The Adaptation of a Perceived Walkability Questionnaire for Adults Living in Northern Climates

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Dedicated to my ʻOhana and Hoaloha near and far.

Natus Vincere

Abstract

Walking is the most popular physical activity reported by adults, and the benefits of walking are well documented in the literature (Fox & Hillsdon, 2007). Walkability refers to the friendliness of neighbourhood characteristics the enables pedestrian walking (Grant, Edwards, Sveistrup, Andrew, & Egan, 2010). A well-known and validated perceived walkability scale, the “Neighborhood Environment Walkability Scale” (NEWS; Saelens, Sallis, Black, et al., 2003) was developed in San Diego, California. Several adapted versions of the NEWS have been previously constructed for continued use in warm climates; however, adaptations of the NEWS for climates with winter walkability have not been developed. The main objective of this dissertation was to adapt the NEWS for colder climates and to assess the reliability and validity of the adapted measure, the NEWS-North, by conducting three studies. The first study consisted of two phases. For the first phase, three focus groups reviewed the NEWS questionnaire in a Canadian context and provided feedback on how to adapt the NEWS for use in Canada and other northern climates. The inclusion of a winter walkability section as well as the removal of American spellings and measurements were among some of the suggestions from the focus groups. An initial draft of the NEWS-North was created based on the results from the focus group. For the second phase, this initial draft was sent to a panel of walkability experts to assess content validation. All of the nine subscales were evaluated as highly important during the content validation. In addition, the experts renamed several section titles to improve precision. In the second study and third study, data from an online pilot test in Ottawa, Canada of the NEWS-North was used. The validity based on the internal structure of the questionnaire (i.e., factorial validity) and reliability (i.e., and internal consistency and test-retest reliability) of the NEWS-North was examined in Study Two. In this study, only subscales with the same Likert scale were examined (i.e., seven subscales) following the instructions of the adaptation protocol. Our results suggested a 7-factor model structure based on a multilevel exploratory factor analyses (MEFA). In addition, the 7-factor MEFA model had good test-retest reliability (ICC = 0.85 to 0.93) as well as adequate internal consistency (α = 0.53 to 0.75). In Study Three, the same seven subscales identified by the MEFA were included. In this study, a two-level Hierarchical Linear Modeling (HLM) with spatial dependency analyses was used to examine the convergent validity in the NEWS-North across 64 Ottawa neighbourhoods. The HLM analyses examined each subscale of the NEWS-North with and without any control variables. More specifically, they determined how each subscale of the NEWS-North predicted walking behaviour in the last two weeks at each level. The individual level (Level One) was comprised of the seven subscales of the NEWS-North from self-reported data along with three control variables (i.e., dog ownership, season, and gender). The neighbourhood level (Level Two) was comprised of the six equivalent subscales measured objectively with one control variable. At the time of this study, unfortunately, an equivalent *winter* subscale was not available at the neighbourhood level. At the individual level without any control variables, only the *sidewalk* subscale was a marginally significant predictor of walking. However, the *sidewalk* subscale reached significance while controlling for dog ownership, season, and gender. At the neighbourhood level without controlling for resident median income after tax, two NEWS-North equivalent subscales were found to predict walking behaviours. The *sidewalk* subscale was marginally significant and the *land-use access* subscale (via Franks walkability index Frank et al., 2010) was significant. While controlling for neighbourhood resident median income after-tax, both the *land-use access* subscale and *sidewalk* subscale were significant predictors of walking over the past two weeks. Overall, this dissertation supports the development for a perceived walkability questionnaire for seasonal climates. In addition, the preliminary results overall provide initial evidence for the reliability and validity of the NEWS-North. Overall implications, limitations, and future applied uses of the NEWS-North are discussed.

Preface

The three manuscripts prepared for this dissertation were conducted and collaborated with my dissertation supervisor, Dr. Elizabeth Kristjansson. Dr. Kristjansson is the second author in all three manuscripts. Mr. Sean Pearce, an academic colleague in Dr. Kristjansson's lab, is the third author on the first manuscript. Mr. Pearce assisted in the facilitation of the three focus groups, the analysis of the data, as well as provided feedback on the first manuscript.

As the first author of each manuscript, I was primarily responsible for the research design, the submission/ addendums to the Research Ethics Board at the University of Ottawa, the recruitment of study participants, the lead investigator in conducting each study (i.e., focus groups and pilot testing a large online study), consent forms, liaising with participants, data entry and/or data retrieval from the hosting website, conducting the data analysis, the interpretation of results, the discussion, and the writing of each manuscript. Dr. Elizabeth Kristjansson provided guidance on the psychometric analyses, provided feedback and refinement of each manuscript and validated the results of all three manuscripts. In addition, two dissertation committee members are authors on the third manuscripts. Dr. Veronika Huta, as third author, contributed to the refinement of the data analysis, statistical analyses guidance, and interpretation of the findings. Dr. Michael Sawada, as forth author, contributed to the research design and both the data collection and analysis of the Geographic Information Systems data. At the time of this thesis submission, none of the three manuscripts have been currently published in a peer-review journal.

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"Great things are done by a series of small things brought together." Vincent Van Gogh

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List of Abbreviations

ANOVA	Analysis of Variance
CCHS	Canadian Community Health Survey
CCHS-HA	Canadian Community Health Survey Healthy Aging
CI	Confidence Interval
EFA	Exploratory Factor Analyses
GIS	Geographical Information Systems
GPS	Global Positioning System
HLM	Hierarchical Linear Modeling
ICC	Intraclass Correlation
IP	Internet Protocol
ISPR	Integrated System of Participation in Research
KMO	Kaiser-Meyer-Oklin
LAPAQ	Longitudinal Aging Study Amsterdam Physical Activity Questionnaire
MCFA	Multilevel Confirmatory Factor Analysis
MEFA	Multilevel Exploratory Factor Analysis
NEWS	Neighborhood Environment Walkability Survey
NEWS-A	Neighbourhood Environment Walkability Scale Abbreviated
NEWS-North	Neighbourhood Environment Walkability Scale for Northern Climates
NPHS	National Population Health Survey
ONS	Ottawa Neighbourhood Survey
SES	Socioeconomic Status

SPSS	Statistical Package for the Social Sciences
Tukey HSD	Tukey Honest Significant Difference

Chapter 1: General Introduction on Walking

The Importance of Walking

The prevalence of obesity in Canada has increased over the past decade. This is a major concern given the myriad of well-documented health-related consequences (Lau et al., 2007; Nguyen & Lau, 2012; Tremblay, Katzmarzyk, & Willms, 2002). Overweight and obese adults have a greater risk of developing hypertension (Francischetti & Genelhu, 2007; Katzmarzyk & Janssen, 2004), musculoskeletal disorders (Butterworth, Landorf, Smith, & Menz, 2012), cardiovascular disease (Thompson, Edelsberg, Colditz, Bird, & Oster, 1999), and type-2 diabetes (Krishnan, Rosenberg, Djoussé, Cupples, & Palmer, 2007). Despite these health threats, approximately 59.9% of Canadian men and 45% of Canadian women over 18 years of age are either obese or overweight (Statistics Canada, 2012). In Canada's capital city of Ottawa, approximately 50.7% of adults are obese or overweight (Statistics Canada, 2013).

Obesity has been called a 'wicked problem', meaning that it is complex, difficult to resolve and that "every attempt to fix it has consequences that complicate things further" (Groves, 2008, p. 2458). Low physical activity may be contributing among the many factors contributing to the obesity epidemic (Bize, Johnson, & Plotnikoff, 2007; Foster-Schubert et al., 2012). For example, adults with low physical activity and high sedentary behaviours (e.g., television watching or prolonged sitting) are more likely to gain weight (Hu, Li, Colditz, Willett, & Manson, 2003; Le Petit & Berthelot, 2006). Being physically active can have several health-related benefits including the prevention of chronic diseases (Boone-Heinonen, Evenson, Taber, & Gordon-Larsen, 2009; Vuori, 2010) and improvements in the quality of life of adults (Bize et al., 2007). The most popular form of physical activity reported by adults is walking (Lee & Moudon, 2004; Owen, Humpel, Leslie, Bauman, & Sallis, 2004).

Maintaining a Healthy Lifestyle by Walking

For the purpose of this dissertation, walking is defined as travelling on foot for either transportation or leisure where the body of an individual is engaging in physical activity. When a sufficient level of physical activity is achieved via walking, walking has been associated with numerous health benefits, including the prevention of mobility loss (Simonsick, Guralnik, Volpato, Balfour, & Fried, 2005), cardiorespiratory system improvements (Quell et al., 2002), and a lower risk of cardiovascular disease (Fox & Hillsdon, 2007). An equally important benefit is that walking has been associated with the prevention of obesity (Wareham, 2007). The popularity of walking is likely due to the ease, simplicity, and low cost of the activity, making it accessible to the vast majority of people (Fox & Hillsdon, 2007; Wen, Kandula, & Lauderdalem, 2007).

The Canadian Society for Exercise Physiology (2011) recommends that Canadian adults between the ages of 18 to 64 engage in moderate to vigorous physical activity for at least 2.5 hours a week to maintain a healthy lifestyle. However, only 14% of women and 17% of men in Canada are meeting the recommended physical activity guidelines (Ottawa Public Health, 2012). Researchers have attempted to understand the reasons why some Canadians engage in regular walking while others do not (Chaudhury et al., 2011; Gauvin et al., 2005).

An Ecological Perspective on Walking

Individual approaches to understanding walking behaviours neglect the important role of the environment in which people live (Sugiyama, 2012). Our neighbourhoods can be conducive to walking; they may also pose many barriers (e.g. crime, high traffic, lack of pedestrian amenities) to walking. It is thus important to understand the multiple levels of influence (e.g., interpersonal, neighbourhood/ community, and larger policy and societal influences on walking behaviour). Health researchers often use an ecological perspective to understand factors related to physical activity (Sallis & Owen, 2002). An ecological perspective refers to the recognition that multiple levels (i.e., factors relating to biology, social environments, etc.) interact with each other to influence physical activity (Richard, Gauvin, & Raine, 2010; Sallis, Owen, & Fisher, 2008). These multiple levels can be visually conceptualized as “nested circles, which represents a level of influence on behaviour” (McLaren & Hawe, 2005, p. 9).

Bronfenbrenner (1986, 2004) was one of the first to develop a multi-level ecological model (i.e., microsystem, mesosystem, exosystem, macrosystem, and chronosystem) for developmental psychology. The microsystem refers to the interactions and activities in the place that the child lives, such as playing at the neighbourhood park or being active in school sports (Bronfenbrenner, 2004). The mesosystem consists of the various interactions within the microsystem, such as school, family, and peers (Bronfenbrenner, 1986). The exosystem refers to both indirect positive (e.g., parents’ occupation benefits) and negative (e.g., the death of a family member) environments that affect the child’s development (Bronfenbrenner, 1986). The macrosystem is the culture and subculture; this includes attitudes, ideology, and social organization (Bronfenbrenner, 2004). The chronosystem occurs over the life course and includes influences on one’s life, including transitioning events (e.g., family member death or beginning school), natural disasters and socially historical events (Bronfenbrenner, 1986). A major benefit of Bronfenbrenner’s model is that it was one of the first multi-level ecological models to be developed. One limitation this model is that it was designed for children but the focus in this dissertation is on adults. Another limitation is that there is a tendency within Bronfenbrenner’s model to include unique neighbourhood variables across two levels as opposed to containing all neighbourhood variables within a single level.

Fitzgerald and Spaccarotella (2009) adapted Bronfenbrenner's popular ecological perspective to understand influences on dietary and physical activity behaviour. The adapted model consists of four levels including intrapersonal, interpersonal, community/institution, and macro level/public policy with unique factors at each level. Their ecological framework at the community-level comprises a variety of factors such as socioeconomic characteristics, social environment, and the built environment (Fitzgerald & Spaccarotella, 2009). A community refers to shared values or governance (Sampson, 2004). It can concern geographical communities, such as neighbourhoods, but can also refer to a cultural or religious or sports community. For example, an Ottawa resident living in their current neighbourhood may feel that they belong to the community of Haitian immigrants as well as to a particular neighbourhood. For the purpose of this thesis, we modified the ecological framework of Fitzgerald and Spaccarotella (2009) to represent the neighbourhood-level rather than the community-level, and combine intrapersonal-level and interpersonal-level to represent the individual-level. The adapted ecological framework is presented later in this chapter. Several studies have found that social and physical factors at the neighbourhood-level affect physical activity, including walking behaviours, of residents (Saelens et al., 2012; Sallis et al., 2006).

Neighbourhood Attributes and Walking in Adults

Types of walking have been categorized into three domains: (a) transportation, (b) recreation or leisure, and (c) exercise; all of which help maintain one's physical health. Well-documented associations between these three types of walking and both physical and social attributes of neighbourhoods provide evidence for the use of an ecological model that takes such factors into consideration.

Physical neighbourhood characteristics. The relationship between physical neighbourhood characteristics and walking has been well-documented. Such characteristics are often referred to as the built environment. Physical attributes that have been of particular interest include neighbourhood attractiveness, safety from traffic, street connectivity, residential density, land-use mix (diversity and accessibility of amenities), and pedestrian infrastructures.

Neighbourhood attractiveness. "Environmental aesthetics" refers to how an individual interprets and responds to their immersed surroundings that include both social and physical environments (Foster, 2009). In the context of neighbourhood attractiveness, several aesthetically pleasing features of neighbourhoods have been reported. Neighbourhood streets with lush trees and maintained front yards (Borst, Miedema, Vries, Graham, & van Dongen, 2008), as well as attractive commercial buildings such as offices (Bentley, Jolley, & Kavanagh, 2010; Borst et al., 2008) and maintained public spaces such as parks (Pikora et al., 2006) are perceived as aesthetically pleasing. On the other hand, unattractive neighbourhoods included characteristics such as neighbourhood streets with litter and graffiti (Borst et al., 2008).

The relationship between perceived neighbourhood attractiveness and walking in adults is mixed. A literature review by Humpel, Owen, and Leslie (2002) reported that self-reported attractive scenery was positively associated with walking for exercise in adults. Adults also reported more walking for exercise or recreation when neighbourhoods were self-reported as aesthetically pleasing (Ball, Bauman, Leslie, & Owen, 2001). Conversely, another literature review comparing studies from 2002 -2006, concluded that self-reported neighbourhood aesthetics was not associated with walking for transportation, and that no conclusions could be drawn about recreational walking (Saelens & Handy, 2008). In summary, there is some discrepancy in the literature regarding recreational walking. It is possible that this inconsistency is due to the way in which neighbourhood aesthetics were operationalized. For example, Ball et al. (2001) only used three items out of the various inclusion criteria for Humpel et al. (2002) literature review to assess neighbourhood attractiveness. Nonetheless, the fact that health benefits and some types of walking behaviour are both associated with aesthetics makes it important to consider.

Perceived safety from traffic. Perceptions of personal safety are quite important to walking behaviour, especially for seniors (Shibata et al., 2015). The majority of walking is done outdoors near or on streets with varying traffic speeds, densities, and commercial/ non-commercial vehicles (Lee & Moudon, 2006; Powell, Martin, & Chowdhury, 2003). Villaveces et al. (2012) reported that enforcement of traffic laws, adequate separation of pedestrians and vehicles, and sufficient visibility of pedestrians (i.e., sufficient street lighting) contributed to perceptions of feeling safe from traffic. However, the link between perceived traffic safety and walking in adults is mixed.

