund, 2006), particularly in the older age group (Tomioka, Iwamoto, Saeki, & Okamoto, 2011). The validity of the questionnaire compared to accelerometers is considered low to moderate (Grimm, Swartz, Hart, Miller, & Strath, 2012; Hurtig-Wennlof, Hagstromer, & Olsson, 2010; Tomioka et al., 2011). Recent modifications included larger font sizes and reversed order of the responses (from light to vigorous activities as opposed to start with vigorous activities) (Hurtig-Wennlof et al., 2010).

2.6.1.2 Objective Measures

2.6.1.2.1 Pedometers

Pedometers are primarily designed to quantify physical activity when the predominant behaviour is walking. They have shown to be suitable for older adults. These devices have shown excellent convergent validity against uniaxial accelerometers (r=0.86) (Tudor-Locke, Williams, Reis, & Pluto, 2002), (r=0.85 and 0.87) (Behrens & Dinger, 2011), activity observation (r= 0.82), moderate with energy expenditure (r= 0.68), and moderate to low with subjective measures (Tudor-Locke et al., 2002). In terms of minimum number of days required for valid results, a range of days has been reported. Although a one-week period is commonly used, a minimum of three days was also considered to be sufficient to predict weekly physical activity (Tudor-Locke et al., 2005). If seasonal effects are considered, the number of days is 8 for men and 4 for women

(Togo et al., 2008). Pedometers are often used to compare the degree of agreement between subjective and objective measures of physical activity.

Although a range of steps have been proposed in the literature, much debate still exists regarding the ideal mean value or range of steps taken per day needed to derive health benefits in this population. A meta-analysis study proposed a mean of 6,565 (95% confidence intervals of 4,897 - 8,233) (Bohannon, 2007) while a systematic review presented a range from 2,015 to 8,938 steps per day (Tudor-Locke, Hart, & Washington, 2009). Another review paper was proposed with the objective to generate public guidelines for older adults and special populations in regards to the number of steps taken per day in comparison to the recent physical activity guidelines of 150 minutes of moderate to vigorous intensity aerobic physical activity per week. It was suggested that taking 7,000 to 10,000 steps per day under free living conditions corresponds to accumulating 30 minutes of moderate-to-vigorous physical activity per day, detected by accelerometers (Tudor-Locke et al., 2011), which is sufficient to gain health benefits.

Pedometers are very useful devices to promote and increase physical activity at a population level, therefore providing health benefits (Bravata et al., 2007). Steps per day have been associated with several health outcomes including optimal body mass index, waist circumference, blood glucose level (Ewald, McEvoy, & Attia, 2010) lipid profile, bone health, health-related quality of life (Tudor-Locke, et al., 2011; Bravata, et al., 2007) and functional status (Snyder, Colvin, & Gammack, 2011).

2.6.1.2.2 Accelerometers

Accelerometers record the frequency, intensity, and duration of physical activity through trunk acceleration in uniaxial, biaxial or triaxial direction depending on the instrument. They can also estimate energy expenditure based on personal characteristics such as age, height, and weight and results are displayed on a screen or downloaded for computer analysis. The suggested number of days worn is between 3 and 7 days (Murphy, 2009). Because of their higher sensitivity, accelerometers have shown that most older adults spend less time in moderate to vigorous physical activity (MVPA) and either do not meet the recommended 150 minutes of MVPA per week (Harris, Owen, Victor, Adams, & Cook, 2009) or do not sustain 10 minute bouts of MVPA per day (Davis & Fox, 2007).

Accelerometers have been shown to be reliable instruments to measure physical activity even among individuals at very old ages and have been used in a number of studies to assess the validity of subjective measures. Another great advantage of accelerometers is the ability to accurately detect minutes spent in MVPA, allowing researchers to identify population groups who do not meet physical activity guidelines. Also, these devices may be used to assess energy expenditure, but they fail to assess full energy costs of certain tasks such as walking and carrying groceries because acceleration patterns may not change significantly in this condition (Murphy, 2009). Some factors related to adherence to this instrument among older adults have been reported. Participants with higher income and education, white race, higher functional and cognitive capacity were more likely to adhere to accelerometer protocol (Gemmill et al., 2011)

2.6.1.2.3 Heart Rate Monitors

Heart rate monitors measure the rate of work produced by the heart, generally beats per minute and some newer devices can also measure heart rate variability (the interval between two consecutive R waves, referred as RR interval). Compact size (watches, chest straps), storage memory to record data for a period of days, and affordable prices make this device very useful for research purposes. Several methods may be used to assess physical activity such as estimated intensity of physical activity, time spent in a determined intensity, and estimated energy expenditure (Freedson & Miller, 2000). Heart rate can vary because of many circumstances that are not activity related (e.g., emotional stress, ambient temperature, and humidity) representing disadvantages of this instrument.

Convergent validity to estimate the duration of light, moderate, and vigorous physical activity was tested against accelerometers, pedometers, and two subjective measurements (the 7-Day recall, daily PA-log) and the heart rate monitor overestimated light activity and underestimated moderate activity (Macfarlane, Lee, Ho, Chan, & Chan, 2006). Despite the feasibility in usage, these devices have been mostly used among adults, children and adolescents, or among adults with particular health conditions such as cardiovascular diseases and obesity. Some reasons may be the fact that older adults normally do not engage in activities that require a range of different intensities, or the fact that this population use medications that may potentially influence heart rate.

2.6.1.2.4 Global Positioning Systems (GPS)

Global Positioning Systems have received a growing focus of interest, particularly in the literature on physical activity in relation to the built environment and transportation planning. Advances in GPS technology have resulted in feasible and portable devices (e.g., GPS watches) that can be self administered, thus facilitating data collection. The advantages include the compact and portable size, the ability to capture data continuously, the precise measurement location as well as distance travelled and trajectories in a given environment, thus allowing researchers to identify features of the neighbourhood environment that are frequently visited among residents. A combination of GPS devices, accelerometry data and geographic information system (GIS) may be a promising strategy because these instruments allow for quantifying intensity of physical activity (using accelerometer) in relation to overall terrain area that was previously mapped (using GIS), allowing to identify the specific sites (on the mapped area) that subjects visited (using GPS). This would be an ideal combination to fully examine patterns of physical activity (Maddison & Ni Mhurchu, 2009). In the Webber and Porter (2009) study, the combination of GPS and accelerometer to monitor physical activity was used among older adults. Some advantages reported were ease of use, acceptability in regards to location being tracked and precise data about participants' location (Webber & Porter, 2009).

Despite being a promising technology, some disadvantages include failure to capture data at indoor positions (urban areas) or under heavy tree cover (natural areas) (Maddison & Ni Mhurchu, 2009), as well as changes between indoor/outdoor environment (exiting from a building) that may delay data acquisition (Webber & Porter, 2009). Battery life is another issue because premature battery failure may occur (Webber & Porter, 2009).

Since the battery lasts approximately 15 hours it may not be sufficient to catch a full range of activities per day (Maddison & Ni Mhurchu, 2009). Nevertheless, GPS is a technology that has the potential to further explain peoples' interactions with their neighbourhood environment.

2.6.2 Measurements of Physical Function and Mobility

2.6.2.1 Subjective Measures

2.6.2.1.1 Activities of Daily Living (ADL) Index and Instrumental Activities of Daily Living (IADL) Index

Activities of Daily Living (ADL) and the Instrumental Activities of Daily Living (IADL) Indexes are the most used measures to assess physical function in older adults and have served as a basis for development and conceptualization of many other instruments. The Katz ADL Index measures daily basic tasks related to self-care, such as: feeding, dressing, transferring, and continence. Scores are based on a "yes" or "no" (1 or 0) answer for each task with high scores indicating greater function (Katz & Akpom, 1976). The IADL contain eight instrumental activities related to an independent lifestyle such as housekeeping, using the telephone, and shopping. Scores go from 1 to 3 with higher values representing decreased impairment (Lawton & Brody, 1969). Although practical instruments the indexes do not assess a broader range of activities and are not sensitive to changes in health status. Furthermore, psychometric properties have not been extensively reported in the literature (Wallace, Shelkey, & Hartford Institute for Geriatric Nursing, 2007).

2.6.2.1.2 The Short Form 36 (SF 36)/ Medical Outcomes Study (MOS)

The Short Form 36 (SF 36)/ Medical Outcomes Study (MOS) is an instrument that contains thirty-six items categorized in 8 dimensions: physical functioning, role limitations (because of physical or emotional problems), bodily pain, social functioning, general mental health, vitality, and general health perceptions. Since there are a variety of dimensions, the SF 36 is often used as a health survey of quality of life (Patel, Donegan, & Albert, 2007). The physical functioning part of the SF 36 instrument, called Physical Functioning 10 (PF 10), addresses ten functional activities that may be limited by one's health (e.g., vigorous activities – running and moderate activities – bowling, walking). The score ranges from 1 to 3 with higher scores indicating greater physical function (Ware & Sherbourne, 1992). The PF 10 has been validated as a measure of physical function and mobility against various performance-based tests in older adults (Syddall et al., 2009).

2.6.2.1.3 Late Life Function and Disability Instrument (LLFD)

The LLFD (Haley et al., 2002) was developed to assess individuals in a range of function levels as well as to detect changes in physical function over time. The instrument is divided into two components: function and disability. The function component includes tasks primarily performed by upper and lower extremities with the latter one subdivided into two levels: basic and advanced tasks. The upper extremity activities contain seven tasks (e.g., unscrew lid without an assistive device, hold full glass of water in one hand, and reach behind back). The lower extremity group is comprised of twenty-five tasks divided into fifteen basic (e.g., get on and off bus, make bed, and bend over from standing position) and nine advanced (e.g., hike a few miles, walk on slippery surface, run one-half mile) tasks. The questions are phrased, *"How much difficulty do you have (doing the activity) without the help of someone else and without the use of assistive devices?"* The response options are "none," "a little," "some," "quite a lot," and "cannot do." Scores go from 0 to 100 in a scaled score with higher scores indicating greater physical function. Test-retest reliability for the overall instrument was 0.97 (Jette et al., 2002). The disability component contains thirty-two tasks related to personal, social, instrumental, and management roles (e.g., visit friends, travel out of town, and work at a volunteer job) measured by frequency of performance and amount of limitation. Scores go from 1 to 5 with higher scores representing higher frequency and lower limitation. Test-retest reliability ranged from 0.68 for task frequency to 0.83 for task limitation (Jette et al., 2002). Concurrent and predictive validity of the LLFD were tested against several objective measures and coefficients ranged from 0.69 to 0.73, confirming the excellent validity (Sayers et al., 2004).

A shorter version of the LLFD was proposed to reduce completion time, which is estimated to be 30 minutes for the longer version. The function component consists of fifteen items with reliability ranging from 0.63 to 0.86 and the disability component consists of eight items with reliability ranging from 0.78 to 0.85 (McAuley, Konopack, Motl, Rosengren, & Morris, 2005). This instrument (short or long versions) has been commonly used in other studies (Hess, Brach, Piva, & VanSwearingen, 2010; McAuley et al., 2007; Melzer & Kurz, 2009).

2.6.2.1.4 The Life-Space Assessment Questionnaire (LSA)

The Life-Space Assessment Questionnaire (LSA) (Baker, Bodner, & Allman, 2003) is a questionnaire designed to evaluate mobility in community-dwelling older adults in a wide range of physical spaces where the older person may travel. The life-space areas go from level 1 to 5 where level one represents inside the bedroom, and progressing to home space, outside home (yard, garden), neighbourhood (less than half a mile or about 5 to 6 city blocks), town (more than 5 miles), and the last level, called unlimited, represents the ability to travel outside the town. Mobility is based on how frequently and how far the person can travel in to each level, as well as the ability to travel with or without assistance.

This questionnaire assesses mobility within the month prior to the assessment and the result is a score that indicates the person's lifestyle for the past month. According to the authors, the one-month period allows for temporary conditions (in the environment or personal level) that may reduce overall mobility (Baker et al., 2003). The questionnaire is suitable for personal or telephone interviews. The scores are calculated by multiplying the life-space level (1-5), the independence level (1 if personal assistance is needed, 1.5 if equipment is needed, 2 if the person is independent – do not need assistance or equipment), and the frequency of mobility in each life-space level (1 less than once a week, 2 between one and three times a week, 3 between four and six times a week, 4 daily). The highest possible score is 120 representing higher mobility (which translates the ability to travel in each life-space level, daily and without assistance). Test-retest reliability of this instrument in a 2-week interval was 0.96.

High correlations have been found between the LSA and other measures of physical function (ADL and IADL, the physical component score of the Medical Outcomes Study, and performance based measures) and overall health measures such as, self rated health, chronic conditions, and depressive symptoms (Baker et al., 2003). The LSA scores were tested against several health measures. Physical function (tested with ADL and IADL Index and the Short Physical Performance Battery, a performance based test) explained most of the variance in LSA scores (45%) compared to sociodemographic variables (12%) and cognitive variables (1%) (Peel et al., 2005). Moreover, Crowe et al. (2008) examined changes in life space mobility (LSA instrument) and its association with cognitive decline over a 4-year period among community-dwelling African American and Caucasian older adults and found that those with a higher life space score had less cognitive decline over 4 years (Crowe et al., 2008).

Auger and colleagues (2009) tested the Life-Space Assessment psychometrics, the applicability of this instrument among mobility device users, and the validity of a French version of the questionnaire. Content validity was confirmed between the English and French versions. Test-retest reliability of the French version was 0.87 over a two-week interval. The authors also reported lower refusal rate over a telephone format, and a reasonable completion time (9 minutes) (Auger et al., 2009).

2.6.2.2. Objective Measures

2.6.2.2.1 The Physical Performance Test (PPT)

The Physical Performance Test (PPT) was developed to screen for functional impairments, to monitor changes in functional status, or to predict subsequent functional decline. It contains nine items such as writing a sentence, picking up a penny from the floor, and turning 360 degrees. The dimensions assessed include balance, coordination, endurance, mobility, and upper body fine motor function. The PPT takes 5 to 10 minutes to complete. Moderate to high concurrent validity was found with two self reported measures (0.65 and 0.80) and the reliability coefficient was 0.87 (Reuben & Siu, 1990). Measurement properties of this scale have not been extensively tested using other objective measures of function.

2.6.2.2.2 The Functional Fitness Test (FFT)

The Functional Fitness Test (FFT) (Rikli & Jones, 1999) was developed to assess physical fitness in older adults in a continuous scale and includes six tasks: upper body (arm curl) and lower body strength (30-second chair stand), upper body (back scratch) and lower body flexibility (chair sit and reach), aerobic endurance (6 minute walking or the 2 minute step), and motor agility and dynamic balance (8 feet up and go). The test focuses on physical performance necessary to perform the ADL. For instance, the 30 second chair stand represents the fitness component necessary to climb stairs. The FFT is intended to reflect normal age-related changes in physical performance and be sensitive to change and takes 30 to 45 minutes to be completed. Excellent intraclass reliability (from 0.81 to 0.96) (Rikli & Jones, 1999) and criterion validity (from 0.73 to 0.83) has been found.

2.6.2.2.3 The Continuous Scale-Physical Functional Performance (CS-PFP)

The Continuous Scale-Physical Functional Performance (CS-PFP) contains sixteen tasks that reflect basic and instrumental activities of daily living, such as dressing, carrying heavy objects, and climbing stairs. All tasks are quantified using a combination of weight, time, and distance. The score ranges from 0 to 100 with higher scores reflecting better function. Test-retest reliability ranged from 0.85 to 0.97, inter-rater reliability ranged from 0.92 to 0.98 and validity was tested using rate of perceived exertion through VO_2max (Cress et al., 1996). A shorter, valid, and reliable version of this test containing 10 items was developed (Cress, Petrella, Moore, & Schenkman, 2005) and high correlations were found with the longer version. Advantages of the CS-PFP are the ability to capture data continuously reducing the possibility of ceiling effects; however, the need for controlled environments, standard conditions, and duration (1 hour) represent disadvantages.

2.6.3 Measurements of Obesity

Obesity can be measured and reported using different methods including dual energy x-ray absorption (DXA), magnetic resonance imaging (MRI), and anthropometric measures such as body mass index (BMI), and waist circumference (WC). Although DXA and MRI methods have higher capability of measuring total body fat and fat distribution compared to methods such as BMI and WC, BMI is the most common way to assess obesity in research and clinical settings because of its practicality (Snijder, van Dam, Visser, & Seidell, 2006). An index can be easily calculated using a height rod and a calibrated scale for weight as opposed to a more expensive apparatus or machine. In some instances, particularly in large epidemiological studies, BMI is also calculated based on self-reports of height and weight. Body mass index has shown to have moderate capability in measuring total body fat and a very low capability of measuring total fat distribution (Snijder et al., 2006).

An alternative way to report obesity is through waist circumference, which corresponds to the measure in centimeters around the abdominal area and represents a measure of central obesity. Waist circumference (WC) has shown to have a low capability in measuring total body fat and very high capability in measuring total fat distribution (Snijder et al., 2006). Waist circumference can be self-assessed or technician-measured where a tape measure is placed around the waist, right above the iliac crest. The person stands with the feet parallel to the floor, free from clothes in the abdominal area and the tape measure is placed around the waist area (McGuire & Ross, 2008).

The Canadian Society for Exercise Physiology recommends protocols from The World Health Organization, (the protocol requires finding the midpoint between the lower border of the rib cage and the iliac crest), as well as from the National Institutes of Health (NIH) (the protocol requires touching the superior border of the iliac crest). However the simplicity to acquire the measurement makes the NIH more suitable for the general population (McGuire & Ross, 2008). With regards to placement of the measuring tape (e.g., minimal waist, umbilicus) and the relationship with mortality (all-cause and cardiovascular disease related), cardiovascular disease, and diabetes, the protocols did not show significant difference (Ross et al., 2008).

Sex-specific threshold values have been reported. Men with waist circumference above 102 cm and women above 88cm are considered at higher risk for negative health outcomes compared to those who are below this threshold. Some of these outcomes include type II diabetes, dyslipidemia (Snijder et al., 2004), and coronary heart disease (Canoy, 2008). Very high values of waist circumference (above 120 cm for men and 110 cm for women) have been associated with increased risk for mortality, irrespective of BMI (Jacobs et al., 2010). Central obesity has shown to be more pathogenic than subcutaneous obesity (Fox et al., 2007).

The health significance of change in waist circumference should be further examined among older adults. Li and colleagues (2009) reported an increase of 2.06 cm in waist circumference over a 1-year period in residents living in neighbourhoods with higher density of fast food. In contrast, a reduction of 1.57 cm in waist circumference was reported among those who increased their activity level to vigorous intensity. However it is unclear whether this reduction in waist circumference is enough to decrease significantly the risk of health-related events (Li et al., 2009a).

Berentzen and colleagues (2011) examined the association between change in waist circumference and risk of myocardial infarction over 8.4 years (Berentzen et al., 2011a) and incidence of diabetes over 5.4 years among middle aged adults (Berentzen et al., 2011b). Although waist circumference was significantly associated with the two health-related measures at a cross-sectional level, and longitudinal analysis showed a change of 5cm in waist circumference, this change did not reach statistical significance.

Body mass index and waist circumference have generated scientific debate with respect to the best individual predictor for obesity-related health risks, or whether the combination of these two measures would be better than the measures used individually. Evidence shows that the addition of waist circumference to the BMI categories increases significantly the chances of detecting health risks among adults (Janssen et al., 2002) and older adults (Jacobs et al., 2010). However the way in which these variables are used influences the results. When BMI and WC are used as continuous variables, the addition of BMI to WC measures does not have significant predictive power for health-related risks compared to when WC is used individually. In contrast, when WC is used in a dichotomized category (high and low risk) BMI remains as a predictor (Janssen, Katzmarzyk, & Ross, 2004). A review examined which of these measures would be the best predictor for cardiovascular risk and evidence showed that the predictive power of WC and BMI depends on the health condition. WC was a stronger predictor for diabetes compared to BMI; however, for conditions such as hypertension and dyslipidaemia, BMI and WC showed similar effects (Huxley, Mendis, Zheleznyakov, Reddy, & Chan, 2010).

In summary, although there are unresolved issues regarding the proper use of self-report measures of height, weight or waist circumference, BMI and WC are often used in epidemiological studies because of the feasibility of the measurement. The use of the two measures combined has shown to increase predictive power of many chronic conditions as opposed to the use of one type of measurement only.

2.6.4 Measurement of the Environment

The built environment can be measured using objective or subjective measures. Objective measures include audit instruments and Geographic Information Systems (GIS). Audit instruments consist of a systematic observation of the physical environment. They are normally used to assess features of the environment that are not covered by GIS such as presence of benches, width of the sidewalks, and landscape maintenance. Audits require the observer to walk (or drive) on both sides of the street collecting data in a systematic way using a paper-pencil or electronic formats with open-ended questions. Features that are commonly examined are: land use-mix, sidewalks, biking facilities, architecture or building characteristics, public spaces and amenities, indicators related to safety (presence of graffiti, broken windows, parking/driveways) (Brownson et al., 2009).

2.6.4.1 Objective measures

The Senior Walking Environmental Assessment Tool (SWEAT) is an audit instrument specifically designed for older adults in the. It covers features pertinent to seniors divided into four major categories: functionality, aesthetics, destination and safety. Features include presence of benches, readability of signage, width of sidewalks, adequate lighting, and presence of trees among others. Inter rater reliability was from good to excellent (Cunningham, Michael, Farquhar, & Lapidus, 2005). This instrument was revisited (SWEAT –R) in order to make it more user-friendly as well as to include other important features for seniors such as housing. Inter rater reliability of the SWEAT-R was from good to excellent (Michael et al., 2009).

Geographic Information Systems are a feasible manner to assess selected geographic boundaries because it does not require assessors on site. GIS *"integrates hardware, software, and data for capturing, managing, analyzing, and displaying all forms of geographically referenced information"* (GIS.com, 2012) and objectively measure features such as population density, land use-mix, access to recreational facilities, street pattern, sidewalk coverage, vehicular traffic, crime, greenness/vegetation among others (Brownson et al., 2009). GIS has a vast applicability and has been used to assess the neighbourhood environment in relation to several health outcomes such as physical activity (Berke et al., 2007a; Frank, Schmid, Sallis, Chapman, & Saelens, 2005; Hoehner, Brennan Ramirez, Elliott, Handy, & Brownson, 2005; King et al., 2005; Michael, Beard, Choi, Farquhar, & Carlson, 2006; Nagel et al., 2008; Owen et al, 2007; Wendel-Vos et al., 2004), physical function (Bowling & Stafford, 2007), disability (Beard et al., 2009) and obesity indicators (Berke et al., 2007a; Frank et al., 2010; Grafova et al., 2008;

Hanibuchi et al., 2011; Li et al., 2009a). Geographical Information Systems have the advantage of providing unbiased data because they do not rely on people's perception of their surrounding area. In this instance a visual map of the area and/or government data are readily available (e.g., census, parcel data) and may be analyzed in a hierarchical fashion (individual and neighbourhood data) to better explain differences across the sample (Li, Fisher, Brownson, & Bosworth, 2005b), consequently reducing the subjectivity of the measurement (data).

Nevertheless, several problems have been reported when using GIS technology. The first is that validity of the data that may be threatened if inaccurate or missing values are present. If data were collected from census or yellow pages, and spatial images were generated in a time point far before the study was conducted there is a temporal concern to validity of the data. In addition, the extent to which this threat affects the recording of physical activity is practically unknown. The second problem is variability in data operationalization that presents a challenge to compare results among different studies (Brownson et al., 2009). One of the problems with variability of data is the choice of GIS-based measures that is used to outline the area under study. The studies reviewed had a large variability of measures used including density measures (population or business) (Li, Fisher, Brownson, & Bosworth, 2005b), presence of facilities (Michael et al., 2006), access to facilities (Hanibuchi et al., 2011), census tract (Balfour & Kaplan, 2002; Beard et al., 2009; Frank et al., 2010; Grafova et al., 2008; Li et al., 2008; Wight et al., 2008), census block (King et al., 2011), and other administrative data (Bowling & Stafford, 2007; Glass, Rasmussen, & Schwartz, 2006).

Census blocks are defined by the smallest geographical area for the purpose of census. It may be formed by streets, roads, railroads, etc (United States Census Bureau, 2000) whereas census tracts represent the combination of several block groups (which are a combination of census blocks). Despite being commonly used to define neighbourhoods, these measures represent a proxy measure and may not necessarily coincide with the actual neighbourhood geographical boundary. Another problem with variability of data is the choice of spatial area for GIS mapping. Some studies used circular buffer zones (straight-line distance) (Berke et al., 2007; Nagel et al., 2008) while others used street network distance (Frank et al., 2010; Hanibuchi et al., 2011). While circular buffer zones involve easier calculation, they tend to overestimate the area under study because the circle area is fixed and may contain areas that are not travelable (e.g., physical barriers). In addition the circular buffer zone does consider street curves; therefore distances are measured in a straight line. In contrast, network distance provides a better estimation of the area covered since street design (including curves) and possible barriers are taken into consideration. As a result, an irregular polygon is drawn rather than a circle (Gutiérrez & García-Palomares, 2008). This approach may be more realistic as pedestrians follow the street design to access places and services instead of a straight line. Berke and colleagues used both circular zone and street network techniques to investigate the association between the built environment and physical activity and obesity among older adults; however the authors did not present specific consideration on the use of each technique (Berke et al., 2007b).

2.6.4.2 Self-reported measures

Self-reported measures are based on people's perception of their environment. Normally, these measures take a questionnaire format, requesting people to provide their opinion about specific features of their neighbourhood. Answers may be expressed in different formats, such as yes/no, present/absent, or rated frequency according to the question content. The attributes measured are the same as those objectively measured. A large number of studies have used this type of measurement (Addy et al., 2004; Brownson et al., 2009; Dawson, Hillsdon, Boller, & Foster, 2007; Eisenstein et al., 2011; Foster, Hillsdon, & Thorogood, 2004; Granner et al., 2007; Miles & Panton, 2006; Poortinga, 2006; Saelens, Sallis, Black, & Chen, 2003; Suminski, Poston, Petosa, Stevens, & Katzenmoyer, 2005).

The Neighbourhood Environment Walkability Scale (NEWS) (Saelens et al., 2003) and the abbreviated version (NEWS-A) (Cerin, Saelens, Sallis, & Frank, 2006) are the most commonly used instruments to measure the neighbourhood environment (Brownson et al., 2009). The NEWS assesses the following environmental characteristics: constructs of residential density, proximity to stores and facilities, street connectivity, facilities for walking and cycling, aesthetics, and safety from crime and traffic. The test-retest reliability of the items ranged from 0.62 to 0.88 (Leslie et al., 2005). Concurrent validity has been confirmed using GIS data (Adams et al., 2009). NEWS –A had confirmatory factor analysis between NEWS and NEWS-A scores ranged from 0.82 to 0.97 at the group level and from 0.83 to 0.97 at the individual level (Cerin et al., 2006).

2.6.5 Factors to Consider when Measuring Physical Activity, Physical Function and Mobility, Obesity, and the Environment

This section will evaluate measures based on criteria such as costs, accuracy of the measure, appropriateness of the instrument (type of study, purpose of assessment, study setting), type of outcome, degree of agreement between objective and subjective measures, the importance of cognitive ability, and the influence of self reported bias.

Costs – In general, subjective measures involve much lower costs compared to objective measures, since these measures only require paper format. As some instruments are very brief (e.g. PASE, PF-10, ADL and IADL Indexes) they can easily be administered by telephone, mail (self-administered), or face-to-face interview and interviewers normally do not need special training, therefore, considerably larger samples may be achieved in a relatively short time making these instruments suitable for population-based studies (Syddall et al., 2009). However, the method of administration may impact psychometric properties of the instrument. The PASE and the PPT for instance had higher reliability (r= 0.84) when administered via mail rather than via telephone interview (Reuben, Valle, Hays, & Siu, 1995; Washburn et al., 1993). BMI and WC are by far the most commonly utilized methods to measure obesity because of their practicality. In addition, no special equipment or personnel is necessary to acquire the measures. Therefore they are very feasible measures for studies that involve large samples (Snijder et al., 2006).

Objective measures are normally labour intensive and involve higher costs related to instrument acquisition, standard environments or training of staff to manipulate and process data, therefore reducing the feasibility of using these instruments in population-based studies. Among physical activity measures, pedometers and heart rate monitors represent the least expensive options, with pedometers being the most cost-effective because of the simplicity to acquire and manipulate data, as opposed to accelerometers and Global Positioning System (GPS) devices that are more expensive and require training in downloading, filtering, and categorizing data. Physical function measures may not necessarily require instrument acquisition; however, depending on the sample size and timeline for data collection, costs may increase since some of these tests require proper space, longer testing times (e.g., FFT and CS-PFP) and individualized assessment.

Despite the variety of audit tools available to measure the environment (Brownson et al., 2009), these instruments have been used in only a few studies with older adults (King, 2008; Michael et al., 2006; Rosenberg et al., 2009). Perhaps some logistic issues that relate to cost such as selection and training assessors and time spent on the site to collect data (Brownson et al., 2009) make this instrument less feasible for measuring the environment. GIS technology is also costly because it requires highly trained personnel and appropriate software. In contrast, subjective measurements are cheaper because they involve paper-based methods and may be used in large epidemiological multi-site studies where a variety of spatial areas need to be covered, reducing the costs of the study (Bowling et al., 2006; Poortinga, 2006).

Accuracy of the measure – The issue of high cost among objective measures is offset by important characteristics such as higher accuracy and precision compared to subjective measures. Among physical activity measurements, pedometers, accelerometers and GPS devices have the ability to capture patterns of activity under free-living conditions throughout the day more accurately and precisely than subjective measures because they do not depend on self-report of the participants regarding their own activity level. Depending on the instrument, unrestricted baseline values can be collected as they capture small amounts of physical activity, and therefore are less likely to suffer floor effects.

Regarding functional measures, tasks are performed in a continuous manner of distance and/or time, rather than described and are less likely to suffer ceiling effects, enabling differentiation in function levels across the sample (e.g., CS-PFP and FFT tests). In using subjective measures among community-dwellers, preference should be given to measures that have a wider functional coverage (e.g., LLFD) in order to increase precision in capturing function (Dubuc, Haley, Ni, Kooyoomjian, & Jette, 2004). Another great advantage of measurement accuracy is the increased sensitivity to detect even minor changes in activity or function. Among measures of the environment, GIS technology is capable of assessing a geographical area with increased accuracy compared to self-reported measures.

Appropriateness of instrument – In selecting physical activity, physical function, mobility, and obesity measurements for the older adult population, consideration should be given to the type of measurement used (objective vs. subjective) in relation to type of study and study setting. In relation to type of study, for population-based studies that require larger samples (Chad et al., 2005) and/or include multi-site data collection (Craig et al., 2003) questionnaires are normally the most appropriate method because of their feasibility. For studies that involve more structured and tailored interventions or require specific samples, objective measurements may be more appropriate to increase representativeness of the outcome.

The study setting may also impact the appropriateness of the instrument. Community-dwellers and continuing care home residents represent two different groups in terms of mobility, physical activity patterns and mental health. For instance, the use of objective measures among nursing home residents such as pedometers has been shown to hinder data captured because of lower walking speeds, gait disorders or cognitive problems, which impact the validity and reliability of the outcome (Cyarto, Myers, & Tudor-Locke, 2004), therefore subjective measures with reduced completion time and assessing overall activities would be more feasible.

However, even in some subjective measures that include light activities such as PASE or Seven Day Recall Physical Activity Questionnaire, they may still not reflect activity patterns for this population since housework, gardening, and yard care may be provided or subjects may not be physically capable of performing (Zalewski, Smith, Malzahn, VanHart, & O'Connell, 2009). In contrast, a number of studies have been conducted in healthy and community-dwelling older adults using objective measures, particularly pedometers and have been shown to be appropriate (Tudor-Locke, et al., 2009). Regarding functional measures, those that assess basic activities such as bathing, dressing, and eating (e.g., ADL and IADL Indexes) may be more appropriate for continuing home care or assisted living settings because of higher levels of physical dependence. However, these measures may fail to effectively evaluate those living independently in the community because some activities are too easy to perform for those who are fit.

Type of Outcome - Physical activity can be reported in different outcomes that should be considered prior to instrument selection. If number of steps or overall activity level are the desired outcomes, pedometers can be used satisfactorily. However, these instruments fail in identifying the intensity, duration and type of physical activity as well as in estimating energy expenditure (Tudor-Locke et al., 2002) or distance taken (Crouter, Schneider, Karabulut, & Bassett, 2003).

For assessment of intensity or time spent in a certain activity, accelerometers are very reliable instruments. They have shown great acceptability among older adults with fewer operational problems in terms of management as batteries can last up to twenty-one days and do not require resetting or recording daily data separately (Davis & Fox, 2007). However, these instruments are not fully reliable in estimating energy expenditure (Murphy, 2009).

If the desired outcome is the distance traveled over a certain period of time, the GPS device can be used, but this technology needs to be further explored, because GPS devices fail to accurately distinguish between types and intensity of physical activity (Maddison & Ni Mhurchu, 2009). Furthermore, the literature needs to be expanded to investigate the feasibility of this instrument among older adults because issues such as reduced battery life, proper placement and management of the device may represent a drawback among this population. Also, older adults who do not interact frequently with the environment (walking trips around the neighbourhood) may represent a challenge for the GPS device's data capture.

When energy costs are the main outcome measure, subjective measures such as the Seven Day Recall Physical Activity Questionnaire or the IPAQ may be used. In spite of estimating energy expenditure, subjective measures have the great advantage of assessing intensity of activities in relation to different types of physical activity where none of the objective measures can assess them. In examining different types of outcomes, caution should be taken in interpreting these outcomes in relation to recommended physical activity guidelines as the different questionnaires may produce high variability in the percentage of people meeting the guidelines (De Cocker, De Bourdeaudhuij, & Cardon, 2009).

The variety of terms proposed to describe physical function may also affect the type of outcome. Despite including similar tasks, some instruments assess physical performance (FFT and CS-PFP), others assess disability (Katz and Lawton Indexes), while others assess physical functioning (SF-36). This may affect the validity of measures as the instruments may not measure the same construct (Reuben et al., 1995). In addition, for subjective measures, the wording of the questions may cause variations in overall response and consequently impact the suitability of the instrument for a particular setting. For instance, the PF10 inquires about activity limitation in relation to health ("does your health limit you in these activities").

The use of composite measures, particularly related to walkability, is a critical issue regarding type of outcome for the built environment. Some studies used a single walkability score that included mixed land use, street connectivity and residential density (Berke et al., 2007; Frank et al., 2010; King et al., 2011; Li et al., 2009b). Using this approach it is not possible to examine relationships between individual features of the built environment and health related outcomes, particularly physical activity and obesity indicators (BMI and waist circumference) among older adults. However, composite scores have shown more robust associations between the built environment and physical function and physical activity compared to when each feature is examined individually (Rosso et al., 2011).

This finding may be explained by the fact that features of the built environment do not exist in isolation (Frank et al., 2003), they are rather inter-related and the approach of composite scores helps to minimize spatial multi-collinearity (Brownson et al., 2009). Similarly, among features of the social environment, studies have also used composites scores including neighbourhood psychosocial hazards (e.g., social disorganization, physical disorder, and economic deprivation) (Glass et al., 2006) as well as economic disadvantage (percentage of the population living in poverty, percentage of households receiving public assistance income, unemployment rate) (Grafova et al., 2008) rather than individual features.

Degree of agreement between measures – This issue may be studied in two ways: First, the degree of agreement between subjective and objective measures and second, the degree of agreement between self-assessed and technician-assessed measures. When subjective and objective measures are compared, overall low to moderate associations has been found. Regarding physical activity and physical function, reasons for this occurrence may be the tendency to over or under report activity participation/functional status, the difficulty to recall activities performed, or the comparison between different types of construct, particularly among functional measures. A review study showed that higher agreement was found between objective and subjective measures when the same construct is considered than when different constructs are considered (Coman & Richardson, 2006). When only objective measures are compared amongst themselves, a higher degree of agreement is usually found (Sherman & Reuben, 1998).

