Associations between Walking Behaviour and Personal and Environmental Factors in Older Adults Living in a Downtown Neighbourhood

By

Lucelia Luna de Melo

A Thesis submitted to the Faculty of Graduate Studies of

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ABSTRACT

The purpose of this study was to investigate the association between personal and environmental factors and walking behaviour among older adults. The sample consisted of 60 people aged 65 years or more (mean = 77 ±7.27, range 65 to 92). Perceived environment was assessed using the Neighbourhood Environment Walkability Scale (NEWS-A, abbreviated version). Physical function was measured using the Functional Fitness Test. Walking behaviour was assessed with pedometers. Three participants had an average number of steps above two standard deviations from the mean, and were considered influential observations. After adjustments for age, health status and physical function, and removing influential observations, increased walking was significantly associated with higher income (β= 0.274, $p<0.05$). After adjusting for age, health and income, and removing influential observations increased walking was significantly associated with higher physical function (β= 0.300, $p<0.05$). No association was found between walking and environmental factors after adjustments for personal factors, and removing influential observations. Among this sample, personal factors (age, annual income, and physical function) accounted for 40.7% (R^2 = 0.407) of the variation. The environment explained 8.7% (R^2 = 0.087) of the variation after controlling for personal factors.

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Chapter 1- Introduction

According to United Nations Organization projections, by the year 2025 the world will include approximately 1.1 billion elderly people (Gandolfi and Skora 2001). In 2011, Canada's total population is projected to be 35.4 million, 5 million of whom will be 65 years of age and over (Rosemberg and Moore 1997). In Manitoba this population will constitute approximately 196,100 people in 2016, and 294,800 in 2031. The 75-84 age group is expected to grow 50% by 2031, totaling 36,000 people (Belanger et al. 2005). Reasons for this occurrence may be the increase in the average life span, especially during the second half of the 20th Century in the developed countries (Bean et al. 2004).

The aging process is associated with physiological changes such as a loss of muscle mass, a decline in nerve conduction compromising reaction speed (Shephard 1997), a decrease in pulmonary ventilation (Chambers et al. 2008), decrease in bone mineral density (Kohrt et al. 2004), and increased fat mass (Sowers et al. 2007). However, the extent of these changes varies from one individual to another (Hillsdon et al. 2005). These age-related changes may lead to a decline in physical capacity (Carlson et al. 1999) compromising the level of physical function and limiting the ability to interact with the social and physical environment (Cavani et al. 2002; Bean et al. 2004).

Significant implications of an aging population include a high incidence of chronic diseases (Abegunde et al. 2007), and increased costs related to health care. These costs may be observed by an increased use of medication (Blumstein et al. 2008; Fillenbaum et al. 1996) and higher hospitalization rate (Jun et al. 2007). Priority has been given to develop adequate and cost-effective health policies in order to enhance quality of life among older adults, such as preventive health care (Gallegos-Carillo et al. 2008), home care services (Leon-Munoz et al. 2007), and chronic care education for health professionals (Boult et al. 2008), as well as an increased number of health professionals in geriatric medicine, particularly in the United States (Besdine et al. 2005).

Regular physical activity has been shown to have numerous health benefits for older adults. These range from the physiological, for example improvements in blood pressure, increased muscle strength (Bean et al. 2004), and better balance control (Buatois et al. 2007), to the psychological, such as improvements in depressive symptoms (Juarbe et al. 2006) and mood management (Sallis and Owen 1999). Better cognitive performance (Landi et al. 2007) and social benefits such as social networks (Greaves and Farbus 2006) have also been reported.

Walking is the most common type of physical activity engaged in by older adults (Michael et al. 2006) accounting for an important portion of total daily activity (Humpel et al. 2004(a)). It is convenient, offers low risk of injuries, and can be performed at different intensities (Ekkekakis et al. 2008, ACSM 2006). Some recognized benefits include improvements in cardio respiratory fitness (ACSM 2006), and in functional capacity (Rooks et al. 1997).

Physical activity is influenced by a variety of factors, including biological, social, psychological, and environmental parameters (Sallis and Owen 1999). Among these, personal factors such as age, gender, health status (Gagliardi et al. 2007), income level (Eyler et al. 2003), functional capacity (Lim and Taylor 2005) and support coming from friends and family (Phongsavan et al. 2007) may influence people's decisions to engage in regular physical activity.