Several studies have shown that greater perceived safety from traffic has been related to more transport walking (Bentley et al., 2010; Leslie et al., 2005). Others have shown that greater perceived safety from traffic is associated with more walking for exercise and recreation (Owen et al., 2004). No associations between perceived traffic safety and recreational walking in adults have also been reported (Sugiyama, Neuhaus, Cole, Giles-Corti, & Owen, 2012; Trost, Owen, Bauman, Sallis, & Brown, 2002). For example, heavy traffic and the presence or absence of streetlights were found not to be associated with perceived safety from traffic nor with recreational or transport walking (Humpel et al., 2002). Saelens and Handy (2008) reported similar results, but suggested that perceived traffic safety could be more of a factor for children.

Despite the difference in the reported results, perceived safety from traffic is important because traffic may influence adult walking in more subtle ways. For example, a pedestrian's decision to illegally cross a street will depend on the heaviness of traffic or the absence of pedestrian crossing aids.

Land use-mix (diversity and proximity). Land use-mix refers to the diversity[1] of establishments (i.e., commercial, non-commercial, residential) and their proximity to residences in a neighbourhood (Frank, Schmid, Sallis, Chapman, & Saelens, 2005; Saelens, Sallis, & Frank, 2003). Research has shown that neighbourhoods with an objectively measured wider diversity of establishments are associated with greater overall walking in adults (Bentley et al., 2010; Moudon et al., 2007). Moreover, a study reported that obesity is less likely in adults if greater objectively measured land use-mix is present (Frank, Andresen, & Schmid, 2004). However, the relationship between land use-mix (diversity and proximity) and walking for transport in adults is mixed. For instance, Frank et al. (2005) found that greater objective diversity of amenities has been related to more transport walking. Adults were more likely to walk for transport if greater perceived mixed land-use was present in their neighbourhood (Humpel, Owen, Iverson, Leslie, & Bauman, 2004). A literature review found similar results for both objectively and subjective measured mixed land- use (Lee & Moudon, 2004). A recent study also found that perceived land use mix was associated with walking for transport (Kerr et al., 2016). On the other hand, another study has found no association between commuting and objectively measured diverse land use (Oliver, Schuurman, Hall, & Hayes, 2011). Cerin, Leslie, Toit, Owen, and Frank (2007) also reported that no association was found between perceived land use mix and adults transport

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[1] Land use mix diversity in an ecological context may sometimes be referred to as 'diversity of richness' however, in this thesis we refer to it as land use mix diversity to maintain consistency of previous adaptations of the original measure.

walking. Recently, Duncan et al. (2010) found that perceived land-use mix and transport walking was not significant.

The relationship between greater perceived access to amenities and walking in adults is also mixed for recreation and exercise walking (Ball et al., 2001; Huston, Evenson, Bors, & Gizlice, 2003; Saelens & Handy, 2008). Adults who perceived that they lived close to local shops (Humpel et al., 2002) and playgrounds (Wen et al., 2007) had a higher level of walking for recreation. A recent study reported that the type of land-use mix that was measured objectively affected overall walking both positively (i.e., greenspaces) and negatively (i.e., industries) in Birmingham, UK (Zandieh, Flacke, Martinez, Jones, & van Maarseveen, 2017).

There has been some discrepancy regarding the proximity to parks, in particular, and recreational walking in adults (de Jong, Albin, Skärbäck, Grahn, & Björk, 2012). On the one hand, positive associations between park access measured objectively and both recreational walking (Oliver et al., 2011) and transport walking (Zlot & Schmid, 2005) have been found. On the other hand, several studies have reported no associations related between objectively measured proximity to parks and recreational walking (Foster et al., 2009; Hillsdon, Panter, Foster, & Jones, 2006) or walking for exercise (Witten, Hiscock, Pearce, & Blakely, 2008). A possible explanation for the varied results may be due to the distance chosen for access to amenities to examine the relationship between adults walking behaviours and land use mix. For example, for both transport and recreational walking, one study used 400 to 1500 meters to examine perceived neighbourhood walkability (McCormack, Giles-Corti, & Bulsara, 2008) while another study used 600 to 1200 meters measured both objectively and perceived neighbourhood walkability (Milward, Spinney, & Scott, 2013).

Residential density. Residential density refers to the number of residents who reside within a particular area. Measures of residential density also concern the impact of the types of housing (e.g., apartment buildings, townhomes, single family homes, etc.) in a specific location on neighbourhood walkability. An area with more apartment buildings has a higher residential density than an area with single-family homes due to the difference in the number of residents living within a similarly-sized area. There is near unanimous agreement on the influence of residential density on transport walking in adults. Wilson, Giles-Corti, and Turrella (2012) reported that adults walked more for transport if their neighbourhood was objectively rated high on residential density. As high residential density neighbourhoods are generally closer to the city centres, their proximity to workplaces is correspondingly higher, leading to more transport walking in adults (Wilson et al., 2012). Several literature reviews that examined both objectively and perceived neighbourhood residential density have also reported similar positive associations between residential density and recreational walking (Durand, Andalib, Dunton, Wolch, & Pentz, 2011; Saelens & Handy, 2008) as well as walking for exercise when residential density was objectively measured (Rodríguez, Evenson, Diez Roux, & Brines, 2009). A possible explanation for the relationship between residential density and walking for exercise and recreational walking may be that areas with high residential density are located closer in the centre of the cities, which has better overall street connections. This, in turn provides adults with more amenities as well as route choices to access amenities (Cao, Mokhtarian, & Handy, 2009; Lee & Moudon, 2004).

Street connectedness. Street connectedness refers to the extent to which streets in a neighbourhood are interconnected as well as the number of streets (Berrigan & Troiano, 2002). Previous research has shown that higher objectively measured street connectivity is often associated with creating a direct walking route as well as the option for multiple routes between the desired destinations (Randall & Baetz, 2002; Wilson et al., 2001). Research on street connectivity consistently reports a strong association with adult walking in all three domains of walking. For example, the literature review by Owen et al. (2004) found that adults who lived in neighbourhoods with higher perceived street connectedness were more likely to walk for recreation or exercise. Similar results have been recently reported for transport walking and objectively measured street connectivity (Frank et al., 2012; Koohsari et al., 2016; Marshall & Garrick, 2010). In addition, a recent study found that perceived street connectivity was associated with walking for transport (Kerr et al., 2016).

Pedestrian walking infrastructures. Infrastructures related to pedestrian walking activity can include a various physical structures (e.g., walking trails or bridges). It has also been hypothesized that public facilities, such as clean and undamaged benches or places to rest, and access to public restrooms can affect adults' walking (Cerin, Chan, Macfarlane, Lee, & Lai, 2011). However, the majority of the literature has examined the importance of sidewalks (Pikora et al., 2006). The research pertaining to walking infrastructures shows that the impact of pedestrian infrastructure on walking varies by the type of walking.

Adults who perceived well-maintained sidewalks in their neighbourhood reported more walking for transport (McCormack, Shiell, Giles-Corti, Begg, Veerman, Geelhoed, & Emery, 2012) but not for exercise when infrastructures were objectively measured (Lovasi et al., 2008). Higher rated objectively quality of sidewalk pavement, such as being level and paved (Pikora et al., 2006), and higher objective greater continuity has been associated with a greater likelihood of walking for transport or recreation in adults (Moudon et al., 2007). Greater recreational walking has been reported for neighbourhoods that have higher perceived walking trails (Huston et al., 2003). On the other hand, Saelens and Handy (2008) reported inconsistent associations between adults' transportation walking and pedestrian infrastructures (e.g., sidewalks and pedestrian islands) when measured either through perceptions or objectively. Trost et al. (2002) similarly reported that the presence of sidewalks measured objectively was unrelated to recreational walking in adults.

Although the research on pedestrian infrastructures and walking behaviours in adults is mixed, it is an important aspect to consider. Infrastructures generally provide additional and preferable routes for walking. For example, bridges not only provide a means to cross a large body of water for pedestrians, but they also usually create more direct walking routes.

Social neighbourhood characteristics. While a number of social characteristics have been examined by researchers, only personal safety from crime and neighbourhood socioeconomic status (SES) will be discussed.

Personal safety from crime. Perceptions of personal safety from crime in one's neighbourhood are often associated with walking behaviour (Miles & Panton, 2006). Kawachi and Berkman (2003) reported that perceived safety from crime could influence physical inactivity more than actual crime rates. Such perceptions may include perceptions related to the presence of neighbourhood surveillance, adequate street lighting, or the likelihood of neighbourhood incivilities such as vandalism (Foster & Giles-Corti, 2008). However, the relationship between residents' perception of crime and its relationship to walking depends on the type of walking.

Mixed results on the connection between self-reported ratings of personal safety of adults in their neighbourhood and walking for exercise have been reported. Several studies have found no relationship between perceived neighbourhood safety and walking for exercise (Shenassa, Liebhaber, & Ezeamama, 2006; Wilbur, Chandler, Dancy, & Lee, 2003), while others have found a relationship between these factors (Suminski, Poston, Petosa, Stevens, & Katzenmoyer, 2005). In terms of walking for transport and recreation, those who perceived that their neighbourhood was safe from crime typically reported a positive association for transport walking (Evenson et al., 2012; Parra et al., 2011) and walking for recreation (McDonald, 2008).

The relationship between the time (e.g., daytime versus night-time) and perceived crime on adults' overall walking has recently been evaluated. Bennett et al. (2007) reported no association between overall walking during the day and perceptions of safety in men and women, but women reported less walking at night when they felt unsafe; this association was significant. Moreover, they suggested that poor perceived safety from crime may inhibit adults from obtaining the recommended physical activity required to maintain a healthy lifestyle (Bennett et al., 2007).

Neighbourhood socioeconomic status. Neighbourhood SES is typically obtained from census data variables such as post-secondary education, unemployment rate, and household income of adults within the boundaries of a specific neighbourhood. These variables are sometimes examined individually and other times they are combined into an index such as the Pampalon Deprivation Index (Pampalon et al., 2012). Neighbourhood SES can also be divided into tertiles, quartiles, and quintiles to create high-, middle-, and low- neighbourhood SES profiles (Oliver & Hayes, 2005). In general, low SES neighbourhoods are less conducive to physical activity (Taylor, Franzini, Olvera, Poston, & Lin, 2012). A study by Moore et al. (2013) found that low neighbourhood SES was associated with higher body mass index in adults when compared to high SES neighbourhoods. In fact, low SES neighbourhoods tend to have fewer facilities (e.g., recreational centers) for maintaining a physically active lifestyle compared to high

SES neighbourhoods (Estabrooks, Lee, & Gyurcsik, 2003; Powell, Slater, Chaloupka, & Harper, 2006).

The relationship between neighbourhood SES and walkability in Canada is mixed. In general, Canadian adults with higher incomes engage in more physical activities related to running, swimming, and weight lifting compared to time walking in their neighbourhood (Humphreys & Ruseski, 2015). Neighbourhoods with lower SES were related to higher walkability when walkability was objectively measured using residential density, population density, land use mix destinations, and street connectivity (Gullón et al., 2017) A study by Sallis et al. (2011) found income disparities in some aspects of self-reported perceived walkability. For example, adults with low income perceived higher street connectivity compared to high income adults (Sallis et al., 2011). Meanwhile, other studies have found no association between neighbourhood SES and walkability (Chudyk, Sims-Gould, Ashe, Winters, & McKay, 2017; Sallis et al., 2009). One possible explanation for these mixed results is that neighbourhood SES is a proxy for other variables. For example, adults in low-income neighbourhoods are likely to endure greater stress from low job control/ financial strain (Stronks, van de Mheen, Looman, & Mackenbach, 1998) and higher crime rates (Sampson, Raudenbush, & Earls, 1997); this may lead to lower walking. But, adults who live in low income neighbourhoods have a greater reliance on walking for daily activities for transport as public transport and/or vehicle ownership is not available due to finances (Chudyk et al., 2017), leading to higher walking for transport.

Examining multiple levels of influence. Multi-level models (i.e., individuals nested within neighbourhoods) are particularly valuable for examining the relationship between neighbourhood characteristics (i.e., social factors and physical factors) and walking in adults, while also assessing individual-level factors. At the individual-level, researchers may include factors such as age, gender and motivation for walking. At the neighbourhood-level, possible social factors may include average income, social cohesion, social disorder and crime, while possible physical factors may include street use mix, intersection density, presence of parks and recreation and food environment.

Santana, Santos, and Nogueira (2009) examined 7669 adults from 143 neighbourhoods in Portugal, Spain and measured both individual-level factors (i.e., gender, age, education, self-rated health, and income) and neighbourhood-level factors (i.e., population density, traffic accidents, crimes against property, swimming pool, parks, post office, and social cohesion). Significant results were found at both levels. At the individual-level, women with lower education, self-rated health, and income walked more for transport and recreation (Santana et al., 2009). At the neighbourhood level, higher social cohesion and availability of health services resulted in more walking for transport or recreation, while property crime was associated with less walking for transport or recreation (Santana et al., 2009).

Fisher, Li, Michael, and Cleveland (2004) reported that adults with higher education and higher self-efficacy for walking had higher walking intensities, while gender and health were not related to walking behaviour. At the neighbourhood-level, greater social cohesion, a higher percentage of low-income residents, more seniors, greater percentage of white residents, and greater pedestrian infrastructures (e.g., paths) were related to a higher amount of recreational walking in adults (Fisher et al., 2004). However, safety from crime and pedestrian walking safety were not significant predictors of walking (Fisher et al., 2004).

Another study has found that different factors were related to recreational walking (Li, Fisher, Brownson, & Bosworth, 2005). At the individual-level, adults' recreational walking improved when greater perceived safety from crime and the proximity to recreational facilities, but access to recreation facilities, safety from traffic, and number of street intersections were not significant in this a cross sectional study (Li et al., 2005). At the neighbourhood-level, greater recreational walking was reported when greater household density, employment density, green spaces, and street connectivity were present (Li et al., 2005). A recent study found that adults who had higher neighbourhood perceptions of walkability (i.e., total score based on aesthetics, safety, land use mix diversity) living in high SES neighbourhoods were less likely to be physically active, such as walking for transport and leisure (Mackenbach et al., 2016).

Despite the inconsistencies found in the literature, these studies have suggested that particularly for neighbourhood-level analyses, both social (e.g., social cohesion) and physical (e.g., pedestrian infrastructures) characteristics influence walking in adults. In general, significant effects at the neighbourhood level tend to be small (Diez Roux, 2001; Saelens & Handy, 2008), while the majority of the variance is at the individual level (Hagger, Chatzisarantis, & Biddle, 2002).

The Importance of Other Multi-Level Attributes that Affect Walking

Although the focus of this thesis is largely on the neighbourhood-level, where neighbourhood is defined by data collected through a secondary project called the Ottawa Neighbourhood Study (explained later in this Chapter), it is important to understand that individual-level factors and policy factors can also affect adult walking behaviours. The importance of these other attributes is briefly discussed.

Individual-level factors. At this level, interpersonal variables and intrapersonal variables comprise the individual-level as previously mentioned. Each factor will briefly discuss selected variables to provide a general overview of commonly used variables in the literature.

Intrapersonal factors. Several intrapersonal factors have been found to influence walking behaviours, but only income, dog ownership, vehicle ownership, and neighbourhood selection will be discussed.