Studies that have used both subjective and objective measurements of the environment showed a low degree of agreement between them when assessing the same environmental feature (Ball, et al., 2008; Michael et al., 2006). Study settings and different populations might have influenced the degree of agreement between the measurements. Another factor that may explain the low agreement between these two types of measurements is the mediating effect of psychosocial factors, as they shape the relationship between physical activity and the built environment, therefore influencing how the person truly notices the surrounding environment (Annear et al., 2009; Carlson et al., 2012; Hovbrandt, Stahl, Iwarsson, Horstmann, & Carlsson, 2007; Wight et al., 2008). Therefore, whenever possible, both types of measurements should be considered, as they allow different interpretations of the neighbourhood environment (McGinn, Evenson, Herring, & Huston, 2007a; McGinn, Evenson, Herring, Huston, & Rodriguez, 2007b).

Differences between self-assessed and technician-assessed measures may also occur with obesity measures. Discrepancies in self-reports of height and weight have been reported and evidence has shown that in comparison to the actual measure, participants tend to under-report their weight and over-report their height leading to an overall underestimation in obesity levels. The trend towards under-report of weight was higher among overweight and obese people compared with normal weight people (Shields, Gorber, & Tremblay, 2008). Age and gender also play a significant role in self-reports of BMI, with older men and women tending to over-report height. Men tend to over-report their weight and women tend to under-report their weight. The trend towards lower self-reported BMI is observed across all age groups and it is particularly present in very old ages (Stommel & Schoenborn, 2009).

Conflicting results have been found with either under or over reports of WC. Under-reporting has been particularly observed among participants with larger waists, those with greater BMI (Bigaard, Spanggaard, Thomsen, Overvad, & Tjonneland, 2005; Spencer, Roddam, & Key, 2004) and older participants (Spencer et al., 2004). Dekkers and colleagues showed opposite results with participants tending to over-report WC, particularly men compared to women (Dekkers, van Wier, Hendriksen, Twisk, & van Mechelen, 2008). When using self reported measures, the implementation of correction equations for body weight and height would be particularly helpful to reduce bias (Hayes, Kortt, Clarke, & Brandrup, 2008). Correction equations may also provide more accurate results while minimizing costs in comparison to physical measurements (Dhaliwal, Howat, Bejoy, & Welborn, 2010).

In general, subjective measures offer great advantages such as low cost, practicality, and readiness particularly among very large samples. These instruments also provide information on type, frequency, and intensity of activity engaged in by older adults and do not involve physical stress, as participants are not required to perform tasks. However, some instruments may suffer from low accuracy, low sensitivity to change, and problems with validity and reliability. Also, psychological and other health factors such as motivation and pain levels may affect response.

In contrast, objective measures have the advantage of increased accuracy, sensitivity to change, and reliability to detect variations in physical activity level or early functional decline. Disadvantages include higher cost, need for trained staff, specific equipment, the need for physical screening prior to performance in some instances, and the dependence on participants' motivation. Moreover, some tests or procedures may not correspond to real life situations when administered in artificial environments affecting the nature of results captured. Despite the wide use in research and clinical settings, some issues such as time constraints, funding, need for support staff, study setting, as well as characteristics of the measures (adequate psychometric properties), and range of activities covered should be carefully considered before selecting a particular measure in order to ensure quality of the outcome measure.

CHAPTER 3: METHODS

3.1 Introduction

This section will be presented in 6 sub sections: overall description of the study, ethics, participant recruitment, study design, procedures, and statistical analyses. The methodological information about the WISER Phase 3 and Phase 4 were extracted from the Wellness Institute Services Evaluation Research (WISER) Program: Phase Three and Phase Four.

3.2 Overall Description of the Wellness Information Survey Evaluation Research Study (WISER)

The Wellness Information Survey Evaluation Research Program is a longitudinal health promotion study that was initiated in 1998 at the University of Manitoba by Dr. Alex Segall (Department of Sociology) and colleagues. The WISER was originally called Wellness Institute Services Evaluation Research because the first (1998-2001) and the second (2002-2003) phases of the study were conducted in affiliation with the Health Leisure and Human Performance Research Institute at the University of Manitoba in collaboration with the Wellness Institute at Seven Oaks General Hospital in Winnipeg. The initial objective of the study was to assess the impact of the Wellness Institute on the health and well-being of the institute members compared to non-members and to assess whether health promotion programs improve health status. Members of the Wellness Institute and non-members who resided in the community were interviewed (community comparison).

The third phase of the study (August 2007- January 2008) was conducted by Drs. Segall and Menec and was funded by Dr. Menec's Canada Research Chair in Healthy

Aging. This phase was not conducted in collaboration with the Wellness Institute. The overall objectives of the third phase of WISER were: (1) to assess stability and change in health status and personal health practices, (2) to examine the extent to which personal health practices and health services utilization contributes to active aging, (3) to examine the impact of the neighbourhood environment on active aging, and (4) to further understand the role of social determinants of health and identify factors that are associated with healthy aging. Individuals aged 45 years of age and older who participated in the first and second phases were contacted for inclusion. The final sample was 1015 participants. In addition to in-person interviews, the third phase also incorporated a physical activity component that included the use of pedometers to measure physical activity levels.

A follow-up study on the WISER Phase 3 participants originated as a possibility of a thesis topic. Given that WISER Phase 3 included measures of neighbourhood characteristics and an objective measure of walking (pedometer data), it provided an ideal platform for longitudinal follow-up. The fourth phase of the WISER study was conducted in September 2010-January 2011. WISER Phase 4 was also funded by Dr. Menec's Canada Research Chair in Healthy Aging. Data collection was conducted under the direction of Dr. Menec. Participants who were 65 years of age and older and who had participated in the third phase of the study were contacted for inclusion. The final sample was 341 participants. Similar to the third phase, in-person interviews and a physical activity component were included. This present thesis focused on the third and fourth phases of the WISER study only.

3.3 Ethics

This thesis was approved (expedited review) by the Education/Nursing Ethics Board (ENREB) (protocol #E2013:026). The third phase and fourth phases of the WISER study were approved by the Psychology/Sociology Research Ethics Board (PSREB) (protocol #P2007:061 and protocol #P2010:071 respectively) with Dr. V. Menec and Dr. A. Segall as the principal investigators.

3.4 Inclusion/Exclusion Criteria for WISER Phase 3 and Phase 4

To be included in the WISER Phase 3, individuals had to: agree to participate in the survey; be 45 or older as of January 1st, 2006; have participated in the first or second phases of the WISER study; have their information (e.g., address and phone number) verified at the time of the tracking; and had to live in the River East, Seven Oaks, Inkster, Point Douglas, East St. Paul or West St. Paul neighbourhoods. Participants were excluded if they were not able to comply with the research procedures.

The inclusion criteria for WISER Phase 4 were the same as for Phase 3 regarding the decision to participate, information tracking, and place of residence. However, in order to be included in WISER Phase 4, participants had to have participated in WISER Phase 3 and had to be 65 years of age or older as of January 1st 2010. The reason why the minimum age was raised to 65 years or older in Phase Four (compared to 45 years and older in Phase Three) was because of the interest in the older adult segment of the sample.

3.5 Description of the Sample

3.5.1 WISER Phase 3

Of the 1500 individuals interviewed in Phase 2 of the WISER study, 1165 were eligible for follow up contact. After the follow-up contact, 938 participants were eligible for WISER Phase 3. Of the 938 eligible participants, 712 completed Phase 3. The response rate was 82.6% and the refusal rate was 12.3%. Reasons for exclusion were:

- participant refusal - not interested (36), lack of time (29), sickness (9), have done enough (4), no specific reason (4).
- proxy refusal - not interested (3), lack of time (2), sickness (2), have done enough (1), no specific reason (1).
- ineligible - hospitalized (3), deceased (5), moved to personal care home (2), moved out of the province (14), were away during the study (6), had language/hearing barrier (1), had dementia (3).
- not contacted - outside of Winnipeg (26), unable to locate (10), would not return phone calls (11), ineligible neighbourhood cluster (44), unable to arrange the interview before end of data collection period (10).

To have a projected sample size of 1000 participants for Phase 3, the sample recruited from WISER Phase 2 participants was supplemented with individuals who had participated in the WISER Phase 1 only. Of the 1835 individuals who participated in WISER Phase 1, 806 were eligible to be contacted for Phase 3. Reasons for exclusion were:

- participant refusal - not interested (22), lack of time (21), sickness (4), no specific reason (1).

- proxy refusal - not interested (1), lack of time (1), sickness (2).
- ineligible - hospitalized (1), deceased (12), moved out of the province (6), were away during the study (12), had language/hearing barrier (2), had dementia (4).
- not contacted - unable to locate (11), not needed/sample quota filled (394), would not return phone calls (4), unable to arrange the interview before end of data collection period (2). This information is shown on a flow chart in Figure 2.

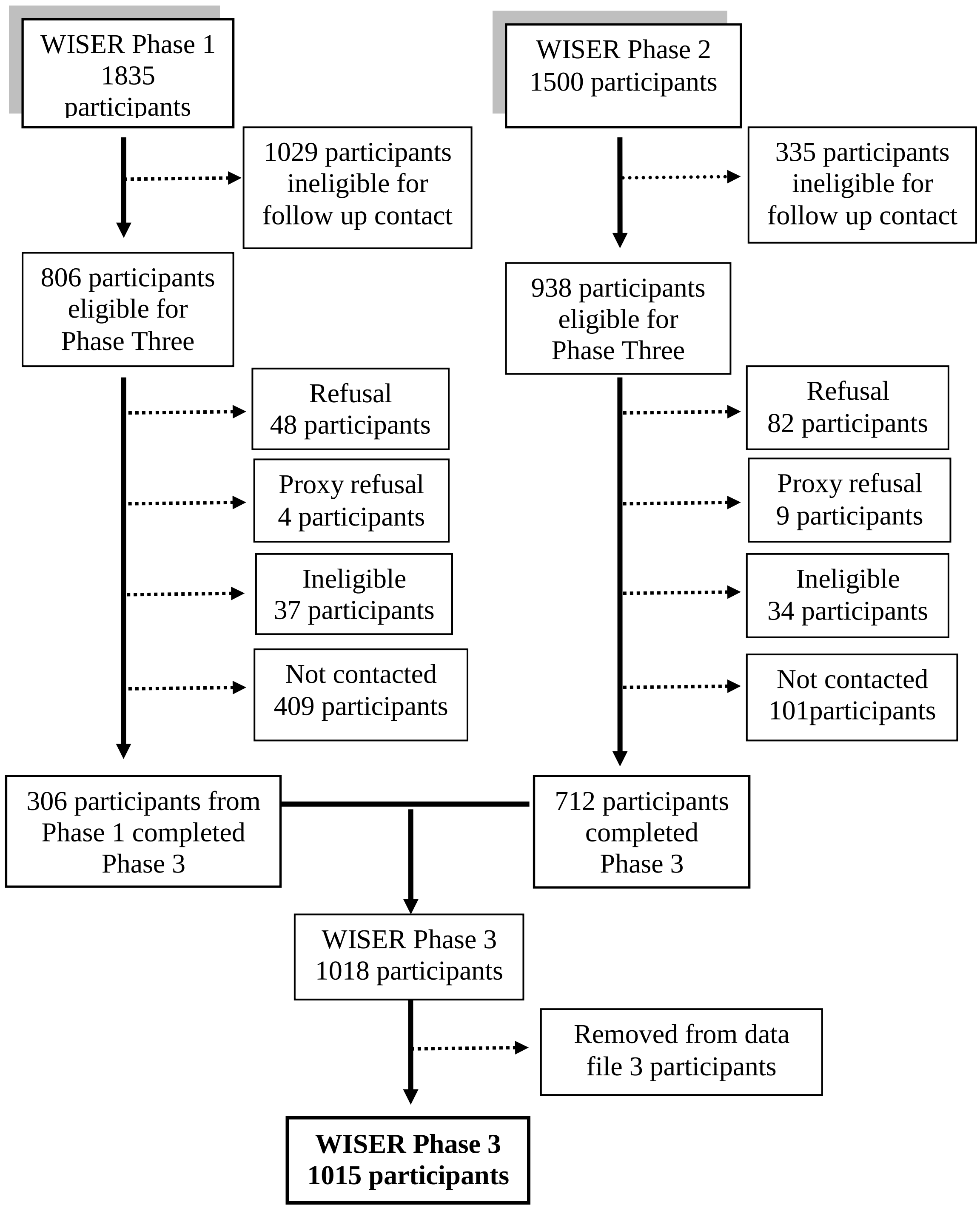


Figure 2. WISER Study –Phase 3 recruitment

3.5.2 WISER Phase 4

Of the 1015 individuals interviewed in Phase 3 of the WISER study, 484 were eligible for follow-up contact for Phase 4. Of the 484 eligible individuals, 342 completed the Phase 4 interviews. The response rate was 71% and the refusal rate was 13.4%. Reasons for exclusion were:

- participant refusal - not interested (17), lack of time (11), sickness (10), have done enough (6), no specific reason (2).
- proxy refusal - not interested (4), sickness (2), no specific reason (1).
- ineligible - hospitalized (3), deceased (24), moved to personal care home (9), moved out of the province (1), were away during the study (13), had language/hearing barrier (1), had dementia (3), caring for terminally ill family member (1).
- not contacted - unable to locate (23), would not return phone calls (8), unable to arrange the interview before end of data collection period (3). Prior to data analysis one interview was eliminated from the data file because 90% of the questions were not answered. The final sample consisted of 341 participants. This information is shown on a flow chart in Figure 3.

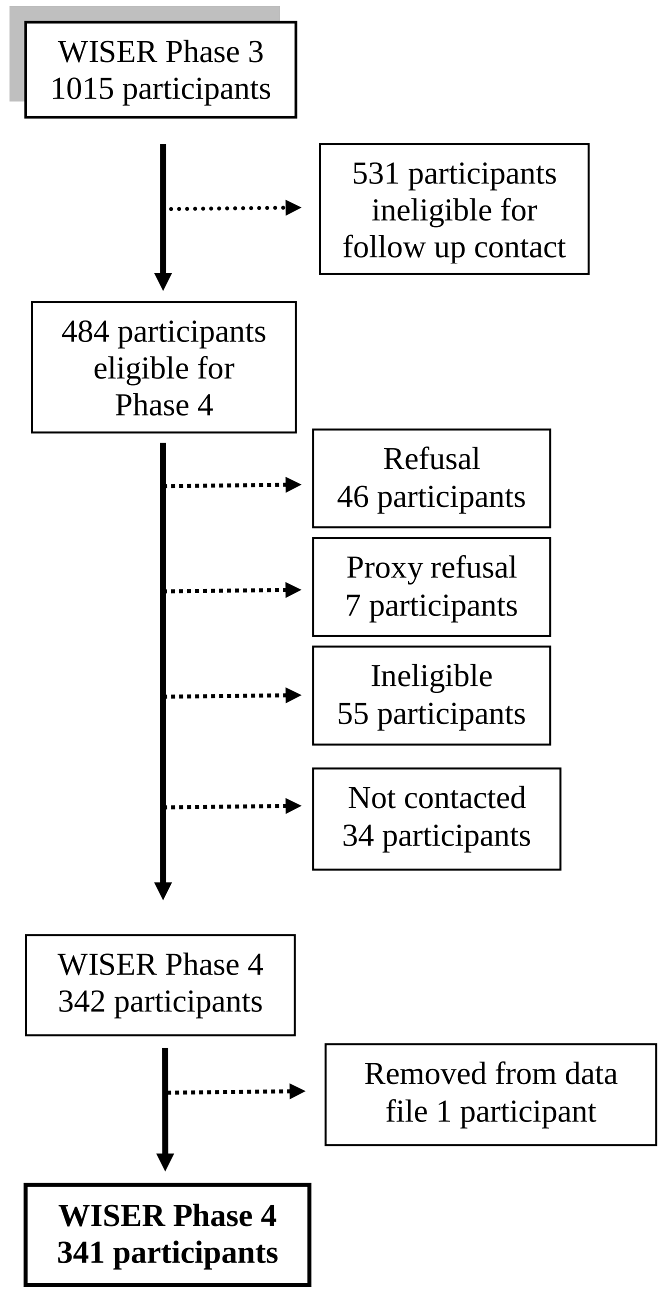


Figure 3. WISER Study –Phase 4 recruitment

3.6 Participant Recruitment and Procedures

3.6.1 WISER Phase 3

In August 2006 the eligible Phase 1 and 2 participants were tracked using the canada411 Internet Service (www.canada411.com), the MTS "Fast Finder", and the Winnipeg telephone directory. The tracking was considered successful if the last name of the individual matched with a known address or telephone number provided in one of the directories. The Winnipeg Free Press on-line obituaries (www.passagesmb.com) were also checked in order to verify whether or not the person was deceased. Death was confirmed if the first and last names, gender, and date of birth matched an obituary entry.

The in-person interviews for the WISER Phase 3 were conducted by eight female interviewers with previous interview experience, five of whom had conducted interviews in the earlier phases of WISER study. The interviewers attended a one-day training session that included a summary of the WISER Phase 3, the roles and responsibilities of an interviewer, as well as techniques on how to contact potential participants, and how to conduct an interview. In addition, training on the physical activity component of the study (pedometer instructions) as well as the use of technology (laptops) to collect data was provided. An interviewer manual and a question-by-question guide containing background information about the WISER Phase 3 were given to interviewers.

In August 2007, a letter was sent to the individuals eligible for Phase 3 to remind them about their previous participation in Phase 1 or 2, to explain the purpose of Phase 3, and to encourage them to participate. They were also informed that an interviewer would contact them by telephone shortly in order to arrange an interview. After the letters were sent, interviewers attempted to make an initial contact within one week. The first telephone contact consisted of identifying the individual (i.e., asking the individual's name), reminding them about the letter of contact, and discussing a convenient date/time for the interview. In the case of not receiving the letter, another was sent after confirming the participant's correct address. In the case of a letter return, another participant tracking was made using the telephone directories and the internet services using the individual's family name.

The procedures were comprised of an in-person interview and a physical activity component.

The In-person Interview

All interviewers wore photo identification for every interview. They were provided with a letter of introduction from the Centre on Aging that was shown to the participant at the time of the interview in order to confirm the interviewer's affiliation with the study. Prior to participation, informed consent was obtained from each participant. All participants were assigned an identification number that was used to record and store all data. No identifying information was linked with any participant data. Only the investigators and the research coordinator had access to the list linking names and identification numbers. The interviews were completed between August 2007 and January 2008. The average time for completion was 56 minutes with a range of 22 to 170 minutes.

The Physical Activity Component

Participants were asked to wear a pedometer for a 3-day period, and record the number of steps taken per day (Appendix 2). They were also asked to complete a 3-question survey (Appendix 2) to detect possible fluctuations in physical activity levels on the days that the pedometer was worn in comparison to the days that the pedometer was not worn. The interviewer provided an explanation about pedometer use according to instructions provided (Appendix 2) as well as directions on pedometer recording and pick up.

3.6.2 WISER Phase 4

In September 2010 the eligible Phase 3 participants were tracked using the same procedure described for Phase 3 above (section 3.6.1). The in-person interviews for the WISER Phase 4 were conducted by five female interviewers with previous interview experience, three of whom had conducted interviews in the earlier phases of WISER study. The interviewers also attended a one-day training session that included the same objectives that were outlined for WISER Phase 3.

In October 2010, a letter was sent to the eligible individuals for Phase 4. The purpose of the letter was to remind them about their previous participation in Phase 3, to explain the purpose of the Phase 4, and to encourage them to participate in the latest phase. The letter also informed them that an interviewer would contact them by telephone shortly in order to arrange an interview. After the letters were sent, interviewers attempted to make an initial contact within one week. The first telephone contact consisted of identifying the individual (i.e., asking the individual's name), reminding them about the letter of contact that was sent, and discussing a convenient date/time for the interview. In the case of not receiving the letter, another one was sent out after confirming the participant's correct address. In the case of a letter return, another participant tracking was made using the telephone directories and the internet services using the individual's family name.

As for WISER Phase 3, the procedures were comprised of an in-person interview and a physical activity component. Participants were also asked to measure their waist circumference.

The In-person Interview

The procedures for the interviews were the same as used for WISER Phase 3. Prior to participation, informed consent was obtained from each participant. The interviews were completed between October 2010 and January 2011. The average time for completion was 61 minutes with a range of 20 to 140 minutes.

The Physical Activity Component

The procedures for the physical activity component for WISER Phase 4 were the same as used for the WISER Phase 3.

3.7 Research Variables

Both WISER Phase 3 and WISER Phase 4 questionnaires included a wide range of measures. The following provides an overview of the specific measures used in this study.

3.7.1 Predictor Variables

3.7.1.1 Demographic Variables

These measures included age and sex (Appendix 3). Age was subsequently dichotomized into < 70 years of age and 70 years or older (Table 1). Other measures such as marital status, educational background and personal income were considered, but were not included because of the relatively small sample size and the danger of over fitting regression models.

3.7.2.2 Health Status

Measures of health status were chosen because they are frequently associated with mobility restriction and decline in physical activity participation (Gagliardi et al., 2007; Lim & Taylor, 2005). Therefore, health status measures have the potential to explain part of the variation in outcomes such as physical activity, physical function and mobility. In addition, self-rated health is associated with perceptions of the neighbourhood environment (Poortinga, Dunstan, & Fone, 2007). Self-rated health, physical function limitations, and total number of chronic diseases were used because they each measure different constructs.

3.7.2.3. Self-rated health - This variable is a predictor of health-related outcomes, such as functional status, disability (Galenkamp, Braam, Huisman, & Deeg, 2012), and mortality (Benyamini, 2011). In this study it was assessed using the single question: "In general, would you say your health is: answers ranged from 1 (excellent) to 5 (poor)" (Appendix 4). A category "*didn't know/ did not respond (DK/R)"* was created to report missing values. For data analysis the ranking was inverted (e.g., from 1 (poor) to 5 (excellent)) and grouped into three categories because of the small sample size in certain categories: 0 –poor/fair; 1 – good; and 2 – very good or excellent (see Table 1).

3.7.2.4. Total number of chronic diseases – Participants were asked about the presence of 25 chronic health problems such as heart disease, osteoporosis and diabetes. A sum score of the number of chronic diseases reported by the participants was generated (continuous variable). The list of chronic diseases can be found in the chronic conditions section of the questionnaire (Appendix 4).

3.7.2.5. Physical function limitations – The physical functioning part of the Short-Form Health Survey (SF-36) (Ware & Sherbourne, 1992) also called Physical Functioning 10 (PF 10) was used to assess physical function limitations. It addresses 10 functional activities that may be limited by one's health including vigorous and moderate activities, as well as walking and climbing stairs (Appendix 4). The PF 10 has been validated as a measure of physical function and mobility against various performance based tests in older adults (Syddall et al., 2009) and has been used to assess the relationship between physical function and physical activity practice (Morey et al., 2008). The score ranged from 0 ("No, not limited at all") to 2 (Yes, limited a lot") for each item with higher scores indicating increased physical function limitation. The sum score of the items was used for this study and was reported as a continuous variable. Table 1 provides further information about the study variables and how they were examined.

Table 1. Additional information about the predictor variables measurement

Variable	Type of Variable	Categorization	Source
Age	Continuous Categorical	Age in years ≤ 70 years and > 70 years	WISER Phase 3
Sex	Categorical	Male Female	WISER Phase 3
Self-rated health	Categorical	1. poor/fair 2. good 3. very good/excellent	WISER Phase 3
Number of chronic conditions	Continuous	Total number of chronic conditions	WISER Phase 3
Physical function limitations	Continuous	Total score for physical function limitations	WISER Phase 3
Perceived neighbourhood environment	Continuous	Traffic Safety Sidewalks Aesthetics Walkability Safety	WISER Phase 3
BMI	Continuous	BMI score	WISER Phase 3

3.7.2.6 Perceived Neighbourhood Environment - Different aspects of the neighbourhood environment were assessed in WISER Phase Three. An 8-item modified version of the Neighborhood Environment Walkability Scale (NEWS) (Saelens et al., 2003) was used to assess the extent to which participants agree or disagree with certain statements related to their neighbourhood environment such as “there are sidewalks on most of the streets in my neighbourhood”. The answers had a 4-point scale ranging from 1 (strongly disagree) to 4 (strongly agree) with higher values corresponding to a more walkable neighbourhood. In some statements where the sentence had a negative connotation such as “Most drivers exceed the posted speed limits while driving in my neighbourhood”; the scale was reversed in order to keep the consistency with the other statements and have higher responses reflect more positive perceptions (Appendix 5).

To reduce the number of variables and create meaningful groupings, factor analysis was used in order to group individual variables that were selected from the NEWS-A scale. Factor analysis is a data reduction technique that allows combining variables to create a smaller number of groupings that explain most of the variance (IBM SPSS Statistics, 2011). Varimax rotation was subsequently used to provide orthogonal groups. The factor analysis and varimax rotation resulted in four categories: traffic safety, sidewalks, aesthetics, and walkability safety. Table 2 shows the results for the factor analysis, including factor loadings, and data categorization for the perceived neighbourhood environment. Based on these results, mean scores were created within each category.

Table 2. Factor analysis and data categorization for the perceived neighbourhood environment.

Proposed neighbourhood category	Variables included	Factor loading	Percentage of variance explained (cumulative)
Traffic safety	1. "There is so much traffic along the street I live on that makes it difficult or unpleasant to walk in my neighbourhood"	0.798	20.28%
	2. "There is so much traffic along nearby streets that makes it difficult or unpleasant to walk in my neighbourhood"	0.831	
	3. "Most drivers exceed the posted speed limits while driving in my neighbourhood"	0.698	
Sidewalks	1. "There are sidewalks on most of the streets in my neighbourhood"	0.888	38.08%
	2. "The sidewalks in my neighbourhood are well maintained (paved, even, and not a lot of cracks)"	0.823	
Aesthetics	1. "There are many interesting things to look while walking in my neighbourhood"	0.823	53.37%
	2. "There are walking paths in or near my neighbourhood that are easy to get to"	0.828	
Walkability safety	1. "There are crosswalks and pedestrian signals to help walkers cross busy streets in my neighbourhood"	0.669	67.07%
	2. "My neighbourhood streets are well lit at night"	0.867	

3.7.2.7. Obesity – Obesity was included as both a predictor and outcome variable in this thesis. As a predictor, it was assessed using body mass index (BMI). BMI was chosen because of its moderate ability of measuring total body fat distribution and its practicality to be used in studies with large samples (Snijder et al., 2006). BMI was self-reported and was calculated by dividing the participant's weight (in Kg) by the squared height (in meters) (Appendix 3); it was used as a continuous variable.

3.7.2 Outcome Measures

3.7.2.1 Physical Activity Level (steps taken per day) - Pedometers were used because they are an objective measure of physical activity and do not depend on participant's report of activity level, increasing the precision of the measure. In addition, the focus of this study is steps taken per day, which is the primary outcome from pedometers. A three-day period for measurement was chosen because it is proven to be representative of a one-week period (Tudor-Locke et al., 2005).

Participants were asked to wear a pedometer (Digiwalker SW - 200) attached on their hip for three consecutive days, and at the end of each day to record the number of steps taken. Participants were encouraged to wear the equipment as long as possible throughout the day and to remove it only for bathing or showering or at night before going to sleep. If there was another reason for removing the equipment, they were encouraged to report the reason for removal (Appendix 2).

In order to be considered valid, the pedometer data were reviewed to ensure that the number of steps was properly recorded (i.e. recorded for 3 consecutive days). Participants who recorded the number of steps for 1 or 2 days only were excluded from the analysis. In addition, participants who did not record any steps in the pedometer recording form due to difficulties in handling the instrument (unable to open the pedometer, unable to find the reset button) or for health reasons (arthritic hands or decided not to wear due to recent hip replacement) were excluded from the analysis.

In some instances, malfunctioning of the pedometer was reported by some participants. In the case of discrepancies between the steps count in comparison to the physical activity levels that participants had reported for the day (i.e. exercised on a treadmill, went for a 4-5 mile walk) the pedometer data was excluded from analysis.

Lastly, in a few instances where participants had very low average number of steps (< 500 steps), the pedometer chart was reviewed together with the 3-question survey in order to check for any discrepancies between the usual physical activity level with and without the pedometer. In the case of low average number of steps, if the number of steps for each day was consistently low for the 3-day period and the participants did not record any malfunctioning or any other discrepancy between the time of wearing the pedometer in comparison to not wearing it, the pedometer data were considered.

The outcome was the mean number of steps (total number of steps taken in three consecutive days divided by three). For longitudinal analysis, the change score in the mean number of steps was calculated (WISER 4 mean number of steps subtracted by WISER 3 mean number of steps). Therefore another criteria for inclusion was for participants to have valid pedometer data at the two time points of the study (i.e., WISER 3 and WISER 4). Table 3 lists all outcome variables for this study (i.e. type of variable and how each outcome was reported).

Out of the total sample size for this study (341 participants), 264 had valid pedometer data at WISER 3 only (missing observations: 77). This number dropped to 232 participants that had valid pedometer data at WISER 4 only (missing observations: 109). The total sample with valid pedometer data at the two time points was 199 participants (missing observations: 142). Table 4 shows the sample size for steps as well the other outcome variables.

3.7.2.2 *Obesity Indicators* – As noted above, obesity indicators were included both as predictor variables and outcome variables. In terms of outcome variables, obesity was assessed using BMI and WC. As mentioned previously, BMI was chosen because of its moderate ability of measuring total body fat distribution and WC was chosen because of its very high accuracy in measuring central body fat distribution (Snijder et al., 2006). BMI was self-reported and was calculated by dividing the participant's weight (in Kg) by the squared height (in meters) (Appendix 3). WC was self-assessed and participants received instructions for measurement according the Canadian Society for Exercise Physiology (Appendix 6). As an outcome, BMI was reported in two ways: as a categorical variable split in three categories according the World Health Organization proposed cut offs: normal weight (BMI between 19 and 24.9), overweight (BMI between 25 and 29.9) and obese (BMI above 30) (World Health Organization, 2000), and as a categorical variable refined by waist circumference. Evidence shows that the addition of WC to the BMI categories significantly increases the chances of detecting health risks among younger (Janssen et al., 2004) and older (Jacobs et al., 2010) adults. For this study, BMI refined by WC was categorized according to body composition-related health benefits for males and females (Canadian Society for Exercise Physiology 2003). The categories were 0 (needs improvement, N=59), 1 (fair, N= 82), 2 (good, N=3), 3 (very good, N= 54), and 4 (excellent, N= 38) with higher values representing greater body composition-related health benefits. For example, a man with a BMI between 18.5 and 24.9 and a waist circumference less than 94 receives a score of 4. If the waist circumference is between 94 and 101, the score is 3. If the waist circumference is above 101, the score is 1 (Canadian Society for Exercise Physiology 2003).

The categories were further divided in two categories: 0 low body composition-related health benefits (containing ‘needs improvement’ and ‘fair’ categories) and 1 high body composition-related health benefits (containing ‘good’ ‘very good’ and ‘excellent’ categories) because of the small number of subjects in the ‘good’ and ‘excellent’ categories. Out of the 341 participants for WISER 4, 324 participants reported height and weight that allowed the calculation of BMI. Regarding WC, 236 participants measured their waist circumference. There were 105 missing values for waist circumference.

3.7.2.3 Life-space Mobility - The Life-Space Assessment Questionnaire (LSA) (Baker et al., 2003) was used to assess life-space mobility. The score (from 0 to 120) was used as continuous variable (see more detailed description of scoring on p. 51). A score of zero represents the lowest level of mobility (the person is inside the bedroom, everyday and needs assistance) and a score of 120 represents travelling outside the town, everyday without assistance (Appendix 7). Out of the 341 participants for WISER 4, 190 had valid answers for the life-space assessment. Responses were considered valid if all the life-space levels were answered consecutively. The questionnaires where the life-space levels were not answered consecutively were excluded from the analysis (e.g., the first 2 life-spaces levels were answered, the third life-space level was not answered and the fourth life-space was answered). There were 151 missing responses for the life-space questionnaire, 130 participants did not answer the questionnaire and 21 participants had invalid scores for the questionnaire.

3.7.2.4 *Physical function* - The Late Life Function and Disability Instrument (LLFD) (Haley, et al., 2002) (the function part of the questionnaire) was used for this study. The 32-item of the function instrument measures upper body and lower body tasks (basic and advanced) and is presented in scaled score (from 0 to 100). A score of zero represents the lowest level of physical function (e.g., "cannot do" a particular task) and 100 represents the highest level of function (e.g., no difficulty performing a particular task). The scaled score was used as a continuous variable (Appendix 8). Out of the 341 participants for WISER 4, 338 participants answered the LLFD instrument.

Table 3. Additional information about the outcome variables

Variable	Type of Variable	Categorization	Source
Physical activity	Categorical (increased vs. decreased)	Steps taken per day (change score)	WISER Phase 3 and WISER Phase 4
Physical function	Continuous	LLFD (function score)	WISER Phase 4
Mobility	Continuous	LSA (mobility score)	WISER Phase 4
BMI	Categorical	BMI in three categories (normal weight, overweight, obese)	WISER Phase 4
WC	Categorical	BMI by WC in 2 categories: high risk, low risk	WISER Phase 4

Table 4. Sample size for the outcome variables and missing values

Outcome variable	Sample size (N)	Missing values
Steps per day (WISER 3 and WISER 4 valid data)	199	142
Life-space mobility (WISER 4 data)	190	151
Physical function (WISER 4 data)	338	3
BMI (WISER 4 data)	324	12
WC (WISER 4 data)	236	105

3.8 Statistical Analyses

All data were analyzed using SPSS version 20. The statistical approach varied according to the purpose of each study (outcome variable). In each study, predictor variables were chosen from WISER 3 and the outcomes were taken from WISER 4. The main predictor variable was the perceived neighbourhood environment as described in the research variables section. The predictor variables also included health-related variables (self-rated health, number of chronic diseases, BMI, and physical function limitations), and demographic variables (age and sex). Regression analysis was used according to the purpose of each study and a series of models were run as follows:

Model 1: perceived neighbourhood characteristics (traffic safety, sidewalks, aesthetics, walkability safety)

Model 2: health variables (self-rated health, number of chronic diseases, physical function limitations, BMI)

Model 3: demographic variables (age and sex)

Model 4: all variables in Models 1 to 3 combined

In Study 1, the outcome variable was the change score in steps taken per day obtained by subtracting the mean number of steps taken in follow up (WISER 4) by the mean number of steps taken in baseline (WISER 3). Steps were analyzed in several different ways. In the final analyses, a categorical variable was used that was created by dichotomizing the change score into two groups: increased number of steps and decreased number of steps. A rationale for why this approach was taken is provided in the Results section. Separate logistic regressions were used for the two age groups (younger adults ≤70; older adults > 70) and the group that decreased steps was used as a reference group.

In Study 2, the outcome variables were Life-Space Mobility assessed using the Life-Space Assessment (Baker et al., 2003) and physical function using the Late Life Function and Disability instrument (Haley et al., 2002). Both were used as a continuous variable (as described in the research variables section). Linear regressions were run for each age group (younger adults ≤70; older adults > 70).

In Study 3, the outcome variable was BMI reported in two ways: as a categorical variable split into three categories (normal weight, overweight and obese), and as a categorical variable refined by waist circumference split into two categories (high and low body composition-related health benefits) as described in the research variables section. Multinomial analysis was run for BMI as a categorical variable in three groups. Multinomial regression is appropriate when the outcome variable consists of 3 or more categories. The regression allows for simultaneous analysis of each category (overweight versus obese), relative to a comparison (normal weight). Because body composition-related health benefits was a dichotomous variable, a logistic regression was run for this outcome.

CHAPTER 4: RESULTS AND DISCUSSION

4.1 Sample Characteristics

Table 5 provides the overall characteristics of the sample. Approximately half of the sample was female (54.8%, N= 187) and the mean age was 71 years. Most participants rated their health as excellent or very good; the mean number of chronic conditions per person was 4, the mean BMI was in the overweight category.

Table 6 shows the demographic and health characteristics after splitting the sample by age (younger and the older participants). In the younger group, the mean age was 66 years (± 2.3), with a range from 62 to 70 years. Most participants rated their health as very good/excellent. The mean number of chronic conditions was 3 diseases per person and the average BMI was in the overweight category. The physical function limitations score was very low, indicative of few functional limitations. In the older group, the mean age was 77 years (± 4.5), with a range from 71 to 91 years. Most participants rated their health as either good or very good/excellent. The mean number of chronic conditions was approximately 4 diseases per person and the average BMI was also in the overweight category. The physical function limitations score was low to moderate.