The environment is one of the least understood factors known to influence physical activity behaviour (Humpel et al. 2002). Neighbourhood characteristics such as aesthetics (King et al. 2006(b)), accessibility to services, street connectivity (Leslie et al. 2005), and land use mix (Frank et al. 2005), may be associated with physical activity participation. However, most research has focused on physical activity in general, and was done with younger adults. There is a need to determine the extent of the relationship between personal and environmental factors on walking in older adults living in the community, and to understand which factors in particular play an important role for walking engagement. This may help health professionals as well as city planners promote effective strategies to increase physical activity participation.

This study addressed the association of environmental factors, each attribute studied individually, as well as several personal factors with physical activity. Several explanatory variables were considered in order to explain walking behaviour among older adults.

1.1 Statement of Purpose

This study examined the association of personal factors and perceived neighbourhood environment with walking levels in community-residing older adults. The specific purposes of the study were two-fold:

1) To examine the relationship between personal factors (age, gender, income, education, number of health conditions self-rated health, social support, and levels of physical function) and walking behaviour in older adults residing in a downtown neighbourhood.

2) To examine the relationship between the perceived local physical environment (accessibility of services, street connectivity, places for walking, neighbourhood aesthetics, and safety) and walking behaviour in older adults residing in a downtown neighbourhood.

1.2 Study Hypotheses

With respect to the relationship between personal factors and walking behaviour (purpose number 1), it is hypothesized that:

1. Younger age, male, higher education and income, better health, higher levels of physical function, and better social support will be associated with a greater number of steps.
2. Participants who do not drive will have a greater number of steps.
3. Participants who walk outdoors, will have a greater number of steps.
4. Participants who walk primarily for health purposes will have a greater number of steps compared to those who walk primarily for recreation or for transportation.

With respect to the relationship between the perceived local physical environment and walking behaviour (purpose number 2), it is hypothesized that:

5. There will be a significant and positive association between perceived access to services, neighbourhood aesthetics, street connectivity, places for walking, and the total score for NEWS-A (which reflects the total friendliness of the neighbourhood), and average number of steps.
6. There will be a significant and negative association between perceived traffic hazards and crime and average number of steps.

1.3 Framework

This study was based on the International Classification of Functioning, Disability and Health (ICF) proposed by the World Health Organization (WHO 2001). This model explains health in a biopsychosocial context. Health conditions are influenced by changes in the micro level, such as alterations in body organs and systems, as well as in the macro level such as social participation and civic life. This model also acknowledges the influence of personal and environmental factors on health. The relationship among these domains does not follow a linear influence, but rather, is all interrelated. Focusing on opportunities for health among older adults, the WHO proposed the Active Aging framework. The objective is not only to promote but also to maximize health, security, and participation among older adults and to provide quality of life (WHO 2002).

Ecological model also was used as framework. This model states that health and well-being are based on a broad interaction between the physical environment, such as architecture and geography, and the social cultural environment in which one lives. This approach acknowledges the importance of public policies, including laws, and rules to influence healthy behaviour (Stokols 1992). Ecological models have been used to explain physical activity participation, as the physical and social environments, as well as public policies exhibit a significant influence on a decision to be physically active (Sallis et al. 2006). As observed, these models acknowledge the broad influence of the environment for health enhancement, thus will be considered as frameworks for this study.

1.4 Study Delimitations

1. This study was done with healthy, community (apartment) dwelling older adults aged 65 and above, thus limiting the generalizability of the results.
2. This study was conducted in the fall and spring in a large Canadian city.

1.5 Study Limitations

These are situations that may impact the results of the study

1. The assessment of environmental factors was done using self reported measurement, consequently it considered participants' perception about the neighbourhood environment rather than an objective measurement.
2. Participants were asked to volunteer for the study; therefore there is the possibility of biased results.
3. Pedometers were self administered and read.

1.6 Assumptions

1. Pedometers (used for a 3-day period) will accurately reflect physical activity levels.
2. Volunteer subjects will be representative of older adults in the community.
3. The perceived neighbourhood environment was measured using a Likert Scale. For statistical analyses, this implies that the difference between any two successive values are equivalent in significance; this means that the difference between "strongly disagree" and "disagree" is equivalent to the difference between "agree" and "strongly agree".

1.7 Definitions

Aging

An intrinsic, progressive and biological process characterized by anatomical, physiological and psychological changes. It is not a consequence of diseases and it is variable among individuals (Freitas et al. 2002(a)).

Age Classification

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

Activities of Daily Living (ADL)

Basic activities related to everyday life (e.g. dress, feeding oneself, use the toilet) (Andreotti and Okuma 1999).

Built Environment

Human-formed, developed or structured areas (e.g. paths, sidewalks, parks) (Centers for Disease Control and Prevention, Available at http://www.cdc.gov/healthyplaces/terminology Accessed April 24, 2008).