The relationship between income of residents and walking behaviour is unclear. A study by Rind, Shortt, Mitchell, Richardson, and Pearce (2015) found no relationship between income and active travel in the United Kingdom. Similarly in British Columbia, income did not influence walking in adults aged 65 years or older (Winters et al., 2015). Although one study found that income influenced walking behaviour, where adults with lower incomes report less total walking (approximately 10.7 minutes) in the United States (Hearst et al., 2013).

Adults who are dog owners who walked a minimum of three times more a week and reach 150 minutes of walking more per week than non-dog owners (Thorpe et al., 2006). Hoerster et al. (2011) reported that 64% of dog walkers and 55% of non-dog walkers met the United States physical activity guidelines. Similar results regarding reaching the recommended physical activity guidelines been reported in the United States (Yabroff, Troiano, & Berrigan, 2008) and in Canada (Brown & Rhodes, 2006). Interestingly, Coleman et al. (2008) reported that 53% of dog owners who walked their dog met the recommended physical activity guidelines compared to 46% of non-dog owners. In reference to dog ownership in Canada, a longitudinal study found that adults with dogs were more likely to walk for recreation during the summer and winter compared to non-dog owners (Lail, McCormack, & Rock, 2011).

Vehicle ownership is another important factor. Adults who have private access to vehicles reported less transport and recreational walking compared to adults without a vehicle (Badland & Schofield, 2008). More vehicles are owned by adults living in suburban neighbourhoods than adults living in urban neighbourhoods (Handy, Cao, & Mokhtarian, 2005).

This is likely due to the fact that suburban dwellers are unlikely to live and work in the same neighbourhood (Badland, Garrett, & Schofield, 2010). As a result, adults who live in suburban neighbourhoods drive more compared to walking to work (Cao et al., 2009).

It is also important to understand factors that draw adults to particular neighbourhoods. One factor that may draw adults to a particular neighbourhood is that the neighbourhood matches their physically active lifestyle (Boone-Heinonen, Gordon-Larsen, Guilkey, Jacobs, & Popkin, 2011). For example, adults who enjoy recreational activities may be more likely to choose a neighbourhood that supports such activities. However, in one study, adults who enjoy walking reported greater transportation walking regardless of the neighbourhood they choose (Norman et al., 2013). Another factor that may influence an adult to select a neighbourhood is finances (Gordon-Larsen, Nelson, Page, & Popkin, 2006). Financial constraints such as being unable to afford a vehicle also make adults rely on more walking as a mode of transportation or to public transit (Grant et al., 2010).

Interpersonal factors. This refers to relationships and interactions that individuals have with others. Several interpersonal factors have been found that can influence walking behaviours. However, only the presence of children and social support will be briefly discussed.

The presence of children in a family can affect adults' walking, including walking children to school and parks. This is to some extent dependant on whether or not the neighbourhood is perceived to be safe for walking (Roberts, 1995). Parents living in low-income neighbourhoods reported the highest concerns about walking their children to school in their neighbourhood due to crime and violence (Gielen et al., 2004). Moreover, adults' recreational walking to local playgrounds with their children was more likely if the physical disorder (e.g., litter and graffiti) of a neighbourhood was low (Miles, 2008).

Social support refers to encouragement and resources given by an individual such as a family member or friend (Due, Holstein, Lund, Modvig, & Avlund, 1999). The relationship between social support and walking duration in adults has been well-documented. For example, the duration of adults' walking can be influenced by whether or not another person accompanied them on their walk. Older adults were more likely to walk for more than 10 minutes when family members were present (Bird et al., 2010). Similarly, adults between 20 to 69 years of age were more likely to walk when family or friends accompanied them compared to walking alone (Due et al., 1999).

Policy factors. Policy factors refer to the implementation, amalgamation, and enforcement of policies at the government level. Policy factors play a key role in the promotion of walking behaviours. For the purpose of this thesis, only walking campaigns and infrastructure policies will be briefly discussed.

The implementation of walking campaigns can influence walking in adults. Some organizations have begun to encourage healthy physical activities over the lunch hour. For example, Carleton University's Healthy Workplace (www.carleton.ca/healthy-workplace) offers a range of programs (e.g., suggestions of where to walk during lunchtime) and activities (e.g., lunchtime sports) to encourage the physical activity of students but also faculty and university employees.

Infrastructure policies such as current sidewalk policies and sidewalk maintenance policies can also influence adults' walking behaviours. Chen, Lin, Wu, You, and Hsu (2013) reported that public policy aimed at sidewalks is important for accessibility and maintenance especially during seasonal changes. For example, policies for winter sidewalk maintenance are important for the accessibility of sidewalks that affect walking (City of Ottawa, 2013).

Pathways across and between levels. As previously discussed, pathways are created when a variable within a level interacts with other variables within that same level or with the surrounding levels to influence physical activity (Richard et al., 2010; Sallis et al., 2008). As a brief example, pathways between sidewalks and neighbourhood walking are discussed. A recent literature review on sidewalks and walking reported several variables that contributed to lower walking that included: poor weather, crowded sidewalks, footwear with poor adhesion, physical barriers, and irregular surfaces of the sidewalks (Orstad, McDonough, Stapleton, Altincekic, & Troped, 2016). However, pathway differences between sidewalks and walking can vary depending on age. In older adults, the main deterrent to walking was uneven and/or slippery sidewalks due to fears of injury (Li et al., 2006). Youths reported more walking in neighbourhoods with sidewalks to more destinations, specifically to parks, shops, and to school (Kerr, Norman, Sallis, & Patrick, 2008). However, in this dissertation, pathways will not be discussed further.

Walkability

Walkability is a concept that brings together many of the aforementioned neighbourhood characteristics that promote walking.

Defining walkability. There is currently no universal definition of walkability. However, researchers today usually define walkability as the friendliness of the physical environment for pedestrian walking (Grant et al., 2010; Marshall, Brauer, & Frank, 2009). Walkability also refers to the ease (Montemurro et al., 2011) and safety (Mehta, 2008) with which pedestrians can walk around their neighbourhood. Walkability measures often consider physical characteristics (e.g., street connectivity, residential density, and pedestrian infrastructure) and social characteristics (e.g., perceived safety from crime) of neighbourhoods.

A neighbourhood with high walkability has greater land use mix (i.e., access and diversity), street connectivity, and residential density when compared to low walkability neighbourhoods (Cerin, Saelens, Sallis, & Frank, 2006; Saelens & Handy, 2008). Furthermore, neighbourhoods with a higher sense of community (Leyden, 2003; Wood et al., 2007), greater social connectedness (Brennan, Baker, Haire-Joshu, & Brownson, 2003), higher pedestrian traffic safety (Galanis & Eliou, 2011; Hoehner, Brennan-Ramirez, Elliott, Handy, & Brownson, 2005), and sufficient pedestrian infrastructures such as continuous sidewalks (Saelens, Sallis, & Frank, 2003) are more conducive to walking. High walkability neighbourhoods tend to be reported as more aesthetically pleasing when compared to low walkability neighbourhoods that tend to have more litter and graffiti (Balfour & Kaplan, 2002; Ross & Microwsky, 2001).

Defining neighbourhood for walkability research. There is a lack of consistency of an overall definition for neighbourhood in literature. However, there are several options of defining 'neighbourhood' in research. For example, postal codes can be used as measures of neighbourhood. A strength includes that the area is standardized and that postal code data is easily accessible (Cho & Choi, 2005). Some limitations include that the resident may not walk the entire area of the postal code boundary; nor does this definition consider residents that live along postal code edges; and that aggregations of census tracts is not how residents necessarily view their perceived neighbourhood boundary (Cho, 2003). Another method is setting a predetermined time duration (e.g., 10 to 15 minutes) for walking within a neighbourhood. A strength of this method includes an area that the resident frequently walks and is familiar with within their neighbourhood. Limitations include that there is no set boundary defining an overall neighbourhood as well as the possibility that perceptions of neighbourhood differ from objectively measured neighbourhoods, such as census units (Coulton, Korbin, Chan, & Su, 2001).

The importance of neighbourhood walkability. Neighbourhoods are often classified as being either a high or low in walkability (Saelens, Sallis, & Frank, 2003). Residents of high walkability neighbourhoods have been found to walk twice as often compared to those in low-walkability neighbourhoods (Saelens, Sallis, & Frank, 2003). High walkability has also been related to better mental and physical health in adults. For example, residents who live in high walkability neighbourhoods have reported lower depression (Berke, Gottlieb, Moudon, & Larson, 2007), lower body mass index scores (Berry, Spence, Blanchard, Cutumisu, Edwards, & Nykiforuk, 2010; Booth, Pinkston, & Poston, 2005), and higher self-rated health (Collins, Hayes, & Oliver, 2009) than individuals living in low walkability neighbourhoods. Of particular interest is the relationship between neighbourhood walkability and obesity. Lower obesity rates have been reported in adults who live in high walkability neighbourhoods in many countries including Canada (Berry, Spence, Blanchard, Cutumisu, Edwards, & Nykiforuk, 2010), the United States of America (Frank et al., 2004), and Australia (Giles-Corti, Macintyre, Clarkson, Pikora, & Donovan, 2003).

A recent Canadian study found that adults in Alberta who had moved to a less walkable neighbourhood were more likely to report less transportation walking compared to non-movers or those who had moved to a more walkable neighbourhood (McCormack, McLaren, Salvo, & Blackstaffe, 2017). Similarly, residents aged 18 years or older who lived in highly walkable neighbourhoods in Alberta were more likely to engage in walking for transportation and spend more minutes per walk during transportation walking compared to low walkability neighbourhoods (Jack & McCormack, 2014). Higher neighbourhood walkability was also associated with greater physical activity in neighbourhoods close to home of adults in Montreal, Quebec (Hajna, Kestens, et al., 2016). Moreover, this study reported that adults living in neighbourhoods with high walkability reported 165 more steps per day (Hajna, Kestens, et al., 2016).

Neighbourhood walkability in Ottawa. Neighbourhoods are often defined only by geographical boundaries categorized by census information that separate land within a particular area by streets or landmarks (Chaudhury, Mahmood, Michael, Campo, & Hay, 2012). However, more recently, researchers have focused on ‘natural neighbourhoods.’ The Ottawa Neighbourhood Study (ONS) defined ‘natural neighbourhoods’ using several criteria: natural barriers, similarity in demographics, real estate maps, and more recently, citizen input (Ottawa Neighbourhood Study, 2013). The ONS is a large multi-sector study that focuses on neighbourhood social determinants of health and understanding how both physical and social characteristics influence health. In this thesis, neighbourhood level data refers to data that was collected from the ONS using their boundary definitions of neighbourhoods.

Measuring Neighbourhood Walkability

Walkability measures comprise objective assessment, subjective assessment, or both. Each option has various advantages as well as its own limitations.

Objective assessment. Assessing neighbourhood walkability through objective measurement is achieved by gathering indicators from public databases that contain information on physical attributes in the neighbourhood. Most often, these databases are obtained from geographic information systems (GIS). GIS refers to “a system designed to capture, store, manipulate, analyze, manage, and present spatial or geographic data” (Geographic Information System, n.d.). The data are plotted on a digital map where the data can be analyzed and manipulated to reveal trends (Leslie et al., 2007). For example, Wilson et al. (2012) used GIS to objectively measure several neighbourhood features, including street connectivity, residential density, street lighting, and land-use mix. Several other studies have also used GIS as an objective measure to examine neighbourhood walkability (Coombes, Jones, & Hillsdon, 2010; Giles-Corti & Donovan, 2002).

Another option is to send trained observers into a neighbourhood to provide ratings on a detailed preselected observational checklist. These lists may include physical characteristics (e.g., sidewalks) and social characteristics (e.g., safety from crime), and each characteristic has been operationally defined. The observers are trained prior to data collection to facilitate coding based on the operational definitions. During data collection, observers are paired with one another and code separately without consulting each other while coding occurs. Some studies have used trained observers to rate neighbourhood characteristics (Gauvin et al., 2005; Pikora et al., 2002). An important benefit of this option is that the observers' ratings can be analysed for inter-rater reliability for overall scores or particular items. One limitation is that the majority of audit tools do not factor in variables such as an individual's physical ability to easily walk around their neighbourhood easily (Chaudhury et al., 2011).

There are several benefits to using GIS, including the ability to precisely map physical indicators related to walking (Oliver et al., 2011), the ease of accessing electronic databases (Leslie et al., 2007), and the fact that the digital map can display multiple or specific indicators at a time (King, Thornton, Bentley, & Kavanagh, 2012). Another advantage is their relatively low cost (Lotfi & Koohsari, 2009). One potential limitation of GIS is the high possibility of incomplete or outdated databases (Bodea, Garrow, Meyer, & Ross, 2008). Furthermore, they cannot easily assess aesthetics and perceived safety (Frank et al., 2005; Lovasi et al., 2013).

Subjective assessment. Neighbourhood walkability can also be measured subjectively to assess both physical (e.g., parks) and social (e.g., personal safety from crime) characteristics of a neighbourhood. Such measures can either be self-report or use trained observers. Self-report measures ask current residents about their perceptions of their neighbourhood using either questionnaires or shortened interviews (telephone or face-to-face). Several studies have used subjective assessments to measure neighbourhood features (Ball et al., 2001; Foster, Hillsdon, & Thorogood, 2004). One important benefit of subjective measures is that they assess what the resident is actually perceiving; we know that perceptions of walkability are closely related to behaviour (Wen, Hawkley, & Cacioppo, 2006). But they also have limitations, including the difficulty of developing items on subjective assessments to accurately capture the construct being measured (Arthaud-Day, Rode, Mooney, & Near, 2005) as well as possible issues in participants' recall of past events (Sallis & Saelens, 2000).

Objective and subjective assessment. Other studies have used both objective and subjective measurements to assess neighbourhood walkability (Tilt, Unfried, & Roca, 2007; Wen et al., 2006). This allows researchers to assess the overlap between the built environment and residents' perceptions, which may aid in understanding what barriers are preventing adults from walking (Dawson, Hillsdon, Boller, & Foster, 2007). For example, Gebel, Bauman, Sugiyama, and Owen (2011) assessed neighbourhood walkability both objectively using GIS and subjectively using a survey of 1027 Australian adults. Recently, a direct observational checklist using mobile GIS technology (i.e., an Apple iPad 2® with cellular capabilities) was used to assess neighbourhood characteristics such as pedestrian infrastructures (Lafontaine, Sawada, & Kristjansson, 2017). However, while good agreement between the two methods has been reported (Arvidsson, Kawakami, Ohlsson, & Sundquist, 2012), others have found poor agreement (McCormack, Cerin, Leslie, Du Toit, & Owen, 2008; Zoellner, Hill, Zynda, Sample, & Yadrick, 2012). One study reported fair agreement; 33% of residents living low walkable neighbourhoods and 32% of residents living in high walkable neighbourhoods agreed with objective assessments (Gebel, Bauman, & Owen, 2009b). Interestingly, in objectively high walkability neighbourhoods, adults with lower education, lower income, that walked less for transport, and were more overweight were more likely to perceive their neighbourhood as less walkable (Gebel et al., 2009b). Due to the fairly low number of studies that have used both objective and subjective assessments to understand walkability, more research is needed to understand the reasons for the differences between the two types of assessments.

Explaining Mixed Results

There are several possibilities to explain why the walkability literature is mixed on which built environment factors are related to adults' walking. These are: the type of measures used, the type of study conducted, and the inclusion of leisure walking as a type of walking.