The sample was drawn from several neighbourhoods in the city of Winnipeg, however the majority were from River East, Seven Oaks and Point Douglas, accounting for 88% of the participants (N=339). Two participants were not included in the neighbourhood description data because the postal code did not link to the postal code conversion file. Appendix 9 contains additional neighbourhood characteristics (i.e.

population density, proportion of the population over the age of 65) and Appendix 10 shows the participant location per neighbourhood in the city.

Table 5. Overall descriptive characteristics of the sample

Characteristic	Mean (± SD) (valid % where indicated)		Range		Missing observations	
	WISER 3	WISER 4	WISER 3	WISER 4	WISER 3	WISER 4
Age (years)	71.54 (± 6.64)	74.6 (±6.66)	62-91	65-94	0	_
Self rated health (valid percent)						
poor/fair	16.8	_	N/A		1	_
good	34.1					
very good/excellent	49.1					
Number of chronic conditions	4 (± 2.45)	_	_		0	_
BMI	27.5(± 4.5)	27.5 (± 4.86)	18 - 55.8	16.5 - 55.9	15	12
Waist circumference	_	98.8 (± 13.46)		63 - 144	_	105
Average number of steps taken	5734 (± 3527)	4575 (± 3570)	220 -21128	213 -21041	77	109
Physical function level (LLFD) (scaled score)	_	63.4 (± 15.8)	_	0-100	_	3
Life-Space Score	_	69.8 (±18.23)	_	19-120	_	151

Table 6. Demographic and health characteristics for younger and older participants

	Age group					
	Younger			Older		
Characteristic	Mean (± SD)	Range	Missing	Mean (± SD)	Range	Missing
Female (%)	46.8%	N/A	0	56.8%	N/A	0
Self rated health (%)		N/A	0		N/A	0
poor/fair	11.7%			18.2%		
good	27.9%			39.8%		
very good/excellent	60.4%			42%		
Number of chronic conditions	3.2 (±2)	0-8	0	4.4 (±2.2)	0-10	2
BMI						
WISER 3	27.8 (±5.0)	18.6 -55.8	5	27.2 (±3.8)	18.0- 40.0	10
WISER 4	27.7 (±5.1)	18.3- 55.9	8	27.2 (±4.5)	18.5-41.6	4
PF 10 score (physical function limitations)	2.67 (±3.3)	0- 14	3	5.32 (±4)	0-14	5
Number of Steps						
WISER 3	6545 (±3790)	721 – 21128	26	4775 (±2924)	220 – 17965	51
WISER 4	5498 (±3930)	708 - 21041	44	3497 (±2744)	213 - 13652	65
Physical function level (LLFD)	69.1 (±15)	36 - 100	1	57.8 (± 13)	0 - 100	2
Life-Space Score	72.9 (±16)	28 - 100	57	65.3 (± 20)	19 - 120	94

4.2 Study 1: The Influence of the Perceived Neighbourhood Environment on Change in Objectively Measured Walking Among Older Adults

Research Hypotheses

As stated earlier, the hypotheses for Study 1 were:

1. There will be a decline in walking activity over a 3-year period that will be mostly explained by advancing age and decreased health status. The decline will be greater in women compared to men.

2. The decline in walking activity will be attenuated by having a positive perception of the neighbourhood environment; those with positive neighbourhood perceptions will show less decline in walking.

Creating the outcome variable

The outcome was the mean number of steps (total number of steps taken in three days divided by three). For longitudinal analysis, the change score in the mean number of steps was calculated (WISER 4 mean number of steps subtracted by WISER 3 mean number of steps). A positive score means that the participant increased the number of steps between the two time points and a negative score means that the participant decreased the number of steps. The sample size for this study consisted of 199 participants with valid pedometer data at the two time points. The range in change score went from -14603 steps (i.e. the participant decreased 14603 steps) to 9388 steps (the participant increased 9388 steps). Figure 4 shows the distribution of the change score and Figure 5 shows the trajectory of steps taken between baseline (phase 3) and follow up (phase 4) by age groups and sex (individual observations). The individual data for the steps change score are shown on Appendix 11.

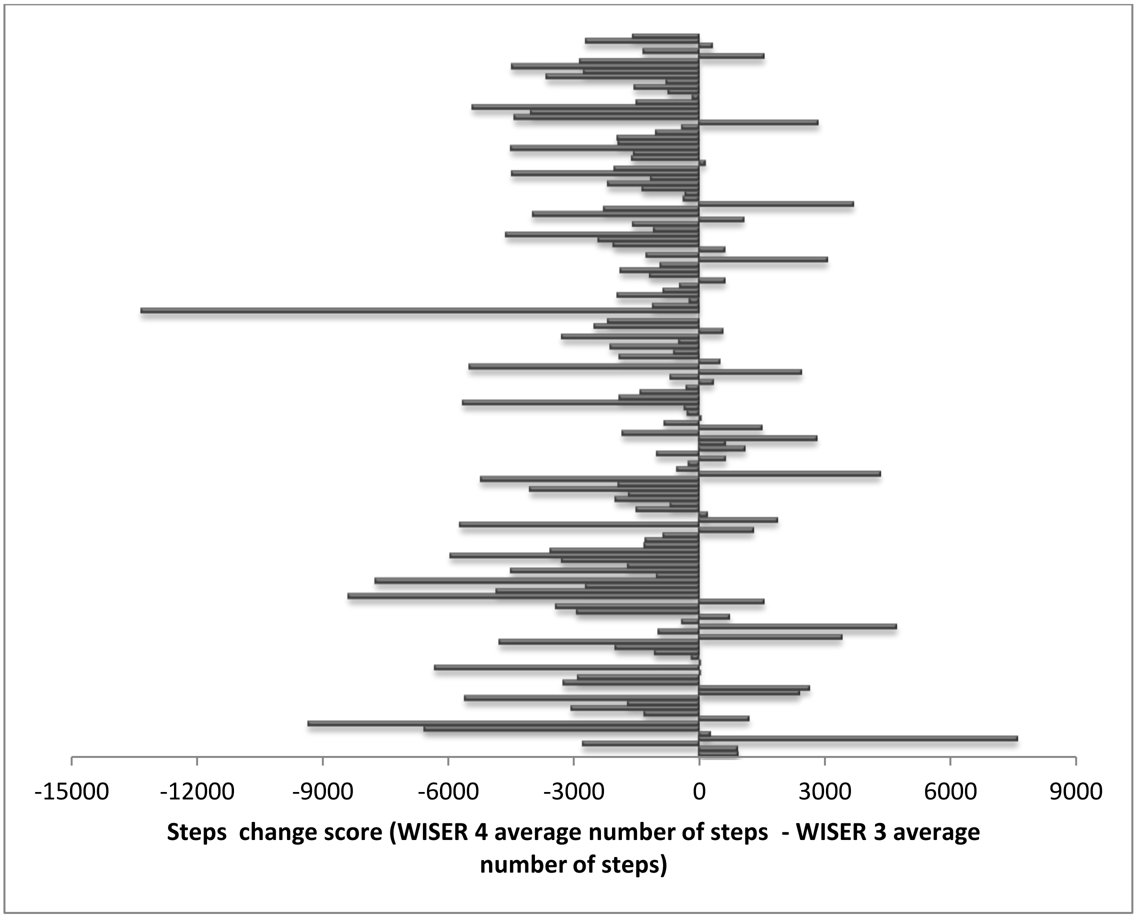


Figure 4. Frequency distribution for the steps change score for the overall sample (N=199)

*Each line represents one participant. Values above 0 (zero) represents a positive change score (the participants increased the number of steps between WISER 3 and WISER 4). Values below 0 (zero) represents a negative change score (the participants decreased the number of steps between WISER 3 and WISER 4).

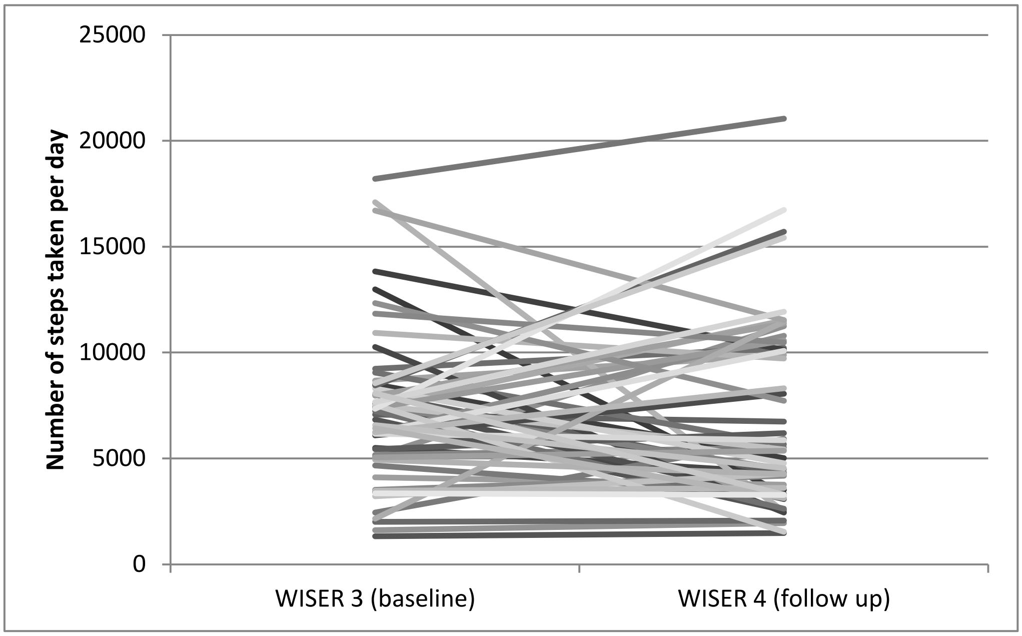


Figure 5a. Trajectory of steps taken between baseline and follow-up for each participant in the younger males group

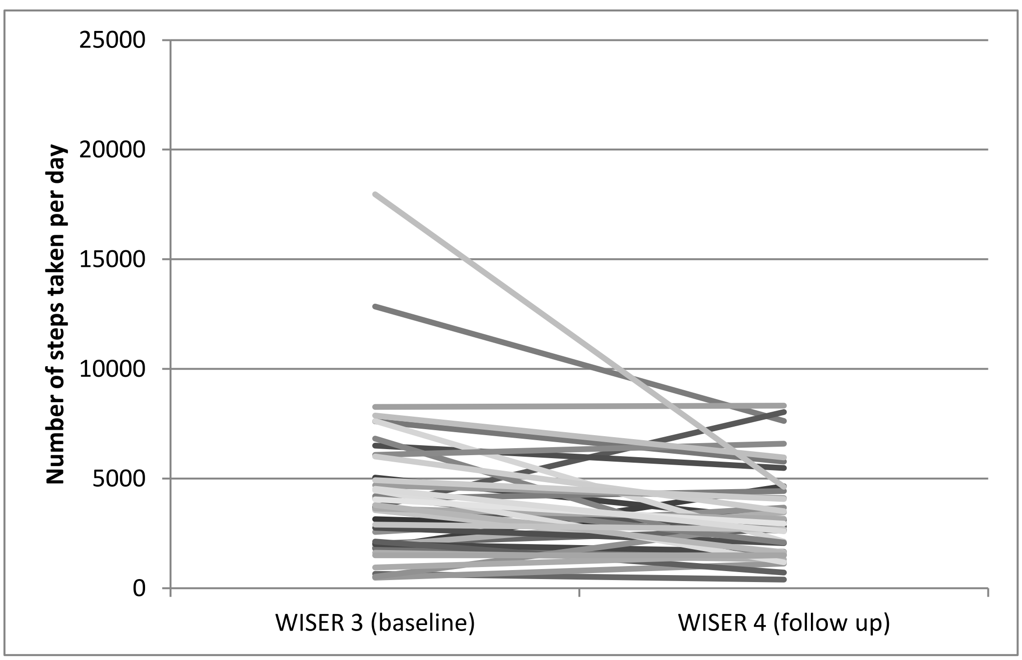


Figure 5b. Trajectory of steps taken between baseline and follow-up for each participant in the older males group

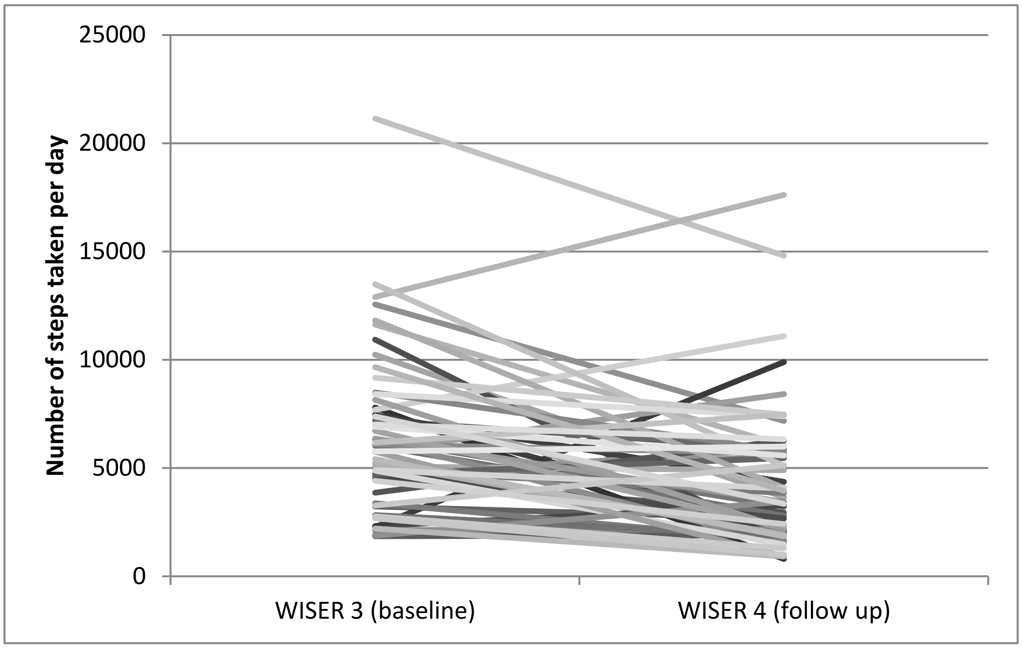


Figure 5c. Trajectory of steps taken between baseline and follow-up for each participant in the younger females group

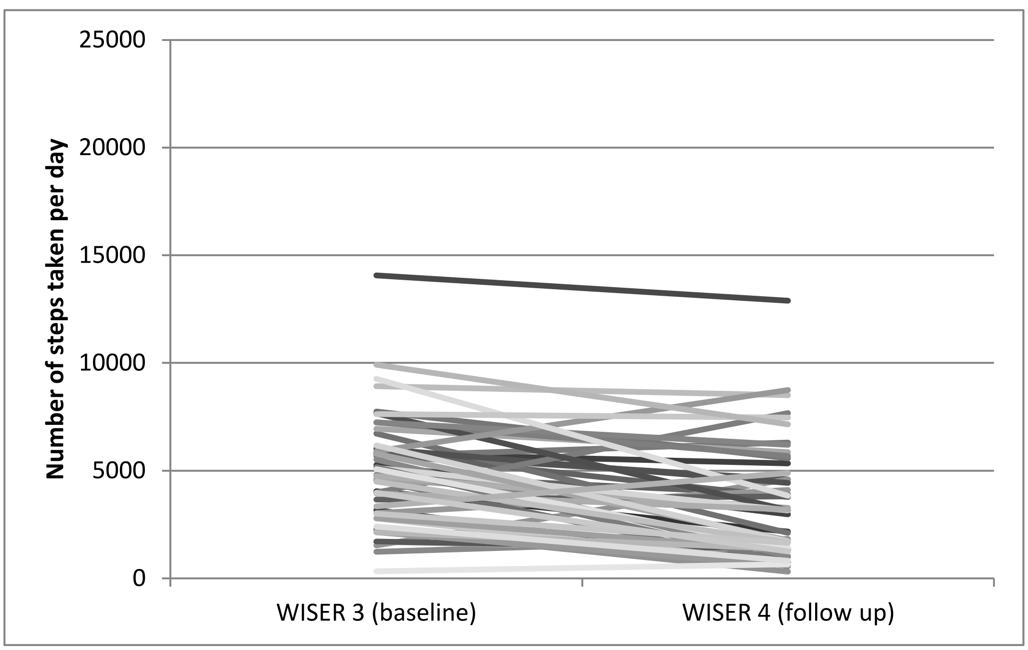


Figure 5d. Trajectory of steps taken between the baseline and follow-up for each participant in the older females group

The change score was examined using several statistical approaches in order to report the most appropriate one. There are currently no universally accepted cut-off points in terms of the recommended change in number of steps per day to promote health among older adults. Table 7 shows the statistical approaches that were considered and the reasons for rejection.

The first approach involved using the total sample and examining the change score as a continuous variable. Although simple, this approach was rejected for several reasons: First, the data were not normally distributed. Second, the change variable does not take into account number of steps taken at baseline. For instance, a decline of 1000 steps for a participant who had 12000 steps at baseline is less relevant compared to another participant who declined the same amount of 1000 steps, but had 2000 steps at baseline. Third, linear regression showed a significant age-effect (i.e. positive B) indicating that the number of steps increased with advancing age. However, this finding was not consistent across the sample. As shown in Figure 5a, this pattern was only present among the younger segment of the sample. In the older segment of the sample the number of steps generally decreased with advancing age.

The second option consisted of treating the change in steps taken in 2 categories, the top 20% of the sample who increased the number of steps the most compared to the remaining sample. The approach was considered in an attempt to better examine those who had the largest increase in number of steps. The 20% was chosen in an attempt to have a potentially sufficiently large subsample for analysis, combined with a meaningful value for the change score (at least a738 step increase) as seen on Appendix 11. This approach was rejected because the sample size in the top 20% group was small (N= 40) and because the comparison 80% was comprised of individuals who increased their number of steps and those who decreased number of steps; therefore, not providing a unique categorization. An alternative approach was to examine the bottom 20% of the sample who decreased the number of steps the most, compared to the rest of the sample was also considered. However, the same issue arose as in the top 20% approach, thus this approach was also rejected.

The third option consisted of dividing the sample into tertiles in order to maintain sufficiently large subsamples based on their change score, with the idea that this would result in three groups represented by those who increased their number of steps, those who decreased their number of steps and those who remained stable. However, the tertile approach was rejected because the range of steps did not match the desired classification (i.e. the ‘stable’ group and the ‘decrease’ group were essentially composed of those who decreased steps). In addition, the significant age effect that was present in the previous approaches remained significant.

The fourth approach consisted in splitting the sample by age groups (i.e. those at the age of 70 or younger and those older than 70 years of age). The age of 70 was chosen because it contains approximately half of the sample in each group. The following options were examined: 1. The change score was examined as a continuous variable. However, as previously mentioned, this approach does not take into account the number of steps at baseline, therefore this option was rejected. 2. The change score was examined as a categorical variable in three groups (those who increased steps, decreased steps and remained stable) with a third of the sample in each group. This option was rejected because the sample size in each group was too small since the sample was already split by age groups.

The fifth option considered splitting the sample by sex and exploring the same options that were previously examined (with change in steps as a continuous variable or categorical variable in two groups or categorical variable in three groups). However, the same problems arose a when splitting the sample by age group. The possibility of splitting the sample by age and by sex was also considered, however this approach was rejected because the sample size in each group was too small for analysis.

Table 7. Statistical approaches considered in creating the change score for steps per day and reasons for rejection

Sample consideration	Statistical approach for the change score	Reasons for rejection:
All sample included	Continuous variable (linear regression)	• Flipped effect for B: significant positive B for age (increasing age was associated with increasing steps) • Data was not normally distributed
	Categorical variable (logistic regression) • Upper 20% of the sample* vs. the remaining *The top 20% of the sample who increased walking the most (above 738 steps)	• Flipped effect for B: significant positive B for age (increasing age was associated with increasing steps) • The upper 20% contained a small sample for analysis (N=40) in comparison to the remaining group
	Categorical variable (logistic regression) • Lower 20% of the sample* vs. the remaining *The bottom 20% of the sample who decreased walking the most (below -3641 steps)	• Flipped effect for B: significant positive B for age (increasing age was associated with increasing steps) • The lower 20% contained a small sample for analysis (N=40)

Sample consideration	Statistical approach for the change score	Reasons for rejection:
	Categorical variable (Multinomial regression) • In three groups (a third of the sample in each group): Increased (from 35 to 9388 steps) Stable (-2031 to -1 steps) Decreased (-14603 to -2036 steps)	• Flipped effect for B: significant positive B for age (increasing age was associated with increasing steps) • The range of steps in each category does not reflect the proposed classification (particularly the 'stable' and 'decreased' classifications)
Split by age (≤ 70 years and > 70 years)	Continuous variable (linear regression)	• None of the covariates were statistically significant
	Categorical variable (logistic regression) • Increased vs. decreased steps	• The cutoff value for 'increased' and 'decreased' steps for younger and older ages were not consistent.
	Categorical variable (multinomial regression) • In three groups (a third of the sample in each group - (increased, stable, and decreased)	• Sample size in each group was too small to allow analyses because the sample was already split by age
Split by sex (males and females)	Continuous variable (Linear regression), categorical variable (in 2 or 3 groups)	• In all the approaches used, age remains statistically significant with a flipped effect for

Sample consideration	Statistical approach for the change score	Reasons for rejection:
		B (positive effect - increasing age was associated with increasing steps)

Having rejected a variety of approaches, the chosen approach involved conducting separate analyses by age groups (i.e. those at the age of 70 or younger and those older than 70 years of age). The change score was treated as a categorical variable, with participants divided into two groups (those who increased steps and those who decreased steps). Although it is recognized that this approach does not differentiate between individuals who increased (or decreased) their number of steps a lot versus only minimally, it is preferable over other options because it provided a reasonable number of participants in each group to allow analyses.

In order to differentiate between the two age groups, the term ‘younger group’ refers to those 70 years of age or younger and the term ‘older group’ refers to those older than 70 years. From the 199 participants, 111 participants were in the younger group and 88 participants were in the older group. In the younger group, 37.8% (N=42) increased the number of steps between baseline and follow up and 62.2% (N=69) decreased the number of steps between the two time points. In the older group, 21.6% (N=19) increased the number of steps between baseline and follow up and 78.4% (N=69) decreased the number of steps between the two time points. For the younger group (≤ 70 years), the increased steps group was represented by a change score ≥ 35 steps (range: 35 to 9388 steps; mean: 2526 steps) and the decreased steps group was represented by a change score below < -81 steps (range: -81 to -14603 steps; mean: -3451). For the older group (> 70 years), the increased steps group was represented by a change score ≥ 55 steps (range: 55 to 4323 steps; mean: 1443 steps) and the decreased steps group was represented by a change score below < -1 steps (range: -1 to -13341 steps; mean: -2097 steps). Different cut-offs for the change score between the younger and older groups were used because of the significant age-effect observed (as seen in Figure 5), therefore it using the same cut-offs for both age groups was not appropriate.

Results

Logistic regression analysis for the younger group showed that none of the perceived neighbourhood variables were associated with the odds of increasing number of steps over a three year-period. Among health-related variables, those with more chronic conditions had decreased odds of increasing steps (OR=0.73) compared to those with fewer chronic conditions. Sex had a significant effect on steps taken. Being female was associated with decreased odds of increased steps (OR= 0.37) compared to being male. When all variables were entered simultaneously in the model, sex and number of chronic conditions were significant predictors of change in steps taken. Being female and having more chronic conditions were associated with decreased odds of increasing steps over a three-year period (OR= 0.38 and 0.74 respectively), as shown in Table 8.

Table 8. Logistic regression analysis for change in steps in the younger group (N=111)

Models		Odds Ratio (Cl)	p value
Model 1: Perceived Neighbourhood characteristics	Sidewalks	1.14 (0.75 – 1.74)	0.52
	Aesthetics	0.89 (0.54 – 1.46)	0.64
	Walkability safety	0.80 (0.45 – 1.42)	0.45
	Traffic safety	1.04 (0.59 – 1.83)	0.87
Model 2: Health variables	Physical function limitations	0.95 (0.82 – 1.10)	0.53
	Number of chronic diseases	**0.737 (0.57 – 0.94)**	**0.01**
	BMI	1.06 (0.96 – 1.17)	0.21
	Self rated health	0.91 (0.44 – 1.87)	0.80
Model 3: Demographic variables	Sex		
	Men (reference group)	**-**	**-**
	Women	**0.37 (0.16 – 0.82)**	**0.01**
Model 4: All variables	Sidewalks	1.02 (0.63 – 1.65)	0.91
	Aesthetics	0.96 (0.55 – 1.68)	0.91
	Walkability safety	0.81 (0.42 – 1.55)	0.53
	Traffic safety	0.97 (0.51 – 1.85)	0.94
	Physical function limitations	0.96 (0.82 – 1.12)	0.64
	Number of chronic diseases	**0.74 (0.57 – 0.97)**	**0.02**
	BMI	1.06 (0.96 – 1.18)	0.22
	Self rated health	1.16 (0.53 – 2.53)	0.70
	Sex		
	Men (reference group)	**-**	**-**
	Women	**0.38 (0.14 – 1.00)**	**0.05**

Table 9 shows the logistic regression analysis for the older group. Among the perceived neighbourhood variables, only walkability safety predicted increase in steps taken. Those with more positive perception of walkability safety had increased odds of increasing steps compared to those with less positive perceptions. Among the health-related variables, only BMI was a predictor of increasing steps. Those with higher BMI had a 17% increase in the odds of increasing steps compared to those with lower BMI. Sex was not a predictor of change in steps taken in the older group. When all variables were entered simultaneously in the model, walkability safety, physical function limitations, BMI, and self-rated health were significant predictors of increase in number of steps taken. Those with more positive perceptions of walkability safety (OR=7.24), increased physical functional limitations (OR=1.34), higher BMI (OR=1.29), and more positive perceptions of their health (OR=7.93) had increased odds of increasing steps over a 3-year period as seen in Table 9.

Table 9. Logistic regression analysis for change in steps in the older group (N=88)

Models		Odds Ratio (Cl)	p value
Model 1: Perceived Neighbourhood characteristics	Sidewalks	0.69 (0.33 – 1.44)	0.33
	Aesthetics	1.21 (0.60 – 2.42)	0.58
	Walkability safety	**3.05 (1.05 – 8.85)**	**0.04**
	Traffic safety	0.78 (0.37 – 1.65)	0.52
Model 2: Health variables	Physical function limitations	1.10 (0.93 – 1.30)	0.25
	Number of chronic diseases	0.85 (0.63 – 1.15)	0.29
	BMI	**1.17 (1.00 – 1.37)**	**0.03**
	Self rated health	1.81 (0.70 – 4.64)	0.21
Model 3: Demographic variables	Sex		
	Men (reference group)	-	-
	Women	0.61 (0.22 – 1.70)	0.35
Model 4: All variables	Sidewalks	0.54 (0.18 – 1.58)	0.26
	Aesthetics	1.75 (0.58 – 5.32)	0.31
	Walkability safety	**7.24 (1.54 – 33.92)**	**0.01**
	Traffic safety	0.46 (0.16 – 1.30)	0.14
	Physical function limitations	**1.34 (1.03 – 1.75)**	**0.02**
	Number of chronic diseases	0.69 (0.41 – 1.14)	0.15
	BMI	**1.29 (1.03 – 1.62)**	**0.02**
	Self rated health	**7.93 (1.67 – 37.49)**	**0.009**
	Sex		
	Men (reference group)	-	-
	Women	0.26 (0.05 – 1.027)	0.09

Discussion

The objective of this study was to examine whether the perceived neighbourhood characteristics (walkability safety, sidewalks, aesthetics, traffic safety) as well as demographic and personal characteristics (e.g., age, sex, health status (self-rated health, number of chronic conditions, BMI, physical function limitations)) predicted change in walking activity over a three-year time period (2007/2008 to 2010/2011). It was hypothesized that there would be a decline in walking activity over a 3-year period mostly explained by advancing age and decreased health status, and that decline would be greater in women compared to men. In addition, the decline in walking activity would be attenuated by having a positive perception of the neighbourhood environment (those with positive neighbourhood perceptions will show less decline in walking). Although a decline in walking activity was originally hypothesized, it was found that this decline was not uniform and some participants in fact increased number of steps, particularly among males in the younger group.

In accordance with the hypotheses, this study showed that age, sex, and health status were significant predictors of change in number of steps taken between 2007/2008 and 2010/2011. Contrary to the hypothesis, among the perceived neighbourhood variables, only walkability safety was a predictor of change in number of steps and only among the older group. That different results emerged for younger versus older adults highlights how important it is to conduct separate analyses for these age groups.

In the younger group, being female and having more chronic conditions were associated with decreased odds of increasing steps. In other words, men tended to increase their walking over a three year time period and those with more chronic conditions tended to decrease their walking behavior. In the older group, those with increased physical functional limitations, higher BMI, and greater perception of their health had increased odds of increasing steps compared to their counterparts. In addition, having more positive perceptions of walkability safety was associated with less of a decrease in walking behavior.

Pedometer data

Regarding the change in number of steps taken over a 3-year period, the categorization by age groups showed different patterns of change in steps for the younger and older groups. The mean increase for the younger group was 2526 steps, while for the older group it was 1443 steps. Conversely, the mean decrease for the younger group was (-) 3451 steps and the mean decrease for the older group was (-) 2097 steps. Although these findings show that the older group had a smaller decline compared to the younger group, it must be noted that the number of steps at baseline for the older group was overall lower compared to the younger group, particularly the younger males (Figure 5) because the level where the participant began was not taken into account (i.e. one participant may have started a 15000 steps while another participant may have started at 5000 steps). These findings suggest that although the older group declined less, the clinical significance of this decline may be greater for the older group than for the younger group.

Previous studies that used pedometers among older adults reported average daily steps of 3000 (Tudor-Locke et al., 2011), 3300 (Bennett, Wolin, Puleo, & Emmons, 2006) and 4000 (Strath, Schwartz, & Cashin, 2009) with a range between 2000 - 9000 steps per day, whereas special populations, such as those with disabilities, or chronic illness that impact their mobility averaged between 1200 and 8800 steps per day. However, no information is currently available in terms of change in number of steps among older adults for health maintenance. As a public health guideline based on a review, Tudor Locke and colleagues proposed a moderate level of walking of 3000 daily steps, based on moderate intensity cadence (i.e. 100 steps per minute, multiplied by 30 minutes of activity per day) (Tudor-Locke et al., 2011). Another recent classification proposed by Tudor Locke and colleagues is based on a cut off to define whether or not a person has a sedentary lifestyle. A 5000-steps cut off was proposed and a person taking less steps than this is considered sedentary (Tudor-Locke, Craig, Thyfault, & Spence, 2013). However this evidence is based on adults and has not been applied to the older adult population.

Evidence for the suggested change in number of steps is not available at this point, particularly among older adults, due to the cross-sectional nature of the majority of the studies. There is currently no evidence to confirm if an increase between 1400 and 2500 steps is enough for health benefits or a decrease between 2000 and 3000 steps found in this study is detrimental for health. In terms of health benefits, it has been shown that if an inactive person increased 2000 steps a day, the metabolic profile can be significantly improved (better insulin sensitivity and lower BMI) (Dwyer et al., 2011). However, in terms of change in steps, little limited evidence is available.

Further research, particularly with longitudinal design, is necessary in order to clarify the estimated range of change in steps taken among older adults. An average decline in number of steps of 1064 steps for men and 2269 steps for women was found over a 5-

year period. Although it represented a lesser decline compared to the present study, the sample was younger which may explain the discrepancy in findings (Dwyer et al., 2011).

In addition to the lack of evidence regarding change in steps taken among older adults, there is also a need to further examine the clinical significance of the change in steps in relation to baseline status. For instance, participants who had high number of steps at baseline (e.g., 15000 steps) and declined 5000 steps would still be above recommended levels. However, participants who had lower number of steps at baseline (e.g., 6000 steps) and dropped the same 5000 steps is now below the recommended number of steps.

The perceived neighbourhood environment as a predictor of change in steps taken

Among the perceived characteristics of the neighbourhood environment, walkability safety was the only predictor of chance in steps per day. Among older adults aged 70 or over more positive perceptions of walkability safety (i.e. presence of crosswalks and pedestrian signals for street crossing; well lit neighbourhood) were associated with an increase in the number of steps or, conversely, a reduced likelihood of decreasing steps. The evidence regarding this particular environmental feature among older adults is very limited at this point; however, previous studies support a positive relationship between perception of walkability safety features and increased physical activity and overall mobility among older adults. Features related to walkability safety in other studies were represented by the presence of traffic calming devices (Strath et al., 2012), proper lighting for walking and safety from crime (Sugiyama et al., 2009) and safety for walking (King, 2008; Li et al., 2005b). All these features were associated with increased physical activity. Shumway-Cook and colleagues (2003) examined perceptions of the neighbourhood environment among older adults with different mobility levels. Mobility disability was defined as the ability to walk half a mile and climb stairs without assistance. Older adults with mobility disability were less likely to walk more than 10 blocks, avoided crossing streets with traffic lights, and avoided busy streets and streets with increased traffic density compared to those without mobility disability. In addition, lighting conditions (i.e. dark neighbourhoods at night) significantly reduced walking trips around the neighbourhood among older adults in all mobility levels (Shumway-Cook et al., 2003).

Despite the agreement of previous studies, longitudinal evidence to confirm whether or not walkability safety can predict change in walking is still very limited. The few studies that included a longitudinal design used different categorization for safety and had conflicting results. One study examined the feature 'safety for walking' without further specification (i.e., from crime, from traffic, sidewalk safety, presence of traffic light, neighbourhood lighting etc.) and found that greater perception of safety for walking was associated with less decline in walking activity over 1 year (Li et al., 2005a). Another study examined 'safety from violence' as part of questionnaire that assessed neighbourhood barriers for physical activity and found no association between change in neighbourhood barriers and walking level over 1 year (Dawson et al., 2007) . Additional studies that include longitudinal design are needed to further explore these effects.

In this study, the relationship between increased walkability safety and increased steps per day was only present among the older group, not the younger group. Perhaps advanced age brings with it a greater concern of personal safety for walking because of physical problems. For example, an individual with mobility problems is likely to be more concerned about the availability of pedestrian signals to make crossing streets safer than somebody without such problems. Physical function limitations also predicted change in steps in the final model (i.e. those with increased functional limitations were 1.34 times more likely to increase steps compared to those with decreased functional limitations). It is not clear why functional limitations would be related to increased steps. A possible explanation is that those with more limitations were less likely to drive, thereby increasing the likelihood that they would walk, even if only short distances. Alternatively, the effect may simply reflect a spurious relationship.

Except for walkability safety, none of the characteristics of the perceived environment predicted change in walking in three years. This finding is not surprising and in is agreement with previous studies. Evidence from cross-sectional studies showed inconsistent findings regarding the association between supportive neighbourhoods and walking among older adults. Regarding sidewalks, the quality of sidewalks and paths including coverage (Nagel et al., 2008), overall poor quality (Mendes de Leon et al., 2009) or simply the presence of sidewalks (de Melo et al., 2010; Giehl, Schneider, Corseuil, Benedetti, & d'Orsi, 2012; Michael et al., 2006) has been examined in several studies, but few found a significant association between good quality of sidewalks/paths and increased physical activity (Giehl et al., 2012; Mendes de Leon et al., 2009; Rosso et al., 2011). Quality of sidewalks was also included as part of neighbourhood social disorder (Mendes de Leon, et al., 2009). Quality of sidewalks might become less of a concern for older adults when this feature is examined in combination with other environmental features such as services/facilities, and safety.

Aesthetics in this study was defined by a pleasant surrounding as well as the presence of paths in the neighbourhood. Studies that examined aesthetics also reported inconsistent results. In some, presence (Giehl et al., 2012) or quality (Sugiyama et al., 2009) of paths in the neighbourhood was associated with increased physical activity. However, others reported no significant associations for perceived aesthetics-related characteristics (de Melo et al., 2010; Shigematsu, et al., 2009). Finally, inconsistencies have also been reported for traffic safety characteristics. In some studies, this feature has shown a positive association with walking and overall physical activity in cross-sectional studies (King, 2008; Li et al., 2005b), while in other studies, no association was found between traffic safety and physical activity (Shigematsu, et al., 2009; de Melo et al., 2010).

