Relationship of Personal Factors and Perceived Built Environmental Factors to Walking Behaviour of Community – Dwelling Middle-aged and Older Adults

By

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ABSTRACT

The purpose of this study was to investigate the relationship between personal factors and perceived built environmental factors and walking behaviour among middle-aged and older adults. The sample consisted of 647 people aged 45 years and above. Walking behaviour was assessed using pedometers. Decreased walking was significantly associated with increased age (r=-0.366, p<0.001). Education level (F=4.13, p=0.016) and self-rated health status (t=6.07, p<0.001) were positively associated with walking. When considering the effect of age, education level was no longer associated with walking. Better perception of general safety (F=3.105, p=0.005) and fewer safety concerns (F=7.531, p=0.001) were positively associated with walking. Age and self-rated health status jointly contributed to the walking behaviour (p<0.001), explaining 16.2% of the variance. These findings may suggest future neighbourhood interventions for age-friendly communities in Winnipeg, and help to accommodate changes through addressing perceived neighbourhood safety concerns and facilitating increased physical activity among middle-aged and older adults.

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Chapter 1: Introduction

Owing to the large number of the baby-boom generation, the age structure of Canada's population began shifting between 2006 and 2012 from large numbers of young people and younger adults to a large population composed of the middle-aged and older age groups (Statistics Canada, May 2012). Beginning in 2011, the first of the baby-boomers began entering the 65 and older age group. It is expected that the proportion of older adults could reach 25.0% of the total population by the end of 2030 and then exceed 40 million by 2036. The population of Manitoba in 2011 had one of the largest increases in growth rate, 5.2% from 2006 to 2011, reaching over 1.2 million (Statistics Canada, February 8, 2012). The proportion of older adults was 14.3% in 2011, which is slightly below the national rate (Statistics Canada, September 19, 2012) and is projected to increase to 18.4% by 2026 (Statistics Canada, May 26, 2010). With these significant shifts in demographics, come a variety of challenges, as Canada's population ages.

Aging is the accumulation of changes in the human body over an extended period of time that lead to decreased functional abilities (Stedman, 2006). It is a complex process which is associated with physiological changes in human systems as well as increased prevalence of diseases such as heart disease, diabetes, cancer, osteoporosis, and dementia. These changes and vulnerability to diseases can lead to changes in health status and loss of independence, which ultimately affects social interactions and quality of life (McPherson & Wister, 2008). The effects of aging are not only reflected in the micro dimension (individual impact), but also in the macro dimension (impact on health care and the economy), and will lead to increased demand for social services support, infrastructure construction, and housing (McPherson & Wister, 2008).

Growing from the need for insight into the impact of these changing demographics, the benefits of physical activity in reducing risk factors of diseases and improving functional abilities have been well established (Vogel et al., 2009). The U.S. Department of Health and Human Services (2008) suggests that middle-aged and older adults can benefit from regular moderate-intensity physical activity including both endurance and muscle-strengthening activities. The World Health Organization (n.d. a) indicates that these benefits can be realized even later in life. In addition to benefiting individuals, the benefits of physical activity are also essential to sustained economic and social development (World Health Organization, 2010).

Walking as a common form of physical activity has benefits for health (Eyler, Brownson, Bacak, & Housemann, 2003; Peterson et al., 2010). For older adults, it is recognized that walking positively affects physical performance, overall fitness and mental health, and negatively affects the odds of metabolic syndrome (Peterson et al., 2010), however there are many additional factors that contribute to walking behaviour.

According to the ecological model, personal, social, and environmental factors have intra- and interrelated influences on physical activity behaviour (Sallis et al., 2006). Intrapersonal factors such as age, gender, socioeconomic status, health status and perceived environment may have multi-level influences on people's behaviour in participation in physical activity. In addition, outdoor spaces and buildings, and community support and health services also strongly influence a person's health behaviours, especially among older people (World Health Organization, 2007).

The investigation of the contribution of the built environment to physical activity behaviour has gained growing interest, and has expanded considerably in the past decade (Saelens & Handy, 2008). While more studies are needed to establish specific causes and effects, it is recognized that a link exists between some aspects of the environment and physical activity behaviour in adults. Older adults' physical activity participation may be under a high built environmental press, that is, pressure determined by the physical environment, particularly by the perceived environment, and be more affected by it due to reduced capacity that declines with age (Giraldez-Garcia et al., 2012). According to previous studies, aesthetics, mixed destinations, and residential density were associated with walking for recreation among adults (Cerin, Saelens, Sallis, & Frank, 2006). Gauvin et al. (2008) suggested that a larger number and variety of neighborhood destinations in one's residential environment were associated with more walking among middle-aged or older adults. However, there are limited studies of environmental factors influencing physical activity targeted within older adults exclusively (McCormack et al., 2004). The extent to which specific perceived environmental factors contribute to the particular physical activity behaviours of older adults has not yet been studied extensively and there is still substantial debate in the field (Saelens & Handy, 2008).

Thus, there is a need for further investigation to understand the extent that specific segments of the perceived built environment are associated with personal factors, and their relationship to walking behaviour. This study will seek to identify features of the perceived built environment that support physical activity and potentially inform future neighbourhood interventions in Winnipeg. Findings from this study may provide insight into the influence of the built environment on walking behaviour, and serve as potential supports for promoting effective community planning and policy interventions to increase physical activity.

1.1 Statement of Purpose

This study examined the relationship between personal factors and perceived local environmental factors and walking behaviour of middle-aged and older adults residing in one suburban area in Winnipeg. There were three specific purposes:

1) To examine the relationship of personal factors (age, gender, education level, and self-rated health status) to walking behaviour;

2) To examine the relationship between perceived built environmental factors (presence and condition of sidewalks, aesthetics, and safety) and walking behaviour;

3) To examine the joint contribution of personal factors and perceived built environmental factors on walking behaviour.

1.2 Study Hypotheses

With respect to the relationship between age, gender, and education level, self-rated health status and walking behaviour (purpose number 1), it is hypothesized that:

1) Participants who are younger aged, male, who have higher education level, and who have better self-rated health status will walk more steps per day than participants who are older aged, female, who have lower education level, and poorer self-rated health status.

With respect to the relationship between perceived built environmental factors and walking behaviour (purpose number 2), it is hypothesized that:

2) There will be a significant and positive association between perceived built environmental factors - presence and condition of sidewalks, aesthetics, and safety - and the average number of steps walked per day.

With respect to the joint contribution of personal factors and perceived built environmental factors on walking behaviour (purpose number 3), it is hypothesized that:

3) Age, gender, education level, self-rated health status, presence and condition of sidewalks, aesthetics, and safety will jointly contribute to the average number of steps walked per day.

1.3 Framework

This study was based on the ecological model which has been recommended as a framework for built environment planners to use in health behavior research (Handy, 2005; C. Lee & Vernez, 2004; Institute of Medicine, 2007; U.S. Centers for Disease Control and Prevention, 2008; Sallis, Owen, & Fisher, 2008). The ecological model incorporates the social and physical environments with an emphasis on multi-level and interacting influences including: intrapersonal, interpersonal, organizational, community, and public policy factors on health behaviors, implying that integrated interventions of the complex determinants may be more effective in behaviour change than single-level interventions (Sallis et al., 2008) (Figure 1.1).

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Figure 1.1. Ecological model of health behaviour

Note. From “An Ecological Approach to Creating Active Living Communities” by J. F. Sallis, R. B. Cervero, W. Ascher, K. A. Henderson, M. K. Kraft, and J. Kerr, 2006, Annual Review of Public Health, 27, p. 301.

An individual’s health behaviour, for example physical activity behaviour, is determined by personal factors varying between age, gender, income and education level, functional status, and psychological status. His/her perception of the environment – if the environment is safe, attractive, and convenient enough to do physical activity – will influence his/her physical activity participation. The actual built environment, including availability of facilities and programs, public transit, and parking within the neighbourhood and workplace will increase physical activity behaviour. Moreover, people will participate in increased activity if they have facilities such as physical activity equipment, a garden, and stairs at home. Availability of social supports and the nature of the cultural environment also correlate with physical activity. The public policy environment provides supports such as health care policies, transportation policies, and public recreation policies, all of which effect behaviour change. Furthermore, the policy environment is dictated by the level of information available, such as health care information, mass media, and mainstream advertisements, which are considered to have a significant effect on daily life (Sallis et al., 2006).

As observed, the broad perspective of the influence of multi-level physical activity behaviour is the key strength of the ecological model; the personal and perceived built environmental factors are two important parts of this model. Thus, part of the ecological model was considered as the primary framework for this study.

1.4 Study Delimitations

1. This study was conducted with healthy, ambulatory, community dwelling middle-aged and older adults (45 years old and above), therefore the generalization of the results may be limited.

2. This study used the data derived from the Wellness Information Services Evaluation Research (WISER) Program Phase Three which was conducted from August 2007 to January 2008 in selected neighbourhoods in Winnipeg, a middle-sized Canadian city located in the prairies.

1.5 Study Limitations

The following are potential confounding factors that may influence the results of the study and may need to be considered and addressed.

1. Pedometers were self-administered, therefore errors or disoperation may cause steps to be missed.
2. The sample area was limited primarily to one suburban area in Winnipeg; therefore the characteristics of this area may have potentially influenced the study's outcomes.
3. The WISER Program Phase Three was conducted from summer to winter; consequently winter weather may influence participants' walking behaviour.
4. This was a cross-sectional observational survey, therefore causality may not be inferred from the results.
5. Participants volunteered for the study, thus there is a possibility for procedural bias.
6. The assessment of built environmental factors was a perceived measurement rather than an objective measurement.
7. There may be a homogenous demographic in the samples profiled in this study.

1.6 Assumptions

1. Average steps per day (over a 3 day period) recorded using pedometers will accurately reflect participants' typical walking behaviour.

2. Volunteer participants will represent middle aged and older adults who live in the community.

1.7 Definitions

Age classification

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

Built environment

"The buildings, roads, utilities, homes, fixtures, parks and all other man-made entities that form the physical characteristics of a community" (U.S. Centers for Disease Control and Prevention, n.d.).

Connectivity

"The ease of travel between two points. The degree to which streets or areas are interconnected and easily accessible to one another. An example of high connectivity would be a dense grid pattern in a downtown area" (U.S. Centers for Disease Control and Prevention, n.d.).

Environment factors

"Physical, social and attitudinal space in which people conduct their lives" (World Health Organization, 2001, p. 10).

Leisure-time physical activity (LTPA)

"Activity undertaken in the individual's discretionary time that substantially increases total daily energy expenditure. The element of personal choice is inherent to the definition" (Bouchard, Blair, & Haskell, 2006, p. 19).

Personal factors

"Background of the individual's life such as age, gender, race, habits, upbringing, coping styles, education, social background, past and current experience, character style, as well as other psychological assets" (World Health Organization, 2001, p. 17).

Physical activity

"Any bodily movement produced by skeletal muscle that results in energy expenditure" (World Health Organization, n.d. b).

Physical function

"The integration of physiological capacity and physical performance mediated by psychosocial factors" (Cress et al., 1996, p. 1243).

Proximity

"Proximity is related to mixed-land uses that create shorter distances between residences and destinations such as stores or work places" (Owen, Humpel, Leslie, Bauman, & Sallis, 2007, p. 388).

Sedentary

“Activities that do not increase energy expenditure substantially above the resting level (1.0 –1.5 metabolic equivalent METs), including activities such as sleeping, sitting, lying down, watching TV, and other forms of screen-based entertainment” (Proper, Singh, Mechelen, & Chinapaw, 2011, p. 174).

Total precipitation

“The sum of the total rainfall and the water equivalent of the total snowfall observed during the day” (National Climate Data and Information Archive, n.d.).

Chapter 2: Literature Review

2.1 Demographics of Aging in Canada and Manitoba

Owing to the baby-boom generational cohorts born in Canada between 1946 and 1965, as well as to increased international migration from the 1950s, Canada's population has grown at a rapid pace. In the 2011 Census, Canada's population was enumerated at 33.5 million (Statistics Canada, February 8, 2012). The growth rate from 2006 to 2011 was 5.9%, which is relatively high when compared to other countries in North America and Europe (Statistics Canada, February 8, 2012). This population growth is expected to continue in future decades, and is expected to exceed 40 million by 2036 (Statistics Canada, May 26, 2010). Due to the baby boom generation reaching 65 and the increased life expectancy, the proportion of older adults has been growing and is projected to accelerate rapidly.

The proportion of seniors aged 65 years and over represented 14.8% of the Canadian population, while the proportion of middle-aged adults was 29.1% (Statistics Canada, May 29, 2012). According to Statistics Canada this number is projected to reach between 23% and 25% of the population by 2036, which accounts for 9.9 to 10.9 million. By 2031, this increase is expected to be at a slower rate, as the entire baby boom generation will have passed 65 years (Statistics Canada, May 26, 2010).

In Winnipeg, the annual growth rate of the senior population is consistent with that of the national average and expected to increase from 0.7% to 1.2% in the 20 years from 2006 to 2026 (Conference Board of Canada, 2007; Statistics Canada, 2009). The population of middle-aged and older adults (45 years and over) was over 307,000 in 2011, 42.1% of the total population. Seniors composed about 14.1% of the total population, an increase of approximately 7.2% from 2006 (Statistics Canada, September 19, 2012).

Consequently, it is a growing challenge to monitor and address the shifting demographic and the needs of this large proportion of older adults, and to develop an age-friendly society for them from both physiological and socio-economic perspectives.

2.2 Benefits of Physical Activity and Aging

The aging is a complex process which involves many internal and external influences: genetic dispositions, physical and social environments, and their impacts on physiological and psychological changes as the aging progresses (Matteson, McConnell, & Linton, 1997). It is both diverse and distinctive from subject-to-subject, accounting for the interactive influences of the varied internal and external factors on individuals, contributing to either a shortened or prolonged life expectancy (Hardman & Stensel, 2009).

Regular physical activity has been widely recognized as a significant factor that affects health outcomes, and benefits both the individual and subsequently public health (U.S. Department of Health and Human Services, 2008). The 2011 Canadian Physical Activity Guidelines recommend that middle-aged and older adults should have at least "150 minutes of moderate- to vigorous-intensity aerobic physical activity per week, in bouts of 10 minutes or more" (Canadian Society for Exercise Physiology, 2011). Older adults with poor mobility are also encouraged to do physical activity to improve balance and prevent falls.

Major research findings demonstrate a variety of health outcomes of physical activity on the individual such as prevention of premature death, diseases and risk factors for disease, promotion of physical fitness, functional capacity, mental health, and the reduction of chances of injuries or sudden heart attacks (U.S. Department of Health and Human Services, 2008). The World Health Organization (World Health Organization, n.d. a) demonstrates that these benefits can be realized even later in life. Furthermore, physical activity helps to improve older adults' health status and quality of life, contributes to an increase in life expectancy, and thus decreases the cost of health care services (Pratt et al., 2000), direct economic costs, and indirect costs which include loss of productivity and pension attributions, and is beneficial to society at large (Colditz, 1999). However, regular physical activity cannot restore damage caused by disease and cannot reverse the aging process.

2.2.1 Cardiovascular Health

The effect of physical activity on cardiovascular health (related to the heart, blood vessels, or circulation) is positive, regardless of age, gender, income, region of residence, ethnicity, and health status (National Institutes of Health, 1995). Regular long-term physical activity can decrease resting blood pressure by reducing cardiac output or total peripheral resistance (Dishman, Washburn, & Heath, 2004). A review of the randomized clinical trials about exercise and physical activity found that aerobic exercise with a mean duration of three months can decrease the mean systolic and diastolic blood pressure (Karmisholt, Gyntelberg, & Gøtzche, 2005). However, there has been no convincing evidence to support a linear dose-response relationship between exercise and lowering blood pressure. A meta-analysis, which combined the results of a number of studies, concluded that exercise performance with intensities ranging from 40% to 70% of the individual's aerobic capacity during 30-60 minute sessions, lasting three to five times per week had an equal overall effect on blood pressure reduction (Fagard, 2001).

As well as the effect on blood pressure, a decrease in resting heart rate has been observed with increasing physical activity (Mensink, Ziese, & Kok, 1999). Also, exercise intensities greater than 70% maximal oxygen uptake (VO_{2max}) can reduce total blood cholesterol and low-density lipoprotein. It has also been shown that regular physical activity can increase VO_{2max} in middle-aged (Laukkanen et al., 2009) and older adults (Puggaard, Larsen, Støvring, & Jeune, 2000; Sillanpää et al., 2009).

2.2.2 Musculoskeletal Health

Deterioration of muscle and skeleton and declining function of the musculoskeletal system is common with age, and may affect independence, cause disability, and influence the quality of life. Evidence suggests that physical activity improves leg power and grip strength in older adults (Chan et al., 2007). Resistance training for older adults can increase muscle mass, strength, and power as well as induce fiber hypertrophy, and hence is effective in reducing sarcopenia which is identified as the loss of lean muscle mass (Bickel, Cross, & Bamman, 2011; Hunter, McCarthy, &

Bamman, 2004). In addition to the effects on muscle, physical activity, especially weight-bearing activity, can increase bone density (G. A. Kelley, K. S. Kelley, & Tran, 2001; Kohrt, Bloomfield, Little, Nelson, & Yingling, 2004) and slow the rate of decline in bone mass for older adults (Daly et al., 2008; Foley, Quinn, & Jones, 2010; Prestwood & Raisz, 2002).

Physical activity also reduces risk of falls among older adults (Cousins et al., 2010) through improving balance ability (Daly et al., 2008). Leisure time physical activity is suggested to be effective in reducing risk of falls (Gregg, Pereira, & Caspersen, 2000). In one study, progressive muscle strengthening, balance retraining and a walking plan resulted in fewer falls, and fewer falls resulting in injury (Karmisholt et al., 2005). There is a concern that vulnerable older adults may be subject to more falls from physical activity (Faber, Bosscher, Chin, & Van Wieringen, 2006). Chan et al. (2007) found that older men participating in household activities are more likely at risk of falling than those doing leisure time activity. Nevertheless, a significant association ($p<0.05$) has been reported between low, moderate, high, and very high physical activity and falls reported; women who reported very high (daily moderate to vigorous-intensity) and moderate level (three to five sessions of vigorous-intensity/week or five to eight sessions of moderate-intensity/week) physical activity had decreased odds of reporting a fall compared with no or very low levels of physical activity ($p<0.05$) (Heesch, Byles, & Brown, 2008).