Different measures. It is possible that the variability in the literature regarding the built environment and walkability may be due to the measure used to examine the relationship. For example, the reported concordance between perceived (i.e., self-reported) and objective measures has ranged from good agreement (Arvidsson et al., 2012), fair agreement (Gebel et al., 2009b), to poor agreement (Zoellner et al., 2012). Despite these inconsistences, perceived walkability in a neighbourhood is important to examine. Adults who perceived their neighbourhood as walkable walked for longer in a week regardless of the purpose of walking, such as for recreation or transport (Yu, Cheung, Lau, & Woo, 2017).

Type of study. The majority of walkability studies are often cross-sectional rather than longitudinal in design. Benefits of cross-sectional studies include lower operating costs; they also require less time of both the researcher and participants due to the shorter durations (Galbraith, Bowden, & Mander, 2017; Kleinbaum, Kupper, & Morgenstern, 1982). However, with cross-sectional studies, it is difficult to determine the direction of causality (Levin, 2006; Sun et al., 2016). Longitudinal studies provide more information on the trends over time (Reiner, Niermann, Jekauc, & Woll, 2013). However, some disadvantages of longitudinal studies include attrition rates and inconsistences in how measures are implemented (Rajulton, 2001).

The variation in results between the built environment and leisure walking may be influenced by the effect weather has on leisure walking. In the winter, there could be less walking due to the cold, but more participation in other sports like snowshoeing. In addition, both icy and un-shovelled sidewalks, trails, etc. may deter walking outdoors (Gallagher et al., 2010). While sidewalk length may not be associated with leisure walking (McCormack, Shiell, Giles-Corti, Begg, Veerman, Geelhoed, Amarasinghe, et al., 2012), sidewalk conditions such as being continuous, flat, and free of weeds may influence leisure walking (Gallagher et al., 2010).

Seasonal Walkability

The relationship between the effects of weather and adults' walking is somewhat mixed. On the one hand, seasonality and weather has been shown to affect walking (Trost et al., 2002). For example, several studies have shown that seasonality can influence domain-specific walking in adults (Klenk et al., 2012; Tucker & Gilliland, 2007). For people living in neighbourhoods in the northern hemisphere, the greatest amount of recreational walking tends to occur during the summer months followed by spring; the least amount of walking occurs in the winter (Shephard & Aoyagi, 2009). The decrease in recreational walking during the winter is likely due to the reduction of daylight and temperature (Matthews et al., 2001). Greater transport walking (Yang, Diez Roux, & Raymond, 2011) and leisure walking (Merchant, Dehghan, & Akhtar-Danesh, 2007) have also been reported in the summer.

A recent longitudinal study found a 14% increase in pedestrian activity in nine city locations across the United Kingdom, the United States, Bulgaria, and Switzerland when a five degree Celsius temperature increase was recorded (de Montigny, Ling, & Zacharias, 2012). On days when there was no precipitation, the amount of pedestrian activity increased by approximately 23% (de Montigny et al., 2012). The presence of snow, cold temperatures, and icy conditions may influence walking (Juvani, Isola, & Kyngas, 2005). A cross sectional study reported that colder temperatures resulted in more sedentary behaviours in adults (Li, Hsu, & Fernie, 2012). The winter season also adds greater potential for physical risks due to the falling or slipping or injury related to poor sidewalk conditions, as well as the inability to access resources if injured (Ripat, Redmond, & Grabowecky, 2010). On the other hand, several studies have reported that weather was not associated with adult walking (Chan & Ryan, 2009; Humpel et al., 2002).

A possible explanation for these conflicting findings is ways in which seasons are defined in relation to walking. For example, Pivarnik, Reeves, and Rafferty (2003) divided seasons into four categories (i.e., winter: January to March, spring: April to June, summer: July to September, fall: October to December) while Plasqui and Westerterp (2004) examined two categories (i.e., summer: May to June, winter: January to February). Another explanation is a lack of consistency examining seasonal attributes such as precipitation (Matthews et al., 2001), wind chill (McGinn, Evenson, Herring, & Huston, 2007), and temperatures (Tu, Stump, Damush, & Clark, 2004).

The significance of winter walkability is especially important in Canada, where the winters can be cold and snowy and icy. Generally speaking, there is less physical activity that occurs in the winter months than in the summer (Reilly & Peiser, 2006; Tucker & Gilliland, 2007). The amount of physical activity in Canada during the winter months is even less. Merchant et al. (2007) reported that only approximately 36% of Canadians are active during the winter season. Moreover, the risk of falling and/or slipping while walking is higher in colder seasons especially those with ice and snow (Bulajic-Kopjar, 2000). Other Canadian studies have also explored seasonal patterns of physical activity. Older adults from Montreal, Quebec reported a greater total daily steps in the summer/spring (6807 steps) than the fall/winter (5803 steps) (Cooke, Daskalopoulou, & Dasgupta, 2016). In Ontario, older adults reported lower physical activity in colder temperatures and on days with high humidity (Jones, Brandon, & Gill, 2017).

The Neighbourhood Environment Walkability Survey

Many of the walkability questionnaires were developed in the United States of America in cities such as Pittsburgh (King et al., 2003) or California (Balfour & Kaplan, 2002). Others were developed in countries such as Australia (Ball et al., 2001) and England (Foster et al., 2004). A popular and comprehensive American walkability questionnaire was developed in California by Saelens, Sallis, Black, and Chen (2003). This questionnaire, the "Neighborhood Environmental Walkability Scale" (NEWS), assesses both social and physical aspects of neighbourhood. The NEWS is developed for predicting walking for transport and recreation (Saelens, Sallis, Black, et al., 2003). The original development of the questionnaire was based on an extensive review of the literature. It comprises questions covering eight factors including residential density, land-use mix (diversity and access), street connectivity, walking/cycling trails, aesthetics, traffic safety, and crime safety (Saelens, Sallis, Black, et al., 2003). Several Canadian studies have also examined the psychometrics of the NEWS in adult samples.. In Calgary, Alberta, McCormack, Friedenreich, Giles-Corti, Doyle-Baker, and Shiell (2013) found NEWS-A had moderate test-retest reliability (.50 to .88) and low to acceptable Cronbach's alpha scores ($\alpha = 0.33$ pedestrian infrastructures to $\alpha = 0.77$ aesthetics). In Montreal, Quebec, Engel et al. (2016) found some concordance evidence between the subjective measure (NEWS-A) and an objective measure (Street Smart Walk Score) of the built environment. However, one important issue with the NEWS and other subjective walkability questionnaires is that they were developed for warm climates and often lack items on winter walkability.

Justification for Adapting the NEWS

The NEWS was selected for adaptation for several reasons. First, the NEWS has shown good reliability[2] (Brownson et al., 2004; De Bourdeaudhuij, Sallis, & Saelens, 2003; Leslie et al., 2005) and support for construct validity[3] (Cerin et al., 2006; Saelens, Sallis, Black, et al., 2003). Adequate factorial validity[4] (Cerin et al., 2006) and concurrent validity (Leslie et al., 2005) have also been reported. The majority of walkability measures provide little information on their reliability and validity, such as construct validity (Gay, Evenson, & Smith, 2010), but the NEWS is one of the exceptions. Second, there have been several adaptions of the NEWS already such as the NEWS abbreviated (NEWS-A; Cerin, Conway, Saelens, Frank, & Sallis, 2009; Cerin et al., 2006), NEWS for Nigeria (Oyeyemi, Adegoke, Sallis, Oyeyemi, & De Bourdeaudhuij, 2012),

[2] Good reliability in this thesis refers to the overlap between two independent raters or test retest reliability of most subscales to fall within values of .70 or higher
[3] Perceived differences were reported in high compared to low objectively measured walkable neighbourhoods was an indicator of support for construct validity
[4] Six of eight subscales of the NEWS were examined to determine whether each subscale formed a factor with individual items loading onto a factor

NEWS for Australia (Leslie et al., 2005), the NEWS-A for Hong Kong (Cerin, Macfarlane, Ko, & Chan, 2007). and the NEWS-A for Chinese adults (Cerin, Macfarlane, et al., 2007).

The NEWS has also been adapted in other countries with colder climates, such as Belgium (De Bourdeaudhuij et al., 2003) and Poland, but these adaptations were more minor. However, these adaptations are fairly minor, simply reducing the number of items (Parra et al., 2011; Salvador, Reis, & Florindo, 2010) and replacing words (Panter & Jones, 2008). Moreover, most adaptions of the NEWS in colder climates had minor wording changes opposed to a subscale dedicated to winter.

Finally, there is no current Canada-focused perceived walkability measure currently in existence, thus the development of walkability questionnaire tailored for Canadians can be more easily generalized to other northern climates who share similar climates and units of measure.

In Belgium, the NEWS was translated into Flemish then pretested with a different sample. The specific adaptations included item omissions related to destinations (e.g., hardware, laundry/ dry cleaners) as well as changing the Likert scale for residential density from 5-point scale (i.e., *none* to *all*) to a 3-point scale (e.g., none, some, a lot) that only included three of the six original items (De Bourdeaudhuij et al., 2003). In Poland, the adaption was based on the NEWS-A. They omitted three (e.g., hills, video stores, laundry facilities) of the 54 original items (Jaskiewicz & Besta, 2016). Other adaptions in the NEWS-A Poland included two new items (e.g., train stop and a beach) and modified two existing items regarding destinations, such as the item ‘park’ to ‘park or forest’ (Jaskiewicz & Besta, 2016).

The NEWS and leisure walking. Despite the fact that the NEWS is generally associated with transportation walking, there are associations between some aspects of the built environment of the NEWS and leisure walking. However, results are mixed. On one hand, adults also reported more walking for recreation when neighbourhoods were perceived to be aesthetically pleasing (Ball et al., 2001) or when they reported aesthetically pleasing features such as neighbourhood streets with lush trees and maintained front yards (Borst et al., 2008). On the other hand, other studies have reported no association between aesthetics and leisure walking (Jack & McCormack, 2014). In terms of perceived quality of sidewalks and leisure walking, one study found that adults reported more walking for recreation in neighbourhoods where quality of sidewalk pavement, such as being level or paved was higher (Pikora et al., 2006) and the sidewalks had greater continuity (Moudon et al., 2007). Meanwhile, others have reported no associations (Sugiyama et al., 2014).

Literature Gaps

From the extensive review of the literature on walkability, a number of gaps become apparent in terms of the content and methodology of subjective walking questionnaires. First, as noted previously, there is no extant questionnaire that assesses neighbourhood walkability in northern climates. Second, the validity of the NEWS questionnaire has not been thoroughly assessed. For example, Saelens, Sallis, Black, et al. (2003) highlighted the need for future research to evaluate more objective and subjective environmental attributes to assess neighbourhood characteristics effectively. Lastly, Canadians engage in walking throughout the year, but there is currently no perceived questionnaire in existence to accurately assess the seasonal barriers and motivators to walking.

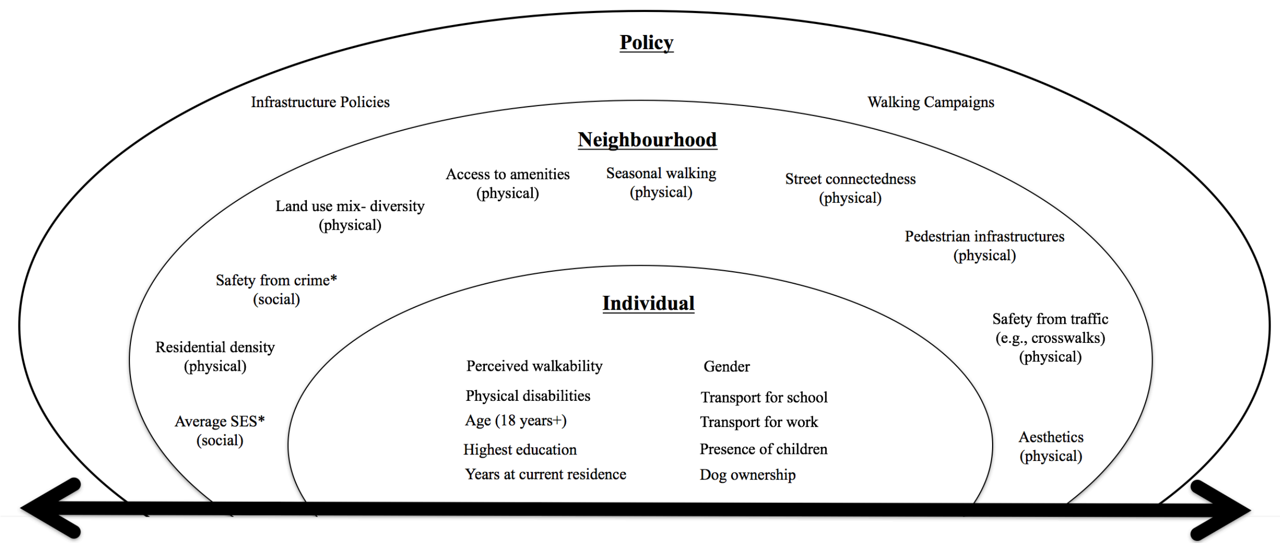
Dissertation Conceptual Model

The aim of this thesis is to address some of these gaps by adapting a well-known self-report measure of neighbourhood walkability for use in Canada and in other northern climates by modifying Fitzgerald and Spaccarotella's (2009) ecological framework (see Figure 1). Both the individual-level and neighbourhood-level was considered in this adaption.

Two types of effects, contextual and compositional, are measured at the neighbourhood-level. Contextual effects include both social and physical features of neighbourhoods that can affect walking behaviours (Veenstra, 2005). Physical attributes of a neighbourhood can include parks, the density of residential dwellings, or the location and diversity of amenities within the boundaries of an individual's residence (Veenstra, 2005). Social environments of neighbourhoods can include social relationships including neighbourhood cohesion and trust (Poortinga, 2006). Compositional effects involve aggregated social attributes within a neighbourhood such as the rate of crime or average income (Macintyre, Ellaway, & Cummins, 2002; Ziersch, Baum, MacDougall, & Putland, 2005).

Figure 1

At the neighbourhood-level, both social and physical characteristics of neighbourhoods are assessed using an adapted ecological framework from Fitzgerald and Spaccarotella's (2009). *Examples of compositional effects assessed in this model are denoted by "*" while contextual effects are the remaining variables in the diagram.*



Dissertation Walkability Definition

For the purpose of this thesis, the definition of walkability includes the built environment that enables pedestrian walking (Grant et al., 2010; Marshall et al., 2009) as well as the ease (Montemurro et al., 2011) and safety (Mehta, 2008) of walking in one's neighbourhood. Our operational definition includes aspects of both physical and social factors of a neighbourhood. Physical factors include beyond Frank's walkability index (Frank et al., 2012) that also includes sidewalks, traffic related infrastructures (cross walk/ traffic lights), and convenience to amenities. Social factors include aesthetics, perceived speed of traffic, and perceived safety from crime.

Dissertation Design and Objectives

We have determined that there is a need for a self-report questionnaire to assess walkability in Canada and other northern neighbourhoods. Therefore, this study aims to adapt a well-known walkability measure for use in Canada and other countries with northern climates. In this thesis, a northern climate refers to both temperature and climate variation with four distinct seasons (i.e., fall, winter, spring, and summer). 'Winter' season in particular, is defined as the presence of snow and ice. The dissertation comprises three studies. In Study One, four focus groups were held to collect feedback on the original questionnaire, identify potential adaptations for the Canadian context, and identify potential ways to shorten the questionnaire. For Study Two and Study Three, the adapted perceived walkability questionnaire, the NEWS-North, was piloted in Ottawa both at the University of Ottawa and across all urban Ottawa neighbourhoods. Using this data, we assessed internal consistency, test-retest reliability, validity based on internal structure and validity based on external relationships.