The finding that the perceived neighbourhood characteristics (e.g., traffic safety, aesthetics, and presence/maintenance of sidewalks) were not strong predictors of change in steps per day among older adults has been reported in previous studies. There is evidence showing that physical activity (i.e., walking) among older adults is mostly explained by personal and behavioural characteristics rather than by neighbourhood characteristics (Ball, 2006; Dawson et al., 2007; Gallagher et al., 2012; Granner et al., 2007; Hall & McAuley, 2010). Shigematsu and colleagues showed that attributes of the neighbourhood environment were more strongly associated with physical activity among young adults (20 to 39 years) than among older adults (65 years or above) (Shigematsu, et al., 2009).

Health status as predictors of change in steps taken

In this study, the average number of chronic diseases was approximately 3 and 4 chronic diseases for the younger and older groups respectively. The three most common chronic diseases were arthritis, hypertension (each disease reported by 50% of the participants) and back problems (reported 30% of the participants). Results showed that having more chronic diseases decreased the odds of increasing steps over a three year time period or, in other words, having more chronic conditions was associated with a decrease in steps. This finding is in agreement with previous studies that showed that older adults with more chronic diseases are considerably less likely to be physically active (Aslan et al., 2008; Chad et al., 2005) or to achieve the recommended amounts of physical activity (i.e. 1000kcal/week) (Ashe et al., 2009). The presence of chronic diseases is a common barrier for physical activity among older adults and it is frequently reported in aging studies (Cohen-Mansfield, Marx, & Guralnik, 2003; Gobbi et al., 2012; Lim & Taylor, 2005; Moschny, Platen, Klaassen-Mielke, Trampisch, & Hinrichs, 2011), particularly among the octogenarians (Moschny et al., 2011).

In the present study, higher number of chronic diseases was a predictor of change in physical activity levels, but only among the younger group. It is possible that the gender effect may explain the significant predictive power of chronic diseases in the younger group only. Another possible explanation why number of chronic diseases did not predict change in steps taken per day among the older group is because there was less variability in chronic diseases in the older group (i.e. most older adults older than 70 years had some chronic diseases) and there was less variability in the change score for steps taken (i.e. most older adults had low number of steps).

As for self-rated health, results showed that more positive perceptions of health were associated with an increase in steps from baseline to follow up. The positive relationship between self-rated health and increased physical activity, and walking specifically, is well known in the literature. Older adults with more positive perceptions of their health are more likely to be physically active (Abu-Omar, Rutten, & Robine, 2004) and to walk more regardless of the location where the activity takes place (indoors or outdoors) (Kerr et al., 2012). Conversely, poor self-rated health is associated with less likelihood of being physically active (Herman, Hopman, Vandenkerkhof, & Rosenberg, 2012). Other studies showed a consistent association between poorer (lower) self-rated health and poorer perception of the neighbourhood environment such as neighbourhood problems (Poortinga, 2006) and increased barriers for walking (Dawson et al., 2007). This could explain why self-rated health was a significant predictor of change in steps in the older group, but not the young one.

The significant positive effect of self-rated health among older adults may also be explained by the Response Shift Theory, which states that there is a divergence between an internal self-rating of health and an actual assessment of health. This may happen as a result of: (1) a change in the person’s internal standards of health rating, (2) a change in participant’s values (i.e. redirecting, prioritizing), (3) redefinition of health (Schwartz, Andresen, Nosek, Krahn, & RRTC Expert Panel on Health Status Measurement, 2007; Sprangers & Schwartz, 1999). In this study, older adults were more likely to report positive perceptions of their health despite the higher number of chronic conditions compared to the younger adults. Arnadottir and colleagues examined determinants of self-rated health and reported similar findings among older adults (i.e. greater perception of health with increasing age) (Arnadottir, Gunnarsdottir, Stenlund, & Lundin-Olsson, 2011)

Self-rated health was a predictor of change in steps only among the older adult group (final model). Those with more positive perceptions of their health had increased odds of increasing steps over a 3-year period. Reasons for this occurrence might be an interaction with other variables such as walkability safety. Tucker-Seeley and colleagues (2009) found that self-rated health significantly explained the relationship between physical activity and the neighbourhood environment among older adults (Tucker-Seeley et al., 2009).

Gender as a predictor of steps taken per day

Gender differences in relation to physical activity participation are commonly reported in the literature. In this study, women were less likely to increase number of steps compared to men or, conversely, men were more likely to increase their activity level. Previous studies show that men are more active than women (Aslan et al., 2008; Chad et al., 2005; Lin, Yeh, Chen, & Huang, 2010; Poortinga, 2006; Yasunaga et al., 2008). According to Statistics Canada, despite the modest increase that was observed in physical activity compared to previous years for both genders, the trend that males are more likely to be active than females has been maintained (Statistics Canada, 2012a). The gender-specific type of physical activity may be a factor that may explain the significant predictive power of gender on change in steps. One study found that women were more likely to do housework related activities and therefore did not increase physical activity levels substantially compared to men (Lin et al., 2010). Lee (2005) reported similar findings between genders. Women were more likely to engage in household activities and men were more likely to engage in exercise. They both walked, but women walked shorter distances (consequently less duration). However the frequency of walking did not differ between genders (Lee, 2005). In the present study, it was not possible to examine change in steps more specifically within each age and sex group, as splitting the sample by gender and age was not possible due to the limited sample size.

Variation in physical activity level between genders in relation to age group has been reported. According to the Canadian Community Health Survey males were more active than females (i.e. more steps taken), but the gender difference in activity level was only present in the younger segment of the sample (40 to 59 years) only (Colley et al., 2011). Although the overall total volume of physical activity through pedometry/accelerometry data is higher among older males, the relative intensity of the activity (low and moderate) does not differ between genders (Yasunaga et al., 2008).

BMI as a predictor of change in steps per day

This study also showed that in the older adult group, higher BMI at baseline was associated with an increased likelihood of increasing steps or, put another way, a higher BMI was associated with a reduced likelihood of decreasing steps. In the younger group, BMI was not a predictor of change in number of steps. The paradoxical finding that higher BMI predicted increase in steps taken per day among the older group may be explained by a protective effect of BMI at older ages. As part of the natural aging process, older adults lose lean body mass (i.e. sarcopenia) (Janssen et al., 2002) and bone mass (i.e. osteopenia) (Shephard, 1997), leading to a lower BMI score. As a consequence of this physiological lower trend for BMI, obesity prevention in older ages should be recommended with caution.

Despite the association between obesity and increased risk for many age-related chronic diseases (Anis et al., 2010), it appears that more extreme values of BMI (i.e. being underweight or obese) are associated with negative health consequences, such as all-cause mortality (de Hollander, Bemelmans, & Groot, 2013) and frailty (Fried et al., 2001; Hubbard, Lang, Llewellyn, Rockwood, 2010) compared to being overweight. Marsh and colleagues found that older adults with lower BMI (<25) or obese (>30) are at a higher risk of developing mobility disability (Marsh et al., 2011). Recent studies suggest that being somewhat overweight in older ages may benefit chronic disease management for conditions such as osteoarthritis, coronary heart disease and osteoporosis (Bales & Buhr, 2009) .

Summary

Overall, findings from this study did not support perceived neighbourhood characteristics (e.g., traffic safety, aesthetics, and presence/maintenance of sidewalks) as predictors of change in steps among community-dwelling older adults. Walkability safety was the only perceived neighbourhood characteristic that predicted increase in walking; however, only among the older group. Change in steps taken per day was mostly explained by personal and demographic variables, age, sex, and health status (BMI, physical function, self-rated health).

4.3 Study 2: Perceived Neighbourhood Environment and Life-Space Mobility and Physical Function

Research Hypotheses:

As stated earlier, the hypotheses for Study 2 were:

1. More positive perceptions of neighbourhood characteristics (in 2007/2008) will be associated with greater life-space mobility and greater physical function (in 2010/2011).
2. Life-space mobility and physical function will be mostly predicted by demographic and health status variables such as age, female sex, more chronic conditions and higher BMI.

Results

For the life-space mobility outcome, the sample size consisted of 190 participants with valid answers for the Life-Space Assessment (LSA), 112 participants in the younger adult group and 78 participants in the older adult group. The mean mobility score for the sample was 69 (±18). After splitting the sample by age groups, the mean mobility score was 72 (±16) for the younger group and 65 (±20) for the older group.

Regarding physical function, the sample size consisted of 338 participants, with 168 participants in the younger adult group and 170 participants in the older group. The mean score for physical function for the sample was 63 (±15). After splitting the sample by age groups, the mean score for physical function was 69 (±15) for the younger group, and 57 (±13) for the older group.

Regression analysis for mobility showed that in the younger group, none of the perceived neighbourhood variables were associated with mobility three years later. Among the health variables, self-rated health was the only predictor of life-space mobility. Those with higher self-rated health had higher life-space mobility three years later compared to those with lower (poor) self-rated health. Sex was also a significant predictor of mobility. Female sex was associated with lower life-space mobility three years later compared to male sex. When all variables were entered simultaneously in the model, self-rated heath and sex remained significant predictors of mobility. Among younger adults, being female was associated with lower life-space mobility and having better self-rated heath was associated with higher life-space mobility three years later, as shown in Table 10.

Table 10. Regression analysis for life-space mobility in the younger group (N=112)

Models		B (Cl)	p value
Model 1: Neighbourhood characteristics	Sidewalks	0.13 (-3.14 – 3.41)	0.93
	Aesthetics	-0.20 (-3.87 – 3.45)	0.91
	Walkability safety	-2.94 (-7.47 – 1.58)	0.20
	Traffic safety	1.07 (-2.85 – 4.990	0.58
Model 2: Health variables	Physical function limitations	-0.54 (-1.73 – 0.65)	0.37
	Number of chronic diseases	0.93 (-0.65 – 2.51)	0.24
	BMI	-0.31 (-1.05 – 0.41)	0.39
	Self-rated health	**8.52 (2.89 – 14.15)**	**0.003**
	Steps taken	0.74 (-5.47 – 6.96)	0.81
Model 3: Demographic variables	Sex		
	Men (reference group)	**-**	**-**
	Women	**-9.02 (-14.89 – -3.15)**	**0.003**
Model 4: All variables	Sidewalks	0.50 (-2.91 – 3.95)	0.77
	Aesthetics	-1.33 (-4.98 – 2.31)	0.46
	Walkability safety	-1.23 (-5.86 – 3.40)	0.59
	Traffic safety	-0.003 (-4.02 – 4.02)	0.99
	Physical function limitations	-0.27 (-1.49 – 0.96)	0.66
	Number of chronic diseases	1.19 (-0.40 – 2.79)	0.14
	BMI	-0.53 (-1.26 – 0.20)	0.15
	Self-rated health	**10.44 (4.67- 16.20)**	**0.001**
	Steps taken	-1.87 (-8.20 – 4.47)	0.55
	Sex		
	Men (reference group)	**-**	**-**
	Women	**-9.93 (-16.64 – -3.21)**	**0.004**

In the older group, regression analysis showed that among the perceived neighbourhood characteristics, positive perceptions of aesthetics were associated with higher life-space mobility and positive perceptions of traffic safety were associated with lower life-space mobility three years later. None of the health-related variables were associated with mobility three years later. Sex was also a significant predictor of mobility in this group. Female sex was associated with lower life-space mobility three years later compared to male sex. When all variables were entered simultaneously in the model, only traffic safety remained as significant predictor of mobility. In the older group, positive perception of traffic safety was associated with lower life-space mobility, as shown in Table 11.

Table 11. Regression analysis for life-space mobility in the older group (N=78)

Models		B (Cl)	p value
Model 1: Neighbourhood characteristics	Sidewalks	0.54 (-4.64 – 5.74)	0.83
	Aesthetics	**5.23 (0.32 – 10.14)**	**0.03**
	Walkability safety	-2.59 (-9.80 – 4.62)	0.47
	Traffic safety	**-7.60 (-14.15 – -1.05)**	**0.02**
Model 2: Health variables	Physical function limitations	-0.01 (-2.01 – 1.99)	0.99
	Number of chronic diseases	-1.09 (-4.06 – 1.86)	0.46
	BMI	0.61 (-1.11 – 2.33)	0.48
	Self rated health	6.07 (-2.51 – 14.65)	0.16
	Steps taken	-2.43 (-15.18 – 10.31)	0.70
Model 3: Demographic and personal variables	Sex		
	Men (reference group)	**-**	**-**
	Women	**-9.32 (-18.17 - -0.46)**	**0.03**
Model 4: All variables	Sidewalks	-0.37 (-7.94 – 7.20)	0.92
	Aesthetics	4.79 (-2.24 – 11.83)	0.17
	Walkability safety	1.02 (-9.11 – 11.17)	0.83
	Traffic safety	**-11.59 (-20.40 – -2.77)**	**0.01**
	Physical function limitations	0.71 (-1.34 – 2.78)	0.48
	Number of chronic diseases	-1.94 (-5.73 – 1.83)	0.30
	BMI	0.29 (-1.49 – 2.09)	0.73
	Self rated health	7.63 (-1.81 – 17.08)	0.11
	Steps taken	1.36 (-11.91 – 14.65)	0.83
	Sex		
	Men (reference group)	-	-
	Women	-11.11 (-24.56 – 2.32)	0.10

Regression analysis for physical function in the younger group showed that none of the perceived neighbourhood variables were associated with physical function three years later. In contrast, of the health-related variables, physical function limitations at baseline, number of chronic diseases, and BMI were significant predictors of physical function three years later. More functional limitations, more chronic diseases, and higher BMI were associated with poorer physical function three years later. Sex was also a significant predictor of physical function. Women had poorer physical function compared to men. When all variables were entered simultaneously in the model, perception of sidewalks, physical function limitations, BMI, and sex remained significant predictors of physical function three years later among younger adults. More positive perceptions of sidewalks and higher BMI was associated with lower levels of physical function three years later. Additionally, women and those with more functional limitations at baseline were associated with lower levels of physical function three years later, as shown in Table 12.

Table 12. Regression analysis for physical function in the younger group (N=168)

Models		B (Cl)	p value
Model 1: Perceived Neighbourhood characteristics	Sidewalks	-2.19 (-4.74 – 0.35)	0.09
	Aesthetics	1.30 (-1.41 – 4.01)	0.34
	Walkability safety	1.69 (-1.69 – 5.08)	0.98
	Traffic safety	0.55 (-2.57 – 3.67)	0.72
Model 2: Health variables	Physical function limitations	**-1.71 (-2.50 – -0.922)**	**0.0001**
	Number of chronic diseases	**-1.34 (-2.59 – -0.09)**	**0.03**
	BMI	**-0.60 (-1.08 – -0.12)**	**0.01**
	Self rated health	0.93 (-3.00 – 7.86)	0.64
	Steps taken	0.56 (-4.13 – 5.26)	0.81
Model 3: Demographic variables	Sex		
	Men (reference group)	**-**	**-**
	Women	**-10.16 (-14.68 – -5.65)**	**0.0001**
Model 4: All variables	Sidewalks	**-2.55 (-4.88 – -0.21)**	**0.03**
	Aesthetics	-0.69 (-3.35 – 1.96)	0.60
	Walkability safety	2.34 (-0.89 – 5.58)	0.15
	Traffic safety	-0.04 (-2.93 – 2.85)	0.97
	Physical function limitations	**-1.38 (-2.15 – -0.61)**	**0.001**
	Number of chronic diseases	-0.99 (-2.20 – 0.22)	0.10
	BMI	**-0.73 (-1.20 – -0.27)**	**0.002**
	Self rated health	3.45 (-0.41 – 7.32)	0.07
	Steps taken	-1.97 (-6.56 – 2.60)	0.39
	Sex		
	Men (reference group)	**-**	**-**
	Women	**-11.05 (-15.76 – -6.35)**	**0.0001**

Finally, regression analysis for physical function in the older group showed that none of the perceived neighbourhood variables were associated with physical function three years later. Of the health-related variables, physical function limitations and number of chronic diseases were significant predictors of physical function. More functional limitations were associated with poorer physical function three years later and higher number of chronic conditions was associated with decreased physical function. Sex was also a significant predictor of physical function among older adults. Women had lower physical function compared to men. When all variables were entered simultaneously in the model, none of the perceived neighbourhood characteristics predicted physical function. The predictors that remained significant were the three previous demographic and health-related variables, as shown in model 4 (Table 13).

Table 13. Regression analysis for physical function in the older group (N=170)

Models		B (Cl)	p value
Model 1: Neighbourhood characteristics	Sidewalks	2.08 (-0.40 – 4.56)	0.10
	Aesthetics	0.78 (-1.63 – 3.21)	0.52
	Walkability safety	0.05 (-3.24 – 3.34)	0.97
	Traffic safety	0.68 (-2.05 – 3.41)	0.62
Model 2: Health variables	Physical function limitations	**-1.21 (-1.80 – -0.62)**	**0.0001**
	Number of chronic diseases	**-1.35 (-2.30 – -0.41)**	**0.005**
	BMI	0.42 (-0.09 – 0.93)	0.10
	Self rated health	2.25 (-0.63 – 5.14)	0.12
	Steps taken	1.55 (-2.44 – 5.54)	0.44
Model 3: Demographic variables	Sex		
	Men (reference group)	-	-
	Women	**-8.48 (-12.54 – -4.42)**	**0.0001**
Model 4: All variables	Sidewalks	1.53 (-0.95 – 4.02)	0.22
	Aesthetics	1.59 (-0.88 – 4.06)	0.20
	Walkability safety	-0.87 (-4.08 – 2.34)	0.59
	Traffic safety	-0.15 (-2.78 – 2.44)	0.90
	Physical function limitations	**-1.11 (-1.74 – -0.480**	**0.001**
	Number of chronic diseases	**-1.42 (-2.48 – -0.37)**	**0.008**
	BMI	0.53 (-0.22 – 1.08)	0.06
	Self rated health	2.25 (-0.79 – 5.29)	0.14
	Steps taken	2.20 (-2.07 – 6.48)	0.30
	Sex		
	Men (reference group)	-	-
	Women	**-3.82 (-7.76 – 0.11)**	**0.05**

Discussion

This study examined the role of the perceived neighbourhood environment on life-space mobility and physical function among older adults. With mobility as the outcome, results showed that of the perceived neighbourhood environment characteristics, traffic safety remained a predictor of mobility in the final model in the older group only. In the younger group, mobility was mostly predicted by health-related and demographic factors such as sex and self-rated health.

With respect to physical function, results showed that of the perceived neighbourhood environment characteristics, sidewalks was a predictor of physical function in the final model only in the younger group. None of the perceived neighbourhood characteristics predicted physical function in the older group. In addition to sidewalks, health-related and demographic factors such as physical function limitations, BMI and sex also predicted physical function three years later in the younger group. In the older group, self-rated heath and sex were predictors of physical function three years later.

The composite score (from 0 to 120) from the LSA has consistently been used in other studies (Al Snih et al., 2012; Auger et al., 2010; Bentley et al., 2012; Crowe et al., 2008; Stewart et al., 2009), consistent with how the scale was used in the present study. The mean score found in this study is in accordance with other aging studies that used the LSA instrument. A mean life-space score of 69 was found in a cross-sectional study (Crowe et al., 2008). A longitudinal study reported scores of 69 (at baseline) and 57 (at follow up) (Bentley et al., 2012). Stewart and colleagues assessed older women before and after urogynecological and gynecological oncology surgeries and showed baseline mean scores of 84 for urogynecological patients and 60 for gynecological oncology patients (Stewart et al., 2009).

Regarding physical function, the mean score found in this study was also in agreement with previous studies that used the same scoring system for the LLFD instrument. Scores of 54.7 (Hess et al., 2010) and 63.7 (Melzer & Kurz, 2009) were reported among older adults. In addition, LLFD scores of 79 and 62 were also reported among normal weight and obese class III middle aged women respectively (Hergenroeder, Brach, Otto, Sparto, & Jakicic, 2011), offering support for the findings from the LLFD scale.

The perceived neighbourhood environment and life-space mobility

This study showed that among the perceived neighbourhood environment variables, traffic safety was the only characteristic that predicted mobility three years later. However, a negative relationship was found. More positive perceptions of traffic safety (i.e. participants disagreed that there is heavy traffic along the streets that made it unpleasant to walk and disagreed that drivers exceed the speed limits) was associated with decreased life-space mobility three years later.

Supplementary analyses were run in order to further examine the unexpected negative association between traffic safety and life-space mobility. The area where the participant lived (inner city versus suburban) was taken into account to examine a possible association with life-space mobility. It was hypothesized that the area where the participant lived might play a significant role on mobility levels in terms of life-space. Inner city residents might face heavier traffic and meet drivers that are more likely to exceed speed limits compared to suburban neighbourhood where traffic is normally less heavy and slower. Therefore, mobility levels would differ between inner city residents compared to suburban residents and would reverse the negative coefficient between traffic safety and life-space mobility. A binary explanatory variable called area of residence was created (inner city versus suburban) (results not shown). However, even after accounting for the area of residence, the negative association between traffic safety and life-space mobility remained significant. Perhaps those who had mobility problems in 2007/2008 avoid traffic; therefore the negative association was found. However, this hypothesis could not be confirmed because mobility data was collected at one time points only (2010/2011).

Although unexpected, this finding may be explained through a life-space context. The LSA scale assesses mobility in relation to a continuum of physical spaces that a person can reach, ranging from rooms inside one's house to travelling outside the city. It is possible that those with positive perceptions about traffic safety in their neighbourhood (who perceived traffic not to be heavy on their streets and on the nearby streets, and who perceived that drivers did not exceed posted limits) were able to maintain mobility levels in the neighbourhood space. Namely, they might have felt safe to walk or to drive in their own neighbourhood and did not have to travel to a further life-space level (i.e. outside the neighbourhood or outside the city) because the neighbourhood level is conducive for mobility. This would suggest that in order for a neighbourhood to be supportive for mobility, higher scores on the LSA scale might not be needed because the participants might not need to reach the further levels. Therefore, the negative relationship between traffic safety and life-space mobility would be interpreted as acceptable for the neighbourhood level life-space.

In addition, those with positive perception about traffic safety and those who perceive their neighbourhoods to have a variety of services and destinations (e.g., shopping centers, grocery shopping, restaurants, banks, post offices) at a walking distance were able to maintain mobility levels at the neighbourhood level and did not have to travel to further distances, consequently going to higher life-spaces. Although the presence of facilities and services in the neighbourhood was not measured in this study, other studies that examined this feature found an association between positive perception of safety traffic and increased walking for errands (King, 2008).

Previous studies that examined traffic safety among older adults have generally shown that increased traffic safety was associated with increased overall mobility (Rosenberg, Huang, Simonovich, & Belza, 2013; Shumway-Cook,A. 2003; Rosenberg et al, 2009). This environmental characteristic appears to be of great importance among older adults regardless of the mobility level. They are likely to encounter high density of traffic (objects or people) requiring them to modify gait patterns to avoid collisions (Shumway-Cook et al., 2003). In addition, barriers related to traffic safety for mobility, such as high traffic speed, drivers exceeding speed limits, lack of driver attention towards pedestrians, were frequently reported in one study of older adults (Rosenberg, Huang, Simonovich, & Belza, 2013).

Interactions between traffic safety and other neighbourhood characteristics have also been reported. Li and colleagues (2005) found an interaction between safety from traffic and street connectivity (those living in neighbourhoods with higher street connectivity and who reported higher safety from traffic were more likely to reported increased neighbourhood walking) (Li, Fisher, Brownson, & Bosworth, 2005b). Although there is evidence to support the relationship between traffic safety and physical activity among older adults, additional studies need to be conducted with life-space mobility as the outcome. In the majority of studies, the outcome was either physical activity or walking specifically. None of the previous studies examined mobility in the context of life-space.

In the older group, aesthetics also predicted mobility. Those with more positive perceptions of neighbourhood aesthetics (i.e. pleasant scenery and walking paths to get to) increased mobility three years later. However, this relationship did not remain significant in the final model. Some studies report positive associations between aesthetics and mobility or walking specifically (Annear et al., 2009; King, 2008), however some did not find any association between the presence or condition of sidewalks and overall mobility.

In this study, traffic safety and aesthetics (in the unadjusted analysis) predicted mobility levels, but only for the older group. Features of the neighbourhood environment that are related to personal safety might become a concern for those above 70 years of age, but not for those younger than 70 years of age. This might be explained by an age-related decline in physical health status, which may affect mobility levels. As a consequence, features of the perceived environment that are related to personal safety become priority for mobility compared to other neighbourhood characteristics (e.g., aesthetics). Evidence from quantitative and qualitative studies have shown the role of safety for physical activity and mobility (Rosenberg et al., 2013; King, 2008; Shumway-Cook, et al., 2003) among those with and without mobility disability.

The perceived neighbourhood environment on physical function

Similar to mobility, few significant effects emerged for perceived neighbourhood environment in relation to physical function. Sidewalks was the only perceived environmental characteristic that predicted physical function and a negative association was found among the younger group only in the final model. Those with more positive perceptions about sidewalks (i.e. presence and maintenance) had lower levels of physical function three years later. The evidence of the association between the presence and maintenance of sidewalks (i.e. present and well maintained) and physical function has shown inconsistent findings in the literature. This inconsistency might be explained by differences in how this neighbourhood characteristic is addressed. Bowling and Stafford found a positive association between sidewalks and physical function (Bowling et al., 2006; Bowling & Stafford, 2007). However, the term ‘somewhere nice to go for a walk’ was used instead of ‘sidewalks’ and this term was included in addition to other features as part of ‘neighbourhood quality of services’. Therefore, findings cannot be solely attributed to the influence of sidewalks, as other features were included in the section. Beard and colleagues found no association between sidewalks and physical function. The authors examined ‘sidewalks’ as part of neighbourhood decay (i.e. filthy sidewalks) which included other items (Beard et al., 2009).

The inconsistent evidence regarding the ‘sidewalk’ feature may result from the limited number of studies that examined the relationship between neighbourhood characteristics and physical function compared to physical activity (Rosso et al., 2011) and the limited number of studies that considered sidewalks as part of neighbourhood characteristics (Clarke & George, 2005; Wight et al., 2008). The evidence between neighbourhood characteristics and other health outcomes, such as physical activity has also shown unexpected findings. Dawson and colleagues found a positive association between increased barriers for physical activity and physical activity levels (Dawson et al., 2007) while Humpel and colleagues found a negative association between specific neighbourhood characteristics (traffic safety) and walking (Humpel, Marshall, Leslie, Bauman, & Owen, 2004).

Nevertheless, some studies showed that sidewalks (presence and maintenance) play an important role for those with functional limitations. Among those with lower body impairments, poor sidewalks and street conditions such as cracks, broken curbs and potholes were associated with difficulty in walking compared to those who live in neighbourhoods with streets in good condition (Clarke et al., 2008). Uneven sidewalks was the most reported barrier among older people with functional limitations reported by Keysor and colleagues (Keysor et al., 2010). This finding suggests that the feature ‘sidewalks’ play a more critical role for those with physical functional limitations compared to those without. Based on this, the unexpected negative association between sidewalks and physical function might be explained by a possible interaction effect with health-related variables (physical function limitations or BMI) and sidewalks, because this neighbourhood characteristic only became significant in the last model. Interactions were not analyzed due to the limited sample size.

Health status as predictors of life-space mobility and physical function

Self-rated health was a significant predictor of life-space mobility while physical functional limitations and number of chronic conditions were significant predictors of physical function in this sample of older adults. More positive perception about health status at baseline predicted higher mobility scores three years later. Additionally, more functional limitations and more chronic diseases at baseline predicted lower physical function three years later. These finding are in agreement with the body of literature about the impact of health status on physical function (Bean, Olveczky, Kiely, LaRose, & Jette, 2011; Wight et al., 2008), mobility (Al Snih et al., 2012; Gagliardi et al., 2007; Stewart et al., 2009) and overall quality of life (Bentley et al., 2012). Bean and colleagues found that the presence of chronic diseases may significantly impact physical function (assessed using the LLFD instrument) in older adults with mobility limitations (Bean et al., 2011).

Results from this study showed that higher BMI at baseline was associated with significantly lower physical function at follow up. However, this association was only found in the younger group. The relationship between higher BMI and lower physical function has been well researched among older adults, and results from this study are in agreement with previous findings. Overall, it has been shown that a significant association between increased ADL difficulty and higher BMI (Wight et al., 2008; Al Snih, et al., 2010). In addition, those in higher BMI categories had the greatest physical function impairments 5 years later compared to those at a normal range of BMI. However, greater mortality risk was only found among those in class II obesity or above (Lang, Llewellyn, Alexander, & Melzer, 2008). Obese older adults, particularly those with BMI above 35, were considerably less mobile (less life-space) (Al Snih et al., 2012). Other studies have consistently shown that obesity is associated with lower levels of physical function and increased disability (Hergenroeder et al., 2011; Riebe et al., 2009; Strobl, Muller, Emeny, Peters, & Grill, 2013; Woo, Leung, & Kwok, 2007) regardless of the type of measure adopted to assess physical function (subjective or objective measure) (Hergenroeder et al., 2011). Longitudinal evidence has shown that over time, the presence of obesity increases the risk of disability among older adults (Samper-Ternent & Al Snih, 2012).

This study showed that the relationship between BMI and physical function was only present in the younger group, not the older one. A possible explanation for the fact that this relationship was not significant among the older group is because of a physiological age-related decline in BMI in older ages, as older adults tend to lose lean body mass (i.e. sarcopenia) (Janssen et al., 2002) and bone mass (i.e. osteopenia) (Shephard, 1997). Therefore, a higher BMI (i.e. being overweight) may have a beneficial rather than a detrimental impact on physical function in older ages and being somewhat overweight may confer health benefits for physical function (Decaria, Sharp, & Petrella, 2012). This evidence among the very old and the oldest old age groups is limited because studies that examined the relationship between obesity and physical function among older adults did not conduct specific analyses by age groups (e.g., 65 to 75 years; 75 to 85 years ; 85 years and older). Most studies used a combined sample of middle aged and older adults (Hergenroeder et al., 2011), or included older adults as one group (65 years and older) (Al Snih et al., 2010; Nam, Kuo, Markides, & Al Snih, 2012; Strobl et al., 2013; Woo et al., 2007).

Although mobility and physical function may be strongly associated (Baker et al., 2003; Bentley et al., 2012), results from this study showed that the predictors for these two outcomes were different. This suggests that these outcomes measure different constructs and should be used in combination in aging studies. Another notable finding from this study is the difference between the types of predictors by age groups. All predictors of physical function in the older group were health-related. In contrast, none of the health-related variables were predictors of life-space mobility in the older group. Health-related variables (self-rated health), only predicted life-space mobility in the younger group. As for the perceived neighbourhood characteristics, none of the neighbourhood characteristics predicted physical function in the older group, only in the younger one (sidewalks). In contrast, traffic safety predicted life-space mobility in the older group and none of the environmental characteristics predicted life-space mobility in the younger group.

Sex as a predictor of life-space mobility and physical function

Sex was a strong predictor of physical function and life-space mobility in this study. Female sex was associated with lower scores for life-space mobility and physical function three years later compared to male sex. This finding is in agreement with various studies that examined the role of neighbourhood environment, demographic and personal characteristics on physical function and life-space mobility. In these studies, female sex was also associated with lower mobility and lower levels of physical function (Bowling et al., 2006; Wight, et al., 2008). Al Snih and colleagues examined factors associated with life-space mobility and found that women had limited life-space compared to men (Al Snih et al., 2012). Baker and colleagues assessed life-space mobility among older adults as part of the measurement property for the LSA and found that women had lower life-space mobility scores compared to men (Baker et al., 2003).

The low life-space mobility and lower levels of physical function among women compared to men can be explained by the fact that older women are generally less physically active than men (Colley, et al., 2011; Yasunaga et al, 2008; McMurdo et al., 2012), have lower volume of physical activity (Lee, 2005) or engage in physical activities that are primarily low intensity type, such as housework related activities (Gagliardi et al., 2007; Lin, et al., 2010). Older women also tend to report more barriers to physical activity and exercise, particularly related to health status, compared to older men (Cohen-Mansfield et al., 2003). These behaviours may directly impact levels of physical function (Brach et al., 2004).

Summary

A noticeable age-difference was also present. In the younger group, none of the perceived environmental characteristics were associated with life-space mobility. In contrast, demographic and health-related characteristics were associated with life-space mobility three years later. Female sex was associated with lower life-space mobility, whereas greater self-rated health was associated with higher life-space mobility. In the older group, traffic safety was the only perceived environmental characteristics associated with life-space mobility and a negative relationship was found (i.e. positive perception of traffic safety was associated with lower life-space mobility). None of the demographic or health-related variables were associated with life-space mobility in the older group.

As for physical function, in the young group, a negative association was found between perception of sidewalks and physical function (i.e. more positive perceptions of sidewalks in the neighbourhood were associated with lower levels of physical function three years later). Health-related variables such as higher BMI were associated with lower levels of physical function three years later. Moreover, fewer functional limitations were associated with higher levels of physical function three years later. In contrast, in the older group, none of the perceived environmental characteristics predicted physical function three years later. The predictors of physical function were all demographic and health-related (i.e. female sex and higher number of chronic conditions were associated with lower physical function whereas less function l limitations were associated with higher physical function three years later).

4.4 Study 3: Perceived Neighbourhood Environment and Obesity Indicators in Older Age

Research Hypotheses

As stated earlier, the hypotheses for Study 3 were:

1. More positive perceptions of neighbourhood characteristics will be associated with lower BMI and greater body composition-related health benefits three years later.
2. BMI and body composition-related health benefits will be mostly predicted by demographic and health status variables such as age, female sex, chronic conditions and steps taken per day.

Results

Regarding BMI as the outcome, the sample size consisted of 324 participants, 29.3% (N=95) were in the normal weight range, 45.1% (N=146) were in the overweight range and 25.6% (N=83) were in the obese range. When BMI was refined by waist circumference (WC), the sample size consisted of 236 participants, 25% (N= 59) in 'need improvement' group, 34.7% (N= 82) in the 'fair' group, 1.3% (N= 3) in the 'good' group, 22.9% (N= 54) in the 'very good' and 16.1% (N= 38) in the 'excellent' group. After combining the WC categories, 40.3% (N=95) of participants were in the high body composition-related health benefits group and 59.7% (N=141) were in the low body composition-related health benefits group.

Table 14 shows the multinomial analysis for BMI. The 'normal weight' group was used as the reference group and the comparisons are between 'normal weight' and 'overweight' groups and between 'normal weight' and 'obese' groups. In this study, splitting the sample by age group (younger: 70 years of age or younger and older: older than 70 years) and by BMI groups (normal weight, overweight, and obese) would have been impractical for analysis due to the small sample size in each group. Therefore, age was entered as a continuous variable in the demographic section.

When comparing normal weight and overweight individuals, results showed that none of the perceived neighbourhood characteristics predicted BMI three years later. Among the health-related variables, BMI at baseline (2007/2008) was the only variable associated with BMI in 2010/2011. For one-unit increase in BMI, there was a 3.19 increase in the odds of being overweight compared to being at a normal weight range. Among the demographic variables, neither age in 2007/2008, nor sex predicted BMI three years later. When all variables were added in the model, BMI in 2007/2008 remained a predictor of BMI in 2010/2011. There was a 3.06 increase in the odds of being overweight at follow up compared to normal weight range.

When comparing normal weight and obese individuals, results also showed that none of the perceived neighbourhood characteristics predicted BMI three years later. Among the health-related variables, BMI at baseline (2007/2008) was the only variable associated with BMI in 2010/2011. For one-unit increase in BMI, there was a 9.87 increase n the odds of being obese compared to being normal weight. Among the demographic variables, only age in 2007/2008 predicted BMI three years later. For a one-year increase in age, there was 0.94 decrease in the odds of being obese compared to normal weight. When all variables were added in the model, walkability safety predicted BMI three years later. More positive perceptions of walkability safety were associated with a odds ratio of .22 of being obese three years later compared to normal weight. Physical function limitations also predicted BMI. For every one-unit increase in function limitations, the odds of being obese relative to normal weight increased by 29%. Age was not associated with BMI in the final model.

Table15 shows the logistic regression analysis for BMI refined by WC as an indication of body composition-related health benefits (high body composition-related health benefits versus low body composition-related health benefits). None of the perceived neighbourhood characteristics predicted body composition-related health benefits. Among the health-related variables, number of chronic diseases, BMI and self-rated health predicted body composition-related health benefits three years later. Those with more chronic diseases, higher BMI, and greater self-rated health had lower odds of body composition-related health benefits three years later compared to those with fewer chronic diseases, lower BMI and poorer self-rated health. Sex was also a significant predictor of body composition-related health benefits. Female sex was associated with lower odds of body composition-related health benefits three years later compared to male sex. All these variables remained significant when entered simultaneously in the last model.