Fractures and osteoporosis are closely linked. Osteoporosis, which is more common in women than in men, is responsible for many incidences of bone fracture and has a high prevalence in older adults (Dishman et al., 2004; Srivastava & Deal, 2002). Scientific consensus shows that moderate-to-vigorous physical activity can reduce the risk of hip fracture (Moayyeri, 2008), and activities that involve weight-loading, for example Tai Chi (Lui, Qin, & Chan, 2008), ultimately stimulate bone structural and architectural modeling to prevent fracture (Gregg et al., 2000; Warburton, Gledhill, & Quinney, 2001).

The incidence of hip fractures increases with age especially after 85 years; it happens more in women than in men (Srivastava & Deal, 2002). Regular walking or leisure-time physical activity can reduce the risk of sustaining a hip fracture in both middle-aged women (Englund et al., 2011) and men (Michaëlsson et al., 2007) when compared with a sedentary group. Similarly, low to moderate intensity physical activity has been observed to prevent fractures in older men and women (Park et al., 2007). Furthermore, studies suggest that weight-bearing exercises are significantly associated with reductions in fracture rates (Appleby, Allen, Roddam, & Key, 2008; Marques et al., 2011). Bicycling possibly increases the risk of fractures (Appleby et al., 2008).

2.2.3 Prevention of Chronic Diseases

As reported by the World Health Organization, chronic diseases have a major effect on adults' quality of life and are a common cause of adults' death in all regions of the world (World Health Organization, 2005). The prevalence of chronic diseases is expected to increase rapidly, especially in populations 65 years and older. By 2030, for example, the number of the total population with diabetes in the world will be 114% of those in 2000, and the number of the population 65 years and older with diabetes will be

134% of those in 2000 (Wild, Roglic, Green, Sicree, & King, 2004). Thus efforts to prevent or reduce the risk of chronic diseases are critical.

Many studies including monozygotic twin research (Carlsson, Andersson, Lichtenstein, Michaëlsson, & Ahlbom, 2007) suggest that physical activity is associated with reduced all-cause mortality (Elsawy & Higgins, 2010), especially from cardiovascular disease (CVD) (Hamer & Stamatakis, 2009).

Leisure-time physical activity and moderate-intensity walking were reported as contributing towards decreased risk of CVD mortality for middle-aged and older men and women (Dishman et al., 2004; Haapanen, Miilunpalo, Vuori, Oja, Pasanen, 1996; LaCroix, Leveille, Hecht, Grothaus, & Wagner, 1996; Sesso, Paffenbarger, Ha, & Lee, 1999). A meta-analysis suggested that walking and cycling for transportation were associated with reduction in CVD risk (Hamer & Chida, 2008). Alternatively, occupational and leisure-time physical activity were related to the reduction of coronary heart disease (CHD) among men and women, while the relationship of CHD to walking and cycling for commuting purposes appeared in women only (Hu et al., 2007).

Strong epidemiological evidence shows that regular physical activity can improve glucose homeostasis (Castaneda, 2003) and decrease plasma insulin level (Roy & Parker, 2007), thus reducing the risk of type II diabetes. It has been shown that vigorous and moderate-intensity physical activity can reduce the risk of incidence of type II diabetes in adults aged 50-69 years (Demakakos, Hamer, Stamatakis, & Steptoe, 2010). Even habitual, low to moderate intensity physical activity is associated with the reduction of risk of type II diabetes in older adults (Pescatello, 1999). A study of older adults (65 years and older) with and without diabetes mellitus (DM) found that those with DM were less likely to meet U.S. physical activity recommendation ($p<0.001$) (Zhao, Ford, Li, & Balluz, 2011). Those 75 years and older, females, the obese, those with heart disease and people with disabilities were also less likely to meet physical activity recommendations.

Cancer is the leading cause of mortality in Canada. Lung, colorectal, prostate and breast cancer make up more than one-half (54.4%) of all cancers diagnosed in Canada (Canadian Cancer Society, 2010). Evidence is strong that regular physical activity can reduce the risk of colon cancer in both men and women (Wolin, Yan, Colditz, & Lee, 2009) and breast cancer in women (Friedenreich, 2011). Moderate or possible evidence shows that lung and prostate cancer risk can also be reduced (Friedenreich, Neilson, & Lynch, 2010).

Alternatively, some epidemiological studies indicate that physical activity can only prevent limited types of cancers (e.g., colon and breast cancer). There is still controversy about the "definitive effect" of physical activity on risk of lung cancer and endometrial cancer (Bouchard et al., 2006). The mechanisms associating reduced cancer risk and physical activity have not been well understood, and will require long-term research in order to determine dose-effects of physical activity in prevention of cancer (Rogers, Colbert, Greiner, Perkins, & Hursting, 2008).

2.2.4 Positive Mental Health

The benefits of physical activity on mental health have been well documented. Physical activity reduces the risk of depression and the symptoms of depression (Conn, 2010; Goodwin, 2003; Strawbridge, Deleger, Roberts, & Kaplan, 2002; Ströhle, 2009; Sund, Larsson, & Wichstrøm, 2011; C. Y. Wang, Yeh, C. W. Wang, C. F. Wang, & Lin, 2011) and feelings of anxiety (Goodwin, 2003; Guszkowska, 2004; Ströhle, 2009).

An increasing number of studies have highlighted that participating in physical activity or exercise programming can improve self-efficacy and self-esteem (Fox, 1999) and reduce stress (Hartfiel, Havenhand, Khalsa, Clarke, & Krayer, 2011; Starkweather, 2007). This beneficial effect occurs not only in the general population, but also in older adults. For example, Tai Chi was found to improve mood disturbance and social support, especially from family, and significantly reduce perceived stress. A significant improvement in self-efficacy barriers and performance was also found (Taylor-Piliae, Haskell, Waters, & Froelicher, 2006). Moreover, the systematic literature review from Barr-Anderson et al. (2011) demonstrated the benefits of accumulating short bouts of physical activity in improving self-efficacy or self-esteem and decreasing stress or depression.

Increasing amounts of evidence has also shown that physically active older adults are less likely to develop dementia or Alzheimer's disease (Larson et al., 2006); even moderate leisure time physical activity can be protective against dementia (Y. Lee et al., 2010). Laurin et al. (2001) examined community-dwelling older adults (65 years and older) from the 1991-1992 Canadian Study of Health and Aging data, using a 5 year follow-up evaluation, and found that physical activity (including walking) was related to lower risks of cognitive impairment, Alzheimer's disease, and dementia of any type; this association tended to be protective against cognitive decline. With the increasing evidence of the benefits from physical activity participation on mental health, physical activity will be playing a more important role in treatment of mental health issues (Mason & Holt, 2012).

2.2.5 Benefits of Walking for Older Adults

Walking is a very popular form of physical activity across the world (Fewster 2004; Giles-Corti & Donovan, 2003), and is the most common type of physical activity reported by older adults (Bird et al., 2010; Clark, 1999; Michael, Beard, Choi, Farquhar, & Carlson, 2006; National Center for Health Statistics, 2001; Saelens & Handy, 2008; U.S. Department of Health and Human Services, 1996). Specifically, data from the National Population Health Survey and Canadian Community Health Survey from 1994/95 to 2007 indicate that walking is popular among women, older adults, people with lower body mass index (BMI), and lower income, who all walk more than their counterparts in Canada (Bryan & Katzmarzyk, 2009).

The benefits of walking for health range from physiological improvement and chronic disease management (I-M. Lee & Buchner, 2008), to psychological improvement and social benefits (Fewster, 2004). Walking is related to the decline of total cholesterol and low-density lipoprotein but offers no significant changes in high-density lipoprotein or triglycerides (Karmisholt et al., 2005). In one study, high levels of walking activity reduced bone resorption, and hence reduced risk of osteoporotic fracture in older women (71.4 ± 4.8 years) (Kitagawa & Nakahara, 2008).

Other epidemiological studies demonstrate that walking is essential for health outcomes; it can not only reduce body weight and body fat, systolic and diastolic blood pressures (Brandon & Elliott-Lloyd, 2006) and rates of chronic diseases (I-M. Lee & Buchner, 2008; Murtagh, Murphy, & Boone-Heinonen, 2010), but also save on health care costs (I-M. Lee & Buchner, 2008). For older adults specifically, walking positively affects mental health (Cheng et al., 2009), functional health (Haley & Andel, 2010), and negatively affects the odds of incident metabolic syndrome (Peterson et al., 2010). Walking also prevents functional declines and physical disability associated with aging (C. H. Wong, S. F. Wong, Pang, Azizah, & Dass, 2003). Boone-Heinonen et al. (2009) reported that the dose of walking (e.g., walking duration, distance, and pace) must also be considered. In general, the reduction of CVD was relative to higher walking volume and intensity. Thus, the benefit of walking has been proposed to be significant for preventing declines in quality of life through improvement of physical and psychological functions among older adults (Le Masurier et al., 2008).

2.3 Factors Influencing Participation in Physical Activity in Middle Aged and Older Adults

2.3.1 The Ecological Model

Several conceptual models have been proposed to illustrate the factors that determine an individual's health, and those factors' inherent relationships. For example, the International Classification of Functioning, Disability and Health (ICF) model (World Health Organization, 2001) suggests that built environmental factors interrelated with personal factors contribute to participation in activity, and therefore affect health conditions. Apart from this, Warner (1997) extended Dahlgren's model, which showed the socio-economic, cultural, and environmental contributions on health, revealing the combined relationship of macro and micro environments on physical activity behaviour. The new model includes some social support elements – values of a society, new social contract and research and development. The ecological model has been recommended by researchers to use in the health behaviour research field (Saelens & Handy, 2008).

The core principle of the ecological model is that the influences of health behaviour are not isolated in effect; they are present on multiple levels and interact across these levels affecting behavioural change. The initial concept of the ecological model only focused on perceived environmental influence; and then social and intrapersonal characteristics were added to broaden the concept (Sallis et al., 2008). When applying the ecological model in physical activity research, there are four domains surrounding physical activity behaviour – intrapersonal factors (e.g., demographics, biological, psychological, and family situation), perceived environment factors (i.e., safety, attractiveness, comfort, accessibility, and convenience), physical settings (i.e., neighbourhood characteristics, recreation, transport, home, workplace, and school environment) and policy environment (i.e., transport, health care, public recreation, and school policies) (Figure 1.1). Within these levels, natural environment and information environment such as media information and counseling can influence physical activity at any given time. Social and cultural environments operate across these levels. In short, individual factors and environmental/policy factors combined correlate with the level of physical activity behaviour (Sallis et al., 2008).

As an example of the application of this model, one study examined the influences of individual factors (psychological), social environmental factors (dog and club ownership and friends support), and physical environmental factors (presence of sidewalks, and access to public space) on walking in adults aged 18 to 59 years (Giles-Corti & Donovan, 2003). The results showed that after adjustments for age, gender, number of young children living at home, income, and education, the effects of these three variables were similarly related to walking; however no multiplicative interactions were found among them.

As observed above, the ecological model provides a theoretical framework suited for the purposes of this study. Following this approach, personal and perceived built environmental factors will constitute the conceptual basis of this study. The factors that influence physical activity and which are directly targeted in this study will be presented in this section.

2.3.2 Personal Factors

2.3.2.1 Age and Gender

In Canada, 50.1% of women and 56.1% of men are moderately active or active (Statistics Canada, 2011a). Middle-aged men and women (45-64 years old) are equally likely to be moderately active in leisure time, 49.5% and 48.5% respectively. Both men and women participate less in physical activity as they age, but women's participation decreases more than men's after 65 years. The proportion participating in moderate physical activity among men and women aged 65 years and above is 47.3% and 37.7%, respectively (Statistics Canada June 21, 2011).

In general, increasing age corresponds to lower rates of physical activity participation - younger adults are more involved in physical activity than those in the older population (Bopp et al., 2006; Pan et al., 2009; Plotnikoff, Mayhew, Birkett, Loucaides, & Fodor, 2004; Poortinga, 2006; Steffen et al., 2006). Males are more active in physical activity than females (Eyler & Vest, 2002; Pan et al., 2009; Plotnikoff et al., 2004; Poortinga, 2006; Reis, Macera, Ainsworth, & Hipp, 2008; Steffen et al., 2006).

Although research shows that men do more physical activity than women, women report leisure time walking more than men, especially among older women with higher income levels (Bryan & Katzmarzyk, 2009; Rafferty, Reeves, McGee, & Pivarnik, 2002). However, when considering the effect of age, some studies found that the prevalence of walking is lower among older women (Craig, Tudor-Locke, & Bauman, 2007; Reis et al., 2008). Cao, Handy, & Mokhtarian (2006) also found that when compared with full-time workers, older people are more likely to walk near their neighbourhoods; and they less frequently walk to the store. This is possibly due to the function limitations that are commonly barriers among older adults.

2.3.2.2 Income and Education Level

Income and education levels are two primary socioeconomic status indicators. Normally, higher income and higher education levels are consistent with higher rates of physical activity participation; less educated, lower income earners are less likely to take part in regular physical activity (Giles-Corti & Donovan, 2002; Plonczynski, 2003; Rafferty et al., 2002), both in middle-aged and older adults (W. C. King et al., 2005; Pan et al., 2009). However, this parallel and positive association is not consistent with findings in some previous studies. In one study, middle-aged and older Swedish men with higher educational attainment had lower levels of total physical activity (Norman, Bellocco, Vaida, & Wolk, 2002). Occupational and transportation walking is more prevalent among adults with lower education levels (Reis et al., 2008). In contrast, data from the 2005 U.S. National Health Interview Survey (N=31,482) found that leisure walking was more prevalent among adults with higher income and education levels; while the prevalence of transportation walking increased with higher education levels but decreased with income levels (Kruger, Hama, Berriganb, & Ballard-Barbash, 2008). It is suggested that the measurement of transportation walking and leisure walking be considered for future research (Kruger et al., 2008).

Physical activity behaviour can be influenced by total household income levels as well. Men and women with a higher family income, regardless of age, are more likely to have sufficient physical activity for both (Pan et al., 2009). Regular walking is also reported to be more prevalent among adults with higher total household incomes (Bryan & Katzmarzyk, 2009).

Average neighbourhood income, which is related to the socio-economic composition of the population, is also observed to correlate with physical activity participation. People living in lower-income neighbourhoods, and neighbourhoods with higher proportions of racial minority groups, such as African American and Hispanic in the U.S.A., had less availability of physical activity-related facilities (Powell, Slater, Chaloupka, & Harper, 2006). Such poor availability may undermine their physical activity participation levels.

Steffen et al. (2006) found that higher education but not income is related to higher physical activity in middle-aged population. The effects of income and education level on physical activity were found to be more significant to middle-aged and older groups and women than younger groups and men (Pan et al., 2009). The finding that people with lower education do more physical activity tends to be within younger age groups (18-25, 26-45 years) (Plotnikoff et al., 2004).

2.3.2.3 Self-rated Health Status

Perceived health is an indicator of overall health status. Perceived confidence in health, performance and accomplishment are motivators of behavioural change (Pan et al., 2009). In Manitoba, 39.2% of older adults rated their health as "Excellent" or "Very Good" and 35.0% described their health as "Good". Men were slightly more likely to describe their health as "Excellent" or "Very Good" than women (Statistics Canada, 2005). Similarly across Canada, approximately 73% of older adults rated their health as "Well", "Good", "Very Good", or "Excellent". However, about 60% to 80% of older adults have activity or mobility limitations, or at least one chronic illness (McPherson & Wister, 2008). It is therefore important to identify the relationship between self-rated health status and physical activity behaviour.

Many studies on aging have focused on how self-rated health affects physical activity behaviour. People with good self-rated health status have a higher chance of having sufficient physical activity, and people with poor self-rated health have lower physical activity participation (Abu-Omar, Rutten, & Robine, 2004; Bopp et al., 2006;

Pan et al., 2009; Plotnikoff et al., 2004; Rutt & Coleman, 2005a; Stronegger, Titze, & Oja, 2010). This relationship is consistent for both genders (Leinonen, Heikkinen, & Jylha, 1999; Pan et al., 2009). Moreover, studies have found that self-rated health status in middle-aged (Norman et al., 2002) and in older adults (Gregg, Kriska, Fox, & Cauley, 1996; Kanagae, 2006; Leinonen et al., 1999) has a positive independent effect on the level of total physical activity. This relationship however, may vary within different countries. Abu-Omar et al. (2004) reported that there was a significant positive relationship between physical activity and self-rated health, after adjusting for personal factors in European Union countries.

Dose-response examination shows that there is a linear positive relationship between leisure time physical activity and self-rated health (Abu-Omar & Rutten, 2008), in both genders, in all age groups (18-29 years, 30-44 years, and 45-64 years), and in all education levels (Galán, Meseguer, Herruzo, & Rodríguez-Artalejo, 2010). A study conducted among Polish adults (Kaleta, Makowiec-Dabrowska, Dziankowska-Zaborszczyk, & Jegier, 2006), a study conducted in the Swedish population aged 25-64 years (Södergren, Sundquist, Johansson, & Sundquist, 2008), a study in the 55 to 89-year-old Dutch population (Parkatti, Deeg, Bosscher, & Launer, 1998), and a study in Korean adults 19 years and older (Han, Kim, Park, Kang, & Ryu, 2009) all confirmed this linear relationship.

2.3.3 Built Environmental Factors

Studies began to examine the role of the built environment on physical activity participation in the late 1980s (Giles-Corti & Donovan, 2002). Supportive built environments have been associated with physical activity behaviour thus enhancing people's health (Handy, Boarnet, Ewing, & Killingsworth, 2002). Poor road safety, high-speed traffic, and long distances between housing and shopping centres and other amenities are recognized as barriers that reduce opportunities for activity. High density of services in neighbourhoods, short distances between residence and workplace, access to green space in residential areas, availability of recreational activity facilities, and availability of cycle tracks or walking paths are positive environmental factors that may promote physical activity for people living in urban areas (Cavill, Kahlmeier, & Racioppi, 2006).

The following sections will review the neighbourhood characteristics – land use, presence of sidewalks and street connectivity, aesthetics, safety, access to transit, and availability of community facilities as both barriers and facilitators of physical activity.

2.3.3.1 Land-use

Since the "Three Ds concept" - density, diversity, and design - which contributes to people's preferred choice in mode of travel, was introduced by Cervero and Kockelman (1997), these specific characteristics of land use have become a focus among urban and transportation planners (C. Lee & Moudon, 2006a). It is suggested that physical activity is more "place-dependent by design or nature" (Sallis, 2009). Therefore, it is necessary to investigate the relationship between built environmental settings (e.g., public open spaces, green spaces, trails) and people's physical activity behaviours.