This dissertation had several research objectives:

- To adapt the NEWS for use in Canada and in other countries with northern climates (Study One)
- To assess both reliability (i.e., test-retest reliability and internal consistency) and validity evidence for internal structure (i.e., factorial reliability) of our adapted questionnaire (Study Two).
- To validate subscales of our adapted questionnaire using both objectively and subjectively assessed measures (Study Three).

Dissertation Literature Contribution

The aim of this dissertation is to contribute to the literature on perceived neighbourhood walkability from the results presented from three studies. For the first study, by adapting a well-known questionnaire to assess seasonal walking, the findings will provide a new questionnaire that can be used in urban neighbourhoods with northern climates to assess neighbourhood barriers of walking. Moreover, future decisions made to improve walkability in similar northern climates can be based on data that comes directly from residents that live in the neighbourhoods examined. As part of the second study, the internal structure validity and test-retest reliability of the adapted questionnaire will be assessed and used to examine the adequacy of the measure's ability to account for seasonal effects of walking. For the third study, two assessments of convergent validity will be used to further provide an estimate of validity of the subscales on the adapted measure. Moreover, this dissertation will evaluate whether the adaptations of the new perceived walkability questionnaire is both valid and reliable overall.

Chapter 2: Study 1

The Adaptation and Content Validation of a Perceived Walkability Questionnaire for use in Northern Climates: The NEWS-North

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Abstract

Background and Objectives: Walkability, or the ease and pleasantness of walking in a particular environment may be particularly important for maintaining the health of adults. Walkability has been related to both walking behaviour and to health outcomes. Several questionnaires have been developed to assess perceived walkability, yet none have assessed winter walkability. The goal of this study was to adapt a well-known American walkability questionnaire, the "Neighborhood Environment Walkability Scale" (NEWS), for use in Canada and similar northern climates (NEWS-North). In such climates, it is essential to consider winter walking conditions as they can limit pedestrian activity and pedestrian safety.

Methods: Canadian adults in three focus groups reviewed the original NEWS and the abbreviated NEWS and provided suggestions/comments on items that needed to be added/changed to make it relevant for pedestrians in northern climates. This feedback was used to create an initial draft of the NEWS-North. As part of content validation, walkability experts considered clarity and relevance of the items; they also identified needed changes.

Results: Suggestions from the focus groups included: changing spelling and measurement to Canadian standards (e.g., miles to kilometers), adding some questions related to winter walking and deleting others to improve the clarity of the measure, as well as the addition of a new subcategory to assess winter walkability. Based on feedback from the expert panel, we removed redundant items and renamed section headings to make them more straightforward. The nine subscales were rated as highly important on the content validation. The original authors of the NEWS reviewed and approved the NEWS-North.

Conclusion: The NEWS-North has been carefully adapted so that it is appropriate for pedestrians in northern environments.

The Adaptation and Content Validation of a Perceived Walkability Questionnaire for use in Northern Climates: The NEWS-North

The number of obese and overweight Canadian adults has increased in the past decade. According to Statistics Canada (2014), approximately 40% of adult men and 27.5% of adult women were overweight, while obesity rates in 2014 were the highest reported since 2003 in men (21.8%) and women (27.5%). Canadian physical activity guidelines recommend 150 minutes of physical activity for adults per week (Tremblay et al., 2011). This is consistent with other results which show that maintaining a physically active lifestyle reduces the risk of adverse health consequences (Lee, Shiroma, et al., 2012; Owen, Healy, Matthews, & Dunstan, 2010).

The most common form of physical activity reported by adults is walking (Lee & Moudon, 2004). This may be due in part to its accessibility; it is also a low-cost form of physical activity (Fox & Hillsdon, 2007). Walking has many health benefits for adults; such as lower risk of cardiovascular diseases (Rubinstein, 2015), the elimination or lowering of stress (Childs & de Wit, 2014), and less depression and anxiety (Goodwin, 2003). In Canada, 65.8% of adults reported walking for more than 60 minutes per week (Larouche, Faulkner, & Tremblay, 2015). Researchers aim to understand why some adults walk more often than others, and the relationship between adults' health and neighbourhood walkability.

Walkability, Theoretical Framework, and Adult Health

Walkability refers to characteristics within a neighbourhood that can either promote and/or enhance walking behaviours in its residents (Grant et al., 2010). In this study, the operational definition of walkability used also includes factors related to the ease (Montemurro et al., 2011) and safety (Mehta, 2008) of pedestrians walking in their neighbourhood. Furthermore, pedestrian walking can be influenced by season. Ecological models are used as a theoretical framework to explain walking behaviours. This is largely due to the fact that ecological models recognize that walking behaviours are influenced by multiple determinants (Sallis et al., 2008). For example, neighbourhood walkability from an ecological perspective would include neighbourhood features that are either physical (e.g., presence of sidewalks) or social (e.g., perceived safety from crime) that have related to walking within the literature.

An ecological model consists of multiple levels with specific variables, where the levels are "nested" thereby each level can influence another level and ultimately a behaviour (McLaren & Hawe, 2005). For the purpose of this paper, we adapted the ecological framework for perceived walkability of Fitzgerald and Spaccarotella (2009) to include three specific levels: individual, neighbourhood, and government. The focus of the current paper is perceived walkability at the neighbourhood level. At the neighbourhood level, research has shown that walkable neighbourhoods are characterized by continuous, well-maintained sidewalks and pedestrian paths (Lo, 2009; Saelens, Sallis, & Frank, 2003), accessible[5] services and amenities (Lo, 2009), high pedestrian safety from traffic (Galanis & Eliou, 2011; Lo, 2009), buffers from traffic for pedestrians (Lo, 2009), perceived high security (Lo, 2009), greater land-use mix (Frank et al., 2010; Lo, 2009) and high aesthetic appeal/visual interest, including trees and landscaping (Balfour & Kaplan, 2002; Lo, 2009).

The relationship between neighbourhood walkability and adult health is well-documented. Not surprisingly, residents of highly walkable neighbourhoods report more walking than residents of less walkable neighbourhoods (Saelens, Sallis, & Frank, 2003). Walkable neighbourhoods have been related to better physical health for adults, including lower rates of cardiovascular disease (Fox & Hillsdon, 2007), lower obesity rates (Berry, Spence, Blanchard,

[5] In terms of proximity and accessibility for people living with disabilities

Cutumisu, Edwards, & Selfridge, 2010) and lower prevalence of mental health issues such as depression (Berke et al., 2007).

Measuring Neighbourhood Walkability

Neighbourhood walkability can be measured by either subjective assessment (e.g., questionnaires given to residents) or objective assessment (e.g., databases or trained observers), however, a combination of both methods is often preferred.

Subjective methods, such as questionnaires, are widely used as they have a low operational cost (e.g., online versus paper copies) for reaching a large number of participants (Sallis & Saelens, 2000). These walkability measures are based on residents' perceptions of the walking environment in their neighbourhood. Criticisms of self-report questionnaires include the potential inaccuracy of the respondent's recall (Sallis & Saelens, 2000) and self-report bias (Kitchen, Williams, & Chowhan, 2011). Nevertheless, perceived walkability has been closely linked to walking and adult health. For example, higher perceived walkability has been related to more walking for transport (Van Cauwenberg et al., 2012), and to maintenance of body mass index over six years (Berry, Spence, Blanchard, Cutumisu, Edwards, & Selfridge, 2010).

Two common objective methods used by researchers are Geographic Information Systems (GIS) data and direct observation. GIS is a computer-based system that provides the capability to map the geographic locations of physical components (e.g., parks or buildings) of a neighbourhood by using electronic databases. Walkability measures derived using GIS mapping and analytical capabilities of GIS are common (Frank et al., 2010). While this method is easily accessed, manipulated, and utilizes the electronic databases (Leslie et al., 2007), one limitation is the exclusion of non-physical components (Lovasi et al., 2013). Several benefits of direct observation include greater objectivity and the immersion of observers in the neighbourhood; thus ratings are more likely to be accurate than out-dated GIS databases (Booth et al., 2005).

Objective and perceived walkability are often differentially related to health behaviours (Ding & Gebel, 2012), which can explain the poor to moderate agreement between measures (Arvidsson et al., 2012). It has been suggested that both methods should be used so that areas of overlap can be identified and our understanding of the reasons behind the differences between the two methods can be improved (Dawson et al., 2007; Ding & Gebel, 2012). The use of both methods allows researchers to leverage the benefits of both data sources (Jauregui et al., 2016).

Perceived Walkability Questionnaires

There are a number of self-reported walkability scales; many were developed in warmer climates, such as in California (Balfour & Kaplan, 2002) and Australia (Ball et al., 2001). The "Neighborhood Environment Walkability Scale" (NEWS; Saelens, Sallis, Black, et al., 2003) is a well-validated and often-used perceived walkability scale. The NEWS has good[6] test-retest reliability: intraclass correlations (ICC) for the 8 subscales ranged from 0.62 to 0.88 (Leslie et al., 2005). Support for factorial validity has been shown in a cross-validation study between the NEWS and the NEWS-A (Cerin et al., 2009). Furthermore, six factors of the NEWS were related to walking for transport; this provides some evidence for construct validity (Cerin et al., 2006; Leslie et al., 2005). In one study, of the 22-items examined, correlations between each of the 22-items and walking for transportation ranged from -0.36 to 0.24 (Adams et al., 2009). The NEWS has been adapted for use in at least 12 countries (in at least two countries with colder climates) and has been translated into five languages (Cerin et al., 2013). Adaptions of the NEWS include

[6] 'Good reliability' refers to the fact that the majority of subscales fall within values of .70 or higher

the NEWS abbreviated (NEWS-A; Cerin et al., 2009; Cerin et al., 2006), NEWS for Nigeria (Oyeyemi et al., 2013) and the NEWS for Australia (Leslie et al., 2005). In Calgary, Alberta, Canada, retest reliabilities on the 20 items on the NEWS-A varied from .33 to .77 (McCormack et al., 2013). However, an extensive modification on winter walkability has not been incorporated into any of the adaptations.

Winter Walkability

Adults are less physically active in winter than in the summer (Tucker & Gilliland, 2007). In Canada, approximately 64% of adults are inactive during the winter (Merchant et al., 2007). Snow and ice conditions on streets and walkways often hinder walking activities (Juvani et al., 2005). The greater risk of injury from falls is due to poorly maintained sidewalks and paths (Ripat et al., 2010). Despite the importance of winter walkability especially for climates in Canada, at the time of writing of this dissertation we could not find any perceived walkability questionnaires that specifically assessed winter walkability in a northern population.

Current Study and Objectives

In order to address this gap in walkability measurement, our goal was to adapt the NEWS for use in northern climates and, in particular Canada, to assess perceived neighbourhood walkability at the individual level.

Our adaptation comprised three phases, following procedures outlined by the original authors (via personal email correspondence from April 2012 to March 2014). In the first phase, focus groups were conducted with Ottawa, Ontario, Canada residents, and an expert panel provided content validation. In these focus groups, we received feedback on the NEWS (e.g., missing walkability concepts for northern climates, ensuring wording was appropriate for Canada). Data from these focus groups were used to adapt the NEWS: our new adapted instrument was named the NEWS-North. After this, the initial draft of the NEWS-North was sent to international experts to assess the adapted measure's content validity. The second phase and third phase involved a large pilot test. The second phase involved the assessment of the internal structure validity (i.e., internal consistency and factorial validity) analyses as well as the test re-test reliability of each subscale of the NEWS-North. The third phased examined both the construct validity and convergent validity of the NEWS-North. In the present paper we report on Phase One: the process and outcomes of the adaption and content validation.

Method

Participants

Focus groups. Fifteen adults who live in Ottawa, Ontario, Canada participated in one of three focus groups. The participants comprised a diverse group of public health experts and citizens concerned with walkability. Most participants were women (80%). Ten participants were recruited from the City of Ottawa's '*Creating Winning Projects for Walkable Communities*' conference, while five participants were recruited from the emails sent to the two public health organizations in Ottawa. Most participants were employed (80%), one participant was a student, and two participants were retired. One participant identified that they had difficultly walking due to having a disability, while the remaining participants could walk without assistance. The majority of participants identified as young- to middle-aged adults (i.e., 18 to 45 years of age; 86%) while two participants were over the age of 60. Reasons for participating in the walkability focus group included: concerns for their and/or neighbourhood children, belief in car independent living, participation in walking for exercise, and accessibility issues for both seniors and people in wheelchairs. The neighbourhoods of participants were varied. Four participants lived in the urban neighbourhood of Sandy Hill. Other Ottawa urban neighbourhoods included

Old Ottawa East, the Glebe, Centertown, and West Wellington. Two neighbourhood suburbs included Orleans and Nepean. However, five participants did not disclose their current residential neighbourhood. Of the 15 participants, one had recently moved from an urban neighbourhood to a suburban neighbourhood.

Content validation: Expert panel. Content validity is the degree to which the content of the questionnaire or test covers the construct of interest (Miller & Lovler, 2015). Content validity is approached two ways. First, content validity is built into the questionnaire through operationally defining the construct of interest. Second, an expert panel then assesses the content validity of a questionnaire. Miller and Lovler (2015) recommend that 3 to 10 experts review a questionnaire for content validity, and that at least one of the included experts should be a psychometrics specialist while the remaining experts should be content experts and lay experts.

The walkability experts contacted for this paper included those who are employed in the federal government, academic sector (i.e., health research), or community occupations related to walking behaviours and health. Eleven experts participated in this study. Eight experts were recruited individually through email. In addition, feedback from our draft adaptation was also received from three of the original authors of the NEWS (Saelens, Sallis, Black, et al., 2003): James Sallis, Brian Saelens, and Larry Frank. There were an equal number of male and female participants. The geographic locations of experts living in North America varied. In Canada, three experts were from Ottawa and one was from British Columbia. In the United States, one expert was from the state of New York, one from the state of California, and one from the state of Washington. In the European Union, one expert was from the United Kingdom and one from Belgium. In addition, two experts were from Australia.

Material

Perceived walkability measure. The NEWS (Saelens, Sallis, Black, et al., 2003) is a 66-item perceived walkability questionnaire that contains eight subscales: *residential density* (e.g., types of residential housing), *land use mix diversity* (e.g., proximity non-residential land uses), *land use mix access* (e.g., ease of non-residential land uses), *street connectivity* (e.g., intersections), *walking/cycling facilities* (e.g., sidewalks), *aesthetics*, *pedestrian traffic safety*, and *crime safety*. Subscales are calculated by the means across all items within that subscale. Most items are scored on a 4-point scale ranging from 1 (*strongly disagree*) to 4 (*strongly agree*), where higher scores denote neighbourhood characteristics that enhance walking. However, “residential density” and “land use mix diversity” subscales are scored differently. “Residential density” items that assess building frequencies (e.g., single family homes) are scored on a 5-point Likert scale ranging from 1 (*none*) to 5 (*all*). “Land use mix-diversity” items assess the time needed to reach non-residential destinations (e.g., grocery stores) and are scored on a 5-point Likert scale ranging from 1 (*31 minutes or more/ do not know*) to 5 (*1 to 5 minutes*). A higher mean subscale score denotes higher walkability in all subscales with the exception of both of the *safety from traffic* and *safety from crime* subscales.