Table 14. Multinomial analysis for BMI in categories (normal weight, overweight and obese) (N=324)

		Overweight vs. normal weight		Obese vs. normal weight	
	Models	**Odds Ratio (Cl)**	**p value**	**Odds Ratio (Cl)**	**p value**
Model 1: Perceived neighbourhood characteristics	Sidewalks	0.88 (0.65 – 1.18)	0.40	0.99 (0.70 – 1.40)	0.95
	Aesthetics	0.91 (0.66 – 1.24)	0.55	0.94 (0.66 – 1.34)	0.74
	Walkability safety	0.95 (0.63 – 1.41)	0.80	0.77 (0.49 – 1.21)	0.26
	Traffic safety	0.81 (0.57 – 1.16)	0.26	0.79 (0.53 – 1.18)	0.25
Model 2: Health variables	Physical function limitations	1.04 (0.89 – 1.20)	0.58	1.17 (0.93 – 1.47)	0.17
	Number of chronic diseases	0.84 (0.65 – 1.08)	0.17	0.90 (0.62 – 1.31)	0.59
	BMI	**3.19 (2.27 – 4.49)**	**0.0001**	**9.87 (5.96 – 16.33)**	**0.0001**
	Self rated health	0.66 (0.31 – 1.40)	0.28	1.82 (0.54 – 6.07)	0.32
	Steps taken at baseline	2.30 (0.78 – 6.73)	0.12	2.05 (0.41 – 10.24)	0.37
Model 3: Demographic variables	Sex				
	Men (reference group)	-	-	-	-
	Women	0.60 (0.35 – 1.03)	0.06	0.65 (0.35 – 1.19)	0.16
	Age	0.97 (0.93 – 1.00)	0.12	**0.94 (0.90 – 0.99)**	**0.02**
Model 4: All variables	Sidewalks	0.60 (0.31 – 1.13)	0.11	1.26 (0.45 – 3.54)	0.65
	Aesthetics	1.07 (0.56 – 2.04)	0.82	2.68 (0.92 – 7.79)	0.07
	Walkability safety	0.93 (0.43 – 2.03)	0.87	**0.22 (0.05 – 0.93)**	**0.04**
	Traffic safety	0.76 (0.37 – 1.55)	0.45	0.69 (0.22 – 2.13)	0.52
	Physical function limitations	1.06 (0.90 – 1.25)	0.47	**1.29 (0.99 – 1.68)**	**0.05**
	Number of chronic diseases	0.70 (0.51 – 0.94)	0.02	0.79 (0.51 – 1.23)	0.31
	BMI	**3.06 (2.43 – 5.33)**	**0.0001**	**13.88 (7.23 – 26.64)**	**0.0001**
	Self rated health	0.55 (0.24 – 1.26)	0.16	1.61 (0.40 – 6.46)	0.50
	Steps taken at baseline	2.12 (0.67 – 6.63)	0.19	1.96 (0.31 – 12.17)	0.46
	Sex	1.77 (0.59 – 5.31)	0.30	4.05 (0.68 – 23.86)	0.12
	Age				
	Men (reference group)	-	-	-	-
	Women	0.97 (0.89 – 1.06)	0.62	0.91 (0.79 – 1.05)	0.23

Table 15. Logistic regression analysis for BMI refined by WC (N=236)

	Models	Odds Ratio (Cl)	p value
Model 1: Perceived Neighbourhood characteristics	Sidewalks	1.31 (0.96 – 1.77)	0.08
	Aesthetics	1.02 (0.74 – 1.40)	0.90
	Walkability safety	1.05 (0.70 – 1.56)	0.80
	Traffic safety	0.94 (0.65 – 1.36)	0.77
Model 2: Health variables	Physical function limitations	1.00 (0.88 – 1.15)	0.89
	Number of chronic diseases	**0.67 (0.53 – 0.85)**	**0.001**
	BMI	**0.59 (0.50 – 0.70)**	**0.0001**
	Self rated health	**0.37(0.19 – 0.72)**	**0.003**
	Steps taken	1.55 (0.68 – 3.53)	0.28
Model 3: Demographic variables	Sex		
	Men (reference group)	**-**	**-**
	Women	**0.46 (0.27 – 0.78)**	**0.004**
	Age	0.98 (0.94 – 1.02)	0.48
Model 4: All variables	Sidewalks	1.17 (0.73 – 1.88)	0.49
	Aesthetics	1.01 (0.59 – 1.71)	0.97
	Walkability safety	1.04 (0.56 – 1.94)	0.88
	Traffic safety	0.75 (0.41 – 1.34)	0.33
	Physical function limitations	1.07 (0.91 – 1.24)	0.38
	Number of chronic diseases	**0.72 (0.55 – 0.92)**	**0.01**
	BMI	**0.54 (0.45 – 0.66)**	**0.0001**
	Self rated health	**0.47 (0.23 – 0.95)**	**0.03**
	Steps taken	1.24 (0.50 – 3.07)	0.63
	Sex		
	Men (reference group)	**-**	**-**
	Women	**0.24 (0.09 – 0.61)**	**0.003**
	Age	0.95 (0.88 – 1.03)	0.23

Discussion

This study examined the role of the perceived neighbourhood environment on obesity indicators in community-dwelling older adults. Results showed that walkability safety was the only perceived neighbourhood environmental characteristic that predicted BMI three years later. The more positive perceptions of walkability safety, the less likely individuals were obese relative to overweight; no such effect was obtained when comparing overweight versus normal weight. Among health-related variables, BMI at baseline predicted BMI three years later in both groups of obese and overweight individuals. Physical function limitations also predicted BMI three years later, but only when comparing obese versus normal overweight individuals. When BMI was refined by waist circumference, none of the perceived neighbourhood characteristics predicted body composition-related health benefits three years later. Being female, having more chronic diseases, higher BMI, and higher greater self-rated health were associated with lower odds of body composition-related health benefits three years later.

The perceived neighbourhood environment as a predictor of obesity and body composition-related health benefits

Walkability safety was the only perceived neighbourhood characteristic that predicted BMI three years later in the final model, but this relationship was only significant when comparing obese to normal weight, not when comparing overweight group to normal weight. Individuals who had positive perceptions of walkability safety in 2007/2008 had decreased odds of being obese in 2010/2011. Walkability safety characteristics in this study included presence of crosswalks and pedestrian signals as well as proper neighbourhood lighting. An explanation for this finding might be because features of walkability safety facilitate overall mobility around the neighbourhood. However, these features have not been extensively studied in the literature with obesity as the outcome.

The majority of studies that examined the relationship between neighbourhood environment and obesity included a variety of characteristics. Overall, greater mixed land use (Eisenstein, et al., 2011; Frank et al., 2010; King et al., 2011; Li et al., 2008; Li et al., 2009a), higher residential (Frank et al., 2010; King, et al., 2011) and population density (Hergenroeder et al., 2011) were associated with lower levels of obesity among older adults. In contrast, low housing density was associated with higher levels of obesity (Booth, Pinkston, & Poston, 2005; Lovasi et al., 2009). Additionally, higher street connectivity (King et al., 2011; Frank et al., 2010; Grafova et al., 2008; Li, et al., 2009a) and increased accessibility of services (Eisenstein et al., 2011) were associated with lower odds of obesity. However, when services available relate to availability and density of fast food, evidence shows that higher density of fast food (Li et al., 2008; Li et al., 2009b) and increased availability of food outlets (Hanibuchi et al., 2011) were associated with obesity or higher waist circumference.

Although street connectivity and density measures are commonly examined in studies of neighbourhood environment and older adults, recent findings that incorporated a longitudinal design have shown that walkability measures were not associated with obesity or risk of being obese. Michael and colleagues conducted a 14-year follow up study to examine the association between neighbourhood walkability (i.e. street connectivity and street density) and obesity. Results showed that walkability measures were not associated with obesity or risk of being obese. The authors suggested that other neighbourhood characteristics, such as such as proximity of parks and retail areas (Michael, Gold, Perrin, & Hillier, 2013) should be considered for future examination. Hanibuchi also mentioned the importance of examining the role of green areas for obesity (Hanibuchi et al., 2011).

In other studies, the association between neighbourhood characteristics and obesity has been partly explained by physical activity levels. Residents from highly walkable neighbourhoods who are also physically active have lower odds of obesity, particularly those who are regularly active and those who exercise at vigorous intensity (Li et al., 2009a). In this study, neighbourhood characteristics related to walkability safety were associated with lower odds of obesity. However, steps taken at baseline were not associated with BMI at follow up. Obesity was mostly predicted by higher BMI at baseline and greater physical function limitations. Perhaps these two factors may lead to reduction in overall mobility around the neighbourhood, therefore leading to increased odds of obesity.

Although a positive relationship was found between walkability safety and BMI, when BMI was refined by waist circumference, none of the perceived neighbourhood characteristics were associated with body composition-related health benefits. This finding suggests that neighbourhood characteristics (i.e. walkability safety) might have a significant statistical effect on BMI (subcutaneous fat), but not on waist circumference (central fat). Additional studies are necessary in order to further examine the relationship between characteristics of the neighbourhood environment and obesity and body composition-related health benefits. Li and colleagues (2009) was one of the few studies available that found an association between highly walkable neighbourhoods and lower waist circumference, however this relationship was only found among those who engaged in vigorous activity (Li et al., 2009a). Factors that limit further comparison with previous studies are the cross-sectional nature of the majority of studies and the choice of obesity measurement (studies included either BMI or WC).

Health status variables as predictors of obesity and body composition-related health benefits

Health status variables also predicted both obesity measures (BMI alone and BMI refined by WC); however the type of health status variable differed according to the outcome of interest. Physical function limitations were a significant predictor of BMI in the obese group. For every one-unit increase in physical function limitations in 2007/2008, the odds of being obese increased by 29% three years later. No significant association was found between physical function limitations and BMI when refined by WC.

The positive relationship between obesity and physical function limitations and disability is commonly reported in the literature. Evidence shows that obesity is a predictor of premature disability (Salihu, Bonnema, & Alio, 2009). Additional studies found that obese older adults, particularly individuals with BMI above 35, had increased functional limitations (Al Snih et al., 2010; Decaria et al., 2012; Riebe et al., 2009; Samper-Ternent & Al Snih, 2012) and were at greatest risk for disability (Decaria et al., 2012; Rejeski et al., 2010; Samper-Ternent & Al Snih, 2012) compared to normal weight older adults.

However, the opposite direction between obesity and physical function limitations found in this study (i.e. those with greater physical function limitations had increased odds of being obese) is less reported in the literature. Physical function limitations in this study included activities such as walking, moderate and vigorous activities, and household tasks. Limitations in these types of activities may lead to an overall decline in mobility, possibly affecting BMI. In addition to physical function limitations, this study examined BMI in 2007/2008 and results showed those with higher BMI at baseline had increased odds of being overweight and obese three years later. The combination of higher BMI and increased physical function limitations at baseline may have increased the odds of obesity three years later. Longitudinal evidence shows a trend towards poorer lower extremity mobility with increasing obesity severity (Vincent, Vincent, & Lamb, 2010).

Although physical function limitations predicted BMI, this measure had no association with BMI when it was refined by WC. This finding suggests that physical function limitations might be more related to overall adiposity than central adiposity. The fact that self-reported BMI (i.e., self-reported height and weight) is a less reliable measure might explain this finding, since it depends on one's report. This finding needs to be further investigated. The relationship between physical function limitations and obesity, particularly when both obesity outcomes are considered (BMI and BMI refined by WC) is less studied (Koster et al., 2008). Koster and colleagues found that older adults with higher BMI had slightly greater mobility limitations compared to those with higher WC (Koster et al., 2008). There is a need for additional studies with longitudinal design to better understand this relationship (Vincent et al., 2010).

The number of chronic diseases was also a significant predictor of BMI, but only when BMI was refined by WC as an indicator of body composition-related health benefits. More chronic diseases in 2007/2008 predicted decreased odds of high body composition-related health benefits in 2010/2011. In addition, higher BMI in 2007/2008 predicted decreased odds of high body composition-related health benefits in 2010/2011. This study found that arthritis and back problems were common chronic diseases. The inability to manage these diseases properly can lead to additional co morbidities and compromised physical function. Furthermore, obesity is a predictor of several negative health outcomes including metabolic syndrome (glucose intolerance, insulin resistance, central obesity, dyslipidaemia, and hypertension), cardiovascular disease, and certain types of cancer such as colorectal and breast cancers (Salihu et al., 2009; Decaria et al., 2012). The combination of these two predictors, more chronic diseases and higher BMI at baseline, may have led to lower body composition-related health benefits three years later.

Self-rated health also predicted BMI, but only when BMI was refined by WC. Better self-rated health in 2007/2008 was associated with decreased odds of high body composition-related health benefits in 2010/2011, a finding that would appear counter-intuitive. Although self-rated health can predict several health-related outcomes, such as functional status, disability (Galenkamp et al., 2012), mortality (Benyamini, 2011) and recovery from illness (Wilcox, Kasl, & Idler, 1996), a negative relationship was found between self-rated health and body composition-related health benefits in this study. This finding may be explained by the fact that self-rated health is a subjective measure and it depends on the person's perception of his/her health status and physical and mental capabilities. Therefore, the perception of health status may not correspond to the actual health status.

Response Shift Theory could possibly explain the divergence between the self-rated health and the actual assessment of health. According to the theory, a shift of the evaluation of one's health status may occur based on change in values or internal standards of health. In the case of older adults, they may lower their standards of good health (Schwartz et al., 2007; Sprangers & Schwartz, 1999). In this study, most participants reported good perception of their health despite the presence of chronic diseases. Therefore, self-rated health in this sample of older adults may have been interpreted beyond the presence of chronic diseases or the physical dimension of health as proposed by the refined BMI measure.

Demographic variables and obesity measures

Among demographic variables, sex was the only variable that predicted BMI, but only when BMI was refined by WC. Females had decreased odds of high body composition-related health benefits in 2010/2011 compared to males. This finding may be explained in several ways. First, females have more sedentary behaviours compared to men. They are less physically active compared to men (Colley et al., 2011; Poortinga, 2006; Statistics Canada, 2012a; Yasunaga et al., 2008) and are less likely to engage in exercise (Lee, 2005). Second, compared to men, women are less mobile, have lower levels of physical function (Bowling et al., 2006; Wight et al., 2008) and more disability, particularly those related to mobility and pain (Statistics Canada, 2008). Third, women are more likely to have chronic diseases compared to men (Aslan et al., 2008). In this study, arthritis and back problems were common chronic diseases reported by older adults and these conditions are particularly common in women (Health Canada, 2003).

Summary

When comparing the two outcomes, BMI individually and BMI refined by WC, results showed that different variables predicted the two outcomes, confirming the importance of using both measures. Despite the moderate ability in estimating total body fat, BMI has very low ability in estimating total fat distribution (Snijder et al., 2006). Therefore, waist circumference as an indicator of central obesity adds to the BMI measure by assessing the person's health risk. The measure of BMI refined by WC can predict other health-related outcomes such as metabolic syndrome (Hou et al., 2013), and well-being (Zaninotto et al., 2010) among older adults, thus, moving beyond a measure of central obesity and risk assessment. A highlight from this study was that variables that predicted BMI were mostly mobility related (e.g., physical function limitation and walkability safety) whereas the variables that predicted BMI refined by WC were mostly health related (e.g., self-rated health and number of chronic diseases).

This study also showed that the perceived neighbourhood environment had a limited influence on obesity measures. Walkability safety was the only neighbourhood characteristic that predicted BMI three years later, however only among obese individuals compared to normal weight individuals. When BMI was filtered by WC, none of the neighbourhood characteristics predicted body composition-related health benefits three years later.

In addition, increased function limitations increased the odds of being obese. BMI was also taken into account and remained as predictor of BMI three years later. A higher BMI in 2007/2008 increased the odds of being overweight and obese in 2010/2011. When BMI was filtered by WC, number of chronic diseases, BMI and self-rated health predicted body composition-related health benefits three years later. More chronic diseases, higher BMI, and greater self-rated health decreased the odds of body composition-related health benefits three years later.

Sex was a predictor of body composition-related health benefits. Sex was the only demographic variable that predicted obesity measures, but only when BMI was filtered by WC. Female sex was associated with lower odds of body composition-related health benefits three years later compared to male sex.

CHAPTER 5: OVERALL DISCUSSION

This study examined the relationship between the perceived neighbourhood environment and health-related outcomes (physical activity (walking), physical function, life-space mobility and obesity measures) over a three-year period among community-dwelling older adults. Results showed significant relationships between the perceived neighbourhood environment, and demographic and health status variables with the selected health-related outcomes. A number of the findings corroborated previous research; however, some associations had an unexpected direction. Table 16 shows the significant relationships between all the predictors and the outcome measures in this study in the final model. The direction of the relationship is shown as '+' for a positive relationship and as '-'for a negative relationship. The expectation of the direction of the relationships is shown as (E) for a relationship in an expected direction and as (U) for a relationship in an unexpected direction.

Table 16. Summary of the significant findings by direction of the relationship and by expectation of the relationship

Predictors	Outcomes								
	Steps taken		**Life-space mobility**		**Physical function**		**BMI**		**BMI by WC**
	Young group	Old group	Young group	Old group	Young group	Old group	Normal weight X overweight	Normal weight X obese	
Sidewalks					- (U)				
Aesthetics									
Walkability safety		+ (E)						- (E)	
Traffic safety				- (U)					
Physical function limitations		+ (U)			- (E)	- (E)		+ (E)	
Number of chronic diseases	- (E)					- (E)			- (E)
BMI		+ (U)			- (E)		+ (E)	+ (E)	- (E)
Self-rated health		+ (E)	+ (E)						- (U)
Steps taken									
Sex	- (E)		- (E)		- (E)	- (E)			- (E)
Age	N/A	N/A	N/A	N/A	N/A	N/A			

Direction of the relationship: ‘+’ positive; ‘-’ negative
Expectation of the direction: (E) – expected, (U) – unexpected

5.1 Findings in Unexpected Directions

Some of the relationships between the explanatory variables and the outcome variable had unexpected directions. These unexpected results might be explained in several ways. First, these findings might be explained by the choice of categorization for the outcome variable. In the second study (function and mobility study), positive perception of traffic safety in 2007/2008 was associated with lower life-space mobility three years later. In this case, perhaps a different scoring system for the Life-Space Assessment instead of the composite score might be more appropriate to further understand the relationship between life-space mobility and the perceived neighbourhood environment. Two possible approaches could be proposed: 1. To include a binary outcome composed of 'places around your house' (encompassing the first two neighbourhood life-space levels) versus 'places in your neighbourhood', (encompassing the neighbourhood life-space level). Therefore, the life-space mobility level in relation to the neighbourhood environment could be specifically examined. 2. To include a binary outcome composed of 'places in your neighbourhood' (encompassing the neighbourhood life-space level) versus 'places outside your neighbourhood' (encompassing the last two life-space levels) in order to examine how the perception of the neighbourhood would affect mobility levels (inside or outside the neighbourhood life-space). Shimada and colleagues (2010) used a different scoring system for the LSA questionnaire to examine if the life-space as frequency of going outdoors and frequency of going into the life-space was associated with functional limitations in frail older adults. The authors examined specifically the following three life-space levels: outside the home, inside the neighbourhood, and inside the town as well as the frequency of visits for each level (Shimada, et al., 2010).

Second, the nature of the variable (subjective versus objective) might explain the findings in unexpected direction. In the third study (obesity indicators study), greater self-rated health in 2007/2008 was associated with lower odds of body composition-related health benefits three years later. This finding may be explained by the fact that self-rated health is a subjective measure of health status. In addition, self-rated health assesses health beyond the physical dimension. It encompasses psychological, emotional, social and economical dimensions that shape one's health (Maniecka-Bryla, Gajewska, Burzynska, & Bryla, 2013).

Third, interaction effects might also explain the unexpected findings. For example, in the first study (steps study) older adults in the older group with increased functional limitations in 2007/2008 had increased odds of increasing steps in 2010/2011. Perhaps an interaction between walkability safety and functional limitations might explain this finding in the older group (i.e. those with increased function limitations who also perceived features of the neighbourhood as being conducive for walking increased the odds of increasing steps). Neighbourhood characteristics that are related to walkability safety were reported among older adults, particularly among those with mobility disability (Shumway-Cook, et al., 2003).

5.2 Health and Demographic Characteristics Were Better Predictors of the Outcome Variable than the Perceived Neighbourhood Environment

This study found that demographic and health characteristics were overall better predictors of the outcomes (steps taken, physical function, mobility and obesity measures) than the perceived neighbourhood environment. Age was an important factor to take into account in the analyses for change in steps, physical function and life-space mobility. Splitting the sample into two age groups showed that the outcome variables were predicted by different set of variables. Sex and health status variables, such as physical function limitations, number of chronic diseases and BMI were also consistent predictors of all the studied outcomes (steps change, life-space mobility, physical function and body composition related-health benefits).

In contrast, the perceived neighbourhood environment had a weaker and inconsistent effect on the studied outcomes. In the steps change study, none of the perceived environmental characteristics predicted change in steps over a 3-year period in the younger group. Only walkability safety predicted change in steps in the older group. In the life-space mobility and physical function study, none of the perceived neighbourhood characteristics predicted mobility three years later in the younger group and only traffic safety, in an unexpected direction, predicted life-space mobility three years later. Only sidewalks predicted, in an unexpected direction, physical function three years later and none of the neighbourhood characteristics predicted physical function in the older group. Finally, in the obesity-related outcomes, only walkability safety predicted the odds of being obese compared to normal weight three years later. None of the perceived neighbourhood characteristics predicted the odds of being overweight compared normal weight. When BMI was refined by WC, none of the perceived neighbourhood characteristics predicted the odds of body composition-related health benefits.

Although a weak and inconsistent effect was found for the perceived neighbourhood environment in this study, it cannot be stated that the neighbourhood environment does not exert an influence on health-related outcomes. Some explanations for this overall weak effect might be: 1. the type of measure (e.g., subjectively measured versus objectively measured). Subjective measures of the neighbourhood environment rely on people's judgement about their surrounding are and may not correspond to the real features of the area. Given that these two types of measurements showed low to moderate degree of agreement (Michael et al., 2006) , it is possible that participants may have under or overestimated their surrounding area. 2. The choice of measurement. In this study, select items from the NEWS scale were chosen, not the full scale. Therefore the choice of select item instead of the full scale may have affected the psychometric properties of the scale and a rather weak and inconsistent effect was observed. 3. Mediating effects. It is possible that the neighbourhood environment has a mediating rather than a direct effect on health-related outcomes. That is, the effect of the neighbourhood environment might be shaped by (i.e. explained though) personal, demographic, health-related and psychological variables.

5.3 Limitations and Strengths of the Study

Several limitations of this study must be acknowledged. First, although previous research suggests that measuring steps with pedometers over a three-day period is sufficient to provide reliable results (Tudor-Locke et al., 2005), a 1-week period could have captured walking patterns more thoroughly. Fluctuations in health or fatigue may be common and may require a longer assessment period. However, the difficulty of pedometer self-assessment among older adults should also be acknowledged. Compliance issues may explain the reduction in sample size with valid pedometer data between baseline and follow up.

In addition, there is no accepted cut off points regarding change in steps taken per day and among older adults. For instance, in this study those who had positive scores for change in steps taken per day were categorized as 'increased'. However, it is not possible to infer at this point what increase in number of steps taken in relation to baseline would be enough for health benefits. It is unlikely that increases of < 500 steps over a three year period (younger and older groups respectively) will bring health benefits for an older person.

Second, several measures in this study, such as life-space mobility, physical function, BMI, physical function limitations, and the neighbourhood environment were assessed using self-reported instruments. Thus there is an increased likelihood of response bias. Regarding physical function limitations, it is possible that participants overestimated or underestimated their actual level of functional ability.

Discrepancies in self reports of height and weight have been reported and evidence shows participants tend to under-report their weight and over-report their height, leading to a lower BMI. The trend towards under-reporting of weight is higher among overweight and obese people compared with normal weight people (Shields et al., 2008). Age and gender have also played a significant role in self-reports of BMI, with older men and women tending to over-report height. Men and women showed a trend towards over-reporting and under-reporting their weight respectively. The trend towards lower self-reported BMI is observed across all age groups and it is particularly present in very old ages (Stommel & Schoenborn, 2009).

Biased results have been found with either under or over reports of WC due to concerns about body shape and size. Under reports of WC is particularly observed among older participants (Spencer et al., 2004), participants with larger waists, and participants with greater BMI (Bigaard et al., 2005; Spencer et al., 2004). Over reports of WC is more commonly reported among men than women (Dekkers et al., 2008).

Although the eligible sample for the fourth phase of the WISER study was comprised of 341 participants, only 236 participants had valid measures for waist circumference and 190 participants had valid Life-Space Assessment scores. This is similar to a study by Bentley and colleagues (2012) about functional status and life-space mobility using the LSA which showed that some participants did not complete all the instruments (Bentley et al., 2012). Compliance issues may have affected the sample size for WC and LSA. The fact that this measure was not assessed during the interview session and was self-assessed (in the case of WC) and filled out (in the case of LSA) at a later time (after the interview, during the pedometer recording time) may explain the missing valid responses and drop outs (i.e. not filling it out the questionnaire). Perhaps if the WC measurement and the LSA questionnaire had been administered during the interview process, the sample size would have been larger. Furthermore, some participants reported difficulty in answering the questionnaire. The sample size for these two outcome variables may have been too low to observe significant effects due to low statistical power.

With respect to measures of the neighbourhood environment, subjective measures rely on participants' perceptions of their surrounding and may not correspond to the actual aspects of the geographical area. When both types of measurements are compared, low to moderate degree of agreement has been reported (Michael et al., 2006). However, subjective measures may be valuable instruments because they take into account one's judgement of the neighbourhood area.

This study was also limited by the neighbourhoods that were included in the analysis. Some of the ideal characteristics of a neighbourhood described in the literature review section were not considered in the study. In addition, it was likely that there was not enough variability across the selected neighbourhoods in this study for a between neighbourhood comparison.

Third, the limited sample size must be acknowledged. Splitting the data in two age groups as well as the use of categorical outcomes (i.e. in the case of change in steps and BMI measures) may have reduced the power to detect other significant effects.

Fourth, although personal characteristics such as socioeconomic status and education have shown an association with outcomes such as physical activity (Giles-Corti & Donovan, 2002), obesity (Grafova et al., 2008) and disability (Beard et al., 2009), this study did not take these characteristics into account. This sample was generally well educated and had a high income level, therefore the results may not be generalizable to the overall population.

Nevertheless, this study adds to the literature by utilizing objective measures of physical activity (pedometers) under independent living conditions instead of self-report measures, providing a better description of walking among this sample of older adults. In addition, a longitudinal design with a three-year interval was used as opposed to previous studies that used a six-month or one-year follow up. A three-year follow up allowed examining predictors of change in walking over time rather than associations at a one-time point only.

The use of life-space mobility and physical function also represented a novel approach.

The fact that the neighbourhood characteristics differ between these two outcomes suggests that these measures assess different constructs and should be examined in combination. Studies examining the relationship between the neighbourhood environment in relation to life-space mobility are very limited at this point and this study represents an original contribution to the literature. Although it was not possible to measure life-space mobility and physical function at two time points and report a change score, the study design allowed examining predictors of these outcomes three years later, moving beyond cross-sectional associations.

In addition, the use of two outcomes, BMI and BMI refined by WC allowed examining obesity (BMI) and body composition-related health benefits (BMI refined by WC). The fact that different variables predicted these two outcomes suggests that these measures assess different constructs. Studies examining the relationship between the neighbourhood environments in relation to both obesity measures among older adults are very limited and this study represents a novel contribution to the literature. Finally, although it was not possible to measure WC at two time points and report a change score of BMI refined by WC, the 3-year interval between the collection of the independent and the covariate variables in 2007/2008 and the outcome variables in 2010/2011, allowed comparisons beyond cross-sectional associations.

A significant age effect was present in this study and the categorization by age groups (younger and older) allowed further examination. Results suggest that the predictors of change in steps as well as predictors of life-space mobility and physical function among older adults may be age-related and this group is not homogeneous. In addition, this study examined several health-related factors; results showed that these factors significantly predicted the outcome variables, giving some confidence that health-related factors must be taken into account when studying this particular age group. Regarding measurements of the neighbourhood environment, this study adds to the literature by examining neighbourhood characteristics individually instead of composite scores in which overall walkability score is provided (Berke et al., 2007a; Frank, et al., 2010; King et al., 2011; Li et al., 2009a; Michael et al., 2013). This allowed examining which particular neighbourhood feature was associated with each outcome.

5.4 Recommendations for Future Research

Although this study examined health-related outcomes, steps taken per day was the only outcome collected at two time points with a 'change score' in walking being reported. The remaining outcome measures, obesity, life-space mobility and physical function were collected at one time point (2010/2011). Future studies among older adults should focus on collecting measures of mobility, physical function and obesity at different time points, therefore a longitudinal design with a change score can be reported. This will allow examining the role of the neighbourhood environment on change in mobility, physical function and obesity measures. It would also allow examining predictors of incident mobility or functional limitations; that is, it would allow identifying individuals who developed mobility or functional limitations over time.

Additional studies with longitudinal design and pedometer data are also necessary in order to examine the acceptable change in number of steps taken per day among older adults for health benefits. For instance, significant health differences may exist between a person who declined 5000 steps in three years, but at baseline had 15000 steps compared to a person who declined the same amount of steps, but had 7000 steps at baseline. This information is currently unavailable in the literature.

Future research should examine the role of the neighbourhood environment among older adults at different levels of mobility (e.g. independent, mobility impaired, disabled), as well as among users of walking devices (e.g., walkers, canes, scooters). It is likely that the perception of the neighbourhood environment may vary considerably depending on the mobility impairment and the type of walking device. In addition, certain characteristics of the neighbourhood that were not significant predictors of life-space mobility, or walking among independent ambulatory older adults, such as sidewalks will prevail among those with mobility impairments.

In addition to the variety of mobility levels, future studies should examine older adults in various age groups (e.g., 65 to 74 years of age, 75 to 84, and 85 years of age and older) to further understand the role of the neighbourhood environment on health-related outcomes among older adults, as findings from this study showed that other factors such as demographic and health status played different roles in the different age groups.

CONCLUSION

This study examined the relationship between the perceived neighbourhood environment and health-related outcomes (physical activity (walking), physical function, life-space mobility and obesity measures) over a three-year period on community-dwelling older adults. Although more positive perceptions of neighbourhood characteristics such as walkability safety, traffic safety and sidewalks were associated with health-related outcomes, overall, the perceived neighbourhood environment was not a strong predictor of health-related outcomes among community-dwelling older adults. Some associations were age-related and some had unexpected directions. In contrast, these outcomes were mostly predicted by demographic and health variables (i.e. chronic conditions, self-rated health, body mass index, physical function limitations).

Nevertheless, despite the inconsistency in findings, this study showed that different health-related outcomes were predicted by different perceived neighbourhood characteristics. Therefore, initiatives targeted at the neighbourhood environment should consider the health outcome of interest (i.e. walking, mobility, physical function or obesity), the specific age group (i.e. old age or very old age and oldest old age), and the importance of demographic and health variables in shaping the relationship between the neighbourhood environment and these outcomes.

APPENDICES LIST

Appendix 1

Descriptive tables for physical activity and physical function instruments

Appendix 1a. Summary of physical activity measurements

Name of the measure	Type of measurement	Primary outcome measured	Main advantage	Main disadvantage
7 Day Recall	Subjective	Type and intensity of activity	Addresses type and intensity of activity using assigned MET values	Relies on participant's estimation of number of hours spent in a certain activity
PASE	Subjective	Type and intensity of activity	List of activities are primarily designed for older adults	Number of activities are limited and are not based on MET values for intensity
IPAQ	Subjective	Type and intensity of activity	Higher usability worldwide due to validation of the instrument to several languages	Not primarily designed for older adults
Pedometers	Objective	Steps taken	Measures physical activity without depending on participant's report	Does not measure intensity of activity
Accelerometers	Objective	Trunk acceleration	Measure activity intensity	More costly compared to pedometers

Heart Rate Monitors	Objective	Heart rate	Practicability and simplicity of the instrument/data acquisition.	Heart rate may vary due to circumstances such as stress and ambient temperature
GPS	Objective	Participant's continuous position over a determined geographical area	Precise track of participant's trajectory over a determined area	Not suitable for indoor environments (e.g., house, apartment) or shaded areas

Appendix 1b.. Summary of physical function measurements

Name of the measure	Type of measurement	Primary outcome measured	Main advantage	Main disadvantage
ADL/IADL	Subjective	Basic tasks related to self-care and instrumental tasks related to lifestyle	Simplicity of the measure	Does not differentiate participants across a range of physical function
SF 36 (PF10)	Subjective	Physical function	Differentiation between light, moderate and vigorous activities	Functional activity is limited by health status
LLFD	Subjective	Physical function and disability	Differentiates participants across a range of functional levels	Time for completion of the questionnaire
LSA	Subjective	mobility	Assesses mobility in a continuum of spaces in addition to frequency of activity and use of assistive devices	Possibility of recall bias
PPT	Objective	Physical function performance	Screens for functional impairments and monitors functional status	Trained personnel and specific equipment is needed
FFT	Objective	Physical functional fitness	Sensitive to change in functional status	Trained personnel and specific equipment is needed
CS- PFP	Objective	Physical function performance	Differentiates participants across a range of physical function	Trained personnel and specific equipment is needed

Appendix 2
Pedometer Chart, Questions & Instructions

Study ID Number: ____________________
Interviewer ID Number: _______________

Date	Time pedometer first put on in the morning	Removal of the pedometer (e.g., bath, nap)		Reasons for Removal	Time pedometer taken off at the end of the day	Number of Steps
		Time off	Time back On			
E.g., #1 October 9	7:00 am	8:10 pm	8:40 pm	Had a bath	10:30 pm	3100
E.g., #2 October 10	7:30 am	10:00 am	10:20 am	Had a shower	11:00 pm	3250

PEDOMETER PICK-UP

A research assistant will come to pick up the pedometer on: ____________________________

Please leave the pedometer, questions, and tape measure in the envelope provided.

****PLEASE REMEMBER TO COMPLETE THE FOLLOWING FIVE QUESTIONS****

PLEASE CALL DAWN VESELYUK AT 474-6583 IF YOU HAVE ANY QUESTIONS DURING THE THREE DAYS YOU ARE WEARING THE PEDOMETER. THANK YOU.

QUESTIONS

1) First, were the days that you wore the pedometer different in any way from a typical day? (Circle 0 or 1)

0 No
1 Yes → **IF YES, please specify why:** ____________________
____
____
____

2) How would you rate your physical activity levels IN THE DAYS THE PEDOMETER WAS WORN? And by *physical activity*, I am not referring to exercise, but simply to the amount you *physically moved around*.

Extremely inactive			Moderately active			Extremely active
1	2	3	4	5	6	7

3) In the days you wore the pedometer, how physically active were you compared to a typical day?

Extremely inactive			Moderately active			Extremely active
1	2	3	4	5	6	7

Pedometer Instructions

- You are being asked to wear the pedometer for 3 DAYS. The interviewer will record the first day you are to begin wearing the pedometer on your chart. You will need to fill in the dates for the remaining two days on your chart.

- Please continue your normal activities while wearing the pedometer, including physical exercise (except for swimming). Try to forget you are wearing it, and just do what you normally would.

- If possible, try and wear the pedometer at all times throughout the day except for bathing or showering. The <u>pedometer is not waterproof</u>, and so if you bathe or shower, please take it off. Remember to record the time the pedometer was removed and the reason (e.g., had a bath/shower) on the chart provided.

- You do <u>not</u> need to wear the pedometer at night when you are sleeping. Please follow the instructions for "how to remove the pedometer", and place the pedometer in a safe place. *BEFORE YOU REMOVE THE PEDOMETER FOR THE NIGHT, REMEMBER TO RECORD THE NUMBER OF STEPS ON YOUR CHART*

- If you nap during the day, you may want to remove the pedometer. Just remember to record the time the pedometer was removed on your chart.

- You are being asked to record the number of steps you take on each of the three days. <u>Each day when you put on the pedometer in the morning, you must remember to press the RESET button</u>.