Mixed land use and residential density are positively related to physical activity (Atkinson, Sallis, Saelens, Cain, & Black, 2005; De Bourdeaudhuij, Teixeira, Cardon, & Deforche, 2005; Frank, Schmid, Sallis, Chapman, & Saelens, 2005) including walking (Cerin et al., 2006; C. Lee & Moudon, 2006b; Moudon et al., 2006) and specifically in older people (Berke, Koepsell, Moudon, Hoskins, Larson, 2007; Strath, Isaacs, & Greenwald, 2007). In women, daily physical activity levels are higher in neighbourhoods with high mixed diverse land use (Kondo et al., 2009). Greater density of destinations is associated with higher walking (Gauvin et al., 2008; Spence et al., 2006). This association also affects transportation activity (Hoehner, Brennan Ramirez, Elliott, Handy, Brownson, 2005; McCormack, Giles-Corti, & Bulsara, 2008), suggesting that increasing the mix of destinations in neighbourhoods could increase walking. Li, Fisher, Brownson, and Bosworth (2005) used multilevel modeling and found that density of places of employment and households in the neighbourhood were positively related to older adult residents' walking behaviour.

According to the survey by Giles-Corti and Donovan (2002), the most popular places people use for physical activity are streets, public open space, beaches, and riverbanks. Perceived lack of green spaces in neighbourhoods is negatively related to physical activity among adults for both men and women (Bolívar, Daponte, Rodriguez, & Sanchez, 2010). This supports the finding that an area with more green and open spaces that is objectively measured (GIS mapping) facilitates more walking among older adults (Li et al., 2005). Moreover, places for walking (Kondo et al., 2009) and places for bicycling (R. Santos, Silva, P. Santos, Ribeiro, & Mota, 2008) are significantly related to physical activity behaviour in women.

2.3.3.2 Presence of Sidewalks and Street Connectivity

Presence of sidewalks is identified as a key indicator of physical activity in adults, however this varies by neighbourhood location (Wilcox, Castro, A. C. King, Houseman, & Brownson, 2000). It is considered to be an important neighbourhood characteristic especially among people with higher income (Brownson, Baker, Housemann, Brennan, & Bacak, 2001; McCormack et al., 2004). Current findings suggest a positive association between physical activity and the presence of sidewalks (Addy et al., 2004; Brownson et al., 2001; Cerin et al., 2006; Sharpe, Granner, Hutto, & Ainsworth, 2004; Strath et al., 2007; Sugiyama, Leslie, Giles-Corti, & Owen, 2009; Velasquez, Holahan, & You, 2009), presence of crosswalks (Cerin et al., 2006; D. King, 2008; McGinn, Evenson, & Herring, 2007; Strath et al., 2007), and presence of curb cuts (D. King, 2008). Sidewalks have also been found to be more important to recreation walking than to transportation walking (C. Lee & Moudon, 2006b).

Women's physical activity behaviours are more influenced by neighbourhood characteristics than men's (McCormack et al., 2004). A study among Portuguese adults suggests that the presence of sidewalks is positively associated with moderate physical activity levels only in women (Santos et al., 2008).

Although the presence of sidewalks is expected to relate to increased physical activity, other studies have found that there is no association among adults (Hoehner et al., 2005; Rodríguez, Aytur, Forsyth, Oakes, & Clifton, 2008; Rutt & Coleman, 2005b; Sallis, Johnson, Calfas, Caparosa, & Nichols, 1997; Thompson, Wolfe, Wilson, Pardilla, & Perez, 2003; Wilcox et al., 2000). In adults residing in suburban areas, there was no significant correlation between sidewalks and recreational physical activity after adjusting for age, self-efficacy and family social support (Troped, Saunders, Pate, Reininger, & Addy, 2003). There were mixed findings in a study of influencing factors of the built environment on physical activity (positive or not significant) among the seniors populations (Cunningham & Michael, 2004). Perceived sidewalk levelness is also reported to be negatively associated with activity for transportation in urban adults (Hoehner et al., 2005). The potential explanation is that the respondents who are frequent walkers or cyclists are more likely to report cracks or heaves on sidewalks, which implies poorer levelness of sidewalks. Respondents who walk less are less likely to report poor levelness of sidewalks, therefore reflecting negative associations.

Higher street connectivity is associated with increasing physical activity (Atkinson et al., 2005; Frank et al., 2005; McGinn et al., 2007; Sugiyama et al., 2009; Wendel-Vos, Droomers, Kremers, Brug, Van Lenthe, 2007), including walking (Doyle, Kelly-Schwartz, Schlossberg, & Stockard, 2006; Pikora, Giles-Corti, bull, Jamrozik, & Donovan, 2003). For example, neighbourhoods with greater numbers of street intersections are positively related to more frequent walking in older adults (Li et al., 2005). Other findings, however, suggest that there is a negative association (Gomez et al., 2010) or no association (Lovasi et al., 2008; Rutt & Coleman, 2005b) between street connectivity and walking. A possible explanation is that high street connectivity leads to more street intersections and crosswalks, contributing to concerns around traffic safety and therefore reducing the likelihood of individuals walking (Gomez et al., 2010). Therefore, these mixed findings on the association between presence of sidewalks and street connectivity indicate that future research is needed to examine the influence of sidewalks and street connectivity on walking.

2.3.3.3 Aesthetics

Aesthetic variables such as the pleasantness of the neighbourhood (Ball, Bauman, Leslie, & Owen, 2001; Bird et al., 2010; Hoehner et al., 2005; Strath et al., 2007; Velasquez et al., 2009) and enjoyable scenery (Brownson et al., 2001; Cunningham & Michael, 2004; Humpelwen, & Leslie, 2002; Humpel, Marshall, Leslie, Bauman, & Owen, 2004; A. C. King et al., 2006; D. King, 2008; Kowal & Fortier, 2007; Spence et al., 2006) have been found to be positively associated with physical activity. The positive relationship to physical activity has also been found in attractiveness of neighbourhood features such as greenery (Li et al., 2008; Sugiyama et al., 2009), tree cover along footpaths (Hoehner et al., 2005; Santos et al., 2008; Sugiyama et al., 2009), shade for sidewalks (Santos et al., 2008), the presence of many interesting and attractive things to see (Bengoechea, Spence, & McGannon, 2005; Santos et al., 2008; Sugiyama et al., 2009), and lack of litter (Cerin et al., 2006) and graffiti (D. King, 2008; Sugiyama et al., 2009). Moreover, aesthetic features such as presence of trees, cleanliness, and interesting views may be more important for recreational walking than for transportation walking (Pikora et al., 2003).

Some research finds that there is a gender difference in the perception of aesthetics, indicating that men are more likely to consider aesthetics as a factor that influences their desire to walk in their neighbourhood (Humpel et al., 2004); while some found no association between the perceived aesthetics and amount of walking by men (Spence et al., 2006).

A few other studies found converse results, for example, Hoehner et al. (2005) found there was a negative association between aesthetic prompters and physical activity, suggesting that the likelihood of less activity in walking or bicycling decreases when the neighbourhood is free from garbage, litter, or broken glass, and is well maintained. Bird et al. (2010) reported similar negative association between well-maintained footpaths and trees that give shade for footpaths and amounts of physical activity of respondents. These are consistent with another finding that people who perceive their neighbourhoods as not tidy or clean are more likely to meet physical activity recommendations than people who perceive their neighbourhood as tidy or clean (Duncan & Mummery, 2005). The potential explanation that the previous studies suggested is that the view of untidiness and uncleanliness may be a result of people who are more physically active and aware of the aesthetics. These individuals also tend to participate in activities outside of their neighbourhoods (Duncan & Mummery, 2005; Hoehner et al., 2005).

2.3.3.4 Safety

Perceived safety is another neighbourhood characteristic that affects physical activity, especially for older adults (Cunningham & Michael, 2004; Kowal & Fortier, 2007; Lees et al., 2007). Women are more likely to be influenced by this factor than men (Bengoechea et al., 2005; Chung & Youngtae, 2009; Doyle et al., 2006; Foster, Hillsdon, & Thorogood, 2004; Strath et al., 2007; Velasquez et al., 2009). Variables that influence people's perception of safety include street lighting (Addy et al., 2004; C. Lee & Moudon, 2008; Lees et al., 2007; Pikora et al., 2003; Velasquez et al., 2009), unattended dogs (A. C. King et al., 2006; Moudon et al., 2007), fear of injuries related to falling especially in older adults (Mathews et al., 2010), security (Chung and Youngtae 2009; Pikora et al., 2003), crime in the neighbourhood (Bird et al., 2010; U.S. Centers for Disease Control and Prevention, 1999; Cerin et al., 2006; Doyle et al., 2006; Hooker, Wilson, Griffin, & Ainsworth, 2005; A. C. King et al., 2006; D. King, 2008; Sugiyama et al., 2009). These factors have also been identified by previous studies with some exceptions, suggesting that presence of unattended dogs (Wilcox et al., 2000), safety for walking, and safety from crime (Sallis et al., 1997; Thompson et al., 2003) are not associated with physical activity. This may be explained by the different neighbourhood locations assessed, in that rural and urban locations may influence perception and hence influence different behaviours.

There is evidence that traffic safety is also important to physical activity behaviour. Presence of crosswalks and pedestrian signals (Cerin et al., 2006) and fewer traffic signals increase walking behaviour (D. King, 2008). Traffic density (Brownson et al., 2001; Hooker et al., 2005; C. Lee & Moudon, 2008; Lees et al., 2007; Strath et al., 2007) and traffic speed (Cerin et al., 2006; A. C. King et al., 2006; Strath et al., 2007) are associated with physical activity including walking (Cao et al., 2006; Pikora et al., 2003), suggesting that heavy traffic and high speed of traffic would decrease residents' physical activity behaviour.

2.3.3.5 Availability of Community Facilities

Accessibility and availability of community facilities within the neighbourhood provide convenience to residents and increase the opportunity for physical activity (Badland & Schofield, 2005; Cerin, Leslie, Sugiyama, & Owen, 2010b). Formal facilities near homes, including gyms and sports courts and fitness facilities (Addy et al., 2004; Brownson et al., 2001; Giles-Corti & Donovan, 2002; C. Lee & Moudon, 2008), recreation facilities (Addy et al., 2004; Giles-Corti & Donovan, 2002; Hoehner et al., 2005; Li et al., 2005; McCormack, Giles-Corti, Bulsara, & Pikora, 2006; Poortinga, 2006; Stronegger et al., 2010; Sugiyama et al., 2009; Velasquez et al., 2009; Wendel-Vos et al., 2007) and in particular free or low- cost recreation facilities (Doerksen, Motl, & McAuley, 2007; Santos et al., 2008) are frequently used as the locations of physical activity; and they are positively related to levels of physical activity for both genders. However, facility availability is only significantly associated with physical activity among people with higher education (i.e., a university degree). A possible explanation for this is people with lower education levels would consider the cost, safety, and level of convenience as barriers to participation (Pan et al., 2009).

Proximity of community services, shops/grocery stores, convenience stores, markets, restaurants, medical services, and post boxes and post offices for example, (within walking or bicycling distance) are associated with increased likelihood of physical activity for both genders (Ball et al., 2001; Doerksen et al., 2007; Handy, Cao, & Mokhtarian, 2006; D. King, 2008; Krizek & Johnson, 2006; C. Lee & Moudon, 2008; McCormack et al., 2008; Moudon et al., 2006; Santos et al., 2008; Stronegger et al., 2010).

Using malls is associated with regular walking (Addy et al., 2004). More women report using shopping malls for walking than men; more males use parks for walking than females (Bird et al., 2010; Eyler et al., 2003; Foster et al., 2004). Men are also more likely to use walking trails compared to women (Bird et al., 2010). However, Velasquez et al. (2009) found that use of shopping malls was not significantly related to leisure time physical activity in adults in Texas, U.S.A.

Parks are another frequently used place for physical activity (Addy et al., 2004; Eyler et al., 2003). Walking for transportation has been correlated with parkland acreage within the city (Zlot & Schmid, 2005). The characteristics of easy access to parks are positive in encouraging physical activity among various populations (Brownson et al., 2001; McCormack, Rock, Toohey, & Hignell, 2010). Specifically, frequency of park visitation has a direct effect on daily physical activity levels among middle-aged and older adults (Mowen, Orsega-Smith, Payne, Ainsworth, & Godbey, 2007). Time walking is longer for men who live in areas with parks (Kondo et al., 2009).

With respect to the gender-specific links between availability of facilities and physical activity, it is found that having bookstores or video rental stores in neighbourhoods has positive effects on men; having facilities for daily necessities (post offices, banks/credit unions, gymnasiums/fitness facilities, and amusement) in the neighbourhood has a positive effect on women (Kondo et al., 2009). In particular, availability of low- cost or free facilities has a strong impact on women (Chung & Youngtae, 2009). The availability of community facilities is equally associated with participating in physical activity in both adults with disabilities and those without disabilities (Christensen, Holt, & Wilson, 2010).

2.3.3.6 Relationship of Built Environment to Walking for Different Purposes

There are different purposes for walking cited by respondents in research. These purposes include: leisure and recreation; exercise; work; errands; transportation and commuting; dog-walking. Disparities among the different purposes for walking, with a focus on the built environment characteristics can be found in previous research. In people aged 45 years or above, there was a significant association between the density of destinations and likelihood of walking for any reason, a moderate association between safety and walking for any reason, whereas no associations with density of destination and safety were found for recreational reasons (Gauvin et al., 2008). While it has been reported that diversity of destinations, residential density, walking infrastructure, aesthetics, traffic safety, and crime were positively related to walking for transportation purposes, it was also found that aesthetics, mixed destinations, and residential density were associated with walking for recreational purposes (Cerin et al., 2006). Also, walking to work is positively related with the degree of urbanization (Craig, Brownson, Cragg, & Dunn, 2002).

In addition, some interesting negative associations have been found. One study demonstrated that walking or bicycling for transportation is negatively associated with neighborhood aesthetics, such as the area being free from garbage, litter, or broken glass, as well as the level of neighbourhood maintenance (Hoehner et al., 2005). Perhaps this is because people who frequently walk or bicycle are more aware of the neighbourhood's condition and maintenance than those who are less likely to walk and bicycle in neighbourhood. This trend is supported and could be explained by findings from Bird et al. (2010), suggesting that older adults who were less likely to be active rated their environment positively, while people who were likely to be more active gave a lower rating to their environment.

2.4 Measurement of the Built Environment

In general, the methods of assessing the built environment include objective measurements and perceived measurements. Geographic Information Systems (GIS), Global Positioning Systems (GPS), and environmental audits are commonly considered to be objective measurements. The Neighbourhood Environment Walkability Scale (NEWS) and the Systematic Pedestrian and Cycling Environmental Scan (SPACES) are questionnaires commonly used to measure perceptions in research about older adults.

2.4.1 Objective Measurement – GIS and GPS

Objective measurements can be used to analyze large areas in urban design and planning fields (McGinn et al., 2007). However, objective instruments are not able to measure social factors and barrier (Kirtland et al., 2003).

The Geographic Information Systems (GIS) are database-oriented systems that have the capability to integrate and analyze spatial data and attribute related datasets (Malczewski, 2004). Thus GIS can provide spatial integration, such as measurement of proximity, connectivity, and density (Saelens, Sallis, Black, & Chen, 2003). According to these functions, built environment dimensions can be derived from GIS to measure land use, density, and design (B. Y. Wong, Faulkner, & Buliung, 2011).

Other objective measurements can be attained with portable Global Positioning System (GPS) receivers. With the positioning information collected from satellites, GPS provides data in the form of latitude and longitude on the Earth's surface thus identifying specific positions at any point in time (Krenn, Titze, Oja, Jones, & Ogilvie, 2011; Taylor, Wooley, & Zito, 2000). It allows researchers to store spatial data and obtain the location information where physical activity occurs at low cost. The application of GPS in health research includes assessing physical activity patterns, travel distances, and routes through built environments (Duncan, Badland, & Mummery, 2009).

However, the application of GPS has some limitations including battery life and memory card space capacity, lack of position records from activities indoors, under heavy tree canopy, and in dense urbanized areas due to the nature of GPS functions (Rodriguez, Brown, & Troped, 2005). Thus the application of GPS still requires more testing in different environmental contexts for reliability and validity.

Another objective measurement of built environment is the environmental audit. It can measure micro-environment characteristics at the street level (Rodríguez, Brisson, & Estupiñán, 2009). The audit items are selected in terms of the purpose of the study. Statistics of built environment are generated from software in the forms of sums, means, and frequencies. For example, to count destinations, facilities, and street segments in the neighbourhood the sum of the number of destinations (e.g., restaurants, grocery stores, and schools) and facilities (e.g., parks, trail, and sports fields) as well as percentage of street segments with certain characteristics (e.g., a bus stop and sidewalks) can be determined (Hoehner et al., 2005). Although using an audit obtains objective data of built environments, it requires creating broad audit dimensions and is not able to capture data beyond the audited area (Hoehner et al., 2005; Rodríguez et al., 2009).

2.4.2 Perceived Measurement - Questionnaires

Cost-efficient self-reported instruments are widely used to measure not only the perception of the built environment but also to investigate whether the built environment affects individual-level physical activity (McGinn et al., 2007). Questionnaires and scales are two types of self-reported instruments. Because some studies combine items and compare them to physical activity behaviour, many studies use different models (e.g., multilevel models and theoretical models), and some studies focus on specific populations, it is difficult to establish inherent comparisons among the built environment studies using self-reported tools (Humpel et al., 2002; Saelens & Handy, 2008).

The Neighbourhood Environment Walkability Scale (NEWS) is a commonly used environmental scale that was introduced by Saelens in 2003. Saelens et al. (2003) assessed different "walkability" levels of neighbourhoods (high-walkability and low-walkability) using NEWS. Five out of eight (62.5%) NEWS subscales had test-retest reliability above 0.75. To date, this scale has been developed in different versions including abbreviated form (NEWS-A), NEWS for Youth (NEWS-Y), and NEWS for different countries (e.g., Chinese version, Chinese version for seniors, Japanese version, Australian version, Brazilian version) (Cerin, Macfarlane, Ko, & Chan, 2007; Cerin, Leslie, Owen, & Bauman, 2008; Cerin, Conway, Saelens, Frank, & Sallis, 2009; Cerin et al., 2010a; Inoue et al., 2009; Rosenberg et al., 2009; Salvador, Reis, & Florindo, 2010). These different versions of the NEWS all show acceptable test-retest reliability, and subscales are significantly correlated with target population physical activity. Usually in this type of questionnaire, participants are requested to provide information about their neighbourhood characteristics and demographics. The question format is best choice, such as Likert Scale ranking system (e.g., strongly disagree, somewhat disagree, somewhat agree, strongly agree) and yes/no or present/absent.