Abbreviated perceived walkability measure. The NEWS-A (Cerin et al., 2009; Cerin et al., 2006) is a 54-item questionnaire that contains the same eight subscales as the NEWS (Saelens, Sallis, Black, et al., 2003) and the same scoring procedures, but with fewer items. The NEWS and NEWS-A both have good factorial validity (Cerin et al., 2009; Cerin et al., 2006). One study reported that six subcategories on both the NEWS and NEWS-A (Cerin et al., 2006) had good construct validity. Evidence for test retest reliability of the NEWS-A has also been found (Cerin et al., 2006; Saelens, Sallis, Black, et al., 2003). Similarly, a higher mean subscale score denotes higher walkability in all subscales with the exception of both of the *safety from traffic* and *safety from crime* subscales.

Compilation of comments and suggestion from focus groups. The feedback from the three focus groups was compiled into one document. The report consisted of nine sections: one for each of the eight subscales of the original NEWS (Saelens, Sallis, Black, et al., 2003) and a section dedicated to overall impressions from participants of the focus groups. Each section included a compilation of the following: (a) suggested items that needed modification (e.g., wording) or the addition of an item, (b) general comments or suggestions of the section, (c) items that were confusing, and (d) reasons why items should be removed.

Adapted perceived walkability draft. The initial draft of the NEWS-North consisted of 56-items with nine subscales. Eight of the original NEWS (Saelens, Sallis, Black, et al., 2003) subscales were included with the addition of a "winter walking" subscale. Most subscales with were rated on a 4-point scale ranging from 1 (*strongly disagree*) to 4 (*strongly agree*) where higher scores on each subscale denoted greater walkability.

Content validity: Expert panel. A content validity checklist was created to assess each subscale of the adapted questionnaire draft. The checklist consisted of a total of 45 items and nine subscales; five items in each section combined close-ended and open-ended items. The first item on the checklist assessed whether the questions in that section were important to overall assessment of walkability. We used a four-point Likert scale that ranged from 1 (*not at all important*) to 4 (*very important*) and experts were asked to explain their answer. Three other items on the checklist included: "are there any items that are missing," "can any items be removed (e.g., items that are unnecessary)," and "are there any items that are problematic such as poor wording or are unclear." Respondents were asked to first rate their response on a dichotomous scale (*no* versus *yes*) and explain their answer. The last question on the checklist was open-ended and asked whether or not the respondent had any further suggestions.

Procedure

Our adaption procedure was based on that provided by Sallis et al. (personal communication, 2015) and was similar to that used in the adaptation of the NEWS for Africa (Oyeyemi et al., 2016).

Focus groups. Permission was obtained from the University of Ottawa Research and Ethics Board. Participants were recruited by email from two sources: (a) a sign-up list at a walkability forum; and (b) an email circulated within two public health organizations. Interested participants were then scheduled for one of three focus groups. Participants also received a reminder e-mail containing information about the session (e.g., date and time) and several documents (e.g., the NEWS and NEWS-A). Before the session, participants were asked to review the NEWS and NEWS-A, bearing in mind its potential use in northern climates, particularly Canada. They then wrote down any initial concerns about item content or item wording, missing items, and overall impressions. They brought this input to a focus group.

Each focus group followed the same pattern. First, participants were given a brief welcome, an outline of the guidelines, and a short overview of the session. After written consent was received, each focus group was audio recorded. As focus groups were conducted over the dinner hour, healthy snacks were provided; participants were also compensated for transportation and parking. Participants were asked several warm up questions (e.g., “what does walkability mean to you and why”). During the remainder of the session, we went through each section of the NEWS and discussed issues relevant to using the NEWS in Canada. Participants were also asked to provide suggestions for content on winter walkability. The feedback received from the three focus groups was used to create a draft of the NEWS-North. Two raters first compiled the initial draft of the NEWS-North independently. A third rater meet with the two other raters to confirm the similarities and the differences were discussed until a resolution was formed.

Content validity: Expert panel. It is recommended that a content validity panel be comprised of 3 to 10 content experts, a few community experts and a psychometric expert. Walking expert, in this thesis, was defined differently for academics, government, and community experts. For academics, we defined our experts as those who had several publications on built environment and walking. Our government experts had to be involved in walkability research or a related policy field. Community experts were defined as those groups who done a lot of thinking, writing and advocacy on walking. The email introduced the project, highlighted its importance and explained that their input was needed as an important step in the development of the NEWS-North. Several documents were attached in the email, including the initial draft of the NEWS-North, the NEWS, the NEWS-A, and the feedback summary from the three focus groups. Experts were asked to complete a content validity checklist on the importance of each questionnaire section on the NEWS-North, whether any necessary items/content were missing from that section, and whether any could be removed. They were also asked about the clarity of wording for items in each section. A consent form was also included.

We sent invitation e-mails to 49 experts altogether. Interested experts completed the consent form, the content validation checklist, and made suggestions for changes to the NEWS-North. We also received and compiled feedback from three of the original authors of the NEWS. Once all checklists, updated questionnaires, and comments were received, this feedback was summarized and used to create a second draft of the NEWS-North. The summaries and second draft of the NEWS-North were sent back to the experts to ensure that the changes adequately reflected their feedback.

Analysis

Focus groups. Each focus group session was transcribed from the audio recording for a qualitative data analysis. The qualitative data were classified into themes by questionnaire section. There were also many comments and suggestions on improvement for the questionnaire. Then, two PhD student raters independently analyzed each of the three focus group transcriptions and created a summary for each group. The third author reviewed the summaries for consistency and all three raters met to resolve disagreements. To ensure fidelity, each focus group summary was sent to all participants for their comments and feedback. After this, the three initial summaries were combined to create an overall summary. This summary was used to create an initial draft of the NEWS-North.

Content validation: Expert panel. After all feedback and the checklist for content validation had been received, two raters separately analyzed both the qualitative and quantitative aspects. The qualitative aspects were examined descriptively, while the quantitative aspects of each subscale were examined by a series of frequency analysis in Statistical Package for the Social Sciences (SPSS) 23®. The third author reviewed their work. All three raters met to create a summary that was used as a basis for developing the NEWS-North. This and the updated NEWS-North were sent back to the expert panel for their approval. After additional modifications, the adapted questionnaire was then sent to the original authors of the NEWS. Their feedback was the final step in creating the NEWS-North.

Results

Feedback: Focus Groups

Overall comments. All participants agreed that the spelling and measurement units in the NEWS needed to be changed from American to Canadian (e.g., “neighborhood" to “neighbourhood”; miles to kilometres). Participants also discussed two main changes that would make the questionnaire more user friendly. First, they suggested that the questionnaire should begin with a section that would be perceived as easier to complete (e.g., *land use mix access*) while moving the longer sections (e.g., *land use mix diversity*) to the end. Second, participants felt that the subscale titles on the NEWS needed to be changed. Theses subscale titles included “places for walking and cycling,” “neighbourhood surroundings,” and “safety from crime.” First, participants strongly discouraged the use of term *cycling* in the title “places for walking and cycling.” The majority of participants felt that the inclusion of cycling on a walkability questionnaire would distract respondents from carefully evaluating walking in their neighbourhood. Second, participants noted that “neighbourhood surroundings” title was too vague as these items corresponded more to attractive features of a neighbourhood. Third, participants felt that “safety from crime” title implied that a neighbourhood was already unsafe. In addition, participants felt that the section was really getting at how friendly and approachable neighbours are in their neighbourhood. Finally, all participants agreed that a section dedicated to the barriers to winter walking was missing from the current questionnaire.

Section feedback. Although we received feedback from all sections of the NEWS, in this paper, we discuss the two sections which needed the most improvement: *street connectivity* and *pedestrian traffic safety*. The addition of a new section and a suggested reformation of two subscales are also discussed.

Street connectivity. Respondents felt that this section had some American references that would not resonate with Canadians. For example, the item "the distance between intersections in my neighborhood is usually short (100 yards or less; the length of a football field or less)" had two problems. First, other sports are more popular than football in Canada (e.g., hockey or soccer). Second, the unit of yards needed to be changed to meters. Third, the respondents found the item, "the streets in my neighborhood do not have many, or any, cul-de-sacs (dead-end streets)" confusing as they did not know if *cul-de-sacs* and *dead-ends* referred to the same street feature.

Pedestrian traffic safety. First, participants suggested the addition of an item which asked about the presence of sufficient crosswalks. For example, a crosswalk at every corner would likely result in fewer pedestrians jaywalking than a crosswalk every four blocks. Participants also suggested the addition of several items to reflect common pedestrian experiences. For example, they suggested items concerning whether drivers were courteous to pedestrians (e.g., reducing speed at a crosswalk) and whether pedestrian signals allowed enough time for all pedestrians (including those with mobility disabilities) to cross the street. Many participants mentioned that the short duration of timed crossings often led to pedestrians being in the middle of the intersection as the traffic signals were close to changing.

Addition of winter walkability subscale. Participants also suggested the creation of a new section dedicated to the challenges of winter walking for pedestrians. Participants cited two main challenges of winter walking: poor snow removal and lack of places to get warm. Participants discussed the inclusion of items pertaining to snow removal such as clearing sidewalk and pedestrian trails after a snowfall. It was suggested that the inclusion of these items should cover people of all ages and abilities, including those with mobility issues, the elderly, or parents using strollers with young children. Another challenge of winter walking is whether there are places to get shelter from the cold. Several participants noted that their own walking routes would change in the winter months to include places to get warm such as malls, stores or bus shelters around their neighbourhood.

Reformation of two subscales. Participants suggested that both the *land use mix-diversity* and *residential density* subscales be reformatted to reduce the total number of items in each subscale. For example, it was suggested that we make the *land use mix-diversity* subscale open-ended questions. It was also suggested that comprehensive list of residential dwellings be created where respondents could “check all that applied” to avoid fatigue. Participants also noted that the current *residential density* subscale that some housing options were missing. These included mobile homes and converted homes into apartments.

It is important to note that in our adaption of the NEWS, we chose to keep the definition of neighbourhood as 10 to 15 minutes for the entire measure for several reasons. Firstly, we wished to maintain the scale’s consistency. Further, residents’ definition of neighbourhood would not likely change, although additional challenges of walking during the winter would appear. Montufar, Arango, Porter, and Nakagawa (2007) reported that greater ’normal walking speeds’ were reported in the summer compared to the winter; as well as lower walking speeds at intersection crossings in the winter compared to the summer. In Montreal, Quebec, a longitudinal study found that fewer step counts were reported in the fall and winter months compared to summer and spring (Dasgupta et al., 2010). Finally, the ‘10 to 15 minute’ definition was used to maintain the ability to compare our adapted measure to other adaptions & original NEWS.

Feedback: Expert Panel

The expert panel evaluated the draft of NEWS-North for relevance and clarity; they were also asked to consider respondent burden.

Content validation. All nine sections of the NEWS-North were judged to be highly relevant. The quantitative results of the expert panel regarding the nine sections can be found in Table 1. Across the nine sections, the majority of the experts (81.82% to 100%) rated the each section as 'very' important. The overall consensus among the experts was that most of the sections did not have many missing, problematic, or unnecessary items. However, a high percentage of the experts stated that the *residential den*sity and *land use mix proximity* sections in the initial draft had problematic items (90.01% and 81.82%, respectively), had missing items (81.82% and 72.73%, respectively), and that the included items were suggested for removal (81.82% and 72.73%, respectively).

The quantitative results of the expert panel included the deletion of items and some modifications. To reduce the length of the questionnaire, the experts suggested removing five items and combining two items into one. Some items also needed to be updated to reflect the current context (e.g., video stores are no longer relevant). To improve the clarity and user friendliness of the questionnaire, the expert panel suggested several modifications. First, they suggested the addition of a "not applicable" option for two sections of the questionnaire (i.e., *land use mix access* and *winter walking*) because not all neighbourhoods have sidewalks. Second, several problematic items in the sections *winter walking* and *traffic safety* were identified. For example, "the pedestrian signals in my neighbourhood give me sufficient crossing time" lacked specificity. This item was modified to "the pedestrian signals in my neighbourhood give me enough time to walk across the street" to remove ambiguity.

Finally, experts agreed on the three title modifications proposed in the initial focus groups. However, while the title for ‘places for walking and cycling’ changed to ‘places for walking,’ the inclusion of a modified cycling item was retained. Experts felt that respondents may choose to walk in multiple areas such as pedestrian trails, sidewalks, and bicycle trails. The removal of bicycle trails would reduce a respondent’s neighbourhood walking data.

Additional items. The experts suggested the addition of several new items to the winter walkability section because important concepts were missing. These included “in my neighbourhood, snow from driveways or the road is often put onto the sidewalks” and “snow banks in my neighbourhood make it difficult for drivers to see pedestrians.” An additional item included “the bicycle trails in my neighbourhood are cleared quickly after a storm” to compliment a modified bicycle item “there are bicycle trails in or near by my neighbourhood that are easy to bike to” in the *land use mix-access* section. This modified bicycle item used the original item in the NEWS (“there are bicycle or pedestrian trails in or near my neighbourhood that are easy to get to), but separated ‘bicycle’ and ‘pedestrian trails’ into two items opposed to one item to be more precise.

Other item additions were in the *land use mix access* section. These new items included “I feel safe walking on most streets in my neighbourhood that don’t have sidewalks” and “the sidewalks in my neighbourhood are free from obstacles (parked bicycles, electricity boxes, garbage bins).”

Response to reformatted structure of subscales. Most experts disagreed with the initial assessment from the three prior focus groups to change the scale structure of *land use mix-diversity* and *residential density*. Although experts agreed that the number of items on the NEWS is large, the restructure of these two subscales would result in several problems. First, the open-ended questions for *land use mix-diversity* would be difficult to analyze as each respondent's response could vary from few destinations to many. Furthermore, the difference in the number of responses between participants would make it difficult to standardized the data for analyses. Second, the experts agreed that the *residential density* did have housing options missing. However, the inclusion of 'houses converted into apartments' would be difficult for questionnaire respondents to perceive in their neighbourhood. Moreover, the inclusion of 'mobile homes' within an urban neighbourhood is quite rare. Often mobile homes are in more rural areas. Thus, the inclusion of these two suggested items would contribute little to perceived walkability of a neighbourhood. Third, by abstaining from structural changes of both these subscales, it allows for comparison to the adaptations currently existent within the literature.

The NEWS-North Finalized to be Pilot Tested

The original NEWS authors approved the changes to the adapted version of the NEWS-North. The adapted questionnaire contains 70 items and 9 subscales based on the content validation, which is similar in length to the NEWS. The NEWS-North included the addition of a "not applicable" option for both the '*places for walking'* and '*winter walking'* sections related specifically to sidewalks. This is an important feature as not every neighbourhood always has a sidewalk on every street. A comparison of the NEWS (Saelens, Sallis, Black, et al., 2003), NEWS-A (Cerin et al., 2009; Cerin et al., 2006), and the finalized NEWS-North can be found in Table 2.

Discussion

To the best of our knowledge, this study is the first to adapt a perceived walkability questionnaire specifically for Canadian and northern use with the inclusion of a winter walkability section. The main objective of this paper our goal was to adapt the NEWS for use in climates with a winter season. This was achieved in two steps. First, feedback from three focus groups (e.g., wording appropriateness for Canadians) was used to create an initial draft of the NEWS-North. Second, an expert focus group examined the content validity of the initial NEWS-North.

Three Focus Groups

The majority of the feedback to improve the NEWS for use in Canada from the three focus groups overlapped, thus demonstrating that modifications of the NEWS were needed for Canadians.