Environmental Factors

Physical, social and attitudinal space in which people conduct their lives (WHO 2001).

Exercise

Represents planned and repetitive body movements for improving or maintaining physical fitness (Brach et al. 2004).

Functional Limitation

Reduced ability to complete specific activities (Morey et al. 1998).

Instrumental Activities of Daily Living (IADL)

Complex activities related to one's adaptation to the environment (e.g. meals preparation, shopping, financial management) (Andreotti and Okuma 1999).

Metabolic Equivalent (MET)

A measure of energy expenditure where 1 MET is equivalent to the energy expended (in kilocalories) divided by resting energy expenditure (in kilocalories) (Montoye et al. 1996).

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 (WHO 2001).

Physical Ability

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

Physical Activity

Body movement that results in increased energy expenditure (Brach et al. 2004), also considered a behaviour (Bean et al. 2004).

Physical Environment Components (attributes)

Neighbourhood aesthetics, land use-mix access, street connectivity, infrastructure for walking/cycling, traffic, and crime safety (Cerin et al. 2006).

Physical Fitness

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

Physical Fitness Components

Muscle strength, endurance, flexibility, aerobic capacity, anaerobic capacity and body composition (Buchner et al. 1992).

Physical Function

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

Physically Active Lifestyle

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

Sedentary

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

Chapter 2 – Literature Review

2.1 Health, Function and Active Aging

Since the mid 1960`s there has been an increasing interest in finding a universal model to describe the relationships between function and health. Several conceptual models have been proposed throughout the years. Nagi's model (Nagi 1965) represented the initial framework and served as the basis for other models. In 1980 the World Health Organization (WHO) proposed the International Classification of Impairments, Disabilities and Handicaps (ICIDH) in order to clarify these concepts (WHO 1980). However, the ICIDH model presented problems in terms of study design, internal consistency and measurement feasibility (Verbrugge and Jette 1994). In order to provide a standard language for a description of health and health related factors the WHO launched the International Classification of Functioning, Disability and Health (ICF) (Figure 1). This model includes a biopsychosocial context with respect to the body, the individual and the society (WHO 2001). As described within the model, *Health* is a term used to represent disorders, diseases, trauma, injuries, aging, and congenital abnormality. *Body function* represents the physiological as well as psychological functioning of the body, while *Body structures* represent anatomical parts of the body (organs, tissues, limbs). *Activity* reflects the execution of a task by the individual, and *Participation* represents the involvement in life situations. Although not included in the model, the WHO defined decreases in each level of the model. Thus, impairments represent problems in body functions or structures, activity limitation represents difficulties in executing activities, while participation restrictions are problems that an individual may experience in life situations. Disability is used as an umbrella term to address impairments, activity limitation, and participation restrictions.

The ICF model includes 2 contextual factors: environmental and personal factors. Environmental factors include: products and technology, natural environment and human-made changes to the environment, support and relationships, attitudes and services, systems and policies. Personal factors include the background of an individual's life such as age, gender, race, health conditions, habits, upbringing, fitness, lifestyle, coping styles, social background, past and current experience, character style, psychological factors, and assets.

The great contribution of the ICF model is that the domains do not follow a linear progression (such as do the other models), but rather are all interrelated. Another unique contribution is that both environmental and personal factors are deemed to influence health. This model has been used to understand function, activity and participation in a variety of health conditions such as geriatric rehabilitation (Gladman 2008), spinal cord injuries (Biering-Sorensen et al. 2006), rheumatologic diseases (Braun et al. 2007), patellar dysfunction (Hegelson and Smith 2008), and depression (Nieto-Moreno et al. 2006). The ICF model has helped to better understand how the various levels of interaction between the person and the environment impact health. It has also demonstrated that appropriate support and intervention is a multidisciplinary process (Gladman 2008).