Another popular self-reported walking behaviour related measure is the Systematic Pedestrian and Cycling Environmental Scan (SPACES) which was developed by a public health study team from Australia in 2002 for measuring physical environment systematically and empirically (Pikora et al., 2002). SPACES is based on four elements – function, safety, aesthetics, and destination – that influence walking and cycling in neighbourhoods. Some studies used this scan and presented positive association between neighbourhood characteristics and physical activity behaviour (Badland, Opit, Witten, Kearns, & Mavoa, 2010; Jago, Baranowski, Zakeri, & Harris, 2005; Pikora et al., 2006).

2.4.3 Agreement between Objective and Perceived Measurements

When perceived and objective measurements are assessed simultaneously, they may attribute different or complimentary results and findings on associations between built environment and physical activity (Humpel et al., 2002). Hoehner et al. (2005) found that aesthetics, number of destinations, and availability of public transit were associated with activity in both perceived and objective measures. Sidewalks and attractive features have been associated with increased physical activity when measured objectively; while bike lanes and access to recreational facilities have been associated with increased activity using perceived measurement.

Poor agreement between the relationship of objective and perceived measures of the built environment characteristics and physical activity has been found in previous studies (Ball et al., 2008; Kirtland et al., 2003; Maddison et al., 2010; McGinn et al., 2007). The possible explanations drawn from these studies are: 1) different dimensions or different focuses are assessed by objective and perceived measures, for example one study assessed presence of sidewalks using objective measures, the other study assessed social and safety variables using perceived measures; 2) participants' perception may not reflect the actual built environment due to different experiences, while the objective instruments measure the "big picture" or the average level of the neighbourhood; 3) an individual's judgment, desire, and expectations may affect their perception and not match the actual built environment. Another reason was identified by Duncan and Mummery (2007), who compared GIS and GPS performance in assessment of the route taken from home to school among primary school children. There was no difference between GIS estimated distance and GPS estimated distance. However, GIS estimated higher traffic volumes than actually measured by GPS ($p<0.001$). Consequently, this study explained that GIS failed to consider individuals' choices and may provide misrepresentation of routes and barriers. This misrepresentation could be different with the estimation of perceived measurements, thus it results in the poor agreement between objective and perceived measurements.

2.5 Measurement of Physical Activity Using Pedometers

The World Health Organization defines physical activity as any bodily movement produced by skeletal muscles that requires energy expenditure (World Health Organization, n.d. b). Due to the complex nature of physical activity behaviour and different needs of qualitative and quantitative research, a variety of physical activity assessment methods/tools have been developed to measure individual and population physical activity patterns, including both objective and subjective measurements.

Subjective measurements include common data collection methods such as self-report questionnaires (e.g., International Physical Activity Questionnaire (IPAQ), Physical Activity Scale for the Elderly (PASE)), behavioural observation, and occupational classification (Dishman et al., 2004). They are inexpensive, labour saving, and can be applied easily to large groups or population samples (Schuit, Schonten, Westerterp, & Saris, 1997). Also, they are considered to be accurate for moderate to higher intensity activities, and usually apply best to healthier and younger groups. When applied to activities of daily living and lower intensity activities, subjective measures require the supplementation of the objective measures (Kriska, 2000).

Common objective measurements include accelerometers, pedometers (Janz, 2006), and physiological markers (Dishman et al., 2004). An accelerometer is a monitor that contains an electromechanical device that detects accelerations in the vertical plane. The accelerometer responds to frequency and intensity of movement thus eliminating error related with differentiating displacement and the effects of gravity (Kavanagh & Menz, 2008; Mathie, Coster, Lovell, & Celler, 2004).

Pedometers are motion sensor devices that are small, inexpensive, portable, and easily operated. They have been popularly used in recording walking steps in nearly all age groups from children to older adults (Dishman et al., 2004).

The basic principle behind the pedometer mechanism is that when a person wears it on their waist belt near their hipbone and makes a foot-strike movement, the bend-and-up movement triggers the electrical circuit in the pedometer, which registers a step (Aggarwal, 2004). These simple types of mechanisms make pedometers very portable and widely used in research and in daily life. Thus the validity of the pedometer is necessary for quantifying physical activity as well as identifying the relationship between physical activity and health outcomes (Colbert, Matthews, Havighurst, Kim, & Schoeller, 2011).

Pedometers have shown good validity in assessing walking-based activities (Crouter, Schneider, Karabulut, & Bassett, 2003; Tudor-Locke, Bassett, Shipe, & McClain, 2011a). However, some previous studies have shown that pedometers may not be sensitive for slow gaits and would underestimate steps taken by frail older adults (Cyarto, Myers, & Tudor-Locke, 2004; Le Masurier & Tudor-Locke, 2003; Wilcox, Tudor-Locke, & Ainsworth, 2002). Nevertheless, pedometers are useful instruments for free-living ambulatory populations (Le Masurier & Tudor-Locke, 2003; Karabulut et al., 2005) and older adults who walk faster and have fewer gait problems (Colbert et al., 2011; Cyarto et al., 2004). Some types of pedometers may underestimate steps in individuals in a free-living environment with a high BMI (overweight or obese) (Tyo et al., 2011).

When considering the degree of agreement between pedometers and self-reported physical activity questionnaires, previous findings suggested a positive but poor agreement (Payn et al., 2008; Tudor-Locke, Williams, Reis, & Pluto, 2002). Several variables such as the individuals who were studied, the self-report instrument used, and questions asked were cited as possible explanations to the positive but poor agreement. In addition, Bassett, Cureton, and Ainsworth (2000) reported that pedometers were more accurate than questionnaires in assessing distances walked. When using energy expenditure as the standard to compare pedometers and physical activity questionnaires among free-living older adults, questionnaires have a low correlation with energy expenditure, while pedometers are moderately correlated with energy expenditure (Colbert et al., 2011).

Pedometers have some limitations when compared with other direct movement monitors. For example, pedometers are not able to capture type, intensity, frequency and duration of activity in comparison with accelerometers (Karabulut et al., 2005). In addition, since many other movements cause vertical force as well, such as sitting down and standing up, jumping, and riding a bicycle, pedometers register them all as steps. Consequently, lack of capability to distinguish body movements and activity type causes loss of accuracy (Crouter et al., 2003; Karabulut et al., 2005).

Government, public health organizations, and researchers encourage people to walk regularly every day using pedometers as a tool. The suggested values for health are 12,000-16,000 steps per day for 8-10-year-old children (girls lower than boys); 7,000-13,000 steps per day for healthy and younger adults (women lower than men); 6,000-8,500 steps per day for healthy older adults; and 3,500-5,500 steps per day for people with disabilities and chronic illnesses (Tudor-Locke & Myers, 2001). Also, Tudor-Locke et al. (2008) proposed indices to classify pedometer-determined physical activity for healthy adults based on previous evidence (Table 2.1, based on information from Tudor-Locke, Hatano, Pangrazi, Kang, 2008). In this case, researchers and practitioners can use this guideline to quantify and monitor physical activity.

Table 2.1

Walking Steps/day Indices of Pedometer-determined Physical Activity Level for Healthy Adults

Walking steps/day	**Physical activity level**
<5000 steps/day	Sedentary lifestyle
5000-7499 steps/day (excludes sports/exercise)	Low active
7500-9999 steps/day (includes volitional activities)	Somewhat active
≥10,000-12,499 steps/day	Active
>12,500 steps/day	Highly active

There have been some studies about how many days are sufficient to estimate pedometer-determined physical activity, and it has been suggested that a minimum of three days of pedometer data is required in order to achieve a minimal reliability of the estimation of free-living physical activity in a week (Hart, Swartz, Cashin, & Strath, 2011; Tudor-Locke et al., 2005), and 5 consecutive days for a one-year period study (Kang et al., 2009).

In summary, clear evidence from the reviewed literature shows that physical activity is beneficial for older adults. Walking as a popular form of physical activity in older adults is considered important for health outcomes regardless of purpose (e.g., for recreation, for transportation). As observed, perceived built environmental factors such as neighbourhood characteristics, safety concerns, and availability of community facilities play an important role in influencing older adults' walking behaviour. Personal factors such as age, gender, socioeconomic level, and self-rated health status contribute differently for walking. It is important for researchers to determine the extent to which personal and perceived built environmental factors contribute to walking behaviour that promoting health in middle-aged and older adults.

Chapter 3: Methods

3.1 Description of the Wellness Information Services Evaluation Research (WISER) Program

This study was a cross-sectional, secondary analysis based on data derived from the Wellness Information Services Evaluation Research (WISER) Program Phase Three. The following sections will introduce the WISER Program, participants' neighbourhood clusters, and WISER Program Phase Three methodology.

3.1.1 The WISER Program

The WISER Program is a longitudinal community health promotion program that was initiated to evaluate the extent to which health promotion programming and services contribute to improving community residents' health status. The program commenced at the University of Manitoba in cooperation with the Wellness Institute at Seven Oaks General Hospital in Winnipeg, Manitoba in January 1998, and it has completed four phases. The first two phases only included in-person interviews and were conducted in affiliation with the Health, Leisure and Human Performance Research Institute of the University of Manitoba. Phase One was carried out between January 1998 and June 2001 with 2034 participants. Phase Two was carried out between January and May 2002, September and December 2002, and January and April 2003 with 1500 participants in total. Phase Three was conducted by Drs. Alexander Segall and Verena Menec between August 2007 and January 2008 with 1015 individuals. This study was funded through Dr. Menec's Canada Research Chair in Healthy Aging. This phase involved two components including in-person interviews and a physical activity component, and consisted of questions on neighbourhood characteristics that were not included in earlier phases of WISER (Centre on Aging, 2008).

The objectives of WISER Phase Three included gaining a better understanding of which social and personal factors contribute to health, assessing change in health status and personal health practices by comparing with earlier phases, and to explore the role of neighbourhood impact on active aging in Manitoba (Centre on Aging, 2008).

3.1.2 Neighbourhood Clusters

Participants of WISER Phase Three resided in different Winnipeg neighbourhood clusters (Table 3.1). As the original participants were members of the Wellness Institute at Seven Oaks General Hospital, the majority of participants (82.7%) in phase three were from River East and Seven Oaks neighbourhood clusters. The neighbourhood clusters map shows their locations in Winnipeg (Figure 3.1).

Table 3.1

WISER Study Phase Three Neighbourhood Cluster Frequency of Participants

Neighbourhood cluster	Frequency	Percent
Valid (non-identified)	1	0.1
Assiniboine South	9	1.1
Transcona	9	1.1
St. James Assiniboia West	15	1.9
St. James Assiniboia East	7	0.9

Table 3.1

WISER Study Phase Three Neighbourhood Cluster Frequency of Participants (continued)

Neighbourhood cluster	**Frequency**	**Percent**
Fort Garry North	3	0.4
Fort Garry South	1	0.1
St. Vital South	1	0.1
St. Boniface West	1	0.1
St. Boniface East	8	1.0
River East West	150	19.2
River East East	31	4.0
River East North*	34	4.3
Seven Oaks West	114	14.6
Seven Oaks East	301	38.4
Seven Oaks North*	17	2.2
Inkster West	35	4.5
Inkster East	8	1.0
Point Douglas North	19	2.4
Downtown West	8	1.0
Downtown East	1	0.1
River Height West	9	1.1
River Height East	1	0.1
Total	783	100.0

* Not represented in Figure 3.1

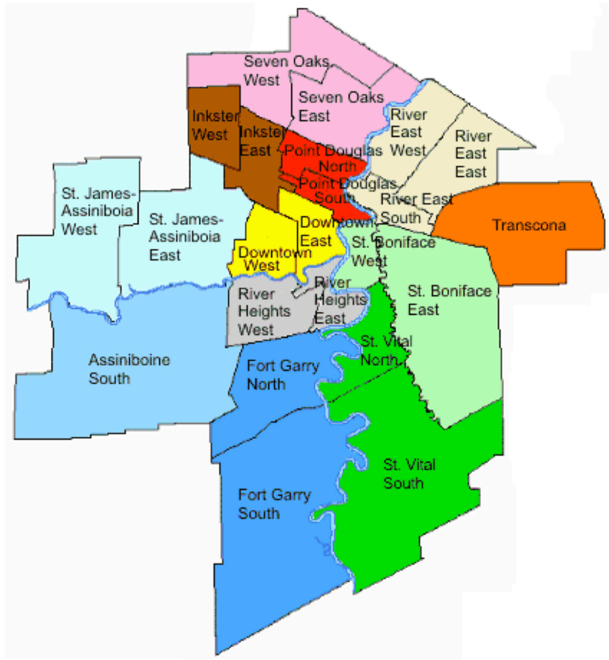

Figure 3.1. Winnipeg neighbourhood clusters map

Note. From "City of Winnipeg neighbourhood cluster profiles - 2006 census," by City of Winnipeg, n.d., http://winnipeg.ca/census/2006/Clusters/ Copyright 1996-2011 by City of Winnipeg. Reprinted with permission.

3.1.3 WISER Program Phase Three Methodology

The WISER Program included people who were community dwelling, healthy, and mobile with limited initial impairment or functional inability. Those living in nursing homes or long-term care facilities were excluded. The inclusion criteria of the WISER Program Phase Three included: 1) participants had participated in an earlier phase of the WISER Program (Phase One or Two); 2) participants were 45 years old or above as of 2006; 3) participants resided in Winnipeg or the surrounding areas of East St. Paul and

West St. Paul; 4) relevant contact information (i.e., address and phone number) remained available.

3.1.3.1 WISER Program Phase Three Data Collection Process

Data collection consisted of two components including an in-person interview and the measurement of steps recorded using pedometers. The interview questionnaire was developed by reorganizing sections and repeating, deleting, or modifying questions from earlier WISER phases, as well as by adding some new questions. The new questionnaire was used for all participants during the Phase Three interview. Interviewers attended a one-day training session to discuss the interviewers' roles and responsibilities, as well as techniques for conducting interviews and computer use. Individuals eligible for Phase Three were sent a letter explaining the study and encouraging them to participate. An interviewer then made initial telephone contact with the participants and arranged a time for interview.

In the first component (in-person interview), prior to the start of the interview, interviewers provided a letter of introduction from the Centre on Aging, University of Manitoba, explained all the components of the study, and provided a consent form to be signed by the participants. The consent form indicated that they consented to participate in the in-person interview, to participate in the physical activity component, and to allow researchers access to their Manitoba Health Records to obtain the health utilization information. Each in-person interview took approximately one hour on an individual basis. The interviewers asked participants both structured and open-ended questions. The likert scales were used for responses, with a variety of scoring categories (e.g., from excellent (1) to poor (5), or from strongly disagree (1) to strongly agree (4)). Sample questions such as:

In general, would you say your health is:

Excellent……...1

Very good…….2

Good………….3

Fair……………4

Poor…………...5

Please indicate the extent to which you agree or disagree with each statement.

	Strongly disagree	Somewhat disagree	Somewhat agree	Strongly agree
a) There are sidewalks on most of the streets in my neighbourhood...........	1	2	3	4

In the second component, some participants volunteered to wear a pedometer for three consecutive days, beginning on a day they selected. Participants recorded the date and number of steps taken each day, including times that the pedometer was put on and taken off, as well as removed temporarily (e.g., for bath, nap) on the pedometer sheet. They also completed a three-question survey: (1) how did the days when the pedometer was worn compare to a typical day; (2) how physically active were participants during the days the pedometer was worn (1=extremely inactive, 4=moderately active, 7=extremely active); (3) how did participants' physical activity during the days wearing the pedometer compare to a typical day (1=extremely inactive, 4=moderately active, 7=extremely active) (see the Pedometer Chart & Three-questions Survey in Appendix A).

Respondents were instructed to wear their pedometer on the waistband or belt while continuing their normal activities, including exercise, except for swimming, and throughout the day, except for bathing or showering. When respondents needed to bathe, shower, or nap during the day, they were required to remove the pedometer and record the time the pedometer was removed, reason, and the time they put their pedometer back on. Every day in the morning, respondents needed to press the RESET button to start to record; every night respondents removed the pedometer when sleeping. The Research Assistant from the Centre on Aging picked up the pedometers and surveys at the respondents' homes or place of employment at an arranged time. The pedometer was positioned above the knee and remained upright and close to body, on the opposite hand that respondents write with.

The type of pedometer used was the New Lifestyles, Digi-Walker pedometer, SW-200. The mechanism of this type of pedometer uses a spring-suspended lever arm to count steps. According to previous studies that compared the accuracy of different types of pedometer, the SW-200 pedometer was suggested to be an appropriate device for measuring number of steps taken by community-dwelling older adults walking outdoors, although it was shown to be compromised in terms of accuracy at slower speeds (Grant, Dall, Mitchell, & Granat, 2008).

In the WISER Program Phase Three pedometer data collection process, there were no records gathered regarding weather, such as mean temperature and snow and rain days. The month in which participants wore pedometers was recorded.

3.1.3.2 Key Variables in WISER Program Phase Three

The questionnaire used in WISER Program Phase Three was organized around seven thematic sections: Section A - Leisure participation; Section B - Health status; Section C - Health beliefs; Section D - Health behaviours; Section E - Neighbourhood characteristics; Section F - Employment and civic engagement; Section G - Demographics. Section E was a new section that was first asked in Phase Three to gain information on perceptions of participants' neighbourhoods such as outdoor spaces, buildings, transportation, facilities, safety, and dwelling. The examination of the perceived environmental factors of this study used some of the questions from Section E. The scoring of the questions included yes/no choice and scaling (e.g., strongly disagree, somewhat disagree, somewhat agree, strongly agree). The questions were generally from existing surveys such as the National Population Health Survey (NPHS), Neighborhood Environment Walkability Scale (NEWS) or abbreviated versions, and General Social Survey (GSS). Some questions were developed by Dr. Verena Menec, Principal Investigator, and her research team. The questions were pilot tested by the research team with volunteers and family members.