- If you take a bath/shower or a nap or want to temporarily remove the pedometer, <u>DO NOT PRESS RESET</u>. Simply take the pedometer off, and when you are done, put it back on again.

- It will be necessary to wear clothing that has a <u>waistband or belt</u> for the 3 days the pedometer is to be worn (full-length dresses and nightgowns may not be suitable as there is no place to attach the pedometer).

- You may wear a coat/jacket while wearing the pedometer – just leave the pedometer where it is (on your waistband or belt) and put your jacket on overtop as you normally would.

- <u>THE PEDOMETER COVER</u>:

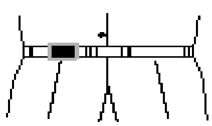
    ▪ When looking at the clip side of the pedometer, you will notice a small arrow and the word 'open'. To open the pedometer cover, push the flap outwards in the direction of the arrow. When closing the pedometer cover, make sure you hear a ‘click’.

▪ Please try to leave the cover of the pedometer closed during the day while you are wearing it.

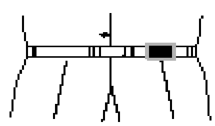
- HOW TO PUT ON THE PEDOMETER (refer to the picture):

▪ Place the pedometer on your waistband or belt.
▪ Position it directly above your knee, *on the opposite hand you normally write with*. (i.e., if you are right-handed, place the pedometer on your left side; if you are left-handed, place the pedometer on your right side).
▪ To attach the pedometer, start by sliding one corner of the clip onto your waistband or belt, moving it into position until it is straight. DO NOT FORCE THE CLIP ONTO A THICK BELT, AS THE CLIP MAY BREAK.
▪ The pedometer should remain upright and stay close to your body (it should not tilt forward, backward, or side-to-side).
▪ The pedometer cover needs to be closed for the pedometer to accurately count steps.
▪ Clip the strap of the pedometer to a belt loop or pocket (to prevent it from falling off).

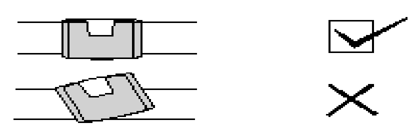
Place the pedometer on your waistband or belt.
Position it above your knee, on the *opposite side as the hand you write with*.



Pedometer worn on the right side for someone who is left-handed



Pedometer worn on the left side for someone who is right-handed



The pedometer should remain upright as indicated in the first picture (it should not tilt)

▪ The pedometer has only one button, the yellow RESET button. Once you have attached the pedometer to your waistband or belt, open the pedometer cover and hold the RESET button for 2 seconds (you will see a zero ‘0’). Close the cover (listen for the ‘click’), and you are ready to begin!

- HOW TO REMOVE THE PEDOMETER:

▪ To remove the pedometer, simply unclip both the pedometer and strap from your waistband or belt. Set the pedometer aside where it will not be disturbed until you put it back on or until it will be picked up.

Appendix 3
Demographics

The next few questions will provide important basic information about yourself.

Study ID Number:____________________ (STUDY_ID*)*

GENDER OF PARTICIPANT: ***(sex)***

1 – Male
2 – Female

Date of birth variables from WISER phase 1 were added to the data file in order to calculate age at the time of the Phase 3 interview: **(w1dob) (w1byear) (w1bmonth) (w1bday)**

Age as of the Phase 3 interview was calculated by taking the date of interview (int_day, int_month, int_year) minus date of birth (w1byear, w1bmonth, w1bday). The same procedure was used for WISER Phase 4.

1a. How tall are you without shoes on?

(htfeet_QG1a) (htinch_QG1a)
______ Feet ______ Inches
N/A (recorded in Cm)...........777.0
DK/R 999.0

OR

(htcm_QG1a)
_______ Centimetres
N/A (recorded in Feet/Inches)............777.0
DK/R...999.0

b. How much do you weigh?

(wtlbs_QG1b)
______ Pounds

N/A (recorded in Kilograms)..... 777
DK/R 999

OR

(wtkg_QG1b)
_______ Kilograms

N/A (recorded in Pounds)..............777.0
DK/R...999.0

Appendix 4
Health Status

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

Excellent.......1
Very good.....2
Good............3
Fair...............4
Poor..............5
DK/R............9

2. Now, I'd like to ask about any chronic health conditions you may **currently** have. This refers to long-term conditions that have lasted or are expected to last 6 months or more, and **have been diagnosed** by a health professional.

Do you have any of the following long-term conditions?

CONDITION:	No	Yes	DK/R
a) Food or other allergies?	2	1	9
b) Asthma?	2	1	9
c) Arthritis or Rheumatism?	2	1	9
d) Back problems excluding arthritis?	2	1	9
e) High blood pressure?	2	1	9
f) Migraine headaches?	2	1	9
g) Chronic bronchitis or emphysema?	2	1	9
h) Diabetes?	2	1	9
i) Epilepsy?	2	1	9
j) Heart disease?	2	1	9
k) Cancer?	2	1	9
l) Stomach or intestinal ulcers?	2	1	9
m) Effects of stroke?	2	1	9
n) Peripheral circulatory problems?	2	1	9
o) Urinary incontinence?	2	1	9
p) Osteoporosis?	2	1	9
q) Alzheimer's disease or other dementia?	2	1	9
r) Cataracts, glaucoma or retinal disease?	2	1	9
s) Dental problems?	2	1	9
t) Skin trouble including acne?	2	1	9
u) Ear trouble (hearing loss?)	2	1	9
v) Depression, anxiety or panic attacks?	2	1	9
w) Any long-term disability, handicap or			
x) Any long-term mental health problem?	2	1	9
y) Any other long-term condition?	2	1	9

3. The following question is about activities you might do during a typical day. Does your health now limit you in any of these activities? If so, how much - a little or a lot?

Does your health limit you in:	No, not limited at all	Yes, limited a little	Yes, limited a lot	N/A	DK/R
Household tasks or activities	0	1	2	7	9
Work or school activities	0	1	2	7	9
Transportation to or from work or leisure activities	0	1	2	7	9
Walking one block	0	1	2 →	7	9
SKIP "MILE" IF WALKING ONE BLOCK IS "LIMITED A LOT":					
Walking more than a mile	0	1	2	7	9
Bending, lifting, or stooping	0	1	2	7	9
Climbing a few flights of stairs	0	1	2	7	9
Moderate activities such as moving a table, carrying groceries or bowling	0	1	2	7	9
Vigorous activities such as running, lifting heavy objects, participating in strenuous sports	0	1	2	7	9

Appendix 5
Neighbourhood Characteristics
NEWS – Modified Version
(Saelens et al., 2003)

The following are some more specific questions about various aspects of your neighbourhood. Please indicate the extent to which you agree or disagree with each statement.

	Strongly disagree	Somewhat disagree	Somewhat agree	Strongly agree	DK/R
a) There are sidewalks on most of the streets in my neighbourhood....................	1	2	3	4	9
b) The sidewalks in my neighbourhood are well maintained (paved, even, and not a lot of cracks).......	1	2	3	4	9
d) There are walking paths in or near my neighbourhood that are easy to get to	1	2	3	4	9
e) There are many interesting things to look at while walking in my neighbourhood....................	1	2	3	4	9
f) There is so much traffic along the street I live on that it makes it difficult or unpleasant to walk in my neighbourhood....................	1	2	3	4	9
g) There is so much traffic along <u>nearby</u> streets that it makes it difficult or unpleasant to walk in my neighbourhood....................	1	2	3	4	9
h) Most drivers exceed the posted speed limits while driving in my neighbourhood	1	2	3	4	9
i) There are crosswalks and pedestrian signals to help walkers cross busy streets in my neighbourhood	1	2	3	4	9
j) My neighbourhood streets are well lit at night	1	2	3	4	9

Appendix 6
Waist Circumference

We would like you to measure your waist circumference

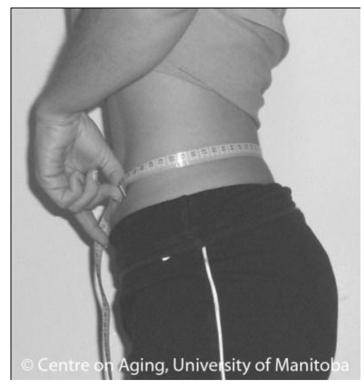
When you take the measurement, your stomach should be relaxed and you should be breathing out.

Make sure the tape measure is not too tight and that it is parallel with the floor.

Don't hold your breath while measuring!

Step 1:

- Stand up straight and remove all clothing and accessories from your waist area.



Step 2:

- Position (or have someone assist you) the measuring tape just above your hip bone (you can find it by pressing the side of your abdomen, close to your waist line).
- Bring the measuring tape all the way around your abdomen.
- Relax, exhale, and measure your waist.

- Be sure that the tape is snug (but does not compress your skin) and that it is parallel to the floor.

Measure: _____________ cm (w4_waist)

Note: Please measure in CENTIMETERS

Appendix 7
Life - Space Assessment
(Baker et al., 2003)

5) These questions refer to your activities just within the *past month*. *PLEASE CIRCLE YOUR RESPONSE IN EACH SECTION*
During the past four weeks, have you been to …

			How often did you get there				**Did you use aids or equipment (e.g., walker, cane)?** **Did you need help from another person?**
i.	**Other rooms of your home besides the room where you sleep? (Level 1)**	No (0)	If you answered NO, complete question **ii**				a. Help from another person (1) b. Equipment only (2) c. No equipment/no help from another person (3) **(w4act1_who)**
		Yes (1) **(w4_act1)**	Less than 1/ week (1) **(w4act1_freq)**	1-3 times /week (2)	4-6 times /week (3)	Daily (4)	
ii.	**An area outside your home such as your porch, deck, or patio, hallway (of an apartment building) or garage, in your own yard or driveway? (Level 2)**	No (0)	If you answered NO, complete question **iii**				a. Help from another person (1) b. Equipment only (2) c. No equipment/no help from another person (3) **(w4act2_who)**
		Yes (1) **(w4_act2)**	Less than 1/ week (1) **(w4act2_freq)**	1-3 times /week (2)	4-6 times /week (3)	Daily (4)	
iii.	**Places in your neighbourhood other than your own yard or apartment building? (Level 3)**	No (0)	If you answered NO, complete question **iv**				d. Help from another person (1) e. Equipment only (2) f. No equipment/no help from another person (3) **(w4act3_who)**
		Yes (1) **(w4_act3)**	Less than 1/ week (1) **(w4act3_freq)**	1-3 times /week (2)	4-6 times /week (3)	Daily (4)	

iv.	**Places outside your neighbourhood but within your city? (Level 4)**	No (0)	If you answered NO, complete question **v**				g. Help from another person (1) h. Equipment only (2) i. No equipment/no help from another person (3) **(w4act4_who)**
		Yes (1) **(w4_act4)**	Less than 1/ week (1) **(w4act4_freq)**	1-3 times /week (2)	4-6 times /week (3)	Daily (4)	
v.	**Places outside your city? (Level 5)**	No	If you answered NO, you have now completed this page				j. Help from another person (1) k. Equipment only (2) l. No equipment/no help from another person (3) **(w4act5_who)**
		Yes **(w4_act5)**	Less than 1/ week **(w4act5_freq)**	1-3 times /week	4-6 times /week	Daily	

A life space score was calculated for each level (Level 1 to 5) for those individuals who answered all three parts of the question (yes/no; frequency; assistance). Prior to creating the life space scores, the assistance variables had to be recoded so the values were 1=help from another person, 1.5=equipment only and 2=no equipment/no help from another person. In addition, the 'yes' value had to be changed as follows: Level 1 – yes=1; Level 2 – Yes=2; Level 3 – Yes=3; Level 4 – Yes=4; Level 5 – Yes=6. The life space scores are calculated as follows: yes/no variable X frequency X assistance. The variable names are as follows: Level 1 (**w4ls_level1**), Level 2 (**w4ls_level2**), Level 3 (**w4ls_level3**), Level 4 (**w4ls_level4**), and Level 5 (**w4_level5**).

Appendix 8
Physical Function
Late Life Function and Disability Instrument
(Haley et. Al., 2002)

In the following section, I will ask you about your ability to do specific activities as part of your daily routines. Some of these may be similar to what I just asked but they are more specific. I am interested in your ***sense of your ability*** to do it on a typical day. It is not important that you actually do the activity on a daily basis. In fact, I may mention some activities that you don't do at all. You can still answer these questions by assessing how difficult you ***think*** they would be for you to do on an average day.

Factors that influence the level of difficulty you have may include: pain, fatigue, fear, weakness, soreness, ailments, health conditions or disabilities.

I want to know how difficult each of the following activities would be for you ***without*** the help of someone else, and ***without*** the use of a cane, walker or any other assistive walking device (or wheelchair or scooter). **[SHOW CARD 3B-1]**

[FOR THE FUNCTION ITEMS, USING FIXED SUPPORT IS ACCEPTABLE (E.G., HOLDING ONTO FURNITURE, WALLS), UNLESS OTHERWISE SPECIFIED IN THE ITEM.

How much difficulty do you have….?

(Remember this is without the help of someone else and without the use of any assistive walking device)	None	A little	Some	Quite a lot	Cannot do	DK/R
F1. Unscrewing the lid off a previously unopened jar without using any devices **(w4_function1)**	5	4	3	2	1	9
F2. Going up & down a flight of stairs inside, using a handrail **(w4_function2)**	5	4	3	2	1	9
F3. Putting on and taking off long pants (including managing fasteners) **(w4_function3)**	5	4	3	2	1	9
F4. Running ½ mile or more **(w4_function4)**	5	4	3	2	1	9
F5. Using common utensils for preparing meals (e.g, can opener, potato peeler, or sharp knife) **(w4_function5)**	5	4	3	2	1	9
F6. Holding a full glass of water in one hand **(w4_function6)**	5	4	3	2	1	9
F7. Walking a mile, taking rests as necessary **(w4_function7)**	5	4	3	2	1	9
F8. Going up & down a flight of stairs outside, without using a handrail **(w4_function8)**	5	4	3	2	1	9
F9. Running a short distance, such as to						

catch a bus **(w4_function9)**	5	4	3	2	1	9
F10. Reaching overhead while standing, as if to pull a light cord **(w4_function10)**	5	4	3	2	1	9
F11. Sitting down in and standing up from a low, soft couch **(w4_function11)**	5	4	3	2	1	9
F12. Putting on and taking off a coat or jacket **(w4_function12)**	5	4	3	2	1	9
F13. Reaching behind your back as if to put a belt through a belt loop **(w4_function13)**	5	4	3	2	1	9
F14. Stepping up and down from a curb **(w4_function14)**	5	4	3	2	1	9
F15. Opening a heavy, outside door **(w4_function15)**	5	4	3	2	1	9
F16. Rip open a package of snack food (e.g., cellophane wrapping on crackers) using only your hands **(w4_function16)**	5	4	3	2	1	9
F17. Pouring from a large pitcher **(w4_function17)**	5	4	3	2	1	9
F18. Getting into and out of a car/taxi (sedan) **(w4_function18)**	5	4	3	2	1	9
F19. Hiking a couple of miles on uneven surfaces, including hills **(w4_function19)**	5	4	3	2	1	9
F20. Going up and down 3 flights of stairs inside, using a handrail **(w4_function20)**	5	4	3	2	1	9
F21. Picking up a kitchen chair and moving it, in order to clean **(w4_function21)**	5	4	3	2	1	9
F22. Using a step stool to reach into a high cabinet **(w4_function22)**	5	4	3	2	1	9
F23. Making a bed, including spreading and tucking in bed sheets **(w4_function23)**	5	4	3	2	1	9
F24. Carrying something in both arms while climbing a flight of stairs (e.g., laundry basket) **(w4_function24)**	5	4	3	2	1	9
F25. Bending over from a standing position to pick up a piece of clothing from the floor **(w4_function25)**	5	4	3	2	1	9
F26. Walking around one floor of your home, taking into consideration thresholds, doors, furniture, and a variety of floor coverings **(w4_function26)**	5	4	3	2	1	9
F27. Getting up from the floor (as if you were laying on the ground) **(w4_function27)**	5	4	3	2	1	9
F28. Washing dishes, pots, and utensils by hand while standing at sink **(w4_function28)**	5	4	3	2	1	9

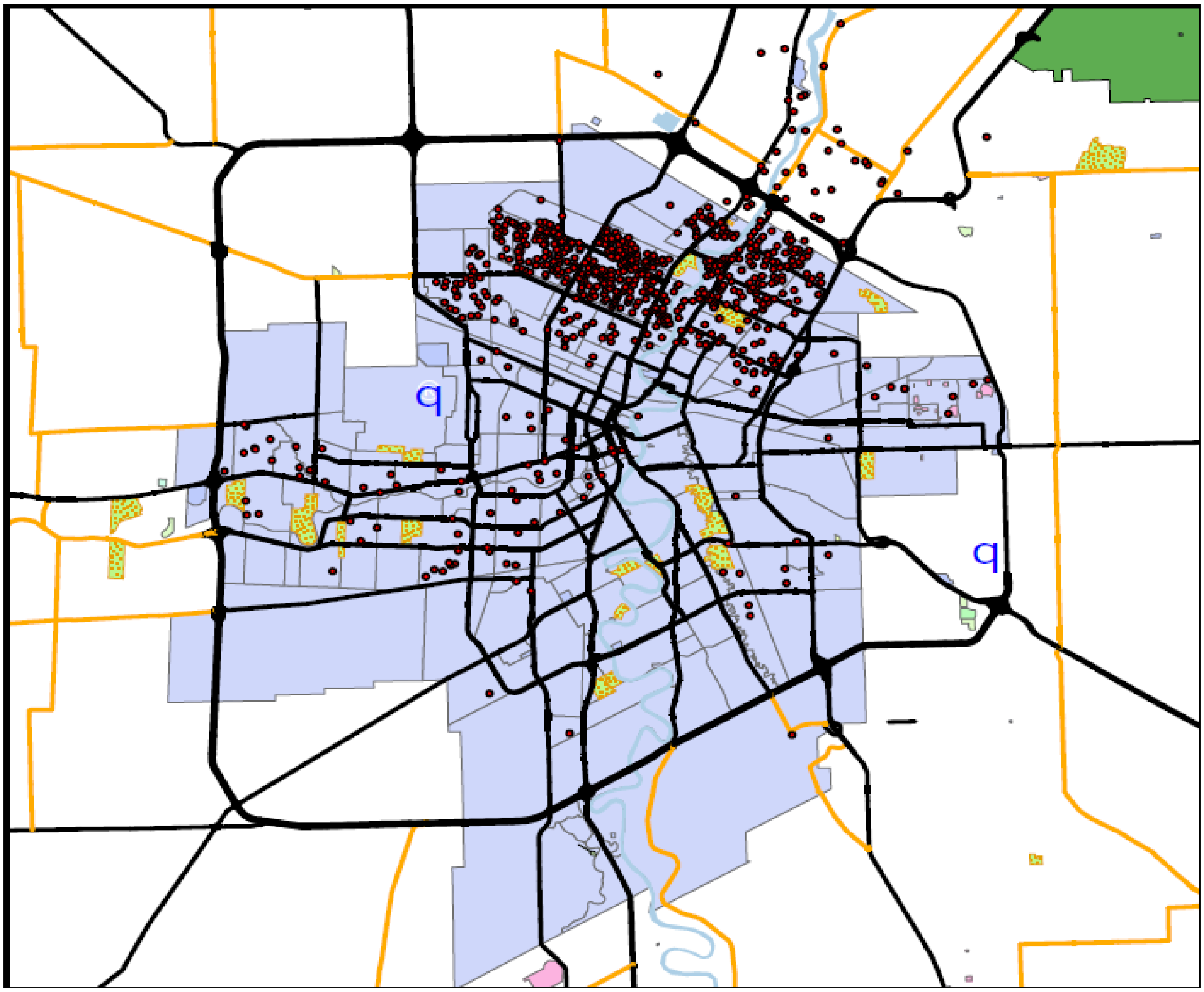
F29. Walking several blocks **(w4_function29)**	5	4	3	2	1	9
F30. Taking a 1 mile, brisk walk without stopping to rest **(w4_function30)**	5	4	3	2	1	9
F31. Stepping on and off a bus **(w4_function31)**	5	4	3	2	1	9
F32. Walking on a slippery surface outdoors **(w4_function32)**	5	4	3	2	1	9

Appendix 9
Neighbourhood characteristics according to the 2006 Census

Neighbourhood cluster name	N	Total population	Population over the age of 65	Population density per km^2	Proportion of the population over the age of 65	Median household income in 2005	Unemployment rate 15 years and over
Assiniboine South	3	34615	5030	565.3	14.5	74992	4.2
Transcona	3	30745	3480	1059.3	11.3	59199	5.2
St. James Assiniboia W.	8	31420	5785	1029.8	18.4	56075	4.4
St. James Assiniboia E.	5	26410	4720	919.5	17.9	48272	4.3
Fort Garry N.	4	31995	4240	1504.3	13.3	69046	4.2
St. Vital S.	2	35145	3395	670.8	9.7	71861	4.0
St. Boniface E.	4	34000	4035	821.0	11.9	71190	3.7
River East W.	67	36375	7910	2822.5	21.7	46007	4.7
River East E.	17	27495	2680	1755.8	9.7	58158	4.7
River East N.	17	8735	905	207.4	10.4	97224	4.6
Seven Oaks W.	36	20785	1880	918.1	9.0	62002	5.1
Seven Oaks E.	140	33810	5580	1960.4	16.5	49577	4.9
Seven Oaks N.	8	4355	695	49.7	16.0	72912	1.6
Inkster W.	1	15955	1030	1779.6	6.5	69198	4.4
Inkster E.	1	13140	1510	1439.4	11.5	35261	6.7
Point Douglas N.	12	25385	3225	4054.1	12.7	39208	6.0
Point Douglas S.	1	12265	1350	2653.8	11.0	22923	14.3
Downtown W.	3	34905	3730	3984.0	10.7	39692	5.8
Downtown E.	2	29935	3450	3960.6	11.5	23586	11.7
River Heights W.	1	34740	5095	2846.1	14.7	53651	4.6
River Heights E.	4	21745	3240	3693.1	14.9	41165	4.4

Appendix 10

Map of the City of Winnipeg with the participant location per neighbourhood*



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Appendix 11

Frequency distribution for the change score in number of steps (WISER 4 average number of steps – WISER 3 average number of steps)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	-14603.33	1	.3	.5	.5
	-13341.67	1	.3	.5	1.0
	-9657.33	1	.3	.5	1.5
	-9347.67	1	.3	.5	2.0
	-8383.67	1	.3	.5	2.5
	-7821.00	1	.3	.5	3.0
	-7732.00	1	.3	.5	3.4
	-6984.00	1	.3	.5	3.9
	-6569.33	1	.3	.5	4.4
	-6323.00	1	.3	.5	4.9
	-5980.67	1	.3	.5	5.4
	-5941.00	1	.3	.5	5.9
	-5705.67	1	.3	.5	6.4
	-5637.00	1	.3	.5	6.9
	-5590.67	1	.3	.5	7.4
	-5491.00	1	.3	.5	7.9
	-5414.67	1	.3	.5	8.4
	-5378.33	1	.3	.5	8.9
	-5221.00	1	.3	.5	9.4
	-5176.33	1	.3	.5	9.9
	-5083.00	1	.3	.5	10.3
	-4839.33	1	.3	.5	10.8
	-4779.33	1	.3	.5	11.3
	-4773.00	1	.3	.5	11.8
	-4607.67	1	.3	.5	12.3
	-4607.00	1	.3	.5	12.8
	-4601.00	1	.3	.5	13.3
	-4499.00	1	.3	.5	13.8
	-4491.33	1	.3	.5	14.3
	-4485.67	1	.3	.5	14.8
	-4480.33	1	.3	.5	15.3

	-4473.33	1	.3	.5	15.8
	-4408.67	1	.3	.5	16.3
	-4283.33	1	.3	.5	16.7
	-4036.67	1	.3	.5	17.2
	-4008.67	1	.3	.5	17.7
	-3983.33	1	.3	.5	18.2
	-3720.67	1	.3	.5	18.7
	-3708.00	1	.3	.5	19.2
	-3641.33	1	.3	.5	19.7
	-3554.67	1	.3	.5	20.2
	-3519.33	1	.3	.5	20.7
	-3475.33	1	.3	.5	21.2
	-3416.33	1	.3	.5	21.7
	-3373.33	1	.3	.5	22.2
	-3300.67	1	.3	.5	22.7
	-3292.67	1	.3	.5	23.2
	-3275.67	1	.3	.5	23.6
	-3245.67	1	.3	.5	24.1
	-3108.33	1	.3	.5	24.6
	-3058.00	1	.3	.5	25.1
	-2994.67	1	.3	.5	25.6
	-2921.67	1	.3	.5	26.1
	-2902.00	1	.3	.5	26.6
	-2839.00	1	.3	.5	27.1
	-2783.67	1	.3	.5	27.6
	-2764.33	1	.3	.5	28.1
	-2712.33	1	.3	.5	28.6
	-2707.33	1	.3	.5	29.1
	-2503.33	1	.3	.5	29.6
	-2414.33	1	.3	.5	30.0
	-2284.33	1	.3	.5	30.5
	-2178.00	1	.3	.5	31.0
	-2175.33	1	.3	.5	31.5
	-2111.33	1	.3	.5	32.0
	-2088.67	1	.3	.5	32.5

	-2036.67	1	.3	.5	33.0
	-2031.00	1	.3	.5	33.5
	-2014.67	1	.3	.5	34.0
	-1997.67	1	.3	.5	34.5
	-1995.67	1	.3	.5	35.0
	-1965.00	1	.3	.5	35.5
	-1950.33	1	.3	.5	36.0
	-1924.67	1	.3	.5	36.5
	-1923.67	1	.3	.5	36.9
	-1912.00	1	.3	.5	37.4
	-1903.33	1	.3	.5	37.9
	-1875.00	1	.3	.5	38.4
	-1830.00	1	.3	.5	38.9
	-1708.00	1	.3	.5	39.4
	-1702.00	1	.3	.5	39.9
	-1690.00	1	.3	.5	40.4
	-1607.33	1	.3	.5	40.9
	-1591.00	1	.3	.5	41.4
	-1582.33	1	.3	.5	41.9
	-1576.67	1	.3	.5	42.4
	-1554.67	1	.3	.5	42.9
	-1543.33	1	.3	.5	43.3
	-1500.67	1	.3	.5	43.8
	-1484.00	1	.3	.5	44.3
	-1410.00	1	.3	.5	44.8
	-1388.33	1	.3	.5	45.3
	-1358.00	1	.3	.5	45.8
	-1347.33	1	.3	.5	46.3
	-1345.67	1	.3	.5	46.8
	-1322.33	1	.3	.5	47.3
	-1320.33	1	.3	.5	47.8
	-1277.67	1	.3	.5	48.3
	-1262.67	1	.3	.5	48.8
	-1216.00	1	.3	.5	49.3
	-1184.67	1	.3	.5	49.8

	-1178.00	1	.3	.5	50.2
	-1161.33	1	.3	.5	50.7
	-1100.33	1	.3	.5	51.2
	-1080.33	1	.3	.5	51.7
	-1070.33	1	.3	.5	52.2
	-1036.33	1	.3	.5	52.7
	-1018.33	1	.3	.5	53.2
	-1012.67	1	.3	.5	53.7
	-975.67	1	.3	.5	54.2
	-912.00	1	.3	.5	54.7
	-861.00	1	.3	.5	55.2
	-854.67	1	.3	.5	55.7
	-823.33	1	.3	.5	56.2
	-782.00	1	.3	.5	56.7
	-737.67	1	.3	.5	57.1
	-702.33	1	.3	.5	57.6
	-685.67	1	.3	.5	58.1
	-683.00	1	.3	.5	58.6
	-593.00	1	.3	.5	59.1
	-562.33	1	.3	.5	59.6
	-526.33	1	.3	.5	60.1
	-474.33	1	.3	.5	60.6
	-465.00	1	.3	.5	61.1
	-418.00	1	.3	.5	61.6
	-413.67	1	.3	.5	62.1
	-372.33	1	.3	.5	62.6
	-351.67	1	.3	.5	63.1
	-345.67	1	.3	.5	63.5
	-336.00	1	.3	.5	64.0
	-330.33	1	.3	.5	64.5
	-312.67	1	.3	.5	65.0
	-296.33	1	.3	.5	65.5
	-282.33	1	.3	.5	66.0
	-257.67	1	.3	.5	66.5
	-223.67	1	.3	.5	67.0

	-178.00	1	.3	.5	67.5
	-161.00	1	.3	.5	68.0
	-81.67	1	.3	.5	68.5
	-1.00	1	.3	.5	69.0
	35.00	1	.3	.5	69.5
	37.67	1	.3	.5	70.0
	55.67	1	.3	.5	70.4
	64.67	1	.3	.5	70.9
	124.33	1	.3	.5	71.4
	146.00	1	.3	.5	71.9
	146.33	1	.3	.5	72.4
	149.00	1	.3	.5	72.9
	212.67	1	.3	.5	73.4
	266.33	1	.3	.5	73.9
	308.33	1	.3	.5	74.4
	325.67	1	.3	.5	74.9
	339.67	1	.3	.5	75.4
	340.67	1	.3	.5	75.9
	348.00	1	.3	.5	76.4
	506.33	1	.3	.5	76.8
	565.33	1	.3	.5	77.3
	607.00	1	.3	.5	77.8
	625.67	1	.3	.5	78.3
	627.33	1	.3	.5	78.8
	641.33	1	.3	.5	79.3
	661.00	1	.3	.5	79.8
	738.33	1	.3	.5	80.3
	762.00	1	.3	.5	80.8
	920.33	1	.3	.5	81.3
	941.67	1	.3	.5	81.8
	979.00	1	.3	.5	82.3
	1058.67	1	.3	.5	82.8
	1063.33	1	.3	.5	83.3
	1105.67	1	.3	.5	83.7
	1194.33	1	.3	.5	84.2

	1202.00	1	.3	.5	84.7
	1295.00	1	.3	.5	85.2
	1520.00	1	.3	.5	85.7
	1547.33	1	.3	.5	86.2
	1556.67	1	.3	.5	86.7
	1872.67	1	.3	.5	87.2
	1971.33	1	.3	.5	87.7
	2076.00	1	.3	.5	88.2
	2402.00	1	.3	.5	88.7
	2448.00	1	.3	.5	89.2
	2632.00	1	.3	.5	89.7
	2812.00	1	.3	.5	90.1
	2832.67	1	.3	.5	90.6
	2851.00	1	.3	.5	91.1
	3066.33	1	.3	.5	91.6
	3164.33	1	.3	.5	92.1
	3402.00	1	.3	.5	92.6
	3404.67	1	.3	.5	93.1
	3480.67	1	.3	.5	93.6
	3688.00	1	.3	.5	94.1
	3859.67	1	.3	.5	94.6
	4096.67	1	.3	.5	95.1
	4263.00	1	.3	.5	95.6
	4323.67	1	.3	.5	96.1
	4576.33	1	.3	.5	96.6
	4721.00	1	.3	.5	97.0
	6146.00	1	.3	.5	97.5
	6866.00	1	.3	.5	98.0
	7251.33	1	.3	.5	98.5
	7612.00	1	.3	.5	99.0
	9304.00	1	.3	.5	99.5
	9388.33	1	.3	.5	100.0

REFERENCES

Abu-Omar, K., Rutten, A., & Robine, J. M. (2004). Self-rated health and physical activity in the european union. *Sozial- Und Praventivmedizin, 49*(4), 235-242.

Adams, M. A., Ryan, S., Kerr, J., Sallis, J. F., Patrick, K., Frank, L. D., et al. (2009). Validation of the neighbourhood environment walkability scale (NEWS) items using geographic information systems. *Journal of Physical Activity & Health, 6 Suppl 1*, S113-23.

Addy, C. L., Wilson, D. K., Kirtland, K. A., Ainsworth, B. E., Sharpe, P., & Kimsey, D. (2004). Associations of perceived social and physical environmental supports with physical activity and walking behavior. *American Journal of Public Health, 94*(3), 440-443.

Aditya, B. S., & Wilding, J. P. (2009). Modern management of obesity. *Clinical Medicine (London, England), 9*(6), 617-21; quiz 622-3.

Ainsworth, B. E., Haskell, W. L., Herrmann, S. D., Meckes, N., Bassett, D. R.,Jr, Tudor-Locke, C., et al. (2011). 2011 compendium of physical activities: A second update of codes and MET values. *Medicine and Science in Sports and Exercise*, *43*(8), 1575-1581.

Al Snih, S., Graham, J. E., Kuo, Y. F., Goodwin, J. S., Markides, K. S., & Ottenbacher, K. J. (2010). Obesity and disability: Relation among older adults living in latin america and the caribbean. *American Journal of Epidemiology, 171*(12), 1282-1288.

Al Snih, S., Peek, K. M., Sawyer, P., Markides, K. S., Allman, R. M., & Ottenbacher, K. J. (2012). Life-space mobility in mexican americans aged 75 and older. *Journal of the American Geriatrics Society,60*(3), 532-537.

Andreotti, R. A., & Okuma, S. S. (1999). Validação de uma bateria de testes de atividades da vida diária para idosos fisicamente independentes. *Revista Paulista De Educaçao Fisica, 13*(1), 46-66.

Angevaren, M., Aufdemkampe, G., Verhaar, H. J., Aleman, A., & Vanhees, L. (2008). Physical activity and enhanced fitness to improve cognitive function in older people without known cognitive impairment. *Cochrane Database of Systematic Reviews (Online), (3)*(3), CD005381.

Anis, A. H., Zhang, W., Bansback, N., Guh, D. P., Amarsi, Z., & Birmingham, C. L. (2010). Obesity and overweight in canada: An updated cost-of-illness study. *Obesity Reviews : An Official Journal of the International Association for the Study of Obesity,11*(1), 31-40.

Annear, M. J., Cushman, G., & Gidlow, B. (2009). Leisure time physical activity differences among older adults from diverse socioeconomic neighbourhoods. *Health & Place*, *15*(2), 482-490.

Aoyagi, Y., Park, H., Watanabe, E., Park, S., & Shephard, R. J. (2009). Habitual physical activity and physical fitness in older japanese adults: The nakanojo study. *Gerontology, 55*(5), 523-531.

Arnadottir, S. A., Gunnarsdottir, E. D., Stenlund, H., & Lundin-Olsson, L. (2011). Determinants of self-rated health in old age: A population-based, cross-sectional study using the international classification of functioning. *BMC Public Health, 11*, 670-2458-11-670.

Ashe, M. C., Miller, W. C., Eng, J. J., Noreau, L., & Physical Activity and Chronic Conditions Research Team. (2009). Older adults, chronic disease and leisure-time physical activity. *Gerontology, 55*(1), 64-72.

Aslan, D., Ozcebe, H., Temel, F., Takmaz, S., Topatan, S., Sahin, A., et al. (2008). What influences physical activity among elders? A turkish experience from ankara, turkey. *Archives of Gerontology and Geriatrics,46*(1), 79-88.

Auger, C., Demers, L., Gelinas, I., Miller, W. C., Jutai, J. W., & Noreau, L. (2010). Life-space mobility of middle-aged and older adults at various stages of usage of power mobility devices. *Archives of Physical Medicine and Rehabilitation, 91*(5), 765-773.

Auger, C., Demers, L., Gelinas, I., Routhier, F., Jutai, J., Guerette, C., et al. (2009). Development of a french-canadian version of the life-space assessment (LSA-F): Content validity, reliability and applicability for power mobility device users. *Disability and Rehabilitation.Assistive Technology, 4*(1), 31-41.

Baker, P. S., Bodner, E. V., & Allman, R. M. (2003). Measuring life-space mobility in community-dwelling older adults. *Journal of the American Geriatrics Society, 51*(11), 1610-1614.

Bales, C. W., & Buhr, G. T. (2009). Body mass trajectory, energy balance, and weight loss as determinants of health and mortality in older adults. *Obesity Facts, 2*(3), 171-178.

Balfour, J.L., & Kaplan, G.A. (2002). Neighbourhood environment and loss of physical function in older adults: Evidence from the Alameda County Study. *American Journal of Epidemiology, 155*(6), 507-515.

Ball, K., Jeffrey, R.W., Crawford, D.A., Roberts, R.J., Salmon, J., & Timperio, A.F. (2008). Mismatch between perceived and objective measures of physical activity environments. Preventive Medicine, 47(3), 294-298.