The reoccurring issue described by participants was the abundance of American wording that would likely be misunderstood by Canadian test takers; the most noticeable being the use of imperial units. As Canada, and most other northern countries use the metric system, this change would enable participants to better understand references to distances, speeds, etc. in units that are more familiar.

Another such issue was references to American culture, such as football. Although the item (“the distance between intersections in my neighborhood is usually short [100 yards or less; the length of a football field or less]”) included distance and a football field, it is likely to be misinterpreted.

Modification of the NEWS. To tailor the NEWS for a Canadian application, two suggestions included re-ordering subscales and changes to the title of selected subscales. The NEWS is quite long, our focus groups suggested that the NEWS-North start with more interesting sections at the beginning while less interesting sections be moved to the end as an additional option to combat participant fatigue while maintaining the order in other sections in the NEWS. It is possible that beginning the questionnaire with a more interesting section with fewer items can improve participants' attention.

Our focus groups also suggested changing three of eight titles on the NEWS. The main reason behind each of the title changes was that the title was too vague and sometimes unclear. An imprecise title could negatively affect responses if a respondent misperceived title and answered accordingly.

The focus group also highlighted the absence of winter walkability items in the NEWS. Previous research has shown that neighbourhood walking in the winter can be affected by the weather (Merchant et al., 2007; Yang et al., 2011). Participants noted two main challenges of winter walking for pedestrians: snow removal and places to warm up from the cold. The participants' experiences with winter walking highlighted the accumulation of unploughed snow on walking surfaces creates uneven and slippery surfaces. Moreover, the temperatures in Ottawa with the wind chill can cause pedestrians walking in their neighbourhood to become colder faster. For example, the wind chill can be amplified by wind tunnels created by high rises in the downtown core. Thus, pedestrians may seek shelter away from the frigid temperatures. This is consistent with previous research that has shown walking in neighbourhoods are limited to poor walking surfaces and cold temperatures (Li et al., 2012; Spinney & Millward, 2011).

Expert Panel

Eleven walkability experts from around North America and Europe were recruited for this study and completed a content validation of the initial draft of the NEWS-North to ensure that all aspects of perceived walkability in the NEWS-North were appropriate for use in Canada.

The quantitative feedback provided by the walkability experts confirmed that all nine of the subscales on the initial NEWS-North draft were highly relevant. Moreover, the majority of the subscales were rated by experts as having few to no missing or problematic items.

The quantitative feedback provided by the walkability experts suggested three main updates before pilot testing to create a more user-friendly questionnaire. Firstly, the addition of a "not applicable" option for the subscales that involve sidewalks was modified. This is important because not every neighbourhood has sidewalks. This indicates that the experts are aware that not all neighbourhoods have sidewalks. In addition, the inclusion of the "not applicable" option allowed for additional flexibility in the interpretation of the data for future analyses. Secondly, problematic items in the sections *winter walking* and *traffic safety* were identified and later modified to remove ambiguity. This is important because the elimination of ambiguity helps to reduce confusion and prevent uncertainty in the responses of items among participants. Thirdly, modifications of the titles on three subscales were implemented to make the subscale context more precise. Our initial draft of the NEWS-North required few modifications of subscale titles due to the fact that most titles were already precise. In addition, five items in total on the initial draft of the NEWS-North were identified for removal due to redundancy in the questionnaire.

The expert panel disagreed with the focus group suggestion of creating an open-ended option for the *land use mix-diversity* subscale and an updated list of housing options for the *residential density* subscale. The experts cited concerns related to data analyses, difficulties in perceptions for the updated list, and the generalizability of results. Open-ended responses are indeed not feasible for a large data collection across many neighbourhoods. In terms of residential density, while there are new housing options emerging in cities, those housing options listed in the NEWS are visually easily identifiable in neighbourhoods. Finally, current adaptions of the NEWS have included the same scaling options (see Leslie et al., 2005; Oyeyemi et al., 2013), which has allowed for comparisons between the adapted questionnaire and the original, but also between adapted questionnaires that contribute to the reliability and validity of the questionnaire. For example, a recent study has shown that the NEWS has been adapted and translated across 12 countries with good reliability and validity (Cerin et al., 2013).

The expert panel also disagreed with the removal of items related to cyclist trails, citing the possible loss of walking data as some pedestrian walk in areas other than sidewalks or trails. Pedestrians may often walk on cyclist trails, as most are really multi-use (Bierlaire & Robin, 2009; Goldstone & Roberts, 2006; Guo & Loo, 2013).

Limitations and Strengths

This study has some limitations. The focus groups contained a relatively small number of people (15), who lived in nine of the 103 neighbourhoods in Ottawa, Ontario, Canada. This may be because we recruited participants during the winter months; we also used only two recruitment strategies for the focus groups. The use of social media to reach the vast Ottawa neighbourhood population could have provided this study with additional participants from many different neighbourhoods. However, the participants recruited for the focus groups were quite diverse: they varied in age, family types (e.g., married with/out children, single) and employment status (e.g., working, retired). Importantly, they also included people with physical disabilities that limit walking. This diversity allowed for different viewpoints on the challenges and barriers of walking in a neighbourhood.

Finally, the fact that only eleven (including three of the original authors) out of forty experts provided us with input could be seen as a limitation. However, eleven experts is slightly above the number suggested by Miller and Lovler (2015). Furthermore, we included a psychometric expert (Dr. Kristjansson) as well as experts from Ottawa Public Health and the Association for Commuter Transportation of Canada as well as people in Population and Public Health and Behavioural Sciences.

Conclusion

We adapted the NEWS for Northern urban Canadian climates, adding new items and modifying existing items without compromising the integrity of the NEWS. We have also changed several other items to update them and/or make them more meaningful for Canadians. We were also cognizant of the need to reduce respondent burden while still getting at the essential concepts.

The NEWS-North will be an important contribution to the study of walkability in Canada and in other northern countries with similar seasons. There is no current perceived walkability measure in existence that encompasses seasonal aspects of walkability. The potential ability to add to the perceived walkability literature with a measure designed specifically for various seasons versus limited items designed by the research to assess seasonal walking.

The NEWS-North also has the potential to advance walkability research and urban design in Canada and other countries with similar climates. This work is potentially valuable for city planners, decision makers, public health organizations, community associations and concerned citizens so that they can understand the factors in their neighbourhoods that facilitate or impede walking.

Table 1

Quantitative Results from the Expert Panel of the NEWS-North (N= 11)

	Importance of each Subscale Overall				Content Evaluation of each Subscale		
Subscale	% VI	% SI	% SU	% VU	% Missing items	% Problematic items	% Unnecessary items
Section A	100	--	--	--	9.09	27.27	18.18
Section B	90.91	--	9.09	--	0	27.27	9.09
Section C	81.82	18.18	--	--	9.09	36.36	36.36
Section D	81.82	18.18	--	--	27.27	36.36	45.45
Section E	81.82	18.18	--	--	36.36	27.27	45.45
Section F	81.82	9.09	9.09	--	9.09	36.36	36.36
Section G	81.82	18.18	--	--	9.09	36.36	27.27
Section H	100	--	--	--	90.01	81.82	81.82
Section I	100	--	--	--	81.82	72.73	72.73

Note. VI= Very important; SI= Somewhat important; SU= Somewhat unimportant; VU= Somewhat unimportant

Section A= Access to services. Section B = Streets in my neighbourhood. Section C = Places for walking. Section D = Winter walking. Section E = Neighbourhood Surroundings/Aesthetics. Section F = Safety from traffic. Section G = Neighbourhood comfort and friendliness. Section H = Types of residences. Section I = Stores, facilities, and other things in your Neighbourhood.

Table 2

A Comparison of the Original Two Walkability Questionnaires and the Adapted Questionnaire for Northern Climates

	Number of Items Between Measures			
	NEWS[a]	NEWS-A[b]	*NEWS-North[c]	Additional NEWS-North Changes
Subscale Title				
A. Types of residences	6	6	6	--
B. Stores, facilities …	23	23	22	--
C. Access to services	7	3	5	--
D. Streets …	5	2	3	--
E. Places for walking & cycling	5	6	9	Section Renamed: "Places for walking" --
F. Neighbourhood surroundings	6	4	6	Section Renamed: "Neighbourhood Surroundings/Aesthetics"
G. Safety from traffic	8	3	6	--
H. Safety from crime	6	3	5	Section Renamed: "Neighbourhood comfort and friendliness"
I. Winter walking	N/A	N/A	8	Section Created
Single items	N/A	4	TBD	--
Total items	66	54	70	--

Note.
**The sample size of the three focus groups was 15 participants*
[a] NEWS (Saelens, Sallis, Black, et al., 2003)
[b] NEWS-A (Cerin et al., 2009; Cerin et al., 2006)
[c] Based on the final version of the NEWS-North

Appendix

Neighbourhood Environment Walkability Scale for Northern Climates (NEWS-North)

We would like to find out how easy and pleasant it is to walk around in your neighbourhood. Please answer the following questions about your neighbourhood and yourself. Please answer as honestly and completely as possible and provide only one answer for each item. There are no right or wrong answers and your information is kept confidential.

A. ACCESS TO SERVICES

Please select the answer that best applies to you and your neighbourhood, both LOCAL and WITHIN WALKING DISTANCE mean within a 10-15 minute walk from your home.

1. Generally, stores are within easy walking distance of my home.

1	2	3	4
Strongly Disagree	Somewhat Disagree	Somewhat Agree	Strongly Agree

2. There are many places (e.g., coffee shops, restaurants, recreation) to go within easy walking distance of my home.

1	2	3	4
Strongly Disagree	Somewhat Disagree	Somewhat Agree	Strongly Agree

3. It is easy to walk to a transit stop (e.g., bus, train) from my home.

1	2	3	4
Strongly Disagree	Somewhat Disagree	Somewhat Agree	Strongly Agree

4. The streets in my neighbourhood are hilly, making my neighbourhood difficult to walk in.

1	2	3	4
Strongly Disagree	Somewhat Disagree	Somewhat Agree	Strongly Agree

5. There are physical barriers (e.g., rivers or busy streets) in my neighbourhood that limit the number of routes for getting from place to place.

1	2	3	4
Strongly Disagree	Somewhat Disagree	Somewhat Agree	Strongly Agree

B. STREETS IN MY NEIGHBOURHOOD

Please select the answer that best applies to you and your neighbourhood.

1. There are walkways in my neighbourhood that connect dead-ends to other streets or trails.

1	2	3	4
Strongly Disagree	Somewhat Disagree	Somewhat Agree	Strongly Agree

2. The distance between intersections in my neighbourhood is usually short (100 meters or less).

1	2	3	4
Strongly Disagree	Somewhat Disagree	Somewhat Agree	Strongly Agree

3. There are many alternative routes for getting from place to place in my neighbourhood. (I don't have to go the same way every time.)

1	2	3	4
Strongly Disagree	Somewhat Disagree	Somewhat Agree	Strongly Agree

C. PLACES FOR WALKING

Please select the answer that best applies to you and your neighbourhood.

1. There are sidewalks on most of the streets in my neighbourhood.

1	2	3	4
Strongly Disagree	Somewhat Disagree	Somewhat Agree	Strongly Agree

2. Sidewalks in my neighbourhood sometimes end in the middle of a block.

1	2	3	4	N/A
Strongly Disagree	Somewhat Disagree	Somewhat Agree	Strongly Agree	Not applicable means no sidewalks in my neighbourhood

3. The sidewalks in my neighbourhood are well maintained (paved, even, and have few cracks).

1	2	3	4	N/A
Strongly Disagree	Somewhat Disagree	Somewhat Agree	Strongly Agree	Not applicable means no sidewalks in my neighbourhood

4. There are pedestrian trails in or near my neighbourhood that are easy to walk to.

1	2	3	4
Strongly Disagree	Somewhat Disagree	Somewhat Agree	Strongly Agree

5. There is a strip (grass/dirt/ concrete) that separates the road from the sidewalks in my neighbourhood.

1	2	3	4	N/A
Strongly Disagree	Somewhat Disagree	Somewhat Agree	Strongly Agree	Not applicable means no sidewalks in my neighbourhood

6. The sidewalks in my neighbourhood are free from obstacles (parked bicycles, electricity boxes, garbage bins).

1	2	3	4	N/A
Strongly Disagree	Somewhat Disagree	Somewhat Agree	Strongly Agree	Not applicable means no sidewalks in my neighbourhood

7. There are benches to rest on in my neighbourhood.

1	2	3	4
Strongly Disagree	Somewhat Disagree	Somewhat Agree	Strongly Agree

8. There are bicycle trails in or near my neighbourhood that are easy to bike to.

1	2	3	4
Strongly Disagree	Somewhat Disagree	Somewhat Agree	Strongly Agree

9. I feel safe walking on most streets in my neighbourhood that don't have sidewalks.

1	2	3	4
Strongly Disagree	Somewhat Disagree	Somewhat Agree	Strongly Agree

D. WINTER WALKING

Please select the answer that best applies to you and your neighbourhood.

1. The sidewalks in my neighbourhood are cleared quickly after a winter storm.

1	2	3	4	N/A
Strongly Disagree	Somewhat Disagree	Somewhat Agree	Strongly Agree	Not applicable means no sidewalks in my neighbourhood

2. The pedestrian trails in my neighbourhood are cleared quickly after a winter storm.

1	2	3	4
Strongly Disagree	Somewhat Disagree	Somewhat Agree	Strongly Agree

3. The sidewalks in my neighbourhood are often slippery in the winter.

1	2	3	4	N/A
Strongly Disagree	Somewhat Disagree	Somewhat Agree	Strongly Agree	Not applicable means no sidewalks in my neighbourhood

4. There are places to get out of the wind (e.g., shops, bus shelters, public buildings) while walking in my neighbourhood.

1	2	3	4
Strongly Disagree	Somewhat Disagree	Somewhat Agree	Strongly Agree

5. Snow banks in my neighbourhood make it difficult for drivers to see pedestrians.

1	2	3	4
Strongly Disagree	Somewhat Disagree	Somewhat Agree	Strongly Agree

6. Most streets WITHOUT sidewalks in my neighbourhood are safe to walk on in the winter.

1	2	3	4
Strongly Disagree	Somewhat Disagree	Somewhat Agree	Strongly Agree

7. In my neighbourhood, snow from driveways or the road is often put onto the sidewalks.

1	2	3	4	N/A
Strongly Disagree	Somewhat Disagree	Somewhat Agree	Strongly Agree	Not applicable means no sidewalks in my neighbourhood

8. The bicycle trails in my neighbourhood are cleared quickly after a winter storm.

1	2	3	4	N/A
Strongly Disagree	Somewhat Disagree	Somewhat Agree	Strongly Agree	Not applicable means no sidewalks in my neighbourhood

E. NEIGHBOURHOOD SURROUNDINGS/AESTHETICS

Please select the answer that best applies to you and your neighbourhood.

1. There are trees along the streets in my neighbourhood.

1	2	3	4
Strongly Disagree	Somewhat Disagree	Somewhat Agree	Strongly Agree

2. Trees give shade for walking in my neighbourhood.

1	2	3	4
Strongly Disagree	Somewhat Disagree	Somewhat Agree	Strongly Agree

3. There are many interesting things to look at while walking in my neighbourhood.

1	2	3	4
Strongly Disagree	Somewhat Disagree	Somewhat Agree	Strongly Agree

4. My neighbourhood is generally clean (e.g., free from litter).

1	2	3	4

Strongly Disagree Somewhat Disagree Somewhat Agree Strongly Agree

5. There are many attractive natural sights in my neighbourhood (such as well landscaped yards, parks and trees).

1	2	3	4
Strongly Disagree	Somewhat Disagree	Somewhat Agree	Strongly Agree

6. There are attractive buildings/homes in my neighbourhood.

1	2	3	4
Strongly Disagree	Somewhat Disagree	Somewhat Agree	Strongly Agree

F. SAFETY FROM TRAFFIC

Please select the answer that best applies to you and your neighbourhood.