3.1.4 Month of Interview

Minimum and maximum temperature (degrees Celsius, °C) and total precipitation (mm) for each day of WISER Phase Three data collection were gathered from the Weather Office website (Environment Canada, http://www.weatheroffice.gc.ca). The mean temperature was the average of the maximum and minimum temperature during the day. The relationship between month and average number of steps was tested to examine the influence of month on walking. The mean temperature of month, mean maximum temperature, mean minimum temperature, and precipitation were used to help explain the difference of average number of steps between months.

3.2 Study Design

The study design was based on the study purposes and hypotheses that were presented in Chapter 1. Data from subjects who were included in WISER Program Phase Three, specifically those who provided their personal information related to the following personal variables, and who recorded steps using pedometers, were included. The total sample of the WISER Program Phase Three was 1015 participants, including 470 males and 545 females. Their ages ranged from 45 to 95 years. 834 individuals (82.2%) wore a pedometer for recording walking steps. There were 51 invalid pedometer data entries. Therefore, the preliminary sample of this study was 783. The invalid pedometer data included 23 pedometers which malfunctioned or did not work, 20 participants did not maintain records on their pedometer sheets, 7 participants only recorded one day rather than 3 days, and 1 participant reported another problem in participating. Approximately 82.6% of the total participants resided in the River East (RE) and Seven Oaks (SO) neighbourhoods. To better represent the specific suburban area of Winnipeg, the final total sample of this study used the participants from RE and SO, the number of participants from this sample was 647 (Figure 3.2). The questions that were analyzed in this study are presented in Appendix B.

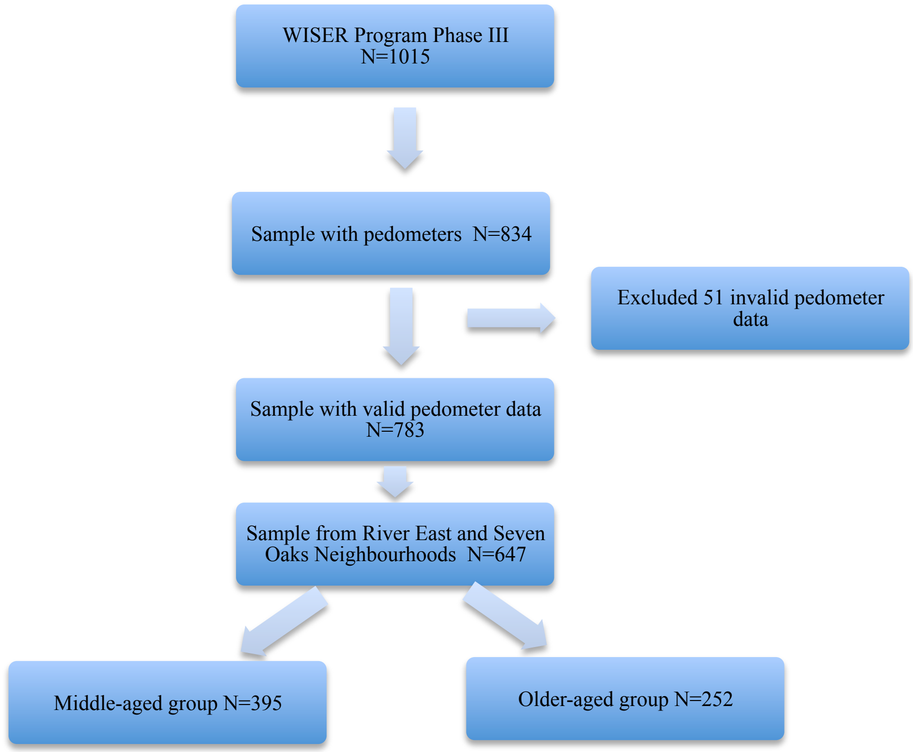

Figure 3.2. Sample of the present study

As noted in Chapter 1, this study addressed three general purposes. The model in Figure 3.3 illustrates how explanatory variables were used to test the three proposed hypotheses. The explanatory variables included personal factors and perceptions of built environmental factors. Specific variables selected from the WISER Program Phase Three questionnaire were related to average number of steps to examine hypotheses #1 and #2. Multiple regression analysis was then used to determine the joint contribution of personal factors and perceived built environmental factors on average number of steps (hypothesis #3).

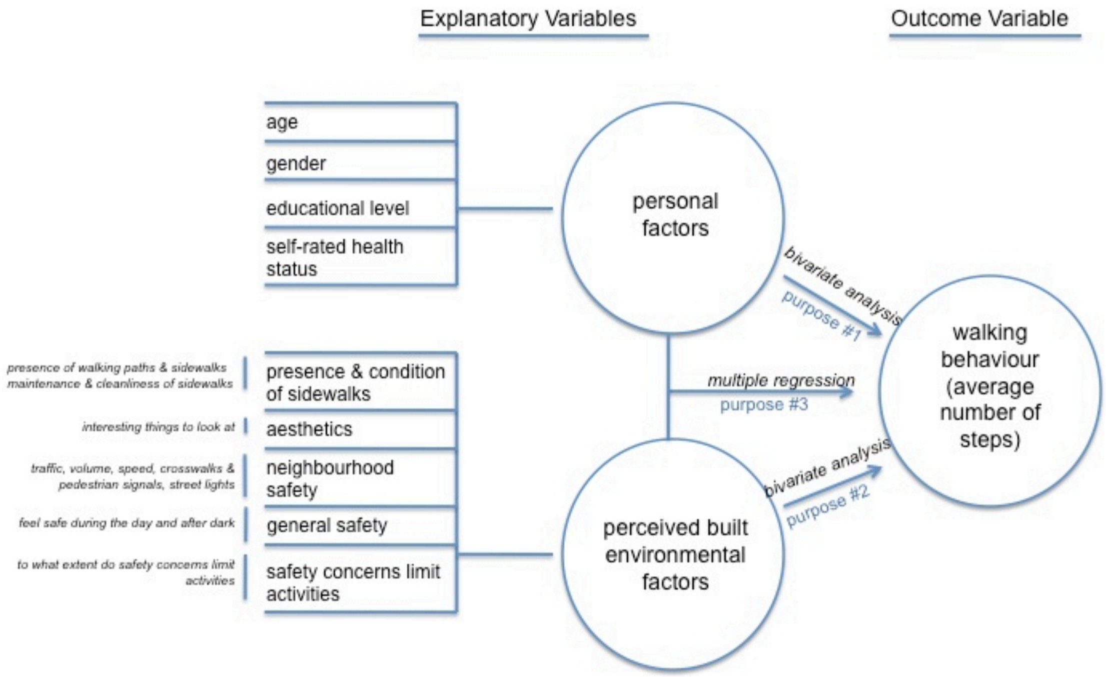

Figure 3.3. Model to test the relationship of personal factors and perceived built environmental factors to walking

3.3 Study Measures

As illustrated in Figure 3.3, specific questions were selected from the WISER Program Phase Three questionnaire to provide explanatory data that could be used to test the three study hypotheses. The three-question survey was examined to verify the validity of the pedometer data. The education questions were from Section G – Demographics; the self-rated health question was from Section B – Health status; the question of perceived built environmental factors were from Section E – Neighbourhood characteristics. Age and gender were generally specified. Table 3.2 and Table 3.3

describe the type of variables and groupings according to question numbers from Appendix B. Variables measuring the perceived built environment that were similar in natures were grouped together. The scoring range is to show the range (minimum to maximum) of those variables that combined several questions. The source column shows the origin of the questions.

Table 3.2

Description of Explanatory Variables (Personal Factors)

Variable	**Source**	**Type**	**Groupings**
Age Group	WISER Phase Three Research Group	Categorical	45 – 64 yr 65 yr and above
Age	WISER Phase Three Research Group	Continuous	45 yr and above
Gender	WISER Phase Three Research Group	Categorical	Male Female
Education	WISER Phase Three Research Group	Categorical	No schooling – Thirteen Some college - diploma Bachelor degree and above
Self-rated health status	National Population Health Survey (NPHS), 1994, 1996. No changes.	Categorical	Excellent/Very good Good/Fair/Poor

Table 3.3

Description of Explanatory Variables (Perceived Built Environmental Factors)

Variable	Source	Type	Groupings	Scoring Range	Coding
Presence and condition of sidewalks	Neighborhood Environment Walkability Scale (NEWS), 2002, version 12 One item was developed by the WISER Phase III Research Group	Continuous	E8 (a) – (d)	4 -16	Higher scores indicate better conditions
Aesthetics	NEWS, 2002, version 12	Continuous	E8 (e)	1 - 4	Higher scores indicate better aesthetics
Neighbourhood safety	NEWS, 2002, version 12	Continuous	E8 (f) – (j)	5 - 20	Higher scores indicate poorer safety
General safety	General Social Survey (GSS), (1988). No change.	Continuous	E9	2 - 8	Higher scores indicate poorer safety
Safety concerns limit activities	General Social Survey (GSS), (2002). Modified.	Continuous	E10	1 - 3	Higher scores indicate fewer concerns

3.4 Statistical Analyses

The statistical analyses were conducted using the statistical software SPSS (version 19.0 for Windows) at the University of Manitoba Centre on Aging. Data were analyzed in three steps. The specific approaches to visualizing the data and statistical tests used at each step are listed below.

Step 1: Descriptive statistics

- Percentages and frequency of response
  - Personal variables, perceived built environmental variables, responses to the three-question survey
- Scatter plot
  - To illustrate the relationship between age (as continuous data) and average number of steps per day
- Histogram
  - To illustrate whether the data set followed Normal distribution

Steps 2: Bivariate statistics

- Two-tailed independent t-test (two-group situations) or one-way analysis of variance (ANOVA) (more than two-group situations)
  - To examine the significance of mean differences in the average number of steps amongst groups in each personal factor
- Pearson Chi-square and cross-tabulations
  - To show the association between personal factors and average number of steps per day

- Pearson correlations
  - To examine the relationship between self-rated physical activity level (three-question survey) and average number of steps per day
- Univariate analysis
  - To determine any relationship between perceived built environmental factors and average number of steps per day

Step 3: Multivariate statistics

- Multiple regression
  - To determine any joint contributions between personal factors and perceived built environmental factors and average number of steps per day

In order to find a multiple regression equation (model) that uses only some of the powerful explanatory variables but still explains as much variation in the outcome variable as it can, forward stepwise regression and backward stepwise regression were both applied.

In the process of forward stepwise regression, each explanatory variable in this study (personal factors and perceived built environmental factors) was regressed on the outcome variable (average number of steps) separately. The explanatory variable that was the most significantly correlated to the outcome variable was selected as the first variable to enter the regression equation. Then each remaining explanatory variable was combined with the first variable to be regressed on the outcome variable. The most correlated variable was then selected as the second variable to enter the regression equation. This process where each explanatory variable, combined with the previous significant explanatory variables and regressed with the outcome variable, was repeated until no significant variables were found.

The process of backward stepwise regression in this study began with an examination of the effect of all of the explanatory variables (personal factors and perceived built environmental factors) on the outcome variable (average number of steps). At each step variables that were not significant were removed and a new regression analysis was performed, starting with the weakest variable, until the model had the minimum number of significant variables. In this way, the process of both forward and backward stepwise regression was used to find a model that best explained the most significant contributions of personal factors and perceived built environmental factors on average number of steps per day.

Statistical results reported when using multiple regression included adjusted r square value (r^2), degrees of freedom (df), t-test value (t), significance value (p), and Beta coefficient (standardized – β). The adjusted r^2 value showed the variation in percentage that the dependent variable (average number of steps per day) was explained by the model. By comparing each model in the process of multiple regression, the study would be able to find which personal factors and perceived environmental factors would make unique contributions to walking (number of steps), and which personal factors and perceived environmental factors would make contributions to walking (number of steps). A p value of 0.05 or less was considered significant in all statistical tests.

Chapter 4: Results

4.1 Participants Characteristics

4.1.1 WISER Three Sample

The total number of participants in the WISER Phase Three Program that had valid pedometer data was 783. Of these participants, 647 lived in the River East (RE) and Seven Oaks (SO) neighbourhoods, accounting for 82.6% of the total WISER Phase Three Program participants. To better represent the specific suburban area of Winnipeg, the final total sample of this study used the participants from RE and SO, the number of participants from this sample was 647. In addition to reporting findings for the total sample, the middle-aged (45-64 years old) and older adult (65 years and above) groups were analyzed independently in order to investigate whether there was a significant difference between middle-aged and older-aged populations in this study. Incomplete or missing responses were not included in the analyses.

Characteristics of the participants are shown in Table 4.1. The mean age for the total sample (N=647) was 62.5 years (*SD*=9.8). The mean age of the middle-aged group was 56.1 (*SD*=5.3) and the mean age of the older-aged group was 72.5 (*SD*=6.1). In some cases, respondents opted not to respond to certain questions. This is reflected by the discrepancies in total valid entries in Table 4.1.

Table 4.1

Demographic Characteristics of Participants

Characteristic	Number	Percentage	Total Valid Entries
Age			647
45-64 years	395	61.1%	
65-94 years	252	38.9%	
Gender			647
Male	316	48.8%	
Female	331	51.2%	
Education Level			644
No schooling – Grade Thirteen	232	35.9%	
Some college – Diploma	228	35.2%	
Bachelor degree and above	184	28.4%	
Self-rated Health Status (SRH)			646
Excellent/Very Good	345	53.3%	
Good/Fair/Poor	301	46.5%	

4.1.2 Walking Behaviour

The mean average number of steps per day was 6,852 steps (*SD*=3866), ranging from 165 to 22,922 steps. The median average number of steps per day for the middle-aged group was 7303 steps, for the older-aged group was 4918 steps. The scatter plot of steps per day taken for each participant is shown in Figure 4.1 with the mean average number of steps per day and two standard deviations illustrated. The histogram shows that the steps per day taken by participants do not follow a Normal distribution precisely, with a long tail on the right of the distribution (Figure 4.2). Thirty-four participants' average number of steps were greater than 2SD of the mean, which was 14,584.

Because steps were not normally distributed, the data were then transformed using Logarithmic transformation, which is frequently used to transform positive continuous data that are skewed toward the right by replacing the original measurements with their logarithms, to restore the data set to normality. The results of the correlation and regression analyses were similar to the untransformed results. Thus, the following results section was presented as the untransformed data.

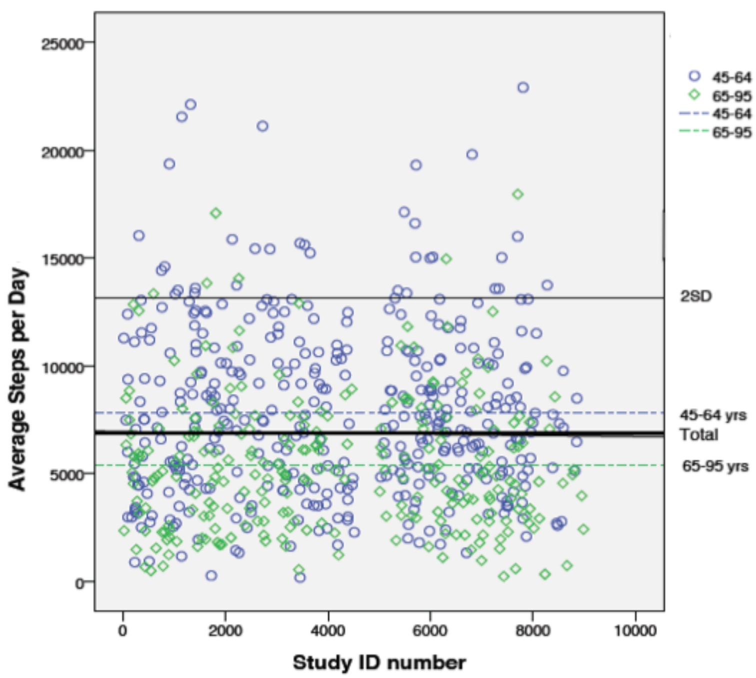

Figure 4.1. Steps per day taken by each participant (lines in this graph indicate mean average number of steps for each group) (N=647)

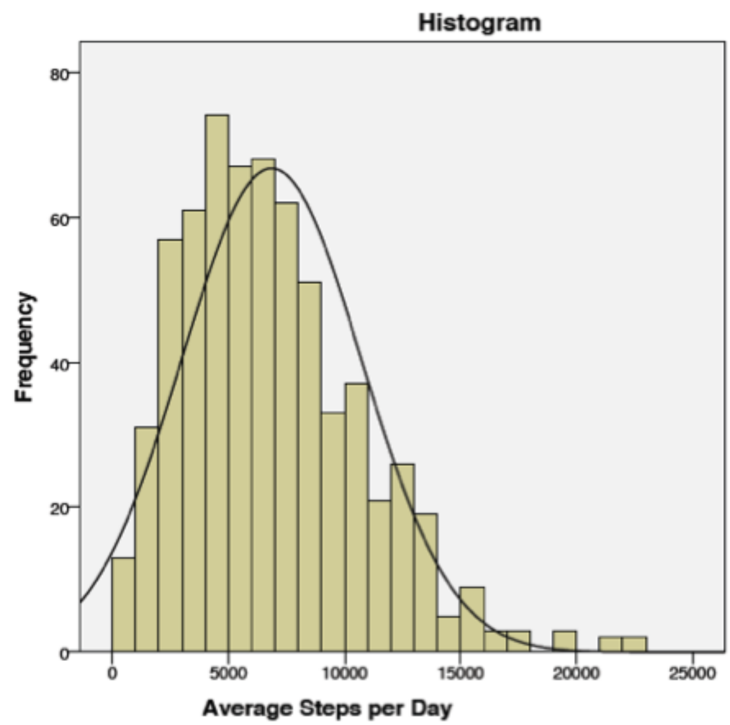

Figure 4.2. Histogram of the average number of steps per day (N=647)

4.1.2.1 Month of Interview and Walking Behaviour

The months that participants wore pedometers included August to the following January. The average temperature and total precipitation for each of these months are shown in Table 4.2. The average number of steps per day taken by participants were fewer in August, November, December, and January than in September and October. One-way ANOVA analysis suggested that there was a significant difference in steps taken by participants between August versus September ($F=3.887$, $p=0.05$) and between September versus November ($F=3.887$, $p=0.016$).