Ball, K. (2006). People, places...and other people? integrating understanding of intrapersonal, social and environmental determinants of physical activity. *Journal of Science and Medicine in Sport / Sports Medicine Australia, 9*(5), 367-370.

Bannerman, E., Miller, M. D., Daniels, L. A., Cobiac, L., Giles, L. C., Whitehead, C., et al. (2002). Anthropometric indices predict physical function and mobility in older australians: The australian longitudinal study of ageing. *Public Health Nutrition, 5*(5), 655-662.

Baumgartner, R. N., Wayne, S. J., Waters, D. L., Janssen, I., Gallagher, D., & Morley, J. E. (2004). Sarcopenic obesity predicts instrumental activities of daily living disability in the elderly. *Obesity Research, 12*(12), 1995-2004.

Bean, J. F., Olveczky, D. D., Kiely, D. K., LaRose, S. I., & Jette, A. M. (2011). Performance-based versus patient-reported physical function: What are the underlying predictors? *Physical Therapy, 91*(12), 1804-1811.

Bean, J. F., Vora, A., & Frontera, W. R. (2004). Benefits of exercise for community-dwelling older adults. *Archives of Physical Medicine and Rehabilitation, 85*(7 Suppl 3), S31-42; quiz S43-4.

Beard, J. R., Blaney, S., Cerda, M. a., Frye, V., Lovasi, G. S., Ompad, D., et al. (2009). Neighbourhood characteristics and disability in older adults. *Journals of Gerontology Series B-Psychological Sciences and Social Sciences, 64*(2), 252-257.

Behrens, T. K., & Dinger, M. K. (2011). Comparisons of accelerometer and pedometer determined steps in free living samples. *Journal of Physical Activity & Health, 8*(3), 390-397.

Bennett, G. G., Wolin, K. Y., Puleo, E., & Emmons, K. M. (2006). Pedometer-determined physical activity among multiethnic low-income housing residents. *Medicine and Science in Sports and Exercise,38*(4), 768-773.

Bentley, J. P., Brown, C. J., McGwin, G.,Jr, Sawyer, P., Allman, R. M., & Roth, D. L. (2012). Functional status, life-space mobility, and quality of life: A longitudinal mediation analysis. *Quality of Life Research: An International Journal of Quality of Life Aspects of Treatment, Care and Rehabilitation,* Benyamini, Y. (2011). Why does self-rated health predict mortality? an update on current knowledge and a research agenda for psychologists. *Psychology & Health, 26*(11), 1407-1413.

Berentzen, T. L., Jakobsen, M. U., Stegger, J. G., Halkjaer, J., Tjonneland, A., Sorensen, T. I., et al. (2011a). Changes in waist circumference and the incidence of acute myocardial infarction in middle-aged men and women. *PloS One, 6*(10), e26849.

Berentzen, T. L., Jakobsen, M. U., Halkjaer, J., Tjønneland, A., Sørensen, T. I. A., & Overvad, K. (2011b). Changes in waist circumference and the incidence of diabetes in middle-aged men and women. *PLoS ONE, 6*(8)

Berke, E., Koepsell, T. D., Moudon, A. V., Hoskins, R. E., & Larson, E. B. (2007a). Association of the built environment with physical activity and obesity in older persons. *American Journal of Public Health, 97*(3), 486-492.

Berke, E., Gottlieb, L.M., Moudon, A. V., & Larson, E. B. (2007b). Protective association between neighbourhood walkability and depression in older men. *Journal of the American Geriatrics Society, 55*(4), 526-533.

Bigaard, J., Spanggaard, I., Thomsen, B. L., Overvad, K., & Tjonneland, A. (2005). Self-reported and technician-measured waist circumferences differ in middle-aged men and women. *The Journal of Nutrition, 135*(9), 2263-2270.

Black, J. L., & Macinko, J. (2008). Neighbourhoods and obesity. *Nutrition Reviews, 66*(1), 2-20.

Blair, S. N., Haskell, W. L., Ho, P., Paffenbarger, R. S.,Jr, Vranizan, K. M., Farquhar, J. W., et al. (1985). Assessment of habitual physical activity by a seven-day recall in a community survey and controlled experiments. *American Journal of Epidemiology, 122*(5), 794-804.

Bohannon, R. W. (2007). Number of pedometer-assessed steps taken per day by adults: A descriptive meta-analysis. *Physical Therapy, 87*(12), 1642-1650.

Bonnefoy, M., Normand, S., Pachiaudi, C., Lacour, J. R., Laville, M., & Kostka, T. (2001). Simultaneous validation of ten physical activity questionnaires in older men: A doubly labeled water study. *Journal of the American Geriatrics Society,49*(1), 28-35.

Booth, K. M., Pinkston, M. M., & Poston, W. S. C. (2005). Obesity and the built environment. *Journal of the American Dietetic Association, 105*(5, Supplement 1), 110-117.

Bouchard, D. R., Dionne, I. J., & Brochu, M. (2009). Sarcopenic/obesity and physical capacity in older men and women: Data from the nutrition as a determinant of successful aging (NuAge)-the quebec longitudinal study. *Obesity (Silver Spring, Md.), 17*(11), 2082-2088.

Bowling, A., Barber, J., Morris, R., & Ebrahim, S. (2006). Do perceptions of neighbourhood environment influence health? baseline findings from a british survey of aging. *Journal of Epidemiology and Community Health, 60*(6), 476-483.

Bowling, A., & Stafford, M. (2007). How do objective and subjective assessments of neighbourhood influence social and physical functioning in older age? findings from a british survey of ageing. *Social Science & Medicine, 64*(12), 2533-2549.

Boyington, J. E., Howard, D. L., & Holmes, D. N. (2008). Self-rated health, activities of daily living, and mobility limitations among black and white stroke survivors. *Journal of Aging and Health, 20*(8), 920-939.

Boyle, P. A., Buchman, A. S., Wilson, R. S., Bienias, J. L., & Bennett, D. A. (2007). Physical activity is associated with incident disability in community-based older persons. *Journal of the American Geriatrics Society,55*(2), 195-201.

Brach, J. S., VanSwearingen, J. M., FitzGerald, S. J., Storti, K. L., & Kriska, A. M. (2004). The relationship among physical activity, obesity, and physical function in community-dwelling older women. *Preventive Medicine,39*(1), 74-80.

Bravata, D. M., Smith-Spangler, C., Sundaram, V., Gienger, A. L., Lin, N., Lewis, R., et al. (2007). Using pedometers to increase physical activity and improve health: A systematic review. *JAMA: The Journal of the American Medical Association,298*(19), 2296-2304.

Bronfenbrenner, U. (1977). Toward an experimental ecology of human development. *American Psychologist,32*(7), 513-531.

Broome, K., Nalder, E., Worrall, L., & Boldy, D. (2010). Age-friendly buses? A comparison of reported barriers and facilitators to bus use for younger and older adults. *Australasian Journal on Ageing,29*(1), 33-38.

Brown, C. J., Roth, D. L., Allman, R. M., Sawyer, P., Ritchie, C. S., & Roseman, J. M. (2009). Trajectories of life-space mobility after hospitalization. *Annals of Internal Medicine,150*(6), 372-378.

Brownson, R. C., Hoehner, C. M., Day, K., Forsyth, A., & Sallis, J. F. (2009). Measuring the built environment for physical activity: State of the science. *American Journal of Preventive Medicine,36*(4, Supplement 1), S99-S123.e12.

Buchner, D. M., Beresford, S. A. A., Larson, E. B., LaCroix, A. Z., & Wagner, E. H. (1992). Effects of physical activity on health status in older adults II: Intervention studies. *Annual Review of Public Health,13*, 469-488.

Canadian Cancer Society. (2013). Cancer Statistics at a glance. Retrieved 08/08, 2013, from http://www.cancer.ca/en/cancer-information/cancer-101/cancer-statistics-at-a-glance/?region=mb

Canadian Fitness and Lifestyle Research Institute. (2007). *Physical activity monitor*. Retrieved 03/26, 2012, from http://www.cflri.ca/node/78

Canadian Society for Exercise Physiology. (2011). *Physical activity guidelines. available at : Http://www.csep.ca/english/view.asp?x=804 retrieved on april 2011*. Retrieved 04/10, 2011, from http://www.csep.ca/english/view.asp?x=804

Canadian Society for Exercise Physiology. (2003). The Canadian Physical Activity, Fitness & Lifestyle Approach. 3rd Edition. Ottawa: Canada. Canadian Society for Exercise Physiology.

Canoy, D. (2008). Distribution of body fat and risk of coronary heart disease in men and women. *Current Opinion in Cardiology 23*(6), 591-598.

Carlson, J. A., Sallis, J. F., Conway, T. L., Saelens, B. E., Frank, L. D., Kerr, J., et al. (2012). Interactions between psychosocial and built environment factors in explaining older adults' physical activity. *Preventive Medicine,54*(1), 68-73.

Carlson, J. E., Ostir, G. V., Black, S. A., Markides, K. S., Rudkin, L., & Goodwin, J. S. (1999). Disability in older adults. 2: Physical activity as prevention. *Behavioral Medicine (Washington, D.C.), 24*(4), 157-168.

Centers for Disease Control and Prevention. (2011). *HRQOL concepts.* Retrieved 11/20, 2011, from http://www.cdc.gov/hrqol/concept.htm

Cerin, E., Saelens, B. E., Sallis, J. F., & Frank, L. D. (2006). Neighbourhood environment walkability scale: Validity and development of a short form. *Medicine & Science in Sports & Exercise,38*(9), 1682-1691.

Chad, K. E., Reeder, B. A., Harrison, E. L., Ashworth, N. L., Sheppard, S. M., Schultz, S. L., et al. (2005). Profile of physical activity levels in community-dwelling older adults. *Medicine and Science in Sports and Exercise,37*(10), 1774-1784.

Chen, Y., & Mao, Y. (2006). Obesity and leisure time physical activity among canadians. *Preventive Medicine,42*(4), 261-265.

Chou, C. H., Hwang, C. L., & Wu, Y. T. (2012). Effect of exercise on physical function, daily living activities, and quality of life in the frail older adults: A meta-analysis. *Archives of Physical Medicine and Rehabilitation,93*(2), 237-244.

Cigolle, C. T., Blaum, C. S., & Halter, J. B. (2009). Diabetes and cardiovascular disease prevention in older adults. *Clinics in Geriatric Medicine,25*(4), 607-41, vii-viii.

Clark, C. R., Kawachi, I., Ryan, L., Ertel, K., Fay, M. E., & Berkman, L. F. (2009). Perceived neighbourhood safety and incident mobility disability among elders: The hazards of poverty. *BMC Public Health, 9*, 162.

Clarke, P., Ailshire, J. A., Bader, M., Morenoff, J. D., & House, J. S. (2008). Mobility disability and the urban built environment. *American Journal of Epidemiology,168*(5), 506-513.

Clarke, P., & George, L. K. (2005). The role of the built environment in the disablement process. *American Journal of Public Health,95*(11), 1933-1939.

Clarke, P., & Nieuwenhuijsen, E. R. (2009). Environments for healthy ageing: A critical review. *Maturitas, 64*(1), 14-19.

Cohen, S., & Syme, S. L. (Eds.). (1985). *Social support and health*. Orlando, Florida: Academic Press.

Cohen-Mansfield, J., Marx, M. S., & Guralnik, J. M. (2003). Motivators and barriers to exercise in an older community-dwelling population. *Journal of Aging and Physical Activity,11*(2), 242-253.

Colley, R. C., Garriguet, D., Janssen, I., Craig, C. L., Clarke, J., & Tremblay, M. S. (2011). Physical activity of canadian adults: Accelerometer results from the 2007 to 2009 canadian health measures survey. *Health Reports / Statistics Canada, Canadian Centre for Health Information = Rapports Sur La Sante / Statistique Canada, Centre Canadien d'Information Sur La Sante,22*(1), 7-14.

Coman, L., & Richardson, J. (2006). Relationship between self-report and performance measures of function: A systematic review. *Canadian Journal on Aging = La Revue Canadienne Du Vieillissement,25*(3), 253-270.

Courneya, K., & Karvinen, K. (2007). Exercise, aging, and cancer. *Applied Physiology, Nutrition, and Metabolism = Physiologie Appliquee, Nutrition Et Metabolisme, 32*(6), 1001-1007.

Craig, C. L., Marshall, A. L., Sjostrom, M., Bauman, A. E., Booth, M. L., Ainsworth, B. E., et al. (2003). International physical activity questionnaire: 12-country reliability and validity. *Medicine & Science in Sports & Exercise,35*(8), 1381-1395.

Cress, M. E., Petrella, J. K., Moore, T. L., & Schenkman, M. L. (2005). Continuous-scale physical functional performance test: Validity, reliability, and sensitivity of data for the short version. *Physical Therapy, 85*(4), 323-335.

Cress, M. E., Buchner, D. M., Questad, K. A., Esselman, P. C., deLateur, B. J., & Schwartz, R. S. (1996). Continuous-scale physical functional performance in healthy older adults: A validation study. *Archives of Physical Medicine and Rehabilitation, 77*(12), 1243-1250.

Crouter, S. E., Schneider, P. L., Karabulut, M., & Bassett, D. R.,Jr. (2003). Validity of 10 electronic pedometers for measuring steps, distance, and energy cost. *Medicine and Science in Sports and Exercise, 35*(8), 1455-1460.

Crowe, M., Andel, R., Wadley, V. G., Okonkwo, O. C., Sawyer, P., & Allman, R. M. (2008). Life-space and cognitive decline in a community-based sample of african american and caucasian older adults. *The Journals of Gerontology.Series A, Biological Sciences and Medical Sciences,*63(11), 1241-1245.

Cunningham, G.O., Michael, Y.L., Farquhar, S.A., & Lapidus, J. (2005). Developing a reliable Senior Walking Environmental Assessment Tool. *American Journal of Preventive Medicine*, 29(3), 215-217.

Cyarto, E. V., Marshall, A. L., Dickinson, R. K., & Brown, W. J. (2006). Measurement properties of the CHAMPS physical activity questionnaire in a sample of older Australians. *Journal of Science and Medicine in Sport / Sports Medicine Australia, 9*(4), 319-326.

Dhaliwal, S.S., Howat, P., Bejoy, T., & Welborn, T.A. (2010). Self-reported weight and height, for evaluating obesity control programs. *American Journal of Health Behavior, 34*(4), 489-499.

Davis, M. G., & Fox, K. R. (2007). Physical activity patterns assessed by accelerometry in older people. *European Journal of Applied Physiology, 100*(5), 581-589.

Dawson, J., Hillsdon, M., Boller, I., & Foster, C. (2007). Perceived barriers to walking in the neighbourhood environment and change in physical activity levels over 12 months. *British Journal of Sports Medicine, 41*(9), 562-568.

De Cocker, K. A., De Bourdeaudhuij, I. M., & Cardon, G. M. (2009). What do pedometer counts represent? A comparison between pedometer data and data from four different questionnaires. *Public Health Nutrition,12*(1), 74-81.

de Hollander, E. L., Bemelmans, W. J., & de Groot, L. C. (2013). Associations between changes in anthropometric measures and mortality in old age: A role for mid-upper arm circumference? *Journal of the American Medical Directors Association, 14*(3), 187-193.

de Melo, L. L., Menec, V., Porter, M. M., & Ready, A. E. (2010). Personal factors, perceived environment, and objectively measured walking in old age. *Journal of Aging and Physical Activity,18*(3), 280-292.

Decaria, J. E., Sharp, C., & Petrella, R. J. (2012). Scoping review report: Obesity in older adults. *International Journal of Obesity (2005), 36*(9), 1141-1150.

Dekkers, J. C., van Wier, M. F., Hendriksen, I. J., Twisk, J. W., & van Mechelen, W. (2008). Accuracy of self-reported body weight, height and waist circumference in a dutch overweight working population. *BMC Medical Research Methodology, 8*, 69.

Di Francesco, V., Zamboni, M., Zoico, E., Bortolani, A., Maggi, S., Bissoli, L., et al. (2005). Relationships between leisure-time physical activity, obesity and disability in elderly men. *Aging Clinical and Experimental Research,17*(3), 201-206.

Dubuc, N., Haley, S., Ni, P., Kooyoomjian, J., & Jette, A. (2004). Function and disability in late life: Comparison of the late-life function and disability instrument to the short-form-36 and the london handicap scale. *Disability and Rehabilitation, 26*(6), 362-370.

Duncan, M., & Mummery, K. (2005). Psychosocial and environmental factors associated with physical activity among city dwellers in regional queensland. *Preventive Medicine, 40*(4), 363-372.

Duncan, M. J., Spence, J. C., & Mummery, W. K. (2005). Perceived environment and physical activity: A meta-analysis of selected environmental characteristics. *The International Journal of Behavioral Nutrition and Physical Activity, 2*, 11.

Dwyer, T., Ponsonby, A. L., Ukoumunne, O. C., Pezic, A., Venn, A., Dunstan, D., et al. (2011). Association of change in daily step count over five years with insulin sensitivity and adiposity: Population based cohort study. *BMJ (Clinical Research Ed.), 342*, c7249.

Eisenstein, A. R., Prohaska, T. R., Kruger, J., Satariano, W. A., Hooker, S., Buchner, D., et al. (2011). Environmental correlates of overweight and obesity in community residing older adults. *Journal of Aging and Health, 23*(6), 994-1009.

Ekkekakis, P., Backhouse, S. H., Gray, C., & Lind, E. (2008). Walking is popular among adults but is it pleasant? A framework for clarifying the link between walking and affect as illustrated in two studies. *Psychology of Sport and Exercise,9*(3), 246-264.

Elsawy, B., & Higgins, K. E. (2010). Physical activity guidelines for older adults. *American Family Physician, 81*(1), 55-59.

Ewald, B., McEvoy, M., & Attia, J. (2010). Pedometer counts superior to physical activity scale for identifying health markers in older adults. *British Journal of Sports Medicine,*

Feng, J., Glass, T. A., Curriero, F. C., Stewart, W. F., & Schwartz, B. S. (2010). The built environment and obesity: A systematic review of the epidemiologic evidence. *Health & Place, 16*(2), 175-190.

Field, A. E., Coakley, E. H., Must, A., Spadano, J. L., Laird, N., Dietz, W. H., et al. (2001). Impact of overweight on the risk of developing common chronic diseases during a 10-year period. *Archives of Internal Medicine, 161*(13), 1581-1586.

Fisher, K. J., Li, F., Michael, Y., & Cleveland, M. (2004). Neighbourhood-level influences on physical activity among older adults: A multilevel analysis. *Journal of Aging and Physical Activity, 12*(1), 45-63.

Flegal, K. M., Carroll, M. D., Ogden, C. L., & Curtin, L. R. (2010). Prevalence and trends in obesity among US adults, 1999-2008. *JAMA: The Journal of the American Medical Association, 303*(3), 235-241.

Fogelholm, M. (2010). Physical activity, fitness and fatness: Relations to mortality, morbidity and disease risk factors. A systematic review. *Obesity Reviews: An Official Journal of the International Association for the Study of Obesity 11*(3), 202-221.

Foster, C., Hillsdon, M., & Thorogood, M. (2004). Environmental perceptions and walking in english adults. *Journal of Epidemiology and Community Health 58*(11), 924-928.

Fox, C. S., Massaro, J. M., Hoffmann, U., Pou, K. M., Maurovich-Horvat, P., Liu, C. Y., et al. (2007). Abdominal visceral and subcutaneous adipose tissue compartments: Association with metabolic risk factors in the framingham heart study. *Circulation,116*(1), 39-48.

Frank, L., Engelke, P., & Schmid, T. (Eds.). (2003). *Health and community design. the impact of the built enviroment on physical activity*. Washington, DC: Island Press.

Frank, L., Kerr, J., Rosenberg, D., & King, A. (2010). Healthy aging and where you live: Community design relationships with physical activity and body weight in older americans. *Journal of Physical Activity & Health, 7 Suppl 1*, S82-90.

Frank, L. D., & Engelke, P. O. (2001). The built environment and human activity patterns: Exploring the impacts of urban form on public health. *Journal of Planning Literature, 16*(2), 202-218.

Fransoo, R., Martens, P., Prior, H., Chateau, D., McDougall, C., Schultz, J., et al. (2011). *Adult obesity in manitoba: Prevalence, associations & outcomes*. Manitoba Centre for Health Policy.

Freedson, P. S., & Miller, K. (2000). Objective monitoring of physical activity using motion sensors and heart rate. *Research Quarterly for Exercise and Sport, 71*(2 Suppl), S21-9.

Freitas, E. V., Py, L., Neri, A. L., Cançado, F. A. X. C., Gorzoni, M. L., & Doll, J. (Eds.). (2011). *Tratado de Geriatria e Gerontologia* (3rd ed.) Guanabara Koogan.

Fried, L. P., Tangen, C. M., Walston, J., Newman, A. B., Hirsch, C., Gottdiener, J., et al. (2001). Frailty in older adults: Evidence for a phenotype. *The Journals of Gerontology.Series A, Biological Sciences and Medical Sciences,56*(3), M146-56.

Gagliardi, C., Spazzafumo, L., Marcellini, F., Mollenkopf, H., Ruoppila, I. T.,.M., & Szemann, Z. (2007). The outdoor mobility and leisure activities of older people in five european countries. *Ageing & Society,27*, 683-700.

Galenkamp, H., Braam, A. W., Huisman, M., & Deeg, D. J. (2012). Seventeen-year time trend in poor self-rated health in older adults: Changing contributions of chronic diseases and disability. *European Journal of Public Health,*

Gallagher, N. A., Clarke, P. J., Ronis, D. L., Cherry, C. L., Nyquist, L., & Gretebeck, K. A. (2012). Influences on neighbourhood walking in older adults. *Research in Gerontological Nursing, 5*(4), 238-250.

Gandolfi, L. M., & Skora, M. C. (2001). Fisioterapia preventiva em grupos na terceira idade.
Fisioterapia em Movimento,13, 55-62.

Gemmill, E., Bayles, C.M., McTigue, K., Satariano, W., Sharma, R., Wilson, J.W. (2011). Factors associated wit adherence to an accelerometer protocol in older adults. *Journal of Physical Activity & Health*, 8(8), 1152-1159.

Giehl, M. W., Schneider, I. J., Corseuil, H. X., Benedetti, T. R., & d'Orsi, E. (2012). Physical activity and environment perception among older adults: A population study in florianopolis, brazil. *Revista De Saude Publica, 46*(3), 516-525.

Giles-Corti, B., & Donovan, R. J. (2003). Relative influences of individual, social environmental, and physical environmental correlates of walking. *American Journal of Public Health, 93*(9), 1583-1589.

Giles-Corti, B., & Donovan, R. J. (2002). Socioeconomic status differences in recreational physical activity levels and real and perceived access to a supportive physical environment. *Preventive Medicine, 35*(6), 601-611.

Gilmour, H., & Park, J. (2006). Dependency, chronic conditions and pain in seniors. *Health Reports / Statistics Canada, Canadian Centre for Health Information = Rapports Sur La Sante / Statistique Canada, Centre Canadien d'Information Sur La Sante, 16 Suppl*, 21-31.

Glass, T. A., Rasmussen, M. D., & Schwartz, B. S. (2006). Neighbourhoods and obesity in older adults: The baltimore memory study. *American Journal of Preventive Medicine, 31*(6), 455-463.

Gobbi, S., Sebastiao, E., Papini, C. B., Nakamura, P. M., Valdanha Netto, A., Gobbi, L. T., et al. (2012). Physical inactivity and related barriers: A study in a community dwelling of older brazilians. *Journal of Aging Research, 2012*, 685190.

Grafova, I. B., Freedman, V. A., Kumar, R., & Rogowski, J. (2008). Neighbourhoods and obesity in later life. *American Journal of Public Health, 98*(11), 2065-2071.

Granner, M. L., Sharpe, P. A., Hutto, B., Wilcox, S., & Addy, C. L. (2007). Perceived individual, social, and environmental factors for physical activity and walking. *Journal of Physical Activity & Health,4*(3), 278-293.

Grimm, E.K., Swartz, A.M., Hart, T., Miller, N.E., Strath, S.J. (2012). Comparison of the IPAQ-Short Form and accelerometry predictions of physical activity in older adults. *Journal of Aging and Physical Activity*, 20(1), 64-79.

Guralnik, J. M., Simonsick, E. M., Ferrucci, L., Glynn, R. J., Berkman, L. F., Blazer, D. G., et al. (1994). A short physical performance battery assessing lower extremity function: Association with self-reported disability and prediction of mortality and nursing home admission. *Journal of Gerontology, 49*(2), M85-94.

Gutiérrez, J., & García Palomares, J.C. (2008). Distance measure impacts in public transport service areas. *Environment and Planning B, 35*(3), 480-503.

Haley, S. M., Jette, A. M., Coster, W. J., Kooyoomjian, J. T., Levenson, S., Heeren, T., et al. (2002). Late life function and disability instrument: II. development and evaluation of the function component. *The Journals of Gerontology.Series A, Biological Sciences and Medical Sciences,57*(4), M217-22.

Hall, K. S., & McAuley, E. (2010). Individual, social environmental and physical environmental barriers to achieving 10 000 steps per day among older women. *Health Education Research*, *25*(3), 478-488.

Handy, S. L., Boarnet, M. G., Ewing, R., & Killingsworth, R. E. (2002). How the built environment affects physical activity: Views from urban planning. *American Journal of Preventive Medicine*,*23*(2 Suppl), 64-73.

Hanibuchi, T., Kondo, K., Nakaya, T., Nakade, M., Ojima, T., Hirai, H., et al. (2011). Neighbourhood food environment and body mass index among japanese older adults: Results from the aichi gerontological evaluation study (AGES). *International Journal of Health Geographics, 10*

Hardy, S. E., & Gill, T. M. (2005). Factors associated with recovery of independence among newly disabled older persons. *Archives of Internal Medicine*,*165*(1), 106-112.

Harris, T. J., Owen, C. G., Victor, C. R., Adams, R., & Cook, D. G. (2009). What factors are associated with physical activity in older people, assessed objectively by accelerometry? *British Journal of Sports Medicine*,*43*(6), 442-450.

Hayes, A.J., Kortt, M.A., Clarke, P.M., & Brandrup, J.D. (2008). Estimating equations to correct self-reported height and weight: Implications for prevalence of obesity in Australia. *Australian and New Zealand Journal of Public Health*,*32*(6), 542-545.

Health Canada. (2003). *Arthritis in canada. an ongoing challenge.* Retrieved 04/20, 2013, from http://www.phac-aspc.gc.ca/publicat/ac/pdf/ac_e.pdf

Hergenroeder, A. L., Brach, J. S., Otto, A. D., Sparto, P. J., & Jakicic, J. M. (2011). The influence of body mass index on self-report and performance-based measures of physical function in adult women. *Cardiopulmonary Physical Therapy Journal*, *22*(3), 11-20.

Herman, K. M., Hopman, W. M., Vandenkerkhof, E. G., & Rosenberg, M. W. (2012). Physical activity, body mass index, and health-related quality of life in canadian adults. *Medicine and Science in Sports and Exercise,44*(4), 625-636.

Hess, R. J., Brach, J. S., Piva, S. R., & VanSwearingen, J. M. (2010). Walking skill can be assessed in older adults: Validity of the figure-of-8 walk test. *Physical Therapy, 90*(1), 89-99.

Hillsdon, M. M., Brunner, E. J., Guralnik, J. M., & Marmot, M. G. (2005). Prospective study of physical activity and physical function in early old age. *American Journal of Preventive Medicine, 28*(3), 245-250.

Hirvensalo, M., Rantanen, T., & Heikkinen, E. (2000). Mobility difficulties and physical activity as predictors of mortality and loss of independence in the community-living older population. *Journal of the American Geriatrics Society,48*(5), 493-498.

Hoehner, C.M., Brennan Ramirez, L.K., Elliot, M.B., Handy, S.L., & Brownson, R.C. (2005). Percived and objective environmental measures and physical activity among urban adults. *American Journal of Preventive Medicine,28*(2 Suppl 2), 105-116.

Hou, X., Lu, J., Weng, J., Ji, L., Shan, Z., Liu, J., et al. (2013). Impact of waist circumference and body mass index on risk of cardiometabolic disorder and cardiovascular disease in chinese adults: A national diabetes and metabolic disorders survey. *PloS One, 8*(3), e57319.

Hovbrandt, P., Stahl. A., Iwarsson, S., Horstmann, V., & Carlsson, G. (2007). Very old people's use of the pedestrian environment: functional limitations, frequency, of activity and environmental demands. *European Journal of Ageing, 4*(4), 201-211.

Hubbard, R. E., Lang, I. A., Llewellyn, D. J., & Rockwood, K. (2010). Frailty, body mass index, and abdominal obesity in older people. *The Journals of Gerontology.Series A, Biological Sciences and Medical Sciences,65*(4), 377-381.

Humpel, N., Marshall, A. L., Leslie, E., Bauman, A., & Owen, N. (2004). Changes in neighbourhood walking are related to changes in perceptions of environmental attributes. *Annals of Behavioral Medicine : A Publication of the Society of Behavioral Medicine*,*27*(1), 60-67.

Hunter, G. R., McCarthy, J. P., & Bamman, M. M. (2004). Effects of resistance training on older adults. *Sports Medicine (Auckland, N.Z.), 34*(5), 329-348.

Hurtig-Wennlof, A., Hagstromer, M., & Olsson, L. A. (2010). The international physical activity questionnaire modified for the elderly: Aspects of validity and feasibility. *Public Health Nutrition*, 1-8.

Hutchison, E. D. (Ed.). (2011). *Dimensions of human behaviour: Person and environment.*
(4th ed.). Thousand Oaks, California: Sage Publications, Inc.

Huxley, R., Mendis, S., Zheleznyakov, E., Reddy, S., & Chan, J. (2010). Body mass index, waist circumference and waist:Hip ratio as predictors of cardiovascular risk--a review of the literature. *European Journal of Clinical Nutrition, 64*(1), 16-22.

IBM SPSS Statistics. (2011). Factor Analysis. Retrieved 07/04, 2013, from http://pic.dhe.ibm.com/infocenter/spssstat/v20r0m0/index.jsp?topic=%2Fcom.ibm.spss.statistics.help%2Fidh_fact.htm.

Inoue, M., Iso, H., Yamamoto, S., Kurahashi, N., Iwasaki, M., Sasazuki, S., et al. (2008). Daily total physical activity level and premature death in men and women: Results from a large-scale population-based cohort study in japan (JPHC study). *Annals of Epidemiology, 18*(7), 522-530.

Jacobs, E. J., Newton, C. C., Wang, Y., Patel, A. V., McCullough, M. L., Campbell, P. T., et al. (2010). Waist circumference and all-cause mortality in a large US cohort. *Archives of Internal Medicine,170*(15), 1293-1301.

Janssen, I., Heymsfield, S. B., & Ross, R. (2002). Low relative skeletal muscle mass (sarcopenia) in older persons is associated with functional impairment and physical disability. *Journal of the American Geriatrics Society,50*(5), 889-896.

Janssen, I., Katzmarzyk, P. T., & Ross, R. (2004). Waist circumference and not body mass index explains obesity-related health risk. *The American Journal of Clinical Nutrition, 79*(3), 379-384.

Jette, A. M. (2006). Toward a common language for function, disability, and health. *Physical Therapy, 86*(5), 726-734.

Jette, A. M., Haley, S. M., Coster, W. J., Kooyoomjian, J. T., Levenson, S., Heeren, T., et al. (2002). Late life function and disability instrument: I. development and evaluation of the disability component. *The Journals of Gerontology.Series A, Biological Sciences and Medical Sciences,57*(4), M209-16.

Kaczynski, A. T., & Henderson, K. A. (2008). Parks and recreation settings and active living: A review of associations with physical activity function and intensity. *Journal of Physical Activity & Health,5*(4), 619-632.

Katz, S., & Akpom, C. A. (1976). 12. index of ADL. *Medical Care, 14*(5 Suppl), 116-118.

Katzmarzyk, P. T., & Janssen, I. (2004). The economic costs associated with physical inactivity and obesity in canada: An update. *Canadian Journal of Applied Physiology = Revue Canadienne De Physiologie Appliquee, 29*(1), 90-115.

Kawachi, I., & Berkman, L. (Eds.). (2000). *Social epidemiology*. New York: Oxford University Press.

Kawachi, I., Subramanian, S. V., & Almeida-Fiho, N. (2002). A glossary for health inequalities. *Journal of Epidemiology & Community Health, 56*, 647-665.

Keeler, E., Guralnik, J. M., Tian, H., Wallace, R. B., & Reuben, D. B. (2010). The impact of functional status on life expectancy in older persons. *The Journals of Gerontology.Series A, Biological Sciences and Medical Sciences,65*(7), 727-733.

Kerr, J., Sallis, J. F., Saelens, B. E., Cain, K. L., Conway, T. L., Frank, L. D., et al. (2012). Outdoor physical activity and self rated health in older adults living in two regions of the U.S. *The International Journal of Behavioral Nutrition and Physical Activity,9*, 89-5868-9-89.

Keysor, J. J. (2003). Does late-life physical activity or exercise prevent or minimize disablement? A critical review of the scientific evidence. *American Journal of Preventive Medicine*, *25*(3 Suppl 2), 129-136.

Keysor, J. J., & Jette, A. M. (2001). Have we oversold the benefit of late-life exercise? *The Journals of Gerontology.Series A, Biological Sciences and Medical Sciences, 56*(7), M412-23.

Keysor, J. J., Jette, A. M., LaValley, M. P., Lewis, C. E., Torner, J. C., Nevitt, M. C., et al. (2010). Community environmental factors are associated with disability in older adults with functional limitations: The MOST study. *The Journals of Gerontology.Series A, Biological Sciences and Medical Sciences,65*(4), 393-399.

King, A. C., Sallis, J. F., Frank, L. D., Saelens, B. E., Cain, K., Conway, T. L., et al. (2011). Aging in neighbourhoods differing in walkability and income: Associations with physical activity and obesity in older adults. *Social Science and Medicine,73*(10), 1525-1533.

King, D. (2008). Neighbourhood and individual factors in activity in older adults: Results from the neighbourhood and senior health study. *Journal of Aging and Physical Activity,16*(2), 144-170.

King, W.C., Belle, S.H., Brach, J.S., Simkin-Silverman, L.R., Soska, T., & Krista, A. M. (2005). Objective measures of neighbourhood environment and physical activity in older women. *American Journal of Preventive Medicine, 28*(5), 461-469.

Kolbe-Alexander, T. L., Lambert, E. V., Harkins, J. B., & Ekelund, U. (2006). Comparison of two methods of measuring physical activity in south african older adults. *Journal of Aging and Physical Activity,14*(1), 98-114.

Koster, A., Bosma, H., Broese van Groenou, M. I., Kempen, G. I., Penninx, B. W., van Eijk, J. T., et al. (2006). Explanations of socioeconomic differences in changes in physical function in older adults: Results from the longitudinal aging study amsterdam. *BMC Public Health, 6*, 244.

Koster, A., Patel, K. V., Visser, M., van Eijk, J. T., Kanaya, A. M., de Rekeneire, N., et al. (2008). Joint effects of adiposity and physical activity on incident mobility limitation in older adults. *Journal of the American Geriatrics Society, 56*(4), 636-643.

Kubo, K., Ishida, Y., Suzuki, S., Komuro, T., Shirasawa, H., Ishiguro, N., et al. (2008). Effects of 6 months of walking training on lower limb muscle and tendon in elderly. *Scandinavian Journal of Medicine & Science in Sports*, *18*(1), 31-39.

Lamb, S. E., Bartlett, H. P., Ashley, A., & Bird, W. (2002). Can lay-led walking programmes increase physical activity in middle aged adults? A randomised controlled trial. *Journal of Epidemiology and Community Health,56*(4), 246-252.

Landi, F., Abbatecola, A. M., Provinciali, M., Corsonello, A., Bustacchini, S., Manigrasso, L., et al. (2010). Moving against frailty: Does physical activity matter? *Biogerontology*, *11*(5), 537-545.

Lang, I. A., Llewellyn, D. J., Alexander, K., & Melzer, D. (2008). Obesity, physical function, and mortality in older adults. *Journal of the American Geriatrics Society,56*(8), 1474-1478.

Larson, N. I., Story, M. T., & Nelson, M. C. (2009). Neighbourhood environments: Disparities in access to healthy foods in the U.S. *American Journal of Preventive Medicine, 36*(1), 74-81.