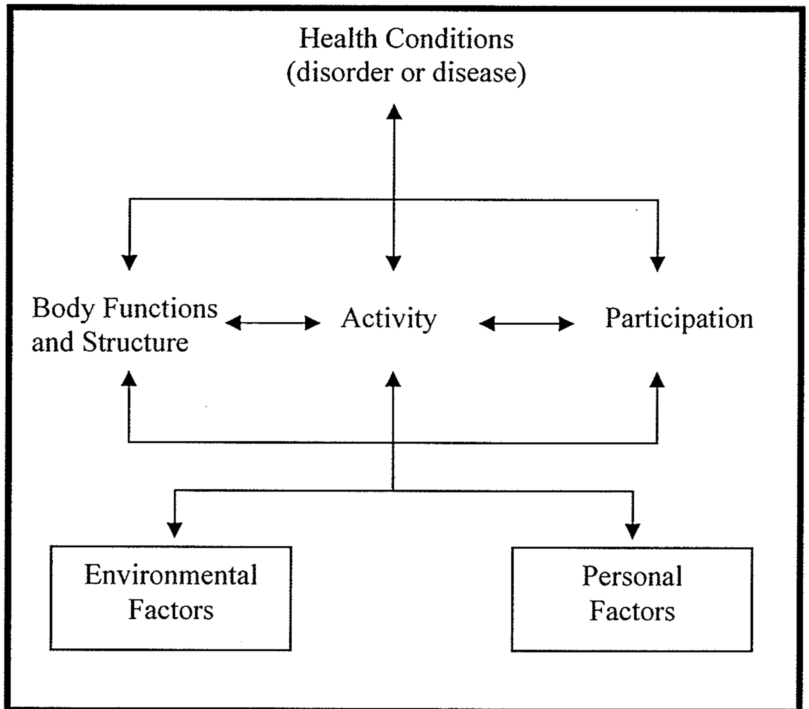

Figure 1. International Classification of Function, Disability and Health Model (ICF) (WHO 2001).

In order to optimize health for the elderly, the WHO launched the Active Aging framework, defined as: "the process of optimizing opportunities for health, participation and security in order to enhance quality of life as people age" (WHO 2002, page 12). The goal is to maximize resources for people, regardless of the level of functional capacity, not only to be physically active, but also to be independent, and able to participate in social, civic, cultural and spiritual activities. Recently, the WHO has acknowledged the importance of both environmental and social factors for active aging in urban settings, and has proposed a new framework called The Global Age-Friendly Cities initiative (WHO 2006). In this project, services, activities and opportunities are developed to enhance mobility and independence as people age, in a respectful environment.

As observed, both ICF and Active Aging acknowledge the influence of personal and environmental factors on activity and participation among older adults. Therefore they will constitute the conceptual basis for this study.

2.2 The Aging Process

The human body relies on a harmonious balance between organs and systems. Aging *per se* is responsible for significant physiological and cognitive changes, which may affect physical and cognitive functions, limiting the capacity to live an independent life (Carlson et al. 1999; Cançado 1999). However, the extent of this decline varies considerably from one individual to another (Hillsdon et al. 2005). This section will consider the main age-related changes and their implications.

2.2.1 Cardiovascular and Respiratory Systems

The main cardiac anatomic changes are a decrease in the number, and enlargement of the remaining myocites. As a consequence, there is a hypertrophy of the heart tissue from 1 to 1.5g per year between 30 and 90 years of age. Thickening of the left ventricle, as well as of the interventricular septum, is also observed (Pereira et al. 2002). An increasing deposition of collagen fibers, particularly in the left ventricle, may lead to ventricular stiffness, reducing the cardiac compliance and impairing diastolic function (Baldi et al. 2007; Pereira et al. 2002). In the vascular system there is a loss of elasticity in the arteries, and an increased deposit of atherosclerotic plaques especially in the coronary, aortic and carotid arteries, which can also be caused by unhealthy habits such as unbalanced diet and smoking (Wagenknecht et al. 2007). These changes lead to an increase in peripheral vascular resistance (Pereira et al. 2002). Physiological changes include an increase in blood pressure, in part because of increased vascular resistance and ventricular stiffeness (Pereira et al. 2002).There is also a significant decline in maximal heart rate and maximal cardiac output which may lead to a decline in maximal oxygen consumption, from approximately 5 to 15% per decade after the age of 25 (Mazzeo et al. 1998; Hollmann et al. 2007).

Aging is also responsible for changes in the respiratory system. Anatomical changes may occur in the chest wall such as the "barrel-shaped" deformity or augmented kyphosis. The loss of elasticity at the articulation of the spine and ribs (Shephard 1997), as well as increased abdominal adiposity (Chambers et al. 2008) can contribute significantly to reductions in pulmonary compliance and ventilation. At the micro level, aging reduces the proper function of the alveolo capillary membrane (Rouatbi et al. 2006); and although arterial oxygen tension does not decrease with advancing age (Guenard and Marthan 1996), pulmonary diffusion and total capillary lung volume presents a significant decrease. However an increase in capillary compliance with negative pressure could be a physiological adaptation for this process (Rouatbi et al. 2006).