Table 4.2

Description of Month of Interview and Steps per Day (N=647)

Month (Year)	**Frequency**	**Mean Average of Steps/day (Mean±SD)**	**Average Temperature (°C) ***	**Mean Max. Temp.**	**Mean Min. Temp.**	**Total Precipitation (mm) ***
August (2007)	184	6553±3697[a]	17.6	24.5	10.6	24.5
September (2007)	156	7646±3882[b]	13.2	19.8	6.5	30.0
October (2007)	99	7792±4552	6.5	12.2	0.8	46.5
November (2007)	114	5924±3610[c]	-4.0	0.4	-8.4	9.5
December (2007)	61	6338±3159	-15.1	-10.0	-20.2	19.5
January (2008)	33	6107±3461	-17.0	-11.4	-22.7	

* Data was obtained from National Climate Data and Information Archive (http:// climate.weatheroffice.gc.ca)
a, b, c $p \leq 0.05$

4.1.2.2 Self-Rated Walking Behaviour

A three-question survey was used to determine whether the pedometer data collected were reflective of the participants' typical activity (Figure 4.3-4.4). One half (49.8%) of participants responded that the days they wore a pedometer were not different from other days, while 32.6% participants responded that the days in which a pedometer was worn were different from a typical day. One hundred and fourteen participants did not answer the question. The majority responded that their physical activity levels in the days that the pedometer was worn as well as when compared to a typical day were both moderately active (score 3-5), respectively 72.6% and 71.9%. This trend was similar in the middle-aged and older-aged groups.

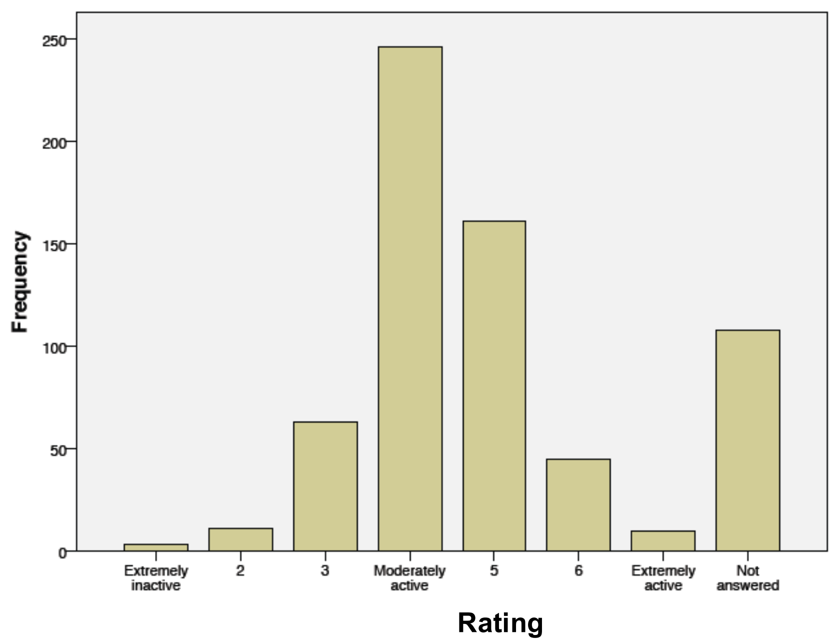

Figure 4.3. Self-rated physical activity levels on days the pedometer was worn (N=539)

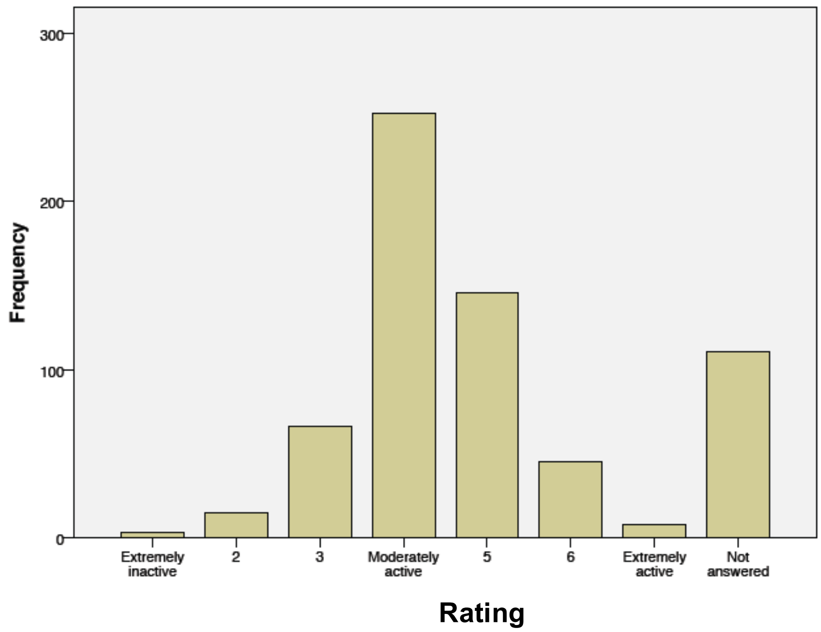

Figure 4.4. Self-rated physical activity levels on days the pedometer was worn as compared to a typical day (N=536).

Pearson correlation showed that self-rated physical activity levels on days the pedometer was worn were positively correlated with average number of steps per day, r(537)=0.302, p<0.001. Similarly, when compared to a typical day, self-reported rating of how physically active participants were on days the pedometer was worn was positively associated with average number of steps per day, r(534)=0.299, p<0.001. This indicated that pedometer data was validated (i.e., participants were neither extremely active or extremely inactive in the days the pedometer was worn), and the days participants wore pedometers were not different from other typical days. When considering the middle-aged and older adults groups separately, these positive correlations were also significant. In middle-aged adults group, self-rated physical activity levels on days the pedometer was worn r(324)=0.336, p<0.001, when compared to a typical day, r(322)=0.337, p<0.001. In older adults group, self-rated physical activity levels on days the pedometer was worn $r(211)=0.322$, $p<0.001$, when compared to a typical day, $r(210)=0.354$, $p<0.001$.

4.2 Relationships between Personal Factors and Average Number of Steps

4.2.1 Relationship among Personal Factors

Pearson Chi-Square statistics were first calculated to examine the relationship among personal variables. Some personal factors were associated with each other, as shown in Table 4.3-4.6. There was a significant relationship between age and education, X^2 (2, N=644) =37.78, $p<0.001$, education and SRH, X^2 (2, N=643) =23.70, $p<0.001$, for the total sample. For middle-aged and older-aged groups, the relation between education and SRH was also significant, X^2 (2, N=393) =8.24, $p=0.016$ and X^2 (2, N=250) =15.47, $p<0.001$ respectively.

Table 4.3

Cross-tabulation of the Frequencies of Education and Age Variables for the Total Sample

		Age groups		Total
		45 – 64 yr	65 yr and above	
Education Groups	No schooling – thirteen	106	126	232
		27.0%	50.2%	36.0%
	Some college – Diploma	152	76	228
		38.7%	30.3%	35.4%
	Bachelor and above	135	49	184
		34.4%	19.5%	28.6%
Total		393	251	644
		100.0%	100.0%	100.0%

Table 4.4

Cross-tabulation of the Frequencies of Education and SRH for Total Sample

			SRH Groups		Total
			Excellent/ Very Good	Good/Fair/ Poor	
Education Groups	No Schooling – Thirteen	Count	97	134	231
		% within groups	42.0%	58.0%	100.0%
	Some College – Diploma	Count	126	102	228
		% within groups	55.3%	44.7%	100.0%
	Bachelor and above	Count	121	63	184
		% within groups	65.8%	34.2%	100.0%
Total		Count	344	299	643
		% within groups	53.5%	46.5%	100.0%

Table 4.5

Cross-tabulation of the Frequencies of Education and SRH for Middle-aged Sample

			SRH Groups		Total
			Excellent/ Very Good	Good/Fair/ Poor	
Education Groups	No Schooling – Thirteen	Count	50	56	106
		% within groups	47.2%	52.8%	100.0%
	Some College – Diploma	Count	82	70	152
		% within groups	53.9%	46.1%	100.0%
	Bachelor and above	Count	88	47	135
		% within groups	65.2%	34.8%	100.0%
Total		Count	220	173	393
		% within groups	56.0%	44.0%	100.0%

Table 4.6

Cross-tabulation of the Frequencies of Education and SRH for Older-aged Sample

			SRH Groups		Total
			Excellent/ Very Good	Good/Fair/ Poor	
Education Groups	No Schooling – Thirteen	Count	47	78	125
		% within groups	37.6%	62.4%	100.0%
	Some College – Diploma	Count	44	32	76
		% within groups	57.9%	42.1%	100.0%
	Bachelor and above	Count	33	16	49
		% within groups	67.3%	32.7%	100.0%
Total		Count	124	126	250
		% within groups	49.6%	50.4%	100.0%

4.2.2 Age, Gender and Average Number of Steps per Day

The bar chart (Figure 4.7) shows that the average number of steps per day was lower with increasing age. The mean average number of steps per day for middle-aged adults was 7806 steps (SD=3984) and for older adults was 5,357 steps (SD=3143). An independent t-test shows that there was a significant difference between age groups, $t(645)$ =8.25, p<0.001). The scatter plot shows that age had a negative association with average number of steps (Figure 4.8). Pearson correlation analysis showed that age and average number of steps per day were significantly correlated, $r(645)$ =-0.366, p<0.001.

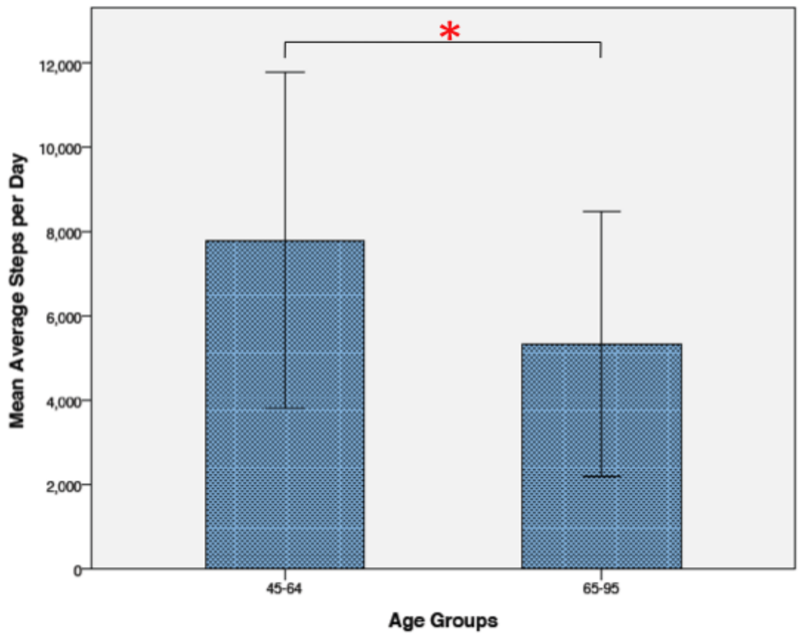

Figure 4.5. Average number of steps per day taken per each age group (N=647)

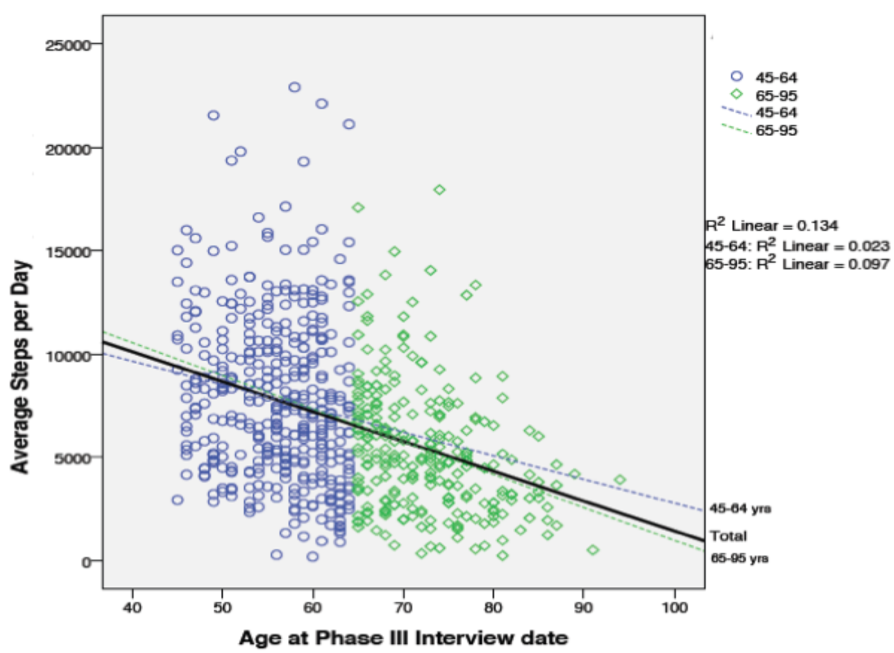

Figure 4.6. Relationship between age and average number of steps per day (with regression lines for each group)

Although the average amount of walking for men was slightly higher than for women, with men taking 7,060 steps per day (*SD*=4072) and women taking 6,653 steps per day (*SD*=3654) respectively, there was no significant difference in the average number of steps per day between men and women in the total sample, $t(645) = 1.34$, $p=0.181$, or in the middle-aged, $t(393) = 1.47$, $p=0.142$ and older age groups, $t(250) = -0.19$, $p=0.848$.

4.2.3 Education Level and Average Number of Steps per Day

Level of education had a positive association with average number of steps per day (Figure 4.9). A one-way analysis of variance (ANOVA) showed that there was a significant difference among education levels on average steps per day, $F(2,641) = 4.13$, $p=0.016$. Post hoc analyses using Tukey HSD indicated that participants with a lower level of education (i.e., no schooling – grade thirteen) had significantly lower average number of steps per day (*M*= 6337, *SD*= 3718) than those with a higher level of education (i.e. bachelor degree and above) (*M*= 7482, *SD*= 4075) ($p=0.012$). However, when separately analyzing the difference in middle-aged and older age groups, the average number of steps per day did not differ among these education groups.

4.2.4 Self-rated Health Status and Average Number of Steps per Day

Self-rated health status had a positive association with average number of steps per day. Those who rated their health as excellent/very good had more steps per day (*M*=7697, *SD*=4089) than those who rated their health as good/fair/poor (*M*=5895, *SD*=3351), *t*(644) =6.07, *p*<0.001 (Figure 4.13). This significant difference was also found in the middle-aged and older age groups as can be seen in Table 4.7.

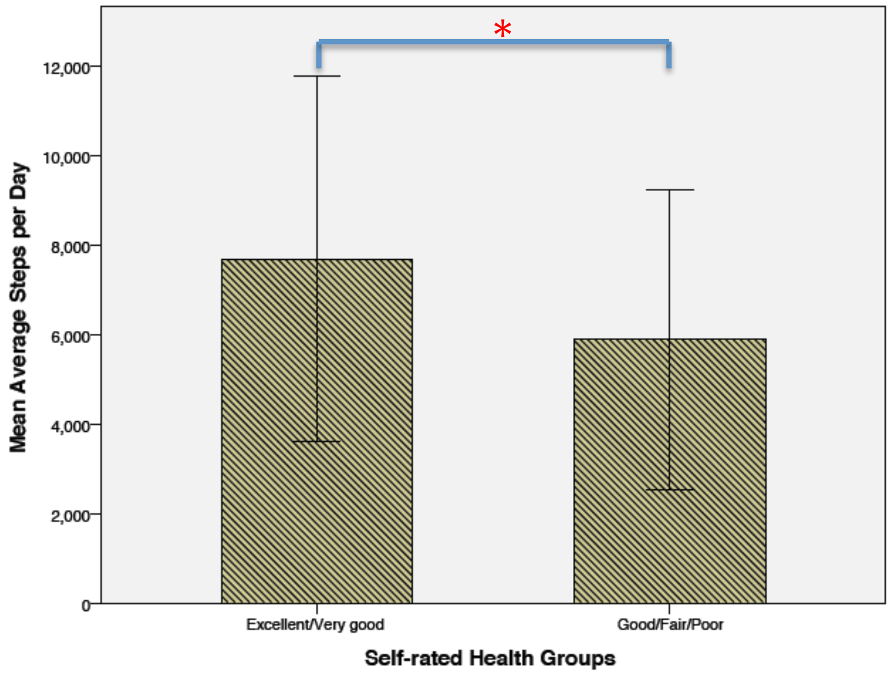

Figure 4.7. Average number of steps per day taken per self-rated health status (N=646)

Table 4.7

Self-rated Health Status on Average Number of Steps for Middle-aged and Older-aged Groups

	Excellent/Very Good		Good/Fair/Poor		T-test	df	p Value
	M	SD	M	SD			
Middle-aged	8645	4183	6751	3453	4.82**	393	<0.001
Older-aged	6029	3330	4707	2814	3.40**	249	0.001

***p*<0.01

4.3 Relationships between Perceived Built Environmental Factors and Average Number of Steps

Table 4.8 presents descriptive statistics for each perceived built environmental variable. To explore the relationship between perceived built environmental factors and average number of steps, scatter plots were used to provide a graphical display of the data. The X- axis in Figures 4.11 – 4.15 showed the scale of each variable.

For the total sample, scatter plots showed that the number of steps reached the highest on the scale at 12.5 in the relationship between presence and condition of sidewalks and average number of steps (Figure 4.11). This shows a trend that when respondents somewhat agree on a good presence and condition of sidewalks, they had the highest average number of steps. For the aesthetics variable, the number of steps reached the highest on the scale at 3.0 in the relationship between aesthetics and average number of steps (Figure 4.12). This shows a trend that when respondents somewhat agree that there are many interesting things to look at in their neighbourhood, they had the highest average number of steps.

For the neighbourhood safety variable, the number of steps reached the highest on the scale at 12 in the relationship between neighbourhood safety and average number of steps (Figure 4.13). This shows a trend that when respondents somewhat disagree that there are problems with neighbourhood safety, they had the highest average number of steps. For the general safety variable, the number of steps reached the highest on the scale at 3 in the relationship between general safety and average number of steps (Figure 4.14). This shows a trend that when respondents feel their neighbourhood is reasonably safe, they had the highest average number of steps. For the safety concerns variable, the number of steps reached the highest on the scale at 3.0 in the relationship between safety concerns and average number of steps (Figure 4.15). This shows a trend that when respondents do not think safety concerns limit their activities outside their home, they had the highest average number of steps.

For middle-aged and older-aged groups, the trends of each relationship between perceived built environmental variables and average number of steps was consistent with the total sample.