Lawton, M. P. (1977). The impact of the environment on aging and behavior. In J. E. Birren, & K. W. Schaie (Eds.), *Handbook of the psychology of aging* (pp. 276-301). New York: Van Nostrand.

Lee, Y. S. (2005). Gender differences in physical activity and walking among older adults. *Journal of Women & Aging, 17*(1-2), 55-70.

Leslie, E., Saelens, B., Frank, L., Owen, N., Bauman, A., Coffee, N., et al. (2005). Residents' perceptions of walkability attributes in objectively different neighbourhoods: A pilot study. *Health & Place, 11*(3), 227-236.

Li, F., Fisher, J., & Brownson, R. C. (2005a). A multilevel analysis of change in neighbourhood walking activity in older adults. *Journal of Aging and Physical Activity,13*(2), 145-159.

Li, F., Fisher, K. J., Brownson, R. C., & Bosworth, M. (2005b). Multilevel modelling of built environment characteristics related to neighbourhood walking activity in older adults. *Journal of Epidemiology and Community Health, 59*(7), 558-564.

Li, F., Harmer, P., Cardinal, B. J., Bosworth, M., Johnson-Shelton, D., Moore, J. M., et al. (2009a). Built environment and 1-year change in weight and waist circumference in middle-aged and older adults: Portland neighbourhood environment and health study. *American Journal of Epidemiology, 169*(4), 401-408.

Li, F., Harmer, P., Cardinal, B. J., Bosworth, M., & Johnson-Shelton, D. (2009b). Obesity and the built environment: Does the density of neighbourhood fast-food outlets matter? *American Journal of Health Promotion : AJHP, 23*(3), 203-209.

Li, F., Harmer, P. A., Cardinal, B. J., Bosworth, M., Acock, A., Johnson-Shelton, D., et al. (2008). Built environment, adiposity, and physical activity in adults aged 50-75. *American Journal of Preventive Medicine, 35*(1), 38-46.

Lim, K., & Taylor, L. (2005). Factors associated with physical activity among older people--a population-based study. *Preventive Medicine, 40*(1), 33-40.

Lin, Y. C., Yeh, M. C., Chen, Y. M., & Huang, L. H. (2010). Physical activity status and gender differences in community-dwelling older adults with chronic diseases. *The Journal of Nursing Research: JNR, 18*(2), 88-97.

Littbrand, H., Stenvall, M., & Rosendahl, E. (2011). Applicability and effects of physical exercise on physical and cognitive functions and activities of daily living among people with dementia: A systematic review. *American Journal of Physical Medicine & Rehabilitation / Association of Academic Physiatrists,90*(6), 495-518.

Lovasi, G. S., Hutson, M. A., Guerra, M., & Neckerman, K. M. (2009). Built environments and obesity in disadvantaged populations. *Epidemiologic Reviews, 31*, 7-20.

Macfarlane, D. J., Lee, C. C., Ho, E. Y., Chan, K. L., & Chan, D. (2006). Convergent validity of six methods to assess physical activity in daily life. *Journal of Applied Physiology (Bethesda, Md.: 1985), 101*(5), 1328-1334.

Maddison, R., & Ni Mhurchu, C. (2009). Global positioning system: A new opportunity in physical activity measurement. *The International Journal of Behavioral Nutrition and Physical Activity, 6*, 73.

Maniecka-Bryla, I., Gajewska, O., Burzynska, M., & Bryla, M. (2013). Factors associated with self-rated health (SRH) of a university of the third age (U3A) class participants. *Archives of Gerontology and Geriatrics,57*(2)*, 156-161.*

Manini, T. M., & Pahor, M. (2009). Physical activity and maintaining physical function in older adults. *British Journal of Sports Medicine, 43*(1), 28-31.

Manty, M., Heinonen, A., Viljanen, A., Pajala, S., Koskenvuo, M., Kaprio, J., et al. (2009). Outdoor and indoor falls as predictors of mobility limitation in older women. *Age and Ageing, 38*(6), 757-761.

Marsh, A. P., Rejeski, W. J., Espeland, M. A., Miller, M. E., Church, T. S., Fielding, R. A., et al. (2011). Muscle strength and BMI as predictors of major mobility disability in the lifestyle interventions and independence for elders pilot (LIFE-P). *The Journals of Gerontology.Series A, Biological Sciences and Medical Sciences, 66*(12), 1376-1383.

McAuley, E., Konopack, J. F., Motl, R. W., Rosengren, K., & Morris, K. S. (2005). Measuring disability and function in older women: Psychometric properties of the late-life function and disability instrument. *The Journals of Gerontology.Series A, Biological Sciences and Medical Sciences, 60*(7), 901-909.

McAuley, E., Morris, K. S., Doerksen, S. E., Motl, R. W., Liang, H., White, S. M., et al. (2007). Effects of change in physical activity on physical function limitations in older women: Mediating roles of physical function performance and self-efficacy. *Journal of the American Geriatrics Society, 55*(12), 1967-1973.

McGinn, A.P., Evenson, K.R., Herring A.H., & Huston S.L. (2007a). The relationship between leisure, walking, and transportation activity with the natural environment. Health and Place, 12(3), 588-602.

McGinn, A.P., Evenson, K.R., Herring A.H., Huston S.L., & Rodriguez, D.A. (2007b). Exploring the associations between physical activity and perceived and objective measures of the built environment. *Journal of Urban Health, 84*(2), 162-184.

McGuire, A., & Ross, R. (2008). *The revision of the measurement of waist circumference in the CPAFLA.* Retrieved 05/03, 2012, from http://www.csep.ca/english/view.asp?x=724&id=84

McMurdo, M. E., Argo, I., Crombie, I. K., Feng, Z., Sniehotta, F. F., Vadiveloo, T., et al. (2012). Social, environmental and psychological factors associated with objective physical activity levels in the over 65s. *PloS One, 7*(2), e31878.

Melzer, I., & Kurz, I. (2009). Self reported function and disability in late life: A comparison between recurrent fallers and non-fallers. *Disability and Rehabilitation, 31*(10), 791-798.

Mendes de Leon, C. F., Cagney, K. A., Bienias, J. L., Barnes, L. L., Skarupski, K. A., Scherr, P. A., et al. (2009). Neighbourhood social cohesion and disorder in relation to walking in community-dwelling older adults: A multilevel analysis. *Journal of Aging and Health, 21*(1), 155-171.

Merrian-Webster Dictionary. (2010). *Definition of ecology.* Retrieved 11/16, 2010, from http://www.merriam-webster.com/dictionary/ecology.

Michael, Y., Beard, T., Choi, D., Farquhar, S., & Carlson, N. (2006). Measuring the influence of built neighbourhood environments on walking in older adults. *Journal of Aging and Physical Activity, 14*(3), 302-312.

Michael, Y. L., Gold, R., Perrin, N., & Hillier, T. A. (2013). Built environment and change in body mass index in older women. *Health & Place, 22C*, 7-10.

Michael, Y. L., Perdue, L. A., Orwoll, E. S., Stefanick, M. L., Marshall, L. M., & Osteoporotic Fractures in Men Study Group. (2010). Physical activity resources and changes in walking in a cohort of older men. *American Journal of Public Health, 100*(4), 654-660.

Michael, Y.L., Keast, E.M., Chaudhury, H., Day, K., Mahmood, A., & Sarte, A.F. (2009). Revisiting the Senior Walking Environmental Assessment Tool. *Preventive Medicine*, *48*(3), 247-249.

Miles, R., & Panton, L. (2006). The influence of the perceived quality of community environments on low-income women's efforts to walk more. *Journal of Community Health*, *31*(5), 379-392.

Miszko, T. A., Cress, M. E., Slade, J. M., Covey, C. J., Agrawal, S. K., & Doerr, C. E. (2003). Effect of strength and power training on physical function in community-dwelling older adults. *The Journals of Gerontology.Series A, Biological Sciences and Medical Sciences*, *58*(2), 171-175.

Montoye, H. J., Kemper, H. C. G., Saris, W. H. M., & Washburn, R. A. (Eds.). (1996). *Measuring physical activity and energy expenditure*. United States of America: Human Kinetics.

Morey, M. C., Pieper, C. F., & Cornoni-Huntley, J. (1998). Is there a threshold between peak oxygen uptake and self-reported physical functioning in older adults? *Medicine and Science in Sports and Exercise,30*(8), 1223-1229.

Morey, M. C., Sloane, R., Pieper, C. F., Peterson, M. J., Pearson, M. P., Ekelund, C. C., et al. (2008). Effect of physical activity guidelines on physical function in older adults. *Journal of the American Geriatrics Society,56*(10), 1873-1878.

Moschny, A., Platen, P., Klaassen-Mielke, R., Trampisch, U., & Hinrichs, T. (2011). Barriers to physical activity in older adults in germany: A cross-sectional study. *The International Journal of Behavioral Nutrition and Physical Activity,8*, 121-5868-8-121.

Motl, R. W., & McAuley, E. (2010). Physical activity, disability, and quality of life in older adults. *Physical Medicine and Rehabilitation Clinics of North America*, *21*, 299-308.

Murphy, S. L. (2009). Review of physical activity measurement using accelerometers in older adults: Considerations for research design and conduct. *Preventive Medicine, 48*(2), 108-114.

Murtagh, E. M., Murphy, M. H., & Boone-Heinonen, J. (2010). Walking: The first steps in cardiovascular disease prevention. *Current Opinion in Cardiology, 25*(5), 490-496.

Nagel, C. L., Carlson, N. E., Bosworth, M., & Michael, Y. L. (2008). The relation between neighbourhood built environment and walking activity among older adults. *American Journal of Epidemiology, 168*(4), 461-468.

Nam, S., Kuo, Y. F., Markides, K. S., & Al Snih, S. (2012). Waist circumference (WC), body mass index (BMI), and disability among older adults in latin american and the caribbean (LAC). *Archives of Gerontology and Geriatrics,55*(2), e40-7.

Nied, R. J., & Franklin, B. (2002). Promoting and prescribing exercise for the elderly. *American Family Physician, 65*(3), 419-426.

Nilsson, C. J., Avlund, K., & Lund, R. (2010). Social inequality in onset of mobility disability among older danes: The mediation effect of social relations. *Journal of Aging and Health, 22*(4), 522-541.

Olivares, P. R., Gusi, N., Prieto, J., & Hernandez-Mocholi, M. A. (2011). Fitness and health-related quality of life dimensions in community-dwelling middle aged and older adults. *Health and Quality of Life Outcomes, 9*(1), 117.

Orsini, N., Bellocco, R., Bottai, M., Hagstromer, M., Sjostrom, M., Pagano, M., et al. (2008). Profile of physical activity behaviors among swedish women aged 56-75 years. *Scandinavian Journal of Medicine & Science in Sports, 18*(1), 95-101.

Owen, N., Cerin, E., Leslie, E., duToit, L., Coffee, N., Frank, L., Bauman, A., Hugo, G., Saelens, B. E., & Sallis, J. F. (2007). Neighbourhood walkability and the walking behavior of Australian adults. *American Journal of Preventive Medicine, 33*(5), 387-392.

Papas, M. A., Alberg, A. J., Ewing, R., Helzlsouer, K. J., Gary, T. L., & Klassen, A. C. (2007). The built environment and obesity. *Epidemiologic Reviews,29*, 129-143.

Patel, A.A., Donegan, D., & Albert, T. (2007). The 36-item short form. Journal of the American Academy of Orthopaedic Surgeons, 15(2), 126-134.

Poortinga, W. (2006). Perceptions of the environment, physical activity, and obesity. *Social Science & Medicine (1982), 63*(11), 2835-2846.

Poortinga, W., Dunstan, F. D., & Fone, D. L. (2007). Perceptions of the neighbourhood environment and self rated health: A multilevel analysis of the caerphilly health and social needs study. *BMC Public Health, 7*, 285.

Rejeski, W. J., Marsh, A. P., Chmelo, E., & Rejeski, J. J. (2010). Obesity, intentional weight loss and physical disability in older adults. *Obesity Reviews : An Official Journal of the International Association for the Study of Obesity, 11*(9), 671-685.

Reuben, D.B., Valle, L.A., Hays, R.D., & Siu, A.L. (1995). Measuring physical function in community dwelling older persons - A comparison of self administered, interviewer – administered, and performance-based measures. *Journal of the American Geriatrics Society*, *43*(1), 17-23.

Reuben, D. B., & Siu, A. L. (1990). An objective measure of physical function of elderly outpatients. the physical performance test. *Journal of the American Geriatrics Society, 38*(10), 1105-1112.

Riebe, D., Blissmer, B. J., Greaney, M. L., Garber, C. E., Lees, F. D., & Clark, P. G. (2009). The relationship between obesity, physical activity, and physical function in older adults. *Journal of Aging and Health, 21*(8), 1159-1178.

Rikli, R. E., & Jones, C. J. (1999). Development and validation of a functional fitness test for community-residing older adults. *Journal of Aging and Physical Activity,7(2),* 129-161.

Rodriguez, D. A., & Joo, J. (2004). The relationship between non-motorized mode choice and the local physical environment. *Transportation Research Part D: Transport and Environment, 9*, 151-173.

Rolland, Y., Lauwers-Cances, V., Cristini, C., Abellan van Kan, G., Janssen, I., Morley, J. E., et al. (2009). Difficulties with physical function associated with obesity, sarcopenia, and sarcopenic-obesity in community-dwelling elderly women: The EPIDOS (EPIDemiologie de l'OSteoporose) study. *The American Journal of Clinical Nutrition, 89*(6), 1895-1900.

Rooks, D. S., Kiel, D. P., Parsons, C., & Hayes, W. C. (1997). Self-paced resistance training and walking exercise in community-dwelling older adults: Effects on neuromotor performance. *The Journals of Gerontology.Series A, Biological Sciences and Medical Sciences*, *52*(3), M161-8.

Rosenberg, D., Kerr, J., Sallis, J. F., Patrick, K., Moore, D. J., & King, A. (2009). Feasibility and outcomes of a multilevel place-based walking intervention for seniors: A pilot study. *Health & Place, 15*(1), 173-179.

Rosenberg, D. E., Huang, D. L., Simonovich, S. D., & Belza, B. (2013). Outdoor built environment barriers and facilitators to activity among midlife and older adults with mobility disabilities. *The Gerontologist, 53*(2), 268-279.

Ross, R., Berentzen, T., Bradshaw, A. J., Janssen, I., Kahn, H. S., Katzmarzyk, P. T., et al. (2008). Does the relationship between waist circumference, morbidity and mortality depend on measurement protocol for waist circumference? *Obesity Reviews: An Official Journal of the International Association for the Study of Obesity*, *9*(4), 312-325.

Rosso, A. L., Auchincloss, A. H., & Michael, Y. L. (2011). The urban built environment and mobility in older adults: A comprehensive review. *Journal of Aging Research, 2011*, 816106.

Rubenstein, L. Z., & Josephson, K. R. (2002). The epidemiology of falls and syncope. *Clinics in Geriatric Medicine, 18*(2), 141-158.

Saelens, B. E., & Handy, S. L. (2008). Built environment correlates of walking: A review. *Medicine and Science in Sports and Exercise,40*(7 Suppl), S550-66.

Saelens, B. E., Sallis, J. F., Black, J. B., & Chen, D. (2003). Neighbourhood-based differences in physical activity: An environment scale evaluation. *American Journal of Public Health*, *93*(9), 1552-1558.

Salihu, H. M., Bonnema, S. M., & Alio, A. P. (2009). Obesity: What is an elderly population growing into? *Maturitas, 63*(1), 7-12.

Sallis, J. F., King, A. C., Sirard, J. R., & Albright, C. L. (2007). Perceived environmental predictors of physical activity over 6 months in adults: Activity counseling trial. *Health Psychology : Official Journal of the Division of Health Psychology, American Psychological Association, 26*(6), 701-709.

Sallis, J. F., Cervero, R. B., Ascher, W., Henderson, K. A., Kraft, M. K., & Kerr, J. (2006). An ecological approach to creating active living communities. *Annual Review of Public Health, 27*(1), 297-322.

Samper-Ternent, R., & Al Snih, S. (2012). Obesity in older adults: Epidemiology and implications for disability and disease. *Reviews in Clinical Gerontology,22*(1), 10-34.

Satariano, W. A., Ivey, S. L., Kurtovich, E., Kealey, M., Hubbard, A. E., Bayles, C. M., et al. (2010). Lower-body function, neighbourhoods, and walking in an older population. *American Journal of Preventive Medicine, 38*(4), 419-428.

Sattelmair, J. R., Pertman, J. H., & Forman, D. E. (2009). Effects of physical activity on cardiovascular and noncardiovascular outcomes in older adults. *Clinics in Geriatric Medicine, 25*(4), 677-702, viii-ix.

Sayers, S. P., Jette, A. M., Haley, S. M., Heeren, T. C., Guralnik, J. M., & Fielding, R. A. (2004). Validation of the late-life function and disability instrument. *Journal of the American Geriatrics Society, 52*(9), 1554-1559.

Schuit, A. J., Schouten, E. G., Westerterp, K. R., & Saris, W. H. (1997). Validity of the physical activity scale for the elderly (PASE): According to energy expenditure assessed by the doubly labeled water method. *Journal of Clinical Epidemiology, 50*(5), 541-546.

Schwartz, C. E., Andresen, E. M., Nosek, M. A., Krahn, G. L., & RRTC Expert Panel on Health Status Measurement. (2007). Response shift theory: Important implications for measuring quality of life in people with disability. *Archives of Physical Medicine and Rehabilitation, 88*(4), 529-536.

Shah, R. C., Buchman, A. S., Boyle, P. A., Leurgans, S. E., Wilson, R. S., Andersson, G. B., et al. (2011). Musculoskeletal pain is associated with incident mobility disability in community-dwelling elders. *The Journals of Gerontology.Series A, Biological Sciences and Medical Sciences, 66*(1), 82-88.

Shephard, R. J. (Ed.). (1997). *Aging, physical activity and health.* Toronto, Ontario: Human Kinetics Publishers.

Sherman, S. E., & Reuben, D. (1998). Measures of functional status in community-dwelling elders. *Journal of General Internal Medicine, 13*(12), 817-823.

Shields, M., Gorber, S. C., & Tremblay, M. S. (2008). Estimates of obesity based on self-report versus direct measures. *Health Reports / Statistics Canada, Canadian Centre for Health Information = Rapports Sur La Sante / Statistique Canada, Centre Canadien d'Information Sur La Sante, 19*(2), 61-76.

Shields, M., & Tremblay, M. S. (2008). Sedentary behaviour and obesity. *Health Reports / Statistics Canada, Canadian Centre for Health Information = Rapports Sur La Sante / Statistique Canada, Centre Canadien d'Information Sur La Sante, 19*(2), 19-30.

Shigematsu, R., Sallis, J. F., Conway, T. L., Saelens, B. E., Frank, L. D., Cain, K. L., et al. (2009). Age differences in the relation of perceived neighbourhood environment to walking. *Medicine and Science in Sports and Exercise, 41*(2), 314-321.

Shimada, H., Ishizaki, T., Kato, M., Morimoto, A., Tamate, A., Uchiyama, Y., et al. (2010). How often and how far do frail elderly people need to go outdoors to maintain functional capacity? *Archives of Gerontology and Geriatrics, 50*(2), 140-146.

Shumway-Cook, A., Ciol, M. A., Yorkston, K. M., Hoffman, J. M., & Chan, L. (2005). Mobility limitations in the medicare population: Prevalence and sociodemographic and clinical correlates. *Journal of the American Geriatrics Society, 53*(7), 1217-1221.

Shumway-Cook, A., Patla, A., Stewart, A., Ferrucci, L., Ciol, M. A., & Guralnik, J. M. (2003). Environmental components of mobility disability in community-living older persons. *Journal of the American Geriatrics Society, 51*(3), 393-398.

Shumway-Cook, A., Patla, A. E., Stewart, A., Ferrucci, L., Ciol, M. A., & Guralnik, J. M. (2002). Environmental demands associated with community mobility in older adults with and without mobility disabilities. *Physical Therapy, 82*(7), 670-681.

Sisson, S. (2005). Taking it to the streets. physical activity and the built environment: Part one. *ACSM's Health and Fitness Journal, 9*(6), 8-11.

Snijder, M. B., van Dam, R. M., Visser, M., & Seidell, J. C. (2006). What aspects of body fat are particularly hazardous and how do we measure them? *International Journal of Epidemiology, 35*(1), 83-92.

Snijder, M. B., Zimmet, P. Z., Visser, M., Dekker, J. M., Seidell, J. C., & Shaw, J. E. (2004). Independent and opposite associations of waist and hip circumferences with diabetes, hypertension and dyslipidemia: The AusDiab study. *International Journal of Obesity and Related Metabolic Disorders: Journal of the International Association for the Study of Obesity, 28*(3), 402-409.

Snyder, A., Colvin, B., & Gammack, J.K. (2011). Pedometer use increases daily steps and functional status in older adults. Journal of the American Medical Directors Association, 12(8), 590-594.

Sodlerlund, A., Fischer, A., & Johansson, T. (2009). Physical activity, diet and behaviour modification in the treatment of overweight and obese adults: A systematic review. *Perspectives in Public Health, 129*(3), 132-142.

Spence, J. C., & Lee, R. E. (2003). Toward a comprehensive model of physical activity. *Psychology of Sport Exercise, 4*, 7-24.

Spencer, E. A., Roddam, A. W., & Key, T. J. (2004). Accuracy of self-reported waist and hip measurements in 4492 EPIC-oxford participants. *Public Health Nutrition, 7*(6), 723-727.

Sprangers, M. A., & Schwartz, C. E. (1999). Integrating response shift into health-related quality of life research: A theoretical model. *Social Science & Medicine (1982), 48*(11), 1507-1515.

Statistics Canada. (2006). *The participation and activity limitation survey.* Retrieved 01/21, 2011, from http://www.statcan.gc.ca/pub/89-628-x/89-628-x2007002-eng.pdf

Statistics Canada. (2007). *A portrait of seniors in canada* No. 89-519-XIE)Statistics Canada.

Statistics Canada. (2008). *The 2006 participation and activity limitation survey: Analytical report.* Retrieved 20/04, 2013, from http://www.statcan.gc.ca/pub/89-628-x/2007002/4125019-eng.htm

Statistics Canada. (2009). 2006 census: portrait of the canadian population in 2006, by age and sex: Subprovincial population dynamics. Retrieved 07/03, 2012, from http://www12.statcan.ca/census-recensement/2006/as-sa/97-551/p17-eng.cfm

Statistics Canada. (2010). Population projections for Canada, provinces and territories 2009 to 2036. Retrieved 20/07, 2011, from http://www.statcan.gc.ca/pub/91-520-x/91-520-x2010001-eng.pdf

Statistics Canada. (2011a). Canadian health measures survey: Adult obesity prevalence in canada and the united states. Retrieved 22/03, 2012, from http://www.statcan.gc.ca/daily-quotidien/110302/dq110302c-eng.htm

Statistics Canada. (2011b). *Leading causes of death.* Retrieved 03/07, 2012, from http://www.statcan.gc.ca/daily-quotidien/111101/dq111101b-eng.htm

Statistics Canada. (2012a). *Canadian community health survey, 2011,* Statistics Canada.

Statistics Canada. (2012b). *Life expectancy, at birth and at age 65, by sex and by province and territory.* Retrieved 20/04, 2013, from http://www.statcan.gc.ca/tables-tableaux/sum-som/l01/cst01/health72a-eng.htm

Stewart, C. M., Wheeler, T. L.,2nd, Markland, A. D., Straughn, J. M.,Jr, & Richter, H. E. (2009). Life-space assessment in urogynecology and gynecological oncology surgery patients: A measure of perioperative mobility and function. *Journal of the American Geriatrics Society, 57*(12), 2263-2268.

Stokols, D. (1992). Establishing and maintaining healthy environments: Toward a social ecology of health promotion. *American Psychologist, 47*(1), 6-22.

Stommel, M., & Schoenborn, C. A. (2009). Accuracy and usefulness of BMI measures based on self-reported weight and height: Findings from the NHANES & NHIS 2001-2006. *BMC Public Health, 9*, 421.

Strath, S. J., Greenwald, M. J., Isaacs, R., Hart, T. L., Lenz, E. K., Dondzila, C. J., et al. (2012). Measured and perceived environmental characteristics are related to accelerometer defined physical activity in older adults. *The International Journal of Behavioral Nutrition and Physical Activity, 9*, 40-5868-9-40.

Strath, S. J., Schwartz, A. M., & Cashin, S. E. (2009). Ambulatory physical activity profiles of older adults. *Journal of Aging and Physical Activity, 17*(1), 46-56.

Strobl, R., Muller, M., Emeny, R., Peters, A., & Grill, E. (2013). Distribution and determinants of functioning and disability in aged adults - results from the german KORA-age study. *BMC Public Health, 13*(1), 137.

Sugiyama, T., Thompson, C. W., & Alves, S. (2009). Associations between neighbourhood open space attributes and quality of life for older people in britain. *Environment and Behavior, 41*(1), 3-21.

Suminski, R. R., Poston, W. S., Petosa, R. L., Stevens, E., & Katzenmoyer, L. M. (2005). Features of the neighbourhood environment and walking by U.S. adults. *American Journal of Preventive Medicine, 28*(2), 149-155.

Swinburn, B., Egger, G., & Raza, F. (1999). Dissecting obesogenic environments: The development and application of a framework for identifying and prioritizing environmental interventions for obesity. *Preventive Medicine, 29*(6 Pt 1), 563-570.

Syddall, H. E., Martin, H. J., Harwood, R. H., Cooper, C., & Aihie Sayer, A. (2009). The SF-36: A simple, effective measure of mobility-disability for epidemiological studies. *The Journal of Nutrition, Health & Aging, 13*(1), 57-62.

Tjepkema, M. (2004). Adult obesity in Canada: Measured height and weight No. 82-620-MWE2005001). Ottawa, Ontario: Statistics Canada.

Togo, F., Watanabe, E., Park, H., Yasunaga, A., Park, S., Shephard, R. J., et al. (2008). How many days of pedometer use reliably predict the annual activity of the elderly? the nakanojo study. *Journal of Aging and Physical Activity, 16,* S35-S35.

Tomioka, K., Iwanoto, J., Saeki, K., Okamoto, N. (2011). Reliability and validity of the International Physical Activity Questionnaire (IPAQ) in the elderly adults: the Fujiwara-kyo Study. *Journal of Epidemiology*, 21(6), 459-465.

Tseng, C. N., Gau, B. S., & Lou, M. F. (2011). The effectiveness of exercise on improving cognitive function in older people: A systematic review. *The Journal of Nursing Research : JNR, 19*(2), 119-131.

Tucker-Seeley, R. D., Subramanian, S. V., Li, Y., & Sorensen, G. (2009). Neighbourhood safety, socioeconomic status, and physical activity in older adults. *American Journal of Preventive Medicine, 37*(3), 207-213.

Tudor-Locke, C. (2003). *Mampo-kei: The art and science of steps counting*. Victoria, British Columbia: Trafford.

Tudor-Locke, C., Burkett, L., Reis, J. P., Ainsworth, B. E., Macera, C. A., & Wilson, D. K. (2005). How many days of pedometer monitoring predict weekly physical activity in adults? *Preventive Medicine, 40*(3), 293-298.

Tudor-Locke, C., Craig, C. L., Aoyagi, Y., Bell, R. C., Croteau, K. A., De Bourdeaudhuij, I., et al. (2011). How many steps/day are enough? for older adults and special populations. *The International Journal of Behavioral Nutrition and Physical Activity, 8*, 80.

Tudor-Locke, C., Craig, C. L., Thyfault, J. P., & Spence, J. C. (2013). A step-defined sedentary lifestyle index: <5000 steps/day. *Applied Physiology, Nutrition, and Metabolism = Physiologie Appliquee, Nutrition Et Metabolisme, 38*(2), 100-114.

Tudor-Locke, C., Hart, T. L., & Washington, T. L. (2009). Expected values for pedometer-determined physical activity in older populations. *The International Journal of Behavioral Nutrition and Physical Activity, 6,* 59.

Tudor-Locke, C., Williams, J. E., Reis, J. P., & Pluto, D. (2002). Utility of pedometers for assessing physical activity: Convergent validity. *Sports Medicine (Auckland, N.Z.), 32*(12), 795-808.

Tudor-Locke, C. E., Bell, R. C., Myers, A. M., Harris, S. B., Lauzon, N., & Rodger, N. W. (2002). Pedometer-determined ambulatory activity in individuals with type 2 diabetes. *Diabetes Research and Clinical Practice,55*(3), 191-199.

United Nations. (2009). *World population aging*. New York: United Nations.

United States Census Bureau. (2000). Decennial Management Division Glossary. Retrieved 09/08, 2013, from http://www.census.gov/dmd/www/glossary.html

US Department of Health and Human Services. (2013). Physical activity guidelines for Americans. Retrieved 07/11, 2013, from http://www.health.gov/paguidelines/default.aspx

van der Bij, A. K., Laurant, M. G., & Wensing, M. (2002). Effectiveness of physical activity interventions for older adults: A review. *American Journal of Preventive Medicine, 22*(2), 120-133.

Vincent, H. K., Vincent, K. R., & Lamb, K. M. (2010). Obesity and mobility disability in the older adult. *Obesity Reviews : An Official Journal of the International Association for the Study of Obesity, 11*(8), 568-579.

Visser, M., Simonsick, E. M., Colbert, L. H., Brach, J., Rubin, S. M., Kritchevsky, S. B., et al. (2005). Type and intensity of activity and risk of mobility limitation: The mediating role of muscle parameters. *Journal of the American Geriatrics Society, 53*(5), 762-770.

Vogel, T., Brechat, P. H., Lepretre, P. M., Kaltenbach, G., Berthel, M., & Lonsdorfer, J. (2009). Health benefits of physical activity in older patients: A review. *International Journal of Clinical Practice, 63*(2), 303-320.

von Bonsdorff, M., Rantanen, T., Laukkanen, P., Suutama, T., & Heikkinen, E. (2006). Mobility limitations and cognitive deficits as predictors of institutionalization among community-dwelling older people. *Gerontology, 52*(6), 359-365.

Wagemakers, A., Vaandrager, L., Koelen, M., Saan, H., & Leeuwis, C. (2010). Community health promotion: A framework to facilitate and evaluate supportive social environments for health. *Evaluation and Program Planning, 33*, 428-435.

Wahl, H. W., & Weisman, G. D. (2003). Environmental gerontology at the beginning of the new millennium: Reflections on its historical, empirical, and theoretical development. *The Gerontologist, 43*(5), 616-627.

Wallace, M., Shelkey, M., & Hartford Institute for Geriatric Nursing. (2007). Katz index of independence in activities of daily living (ADL). *Urologic Nursing, 27*(1), 93-94.

Warburton, D. E., Nicol, C. W., & Bredin, S. S. (2006). Health benefits of physical activity: The evidence. *CMAJ : Canadian Medical Association Journal = Journal De l'Association Medicale Canadienne, 174*(6), 801-809.

Washburn, R. A., & Ficker, J. L. (1999). Physical activity scale for the elderly (PASE): The relationship with activity measured by a portable accelerometer. *The Journal of Sports Medicine and Physical Fitness, 39*(4), 336-340.

Washburn, R. A., Smith, K. W., Jette, A. M., & Janney, C. A. (1993). The physical activity scale for the elderly (PASE): Development and evaluation. *Journal of Clinical Epidemiology, 46*(2), 153-162.

Ware, J. E.,Jr, & Sherbourne, C. D. (1992). The MOS 36-item short-form health survey (SF-36). I. conceptual framework and item selection. *Medical Care, 30*(6), 473-483.

Webber, S.C. & Porter, M.M. (2009). Monitoring mobility in older adults using global positioning system (GPS) watches and accelerometers: a feasibility study. *Journal of Aging and Physical Activity*, 17(4), 455-467.

Wen, M., Hawkley, L. C., & Cacioppo, J. T. (2006). Objective and perceived neighbourhood environment, individual SES and psychosocial factors, and self-rated health: An analysis of older adults in cook county, illinois. *Social Science & Medicine (1982), 63*(10), 2575-2590.

Wendel-Vos, W., Droomers, M., Kremers, S., Brug, J., & van Lenthe, F. (2007). Potential environmental determinants of physical activity in adults: A systematic review. *Obesity Reviews: An Official Journal of the International Association for the Study of Obesity, 8*(5), 425-440.

Wendel-Vos, W., Schuit, A.J., De Niet, R., Boshuizen, H.C., Saris, W.H.M., & Kromhout, D. (2004). Factors of the physical environment associated with walking and bicycling. *Medicine Science in Sports and Exercise, 36*(4), 725-730.

Weuve, J., Kang, J. H., Manson, J. E., Breteler, M. M., Ware, J. H., & Grodstein, F. (2004). Physical activity, including walking, and cognitive function in older women. *JAMA : The Journal of the American Medical Association, 292*(12), 1454-1461.

White, D. K., Jette, A. M., Felson, D. T., Lavalley, M. P., Lewis, C. E., Torner, J. C., et al. (2010). Are features of the neighbourhood environment associated with disability in older adults? *Disability and Rehabilitation, 32*(8), 639-645.

Wight, R. G., Cummings, J. R., Miller-Martinez, D., Karlamangla, A. S., Seeman, T. E., & Aneshensel, C. S. (2008). A multilevel analysis of urban neighbourhood socioeconomic disadvantage and health in late life. *Social Science & Medicine (1982), 66*(4), 862-872.

Wilcox, V. L., Kasl, S. V., & Idler, E. L. (1996). Self-rated health and physical disability in elderly survivors of a major medical event. *The Journals of Gerontology.Series B, Psychological Sciences and Social Sciences*, *51*(2), S96-104.

Wong, C. H., Wong, S. F., Pang, W. S., Azizah, M. Y., & Dass, M. J. (2003). Habitual walking and its correlation to better physical function: Implications for prevention of physical disability in older persons. *The Journals of Gerontology.Series A, Biological Sciences and Medical Sciences,58*(6), 555-560.

Woo, J., Leung, J., & Kwok, T. (2007). BMI, body composition, and physical functioning in older adults. *Obesity (Silver Spring, Md.), 15*(7), 1886-1894.

World Health Organization. (2000). *Obesity: Preventing and managing the global epidemic* No. 894). Geneva, Switzerland: World Health Organization.

World Health Organization. (2001). *World health organization. 2001. international classification of functioning, disability and health:ICF*. Geneva, Switzerland: World Health Organization.

World Health Organization. (2006). *Global age-friendly cities: A guide*. Geneva, Switzerland: World Health Organization.

World Health Organization. (2011a). *Disability and health.* Retrieved 04/28, 2012, from http://www.who.int/mediacentre/factsheets/fs352/en/

World Health Organization. (2011b). *World report on disability*. Geneva, Switzerland: World Health Organization.

World Health Organization. (2012a). *International classification of functioning disability and health. ICF browser*. Retrieved 03/10, 2012, from http://apps.who.int/classifications/icfbrowser/

World Health Organization. (2012b). *Obesity and overweight.* Retrieved 03/15, 2012, from http://www.who.int/mediacentre/factsheets/fs311/en/index.html

Yasunaga, A., Togo, F., Watanabe, E., Park, H., Park, S., Shephard, R. J., et al. (2008). Sex, age, season, and habitual physical activity of older japanese: The nakanojo study. *Journal of Aging and Physical Activity*, *16*(1), 3-13.

Yen, I. H., Michael, Y. L., & Perdue, L. (2009). Neighbourhood environment in studies of health of older adults: A systematic review. *American Journal of Preventive Medicine, 37*(5), 455-463.

Young, A. F., Russell, A., & Powers, J. R. (2004). The sense of belonging to a neighbourhood: Can it be measured and is it related to health and well being in older women? *Social Science & Medicine (1982), 59*(12), 2627-2637.

Zalewski, K. R., Smith, J. C., Malzahn, J., VanHart, M., & O'Connell, D. (2009). Measures of physical ability are unrelated to objectively measured physical activity behavior in older adults residing in continuing care retirement communities. *Archives of Physical Medicine and Rehabilitation, 90*(6), 982-986.

Zaninotto, P., Pierce, M., Breeze, E., de Oliveira, C., & Kumari, M. (2010). BMI and waist circumference as predictors of well-being in older adults: Findings from the english longitudinal study of ageing. *Obesity (Silver Spring, Md.), 18*(10), 1981-1987.