2.2.2 Muscular System

Aging is responsible for a gradual decrease in the number, and in the average size, of muscle fibers. This gradual loss of type II (faster contraction) and type I (slow contraction) muscle fibers, known as sarcopenia, may affect muscle strength and power (Janssen et al. 2002; Mazzeo et al. 1998). It is caused by reduction in protein synthesis and an increase in muscle protein degradation, contributing to a significant reduction in muscle cross sectional area (Di lorio et al. 2006). Satellite cells, mainly responsible for muscle growth and reparation, are significantly reduced in type II fibers, perhaps being a factor that contributes to accelerated loss (Verdijk et al.2007). Changes in diameter of these fibers, particularly type II are also observed, suggesting that remaining fibers attempt to compensate muscle loss, and optimize strength (Frontera et al. 2008). A selective denervation of muscle fibers with aging occurs, most notable among the largest and fastest motor units (Brown 1972). The reinervation of these fibers happens by an axonal sprouting from an adjacent motor unit that has retained its neuromuscular supply. Fat and connective tissue also gradually infiltrate the muscle (Shephard 1997). All these anatomical changes result in a decline in muscle strength, one of the most significant factors observed during the aging process as it impacts physical function and leads to disability. Changes in muscle power with advancing age have received considerable attention because the decline in muscle power is even greater, especially later in life (Bean et al. 2004; Skelton et al. 1994), particularly in big muscles such as the quadriceps (Skelton et al. 1994).

2.2.3 Nervous System and Cognition

Aging is associated with several anatomic alterations in the nervous system. A decrease in the number and size of nerve cells, as well as the diameter of the axons is observed (Watanabe et al. 2007; Gandolfi and Skora 2001). This decrease is progressive, accounting for 10% to 20% of total reduction in cerebral mass between 20 and 90 years of age (Shephard 1997). There is a reduction in the speed of nerve conduction and demyelination of the axons, impacting not only motor, but also cognitive functions (Kovari et al. 2004). Parts of the brain present an altered function regarding the production of neurotransmitters, with significant reduction observed (Mora et al. 2007). Visual impairments are mainly observed because of age-related macular degeneration. Associated diseases such as glaucoma, cataracts and diabetic retinopathy contribute to reduction in visual field and visual acuity (Quillen 1999). Impairments are also noted in the olfactory system. One of the reasons is the neuronal distribution in the olfactory neuroepithelium (Biacabe et al. 1999). The vestibular system loses ciliar cells and nerve fibers around the semicircular canal (40% loss after the age 70) (Junior and Heckmann 2002). Proprioceptors and skin receptors experience impairments with aging that compromise sensory information (Junior and Heckmann 2002). Because aging is characterized by a decline in reaction time, and movement velocity (Borah et al. 2007), it impacts directly the maintenance of posture, balance and gait. This process in association with diseases, limits the ability to control body movements and ensure proper balance control, especially in situations of conflicting sensory information (Buatois et al. 2007; Matsumura and Ambrose 2006). The decrease in balance control is directly associated with an increased risk for falls (Buatois et al. 2007). These neurological changes may also compromise important intellectual functions such as cognition and learning capacity (Kliegel et al. 2007).

2.2.4 Osteoarticular System

During one's lifetime, the mechanical stress placed on the bones, ingestion of calcium, and sex hormones are factors that significantly contribute to peak bone mass (Pereira et al. 2002). Aging greatly impacts bone health. There is a decrease of bone mineral content (BMC) that occurs faster in women (36g/decade) than in men (30g/decade) (Shephard 1997). Women are more vulnerable because of processes related to menopause that lead to an accelerated loss of calcium (Freitas et al. 2002(b); Kohrt et al. 2004). In early old age, bone loss is greater in trabecular than in cortical bone. Bone loss is directly related to an increased risk of osteoporosis (Davis et al. 2006; Eastell 2007), however it may be just a consequence of advancing age, known as senile osteoporosis or type II (Vieira et al. 2002), or a consequence of decline in estrogen (osteoporosis type I). Early bone health intervention in older adults is necessary, as the risk of fractures increases with advancing age (Davis et al. 2006).

Tendons and ligaments are structures that differ in composition and shape, however they are mainly composed of type I collagen. Changes in the structure of collagen that occur during aging are loss of fiber orientation, inactivity, and decrease in vascular nourishment, which compromise the elasticity of tendons and the stability of ligaments (Freitas et al. 2002(b)). Such changes lead to a reduced capacity to respond properly to mechanical forces and stress resistance (Zschabitz 2005). Aging of the osteoarticular system also affects posture. The most reported change is an increase in thoracic kyphosis, sometimes followed by an increase in lumbar lordosis (Gandolfi and Skora 2001).