Table 4.8

Descriptive Statistics of the Perceived Built Environmental Variables

Variable	**Valid Entries**	**Mean (SD)**	**Median**	**Minimum**	**Maximum**	**Range**
Presence and condition of sidewalks	566	11.73 (2.55)	12	4	16	12
Aesthetics	623	2.92 (0.88)	3	1	4	3
Neighbourhood safety	620	12.37 (2.43)	12	5	20	15
General safety	630	3.53 (1.23)	3	2	8	6
Safety concerns limit activities	643	2.65 (0.52)	3	1	3	2

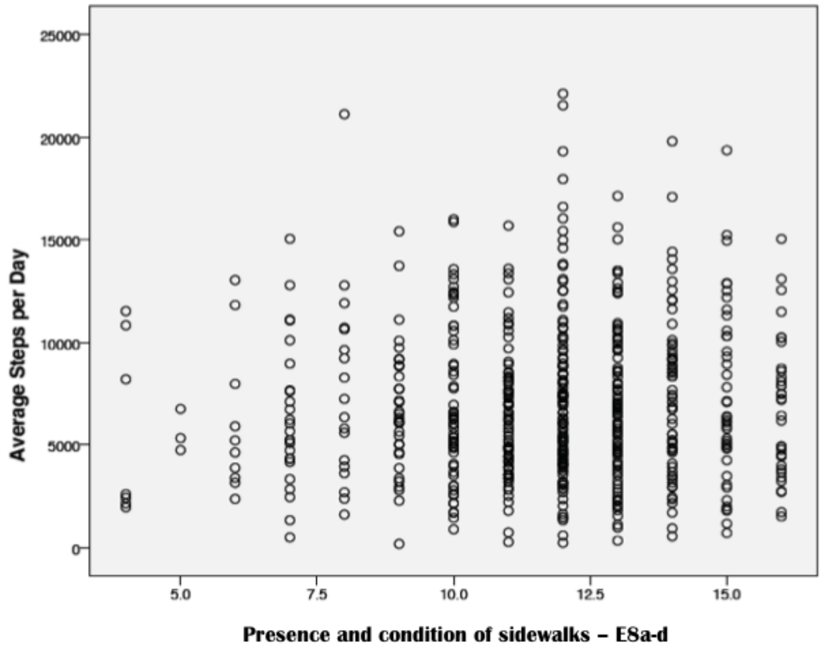

Figure 4.8. Scatter plot of the relationship between presence and condition of sidewalks and average number of steps per day

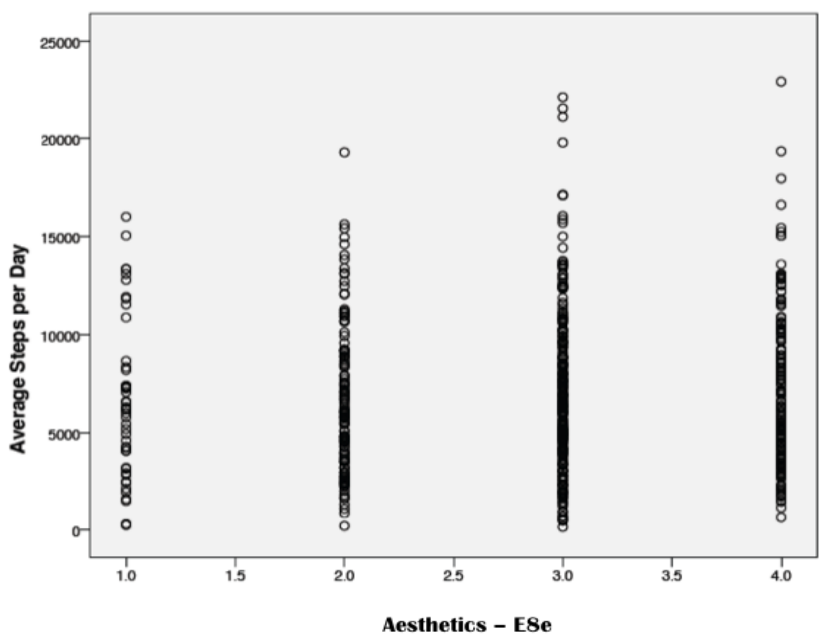

Figure 4.9. Scatter plot of the relationship between aesthetics and average number of steps per day

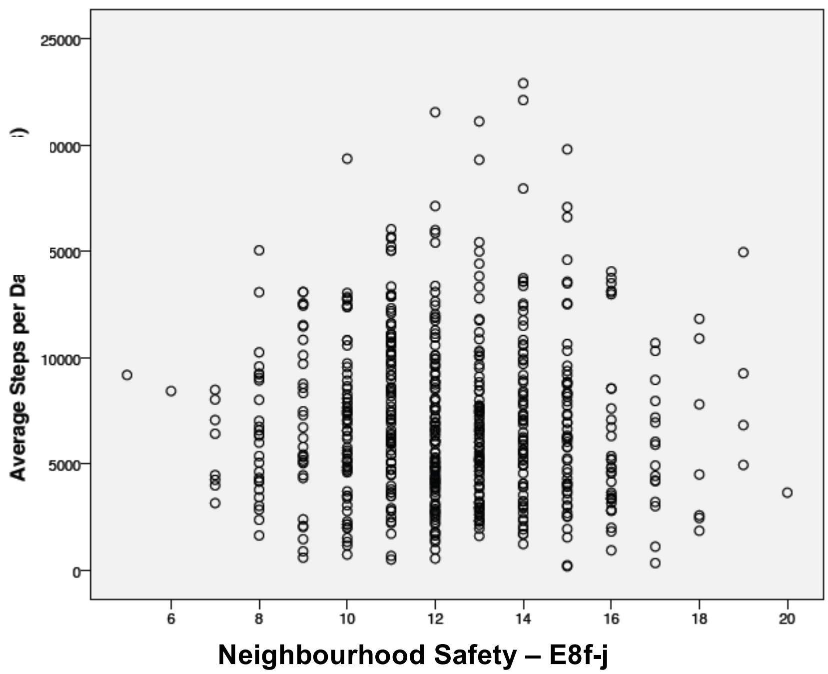

Figure 4.10. Scatter plot of the relationship between neighbourhood safety and average number of steps per day

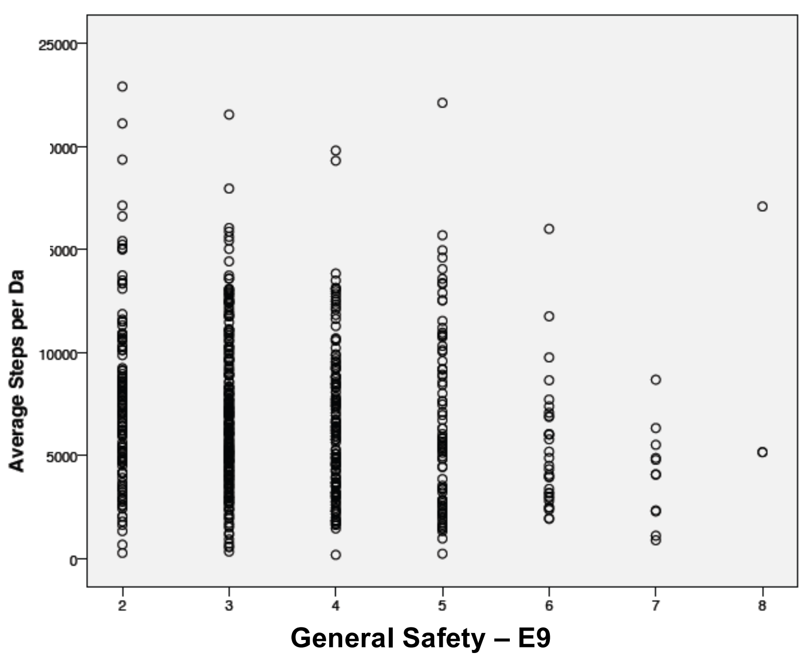

Figure 4.11. Scatter plot of the relationship between general safety and average number of steps per day

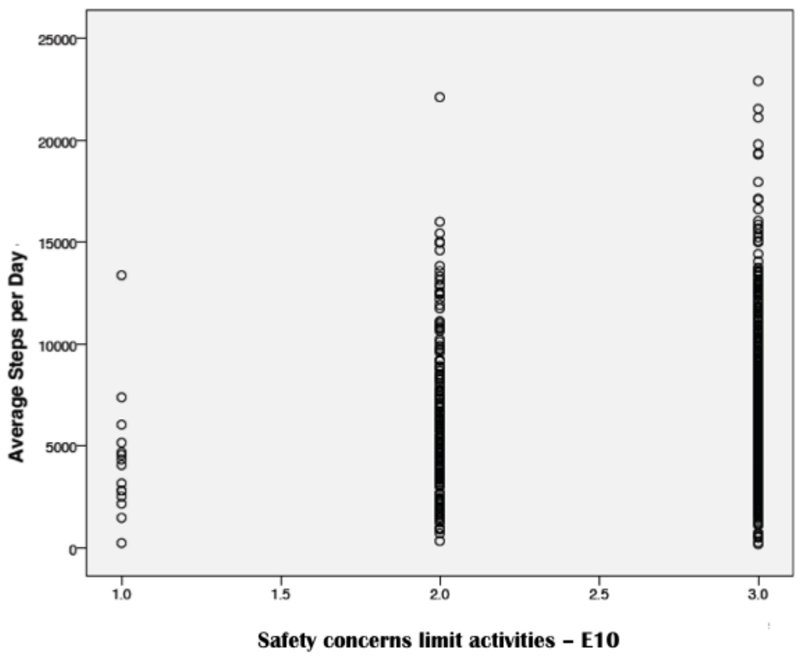

Figure 4.12. Scatter plot of the relationship between safety concerns and average number of steps per day

To further explore the relationship between perceived built environmental factors and average number of steps, each perceived built environmental variable was entered into univariate regression. The models that showed significance are shown in Table 4.9.

Table 4.9

Univariate Regression Model between Perceived Built Environmental Variables and Average Number of Steps per Day

Model	Standardized Coefficient (β)	Adjusted R^2	df	F	Significance Level (p)
Total sample					
1 General safety	0.138	0.017	629	12.200	0.001
2 Safety concerns	0.148	0.020	642	14.305	<0.001
Middle-aged group					
General safety	0.105	0.008	393	4.335	0.038

4.4 Joint Contribution of Personal Factors and Perceived Built Environmental Factors on Average Number of Steps

One of the purposes of this study was to examine the joint contribution of personal factors and perceived built environmental factors on average number of steps by entering the independent variables of age, gender, education, and self-rated health status into a multiple regression analysis along with perceived built environmental variables including presence and condition of sidewalks, aesthetics, neighbourhood safety, general safety, and safety concerns. Stepwise forward and backward regression were both applied, only backward regression results were reported.

The total valid entries (N=527) were entered into multiple regression analysis, only age and self-rated health status showed significance (Table 4.10). In model one, 12.2% of the variance in the average number of steps per day was explained by age. In model two, 16.2% of the variance in the average number of steps per day was explained by both age and self-rated health status. For the middle-aged group (N=340), self-rated health status showed significance, the proportion of variance was 4.7%. Similarly for the older-aged group (N=187), self-rated health status showed significance, the proportion of variance was 5.8%.

Table 4.10

Regression Model of Personal Variables and Perceived Built Environmental Variable and Average Number of Steps per Day

Model	Standardized Coefficient (β)	df	t-test	Significance level (p)
Total sample				
1 Age	-0.349	525	-8.531	p<0.001
2 Age	-0.333	524	-8.305	p<0.001
Self-rated health status	-0.201		-5.014	p<0.001
Middle-aged sample				
Self-rated health status	-0.218	338	-4.100	p<0.001
Self-rated health status	-0.241	185	-3.375	p=0.001

Chapter 5: Discussion

The purpose of this study was to investigate the relationship between personal factors (age, gender, education level, and self-rated health status) and perceived built environmental factors (presence and condition of sidewalks, aesthetics, and safety) and walking behaviour in middle-aged and older adults residing in a suburban neighbourhood. In addition, the joint contribution of personal factors and perceived built environmental factors to walking behaviour was examined. The results partially support the hypothesis that several personal factors (age, education level, and self-rated health status) would be significantly related to more walking. However, the hypothesis that perceived built environmental factors would be related to walking behaviour was not supported, with the exception of safety, which was found to be somewhat related to walking behaviour. The results will be discussed and interpreted in this chapter, and comparisons will be made between the results of this study and previous research. Finally, the limitations of this study and future research recommendations will be considered.

5.1 Participant Characteristics

The participants in this study were healthy, ambulatory middle-aged and older adults, all residing in the community. Although the initial sample from the WISER Three research was taken from neighbourhoods across the city, the final sample included in the present study was from the RE and SO neighbourhoods only. The middle-age group comprised 61.1% of the total sample and the older-aged group comprised 38.9% of the total sample. The ratio of middle-aged and older-aged adults in this study was 1.6:1. According to the Canadian census in 2011, in Winnipeg, the proportion of middle-aged adults was 27.6%, older adults was 14.4% (Statistics Canada, May 29, 2012), a ratio of 1.9:1. Thus, the population demographic of this study reflects the trend that the number of middle-aged adults is above 1.5 times that of the population of older adults. In addition, the volunteers for the WISER Program Phase Three were healthy, ambulatory, and involved in the pedometer component of this study; therefore this may reflect higher participation from middle-aged groups rather than older-aged groups. The ratio of men and women of the total sample was 1:1.047. In the middle-aged group, the ratio of men and women was 1:1.005; in the older-aged group, the ratio of men and women was 1:1.136. There was no predominant gender disparity in this study. The ratio reflects the trend in Winnipeg that the ratio between men and women is maintained at approximately 1:1.1. The ratio of men to women in the middle-aged and older adult population was 1:1.2. In the middle-aged group in Winnipeg, the ratio was 1:1.1; in the older-aged group, the ratio was 1:1.4 (Statistics Canada, May 29, 2012).

In the total sample, 63.6% completed some form of higher education (college diploma, university degree). In Manitoba, the population aged 25 to 64 with a college or university education was 44%, compared with 51% in Canada. The population aged 25 to 64 with below secondary education was 15% (Statistics Canada, September 11, 2012). The sample of this study is more highly educated than average in Manitoba. According to the data from the WISER Program Phase Three, over 50% of the participants in this study reported an average total family income above $70,000, and 34.4% of the participants reported incomes above $90,000. In Winnipeg in 2010, husband-wife families had an average total family income of $97,600; the median total family income was $86,700 (Statistics Canada, June 18, 2012). Therefore, the RE & SO neighbourhoods are suburban areas and consist of generally middle-income household.

In this study, findings showed that 53.3% of participants reported “excellent” or “very good” health status. The proportion decreased with age, showing that middle-aged adults tended to rate their health status higher compared to older adults. This trend is consistent with national findings. In 2011, 59.9% of Canadians aged 12 and above perceived their health as “excellent” or “very good”. The percentage decreases from 58.8% in males and 58.9% in females in middle-aged groups to 35.3% in males and 37.4% in females in older-aged groups (Statistics Canada, 2011b). However, the overall percentage of “excellent” or “very good” in this study is lower than overall national levels. Perhaps this is because in Manitoba, the proportion was below the national average, which was 56.7% (Statistics Canada, 2011b).

5.1.1 Walking Behaviour

The average number of steps per day taken by the total sample was 6,852. In the middle-aged group, the average number of steps per day was 7,806; in the older adult group 5,357. The median average number of steps per day for middle-aged group was 7303 steps, for older-aged group was 4918 steps. An expected range of steps per day for free-living healthy middle-aged and older adults that was suggested by Tudor-Locke et al. (2009a) is between 2,000 and 9,000. The recommendation threshold in terms of steps per day for community-dwelling healthy adults (approximately 20-65 years of age) is 7,000 to 8,000 (Tudor-Locke et al., 2011b); for community-dwelling healthy older adults is 7,000 to 10,000 (Tudor-Locke et al., 2011c). According to these step indices, the average steps per day taken in the current investigation falls in the expected values for both middle-aged and older adults; however, only the middle-aged group meets the recommendation of steps per day, while the older-aged group is below the recommendation. Furthermore, according to the graduated step indices revisited by Tudor-Locke et al. (2008) for healthy adults, participants in this study can be classified as low active, while middle-aged adults are somewhat active and older adults are low active.

It is noteworthy to underscore that the sample that the recommended threshold of steps per day for adults is based on is younger than the current study; therefore, the total sample of this study did not meet the recommendation while the middle-aged group did. Perhaps functional limitations (e.g., lower extremity strength and power) that are commonly barriers among older adults might have an influence on steps taken by the sample (Paterson & Warburton, 2010; Puthoff, Janz, & Nielson, 2008). When considering the older-aged group, the large standard deviation reveals a wide distribution of ambulatory behaviour in the present sample. The steps range from 165 steps per day to 22,922 steps per day. Thirty-four participants' average number of steps were greater than 2SD of the mean, which was 14,584. Twenty-nine of these participants were middle-aged adults, five were older adults. They all rated their health status as greater than good. Thirty-one of these participants' pedometer data were taken during August and October, the other 3 were taken in November. Considering these factors, it seems reasonable that they have more steps. In order to normalize the complete data set, data was entered into logarithmic transformation. However, due to similar results found between transformed and untransformed data, the untransformed data were used in this study.

Because pedometers vary in how measurements are taken, it is important to address the methodological aspects of pedometers for step count assessments. In this study, the pedometers used a spring suspended horizontal lever arm to count the number of steps taken. This required pedometers to be kept in a vertical position at the waist to register steps properly. Also, the accuracy of the SW-200 pedometer is affected at slower walking speeds (Grant et al., 2008; Tyo et al., 2011). Therefore, it is possible, especially among older adults, that some participants had walked at slow speeds causing an underestimation of steps counted. In addition, pedometers may count accelerations from hip and foot and ground contact time, which may reduce the accuracy in detecting steps (Tudor-Locke et al., 2011a). Pedometers were self-monitored after participants were given instruction by researchers during in-person contact throughout this study. Participants who are more physically inactive are likely to remove the pedometer early (Tudor-Locke, Johnson, & Katzmarzyk, 2009b). In addition, some participants may have failed to put on the pedometer as soon as they got up in the morning or resumed from napping, bathing, or swimming. These issues would cause some steps to be missed.

Most people perceived that there was no difference in walking between the days they wore a pedometer and typical days. Additionally, most people reported that they were moderately active on the days wearing a pedometer, even when compared to a typical day. This indicates that the average number of steps during the three consecutive days that the pedometer was worn reflected participants' walking behaviour in a typical day. This also suggests that the pedometer data in this study are valid and adequately represents middle-aged and older adults' walking behaviour.

Findings from the present study are consistent with the trend demonstrated from previous studies that the highest mean of average steps per day are in September, while the lowest average steps per day falls during the winter. This is perhaps because during spring and fall months there are suitable daylight hours and temperatures for daily activity (Kang et al., 2012). Steps taken were lower in August than in September and October in this study because the mean maximum temperature in August was the highest among other months. Also, due to the cold weather in Winnipeg during November, December, and January, which were all below zero degrees Celsius in the years the data was collected, people perhaps tend to walk less thus the steps taken decreased sharply during these months. This has been supported by studies reporting that people have more steps taken in summer than in winter, and the steps per day are fewer in July and December than the remaining months (Kang et al., 2012; Tudor-Locke et al., 2004). This is possibly because people take more vacation time during these two months (Tudor-Locke et al., 2004). Tudor-Locke et al. (2004) have also suggested researchers consider data collection in the "intermediary seasons" (i.e., spring and fall) to avoid vacation time and better represent a typical day's walking behaviour. The present study did not examine the influence of the average temperature and mean precipitation in the month, because the days that pedometers were worn were randomly selected by participants, and the average temperature and mean precipitation of the month could not represent the day's weather conditions.

5.2 Personal Factors and Walking Behaviour

5.2.1 Age and Gender

It was hypothesized in this study that age would be negatively associated to the average number of steps per day among middle-aged and older adult populations. Results supported this hypothesis showing that the average number of steps per day were lower with advancing age in the total sample as well as in the middle-aged and older-aged groups. Particularly, the association was greater in the older-aged group than in the middle-aged group. When comparing steps taken between these two subgroups, the results suggested that the average number of steps differed significantly between middle-aged and older adults. The findings of the effect of age on steps taken is supported by other reports in terms of both physical activity (Berrigan, Troiano, McNeel, DiSogra, & Ballard-Barbash, 2006; Norman et al., 2002; Pan et al., 2009; Plotnikoff et al., 2004; Yorston, Kolt, & Rosenkranz, 2012), and of pedometer-determined walking (Bassett, Wyatt, Thompson, Peters, & Hill, 2010; De Cocker, Cardon, & De Bourdeaudhuij, 2007; Payn et al., 2008; Sisson, Camhi, Tudor-Locke, Johnson, & Katzmarzyk, 2012).

According to the results of this study, no relationship between gender and average number of steps per day was found in either the total sample or the age-related subgroups. This is contrary to some other findings that gender has an influence on walking behaviour, and that men take more steps than women (Bassett et al., 2010; Bauman et al., 2012; De Cocker et al., 2007). Perhaps the different population studied might have influenced the significance of the comparison between genders and steps per day, as the sample of the present study was an older age group than those studies that included younger aged adults.

Although some previous studies found a difference between gender in physical activity levels (Berrigan et al., 2006; Pan et al., 2009; Poortinga, 2006; Prince et al., 2011) and in walking (Bassett et al., 2010; De Cocker et al., 2007; Sisson et al., 2012), results of the current study contributes to existing literature by demonstrating that there is no significant gender difference in engagement in leisure time physical activity (Sørensen & Gill, 2008). This is perhaps because of the different demographics between the current study and previous studies. Participants in the current study were middle-aged and older adults, while previous studies included younger adults.

5.2.2 Education Level

In the current investigation, there was a positive association between education level and walking, particularly among people who had a bachelor degree and above who accumulated a higher number of steps than people who had thirteen years of education and less. However, when considering the effect of age, this association disappeared.

When considering the positive association in the whole sample, other researchers have examined the impact of education level on walking and revealed results finding that higher education level is consistent with higher participation in physical activity (Abu-Omar et al., 2004; Ball et al., 2007; Berrigan et al., 2006; Giles-Corti & Donovan, 2002; Plonczynski, 2003; Rafferty et al., 2002; Steffen et al., 2006), in middle-aged and older adults (W. C. King et al., 2005; Pan et al., 2009), and in walking (Addy et al., 2004; Bassett et al., 2010; Bauman et al., 2012). As noted previously, this is perhaps because higher education helps people acquire a range of knowledge in understanding and practicing physical activity (Pan et al., 2009). Additionally, people who have higher education tend to have a higher income level; this would promote resources and access to physical activity facilities (Pan et al., 2009). Furthermore, the sample of the present study was predominantly from middle-income neighbourhoods, which may be another reason for the positive associations found. Previous studies found that average neighbourhood income correlates to physical activity participation (Hoehner et al., 2005; Sallis et al., 1997). This may be because people living in higher-income areas are expected to have access to physical activity facilities and programs, as well as an enjoyable and safe environment (Sallis et al., 1997); while people living in lower-income areas have less availability of physical activity-related facilities (Powell et al., 2006) and unsafe environment.

Controversially, some studies have found a negative association between education level and walking (Craig et al., 2007; Plonczynski et al., 2004; Reis et al., 2008). In the current study, significance disappeared when considering the effect of age, Reindicating that education level is not an independent factor to walking. This is perhaps due to different demographics (younger age vs. older age) as well as engagement of different purposes of walking (leisure time walking or transportation walking) (Kruger et al., 2008).

5.2.3 Self-rated Health Status

This study found a significant association between self-rated health status and walking, indicating that people who rated their health as “Excellent or “Very Good” took more steps per day compared to those who rated their health as “Good/Fair/Poor”. This difference was found in the total sample, and in the middle-aged, and older aged groups.

This is consistent with previous studies, as self-rated health status has a positive association with level of physical activity in middle-aged (Abu-Omar et al., 2004; Norman et al., 2002; Pan et al., 2009) and older adults (Abu-Omar et al., 2004; Gregg et al., 1996; Kanagae, 2006; Leinonen et al., 1999; Pan et al., 2009). Bauman et al. (2012) stated in a recent systematic review that self-rated health status is a clear determinant of physical activity.

The association between self-rated health status and walking can be confirmed by dose-response examinations, showing that there is a linear positive relationship between physical activity and self-rated health across all age groups (Abu-Omar & Rutten, 2008; Galan et al., 2010; Kaleta et al., 2006; Södergren et al., 2008; Han et al., 2009). It is generally understood that health problems such as physical function problems and pain limitations have been the most observed barrier to limit participation of physical activity (Kanagae et al., 2006; Plonczynski et al., 2004); alternatively, people who benefit from physical activity tend to perceive their health status better (Abu-Omar et al., 2004; Abu-Omar et al., 2008).

In conclusion, the above evidence supports hypothesis #1 of this study that younger aged people with higher education, and better self-rated health will walk more steps per day, with the exception of gender which had no significant impact on average steps per day. However, when considering age, education level is no longer an independent factor.

5.3 Perceived Built Environmental Factors and Walking Behaviour

5.3.1 Safety

This study found that perceived general safety (during the day and after dark), and safety concerns that limit activities outside of home were significantly associated with walking among middle-aged and older adults in the univariate analyses, although these affects were no longer significant once personal factors were controlled for. This suggests that perceived safety is somewhat related to middle-aged and older adults' walking behaviour, the safer the neighbourhood is perceived, the more likely people are to walk; the less safety concerns that people have, the more likely they are to walk. This is consistent with previous studies demonstrating that traffic safety (Cao et al., 2006, Pikora et al., 2003), presence of crosswalks and pedestrians signals (Cerin et al., 2006), and street light (Addy et al., 2004; Pikora et al., 2003) are associated with walking; perceived general safety affects physical activity (Christensen et al., 2010; Foster et al., 2004; Sharpe et al., 2004; Trost, Owen, Bauman, Sallis, & Brown, 2002; Velasquez et al., 2009) as well as walking (Bird et al., 2010; Doyle et al., 2006; Li et al., 2005; Saelens & Handy, 2008; Satariano et al., 2010).

Specifically, the association of the perception of safety in this study was in the total sample and in the middle-aged group, rather than older age group. This is in contrast with the idea that to the older adult population, perceived safety within the neighbourhood is highly influential on the rates of physical activity (Brownson et al., 2001; U.S. Centers for Disease Control and Prevention, 1999; D. King, 2008). Cunningham & Michael (2004) demonstrated that lower neighbourhood safety was associated with a decrease in physical activity among older people. This is perhaps because older people who reported that their neighbourhood was unsafe tend to have more functional limitations, thus they feel more vulnerable and unsafe (Cunningham &

Michael, 2004; Satariano et al., 2010). In the present study, older people were more healthy and ambulatory, thus safety concerns or fear of neighbourhood problems did not appear to be a barrier; perhaps this is the reason no association was found between perception of safety and walking in older adults.

Alternatively, some research does not support this finding showing that safety is not associated with physical activity (Humpel et al., 2002; Thompson et al., 2003) and walking (Bird et al., 2009; Gauvin et al., 2008). Perhaps one of the differences is that the sample of the present study is from a suburban area, and the samples from previous studies are living in urban settings. In addition, different measures of safety such as general perception of neighbourhood safety, specific neighbourhood safety issues (e.g., street lighting, surveillance, unattended dogs, graffiti and vandalism, having window bars, having neighbourhood-watch signs, and crime), personal safety (fear of injury or falling), and traffic safety may influence variability of results (Humpel et al., 2002).

5.3.2 Other Perceived Built Environmental Factors

This study found a trend in perceived built environmental factors that people were likely to walk more when presence and condition of sidewalks, and aesthetics are perceived to be good; people were likely to walk more when they perceived safety is reasonably good and no safety concerns limit their activities. When the perception of neighbourhood safety was intermediate (i.e., somewhat disagree or somewhat agree) people were more likely to walk.

Other than safety, none of the other perceived built environmental factors in this study were associated with walking (i.e., presence and condition of sidewalks, aesthetics, availability of community facilities, facilities that meet senior's needs). This is contrary to expectations of this study and evidence from previous research. Studies demonstrated the existence of a relationship between perceived built environmental factors and walking, including presence and condition of sidewalks (C. Lee & Moudon, 2006b; Pikora et al., 2003), aesthetics (Bird et al., 2010; Hoehner et al., 2005; Strath et al., 2007), availability of facilities (D. King, 2008; C. Lee & Moudon, 2008; McCormack et al., 2008; Stronegger et al., 2010). However, the weak association of these variables in this study is supported by other research stating that sometimes the association is less clear, and there has been difficulty explaining the influence of built environmental factors on walking; this weak association reflects the sometimes controversy of methods in this research field (Sallis et al., 1997; Thompson et al., 2003; Van Cauwenberg et al., 2011). Firstly, current data was collected in a suburban setting while other studies have focused on urban areas where development and design has been more activity friendly. The homogeneity of the participants may also reduce the amounts of variance (Gauvin et al., 2008; Sallis et al., 1997). Secondly, inconsistency in findings may be due to a number of factors, including different theoretical frameworks used in this study and previous studies (Rosso, Auchincloss, & Michael, 2011). For example, in this study defining facilities as grocery stores, pharmacies and other such living necessities, while other studies defined facilities as gyms, trails and other such exercise-related facilities may present different outcomes (Cunningham & Michael, 2004). Defining different outcomes may also cause different results (e.g., physical inactivity vs. walking for various purposes) and sample differences (Saelens & Handy, 2008). Thirdly, inconsistent findings in this study may result from inconsistent methods of measurement of walking, such as using subjective measurement (survey, self-report) or objective measurement (GIS, pedometer, accelerometer) (Saelens & Handy, 2008). This is critical to the investigation of the relationship between built environmental factors and physical activity (Berrigan et al., 2006). Fourthly, different measures of built environment (subjective in this study vs. objective in some other studies) may present varying results, and therefore limit the correlation being found (Sallis et al., 1997). Lastly, it is possible that people who perceive their neighbourhood as less activity friendly (in terms of convenience and enjoyment) tend to do activity outside of their neighbourhood thus weakening the relationship (Duncan & Mummery, 2005; Hoehner et al., 2005; Sallis et al., 1997). It is also possible that these variables are not strong enough to explain the variance or influence people's walking behaviour over and above the safety variable and personal variables.

Except for the potential explanations outlined from the methodological approach, neighbourhood location (urban, suburban, or rural) may provide an explanation why there was no relationship found between presence of sidewalks and walking behaviour in this study. Presence of sidewalks has not been found to be associated with physical activity in suburban areas in previous studies (Rodríguez et al., 2008; Troped et al., 2003). This is perhaps because having walkways plays an important role in determining physical activity in a dense area with heavy traffic (McGinn et al., 2007). Thus the presence of sidewalks may be less important in suburban areas than in urban areas.

5.3.3 Limitations and Strengths

The results of this study must be considered in the context of several limitations. First, this study was conducted within the same geographic area, which may limit the generalizability of the results. Second, voluntary participation in pedometer sessions may also have resulted in recruitment bias. Third, cross sectional studies limit the ability of drawing any causative relationship from the associations presented. It is therefore not clear whether it is the environment that supports people's walking behaviour, or whether it is the self-selection of people who choose to live in a supportive neighbourhood that has more impact on walking behaviour. Fourth, although this study used an objective measure of walking, it did not assess the purpose for or location of walking (e.g., indoor or outdoor). In addition, reported perceived built environment may be biased based on the experience of each individual participant. Statistically, no adjustment was made for these factors. The removal of participants with missing data may limit the validity of the results.

However, this study's ability to identify suburban residents specifically, as well as use the data from a large sample pool, strengthened the evidence presented. Additionally, this study focused on middle-aged and older adult populations, and examined the extent to which perceived built environmental attributes affect these population's walking behaviour - one of the few studies to take this approach. Another strength of this study was the use of multi-variate analyses which is a useful tool to identify the joint contribution of personal factors and perceived built environmental factors. Because the WISER Program Phase Three is part of a longitudinal study, the findings of this study may help to make a comparison with other phases of the WISER program. Despite the limitations presented above, findings from this study that age, education, self-rated health status, and perceived safety of neighbourhood are associated with pedometer-determined walking behaviour can contribute to existing literature examining the relationship between perceived built environmental factors and walking among middle-aged and older adults.

5.3.4 Recommendations for Future Research

Future research on interventions to increase built environment supports for walking for middle-aged and older adults should target expanding safety (during the day and after dark) for older adults. Longitudinal and experimental studies may be more instructive and imply causality (Ball et al., 2001; Saelens & Handy, 2008). This study may provide some evidence that improvements to safety may help to increase middle-aged and older adults' walking, enhancing and promoting an active lifestyle. Future research should address the differential effects of built environmental factors on specific walking purposes such as walking for recreation, and walking for transportation. The combination of perceived and objective built environmental factors may also help to standardize the measurement of built environment.

Conclusions

Several personal factors were associated with walking among middle-aged and older adults. Younger age, higher education level, and better self-rated health status were related to walking. However, when considering the effect of age, higher education level was no longer related to walking. Gender had no association with walking. Furthermore, some perceived built environmental factors were found to be associated with walking. Better perception of general safety and fewer safety concerns was positively associated with walking among middle-aged and older adults, although this effect was no longer significant when personal characteristics were taken into account. No association was found between presence and condition of sidewalks, aesthetics, and neighbourhood safety and walking. Age and self-rated health status jointly contributed to walking behaviour in middle-aged and older adults among personal factors and perceived built environmental factors. These findings may provide support to interventions for local development for age-friendly communities, and help to accommodate changes for seniors by initiating discussions with the community on how to address perceived neighbourhood safety concerns to facilitate increased physical activity among middle-aged and older adults. A preliminary conclusion drawn from this study is that built environmental planning and policy interventions may be needed to provide increased safety features (such as street lighting, crosswalks and pedestrian signals, and traffic speed limit) in neighbourhoods to remove barriers and encourage walking, particularly for middle-aged and older adults.

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Appendices List

Appendix A - Pedometer Chart & Three-question Survey

Study ID Number:

Interviewer ID Number:

Date	Time pedometer first put on in the morning	Removal of the pedometer (e.g., bath, nap)		Reason for removal	Time pedometer taken off at the end of the day	Number of steps
		Time off	Time back on			
E.g., #1 August 10	6:30 am	12:00 pm	1:00 pm	Had a nap	11:00 pm	5000
E.g., #2 October 7	7:00 am	8:00 pm	8:30 pm	Had a shower	10:00 pm	6100

Three-question Survey

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 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) And, 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

Appendix B - Questions from WISER Program Phase Three Questionnaire

Gender of participant:
1 – Male
2 – Female

Section B: Health Status
1 a. In general, would you say your health is:

Excellent	1
Very good	2
Good	3
Fair	4
Poor	5
Don't know/response (DK/R)	9

Section E: Neighbourhood Characteristics
8. Outdoor spaces and buildings and transportation questions.

	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
c) In the winter, sidewalks are cleared of snow and ice in a timely manner	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 nearby streets that it makes it difficult or unpleasant to walk	1	2	3	4	9

in my neighbourhood					
h) Most drivers exceed the posted speed limits while driving in my neighbourhood	1	2	3	4	9
	Strongly disagree	Somewhat disagree	Somewhat agree	Strongly agree	DK/R
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

9. How safe do you feel or would you feel walking alone in your neighbourhood…

…during the day?

Very safe................................1
Reasonably safe 2
Somewhat unsafe 3
Very unsafe.............................4
DK/R 9

…How about after dark?

Very safe................................1
Reasonably safe 2
Somewhat unsafe 3
Very unsafe.............................4
DK/R 9

10. To what extent do safety concerns limit your activities outside your home?

A great deal 1
Somewhat.......2
Not at all.........3
DK/R 9

Section G: DEMOGRAPHICS

4. What is the highest level of education that you have attained?

No schooling	1
One to eight years	8
Nine	9
Ten	10
Eleven	11
Twelve	12
Thirteen	13
Some university, community college, technical or trade college	14
Diploma or certificate from a community college, technical or trade college	15
Bachelor's or undergraduate degree from a university	16
Master's degree, doctorate, or degree in medicine or dentistry	17
DK/R	99

5. What is your best estimate of the total income before taxes and deductions of all household members from all sources in the past 12 months?

a) No income	1
b) Less than $10,000	2
c) $10,001 to $20,000	3
d) $20,001 to $30,000	4
e) $30,001 to $40,000	5
f) $40,001 to $50,000	6
g) $50,001 to $60,000	7
h) $60,001 to $70,000	8
i) $70,001 to $80,000	9
j) $80,001 to $90,000	10
k) $90,001 to $100,000	11
l) More than $100,000	12
DK/R	99