1. There is so much traffic along nearby streets that it makes it difficult or unpleasant to walk in my neighbourhood.

1	2	3	4
Strongly Disagree	Somewhat Disagree	Somewhat Agree	Strongly Agree

2. Many drivers exceed the posted speed limits while driving in my neighbourhood.

1	2	3	4
Strongly Disagree	Somewhat Disagree	Somewhat Agree	Strongly Agree

3. There are enough crosswalks and pedestrian signals to help walkers cross busy streets in my neighbourhood.

1	2	3	4
Strongly Disagree	Somewhat Disagree	Somewhat Agree	Strongly Agree

4. The pedestrian signals in my neighbourhood give me enough time to walk across the street.

1	2	3	4
Strongly Disagree	Somewhat Disagree	Somewhat Agree	Strongly Agree

5. When walking in my neighbourhood, there are a lot of exhaust fumes (such as from cars, buses).

1	2	3	4
Strongly Disagree	Somewhat Disagree	Somewhat Agree	Strongly Agree

6. Most DRIVERS in my neighbourhood are courteous and concerned for pedestrian safety.

1	2	3	4
Strongly Disagree	Somewhat Disagree	Somewhat Agree	Strongly Agree

G. NEIGHBOURHOOD COMFORT AND FRIENDLINESS

Please select the answer that best applies to you and your neighbourhood.

1. My neighbourhood streets are well lit at night.

1	2	3	4
Strongly Disagree	Somewhat Disagree	Somewhat Agree	Strongly Agree

2. Walkers and cyclists on the streets in my neighbourhood can be easily seen by people in their homes.

1	2	3	4
Strongly Disagree	Somewhat Disagree	Somewhat Agree	Strongly Agree

3. I often see and speak to other people when I am walking in my neighbourhood.

1	2	3	4
Strongly Disagree	Somewhat Disagree	Somewhat Agree	Strongly Agree

4. I feel safe walking in my neighbourhood during the day.

1	2	3	4
Strongly Disagree	Somewhat Disagree	Somewhat Agree	Strongly Agree

5. I feel safe walking in my neighbourhood at night.

1	2	3	4
Strongly Disagree	Somewhat Disagree	Somewhat Agree	Strongly Agree

H. TYPES OF RESIDENCES IN YOUR NEIGHBOURHOOD

Among the residences in your neighbourhood.......

1. How common are detached single-family residences in your immediate neighbourhood?

1	2	3	4	5
None	A few	Some	Most	All

2. How common are townhouses or row houses of 1-3 stories in your immediate neighbourhood?

1	2	3	4	5
None	A few	Some	Most	All

3. How common are apartments or condos of 1-3 stories in your immediate neighbourhood?

1	2	3	4	5
None	A few	Some	Most	All

4. How common are apartments or condos of 4-6 stories in your immediate neighbourhood?

1	2	3	4	5
None	A few	Some	Most	All

5. How common are apartments or condos of 7-12 stories in your immediate neighbourhood?

1	2	3	4	5

None	A few	Some	Most	All

6. How common are apartments or condos more than 13 stories in your immediate neighbourhood?

1	2	3	4	5
None	A few	Some	Most	All

I. STORES, FACILITIES, AND OTHER THINGS IN YOUR NEIGHBOURHOOD

About how long would it take to get from your home to the NEAREST businesses or facilities listed below if you WALKED to them?

1. Please select only one option for each business or facility.

	1-5 min	6-10 min	11-20 min	21-31 min	31+ min	Don't know
a) convenience/small grocery store	☐	☐	☐	☐	☐	☐
b) supermarket	☐	☐	☐	☐	☐	☐
c) hardware store	☐	☐	☐	☐	☐	☐
d) fruit/vegetable market	☐	☐	☐	☐	☐	☐
e) laundry/dry cleaners	☐	☐	☐	☐	☐	☐
f) clothing store	☐	☐	☐	☐	☐	☐
g) post office	☐	☐	☐	☐	☐	☐
h) public library	☐	☐	☐	☐	☐	☐
i) elementary school	☐	☐	☐	☐	☐	☐
j) other schools	☐	☐	☐	☐	☐	☐
k) book store	☐	☐	☐	☐	☐	☐
l) fast food restaurant	☐	☐	☐	☐	☐	☐
m) coffee place	☐	☐	☐	☐	☐	☐
n) bank/credit union	☐	☐	☐	☐	☐	☐
o) non-fast food restaurant	☐	☐	☐	☐	☐	☐
p) pharmacy/drug store	☐	☐	☐	☐	☐	☐
q) salon/barber shop	☐	☐	☐	☐	☐	☐
r) public transportation	☐	☐	☐	☐	☐	☐
s) park	☐	☐	☐	☐	☐	☐
t) recreation center	☐	☐	☐	☐	☐	☐
u) gym or fitness facility	☐	☐	☐	☐	☐	☐

2. Please select only one option.

	I do not have work away from home or do not attend school	1-5 min	6-10 min	11-20 min	21-31 min	31+ min	Don't know
v) your job or school	☐	☐	☐	☐	☐	☐	☐

Chapter 3: Study 2

The Reliability and Internal Validity of the NEWS-North

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Abstract

Objectives: Our adapted measure, the NEWS-North, was adapted from an American subjective neighbourhood walkability questionnaire to assess winter walkability in addition to walkability aspects already included from the original questionnaire (e.g., pedestrian infrastructures, street connectivity, aesthetics). In this paper, we report on the findings from a pilot test of the NEWS-North where we aimed to assess: (a) validity based on the internal structure of the questionnaire (i.e., factorial validity), and (b) reliability (test retest reliability and internal consistency.

Method: Data for the online pilot study came from recruiting both students (*n* = 224) and residents (*n* = 210) from Ottawa neighbourhoods through various strategies (e.g., university recruitment for students; community and social media for residents). Participants completed demographic questions, including residential postal code, and the NEWS-North. Participants were also given the option to complete a follow-up study three weeks later as part of test-retest reliability. The self-reported postal codes were linked to neighbourhood boundaries in Ottawa based on the definitions of the Ottawa Neighbourhood Study. Data analyses included a multilevel exploratory factor analyses (MEFA) to examine the validity of the internal structure as well as and internal consistency and test-retest reliability. Two additional analyses were performed to examine our pilot test sample for differences in perceptions on the NEWS-North as a function of season and participant. The MEFA was conducted on seven of the nine proposed NEWS-North subscales that had the same Likert scale.

Results: The final MEFA yielded an expected 7-factor structure with the shifting of some items compared to the original measure. The inclusion of a winter subscale was included with the majority of these items loading onto the proposed factor (i.e., the *winter walking* subscale). Interestingly, the MEFA yielded two factors rather than a single factor for *places for walking*

subscale. The test-retest reliabilities of the final scales (ICC = 0.85 to 0.93) as well as the internal consistency of the seven subscales were adequate (α = 0.53 to 0.75).

Conclusion: The factor structure proposed by the original model was supported by the present analyses with a few differences. In addition, the results also showed that the NEWS-North had high test-retest reliability. In the next stage, we will assess the convergent validity of the NEWS-North. In future research, the questionnaire should be adapted and then validated for francophones. The NEWS-North has the potential to be used within communities and municipalities to guide decisions on how to improve walking in neighbourhoods.

The Reliability and Internal Validity of the NEWS-North

Walking is the most common physical activity reported by adults (Lee & Moudon, 2004).Walking can be used for transportation, leisure, or exercise. Walking is a popular physical activity option due to its easy accessibility at any time, with no cost or equipment required (Morris & Hardman, 1997). Furthermore, walking is a self-regulated activity with little to no equipment or cost required to participate (Morris & Hardman, 1997).

The benefits of walking to maintain a healthy lifestyle have been well documented. Adults who walk regularly reported decreases in depression (Barton, Hine, & Pretty, 2009), decreases in stress (Roe & Aspinall, 2011), and improvements in positive affective states (Kinnafick & Thøgersen-Ntoumani, 2014). In a longitudinal study, adults aged 65 years or older who do not routinely walk are at a 30% increased risk of depression (Lee, Lan, & Lee, 2012). Walking has also been found to improve the physical health of adults. For example, middle to older aged adults who engaged in regular walking were less likely to develop cardiovascular disease (Boone-Heinonen et al., 2009). A recent systematic review found that regular walking can reduce seven chronic conditions such as stroke, osteoporosis, and cardiovascular disease (Warburton, Charlesworth, Ivey, Nettlefold, & Bredin, 2010). Walking can also reduce medical costs. For example, American adults aged 40 to 79 years who spent less than 60 minutes a day walking paid 13% more in medical costs than those adults who walked over 60 minutes (Tsuji et al., 2003).

Walking Habits of Canadians

According to the Canadian guidelines for physical activity, adults between the ages of 18 to 64 years should participate in at least 150 minutes of physical activity per week (Tremblay et al., 2011), yet only 15% of Canadians aged 6 to 79 years meet the suggested minimum physical activity (Colley et al., 2011). The increase in sedentary lifestyles may be partially due to the fact that most of us live in car dependent neighbourhoods, towns, and cities. Car dependency refers to the reliance of a vehicle due to distances to access to urban amenities and services (Newman & Kenworthy, 2006). People who lived in car-dependent neighbourhoods were less likely to be physically active each day than those in non-car dependent neighbourhoods (Frank, Saelens, Powell, & Chapman, 2007). In Ontario, adults aged 20 years or older in car-dependent neighbourhoods were at higher risk of obesity and being overweight (Chiu et al., 2015).

Defining Walkability

Broadly defined, walkability refers to the friendliness of a neighbourhood towards walking (Grant et al., 2010). Talen and Koschinsky (2013) describe a walkable neighbourhood as a 'safe, well serviced neighbourhood' where walking is comfortable and interesting (p. 47). They further state:

> A walkable neighbourhood has the following characteristics: it has an urban form that maximizes pedestrian activity and minimizes environmental degradation: it is associated with social, economic and land use diversity as opposed to homogeneity: it connects uses and functions: it has a high quality public realm that provides opportunities for interaction and exchange: it offers equitable access to goods, services and facilities and it protects human health (Talen & Koschinsky, 2013, p. 44).

For the purpose of this study, walkability is defined as built environment factors (Grant et al., 2010; Marshall et al., 2009) related to enabling pedestrian walking. This includes social factors such as aesthetics and safety from traffic, but also physical factors such as street connectivity. Our definition also includes the ability to walk without difficulty (Montemurro et al., 2011), which can include other physical factors such as sidewalks. Lastly, our definition of walkability also incorporates walking in the winter.

Characteristics of a Walkable Neighbourhood

A walkable neighbourhood is characterized by several components such as, but not limited to the following: (a) greater land-use diversity (e.g., a variety of stores and franchises), greater destinations, and greater number of intersections (Talen & Koschinsky, 2014a); (b) traffic control measures such as the reduction of automobile speeds and speed bumps (Montemurro et al., 2011); (c) better sidewalk maintenance such as walking surfaces with better snow removal or free of holes (Wang, Chau, Ng, & Leung, 2016), (d) greater green spaces such as more parks (Wang et al., 2016); and (e) a greater sense of community, such as interacting with neighbours (Wood, Frank, & Giles-Corti, 2010), and greater social capital, such as personal connections (Rogers, Halstead, Gardner, & Carlson, 2010) within a neighbourhood either objectively or subjectively measured.

Neighbourhood Walkability and Health

The relationship between neighbourhood walkability, health behaviour, and health has been studied extensively. In a cross-sectional study, adults aged 20 to 65 years of age who lived in high walkability neighbourhoods reported a higher rate of walking for transportation (Owen et al., 2007b). In Belgium, adults aged 20 to 65 years who lived in neighbourhoods with high walkability also reported more recreational walking (Van Dyck et al., 2011). Young Japanese men (mean age 22.5 years) who lived in high walkable neighbourhoods reported improvements in their overall mood and decreases in feelings of anxiety (Song et al., 2013). Moreover, in South Korea, adults aged 20 years or older who lived in highly walkable neighbourhoods for at least two years were less likely to be overweight, have diabetes, or report hypertension (Lee et al., 2015). Improvements to adults’ mental health have also been found. A study by Berke et al.

(2007) reported that neighbourhoods with higher walkability protected against depressive symptoms in men although not women aged 65 years or older who lived in Washington, DC.

In a longitudinal study in Portland, Oregon, adults aged 50 to 75 years at baseline who lived in low walkable neighbourhoods with a high level of fast food restaurants had increases in blood pressure over time compared to those adults living in highly walkable neighbourhoods with a high level of fast food restaurants (Li, Harmer, Cardinal, & Vongjaturapat, 2009). In another longitudinal study, an increase of 36 minutes per week in overall walking was reported in residents aged 16 to 94 years in the United Kingdom who lived in highly walkable neighbourhoods (Longo, Hutchinson, Hunter, Tully, & Kee, 2015). In addition, greater perceived neighbourhood walkability was associated with a lower likelihood of worsening depressive symptoms for adults aged 60 years or older from Los Angeles, California (Hernandez et al., 2015).

Neighbourhood Walkability and Health in Canada

Several articles have used the National Population Health Survey (NPHS) longitudinal dataset and have restricted analyses to Canadians aged 18 to 55 years. One study found that men who lived in high walkability neighbourhoods had the lowest decrease in body mass index over time (Wasfi, Dasgupta, Orpana, & Ross, 2016), and that men and women living in neighbourhoods with high walkability had the greatest increase in moderate utilitarian walking (Wasfi, Dasgupta, Eluru, & Ross, 2016). Canadians who moved to a highly walkable neighbourhood were 59% more likely to participate in moderate to high utilitarian walking (Wasfi, Dasgupta, Eluru, & Ross, 2015). Furthermore, Canadian men who moved to a low walkability neighbourhood had a higher body mass index (Wasfi, Dasgupta, Orpana, et al., 2016). Other studies have used the Canadian Community Health Survey (CCHS), a cross-sectional survey of Canadians aged 12 years or older. Canadians who lived in a high walkability neighbourhood reported the most walking activities (Thielman, Rosella, Copes, Lebenbaum, & Manson, 2015). Ontario adults 20 years or older who moved from a low to high walkability neighbourhood were at lower risk for incident hypertension (Chiu et al., 2016b). In another study, data from the CCHS-Healthy Aging (CCHS-HA), a cross-sectional survey across ten provinces, found that adults aged 45 years or older reported greater mobility in neighborhoods with greater walkability (Hirsch, Winters, Clarke, Ste-Marie, & McKay, 2017).

Other Canadian studies have examined walkability and health with new participant data as opposed to large preexisting datasets. For example, adults from Montreal, Quebec with diabetes mellitus type 2 who lived in the highest walkability neighbourhood walked more in their neighbourhood when compared to those in the lowest walkability neighbourhood (Hajna, Ross, Joseph, Harper, & Dasgupta, 2016). One study examined walkability in adults that relocated to a low walkability neighbourhood in Alberta and reported a 36.4% perceived decrease in their transportation walking (McCormack et al., 2017). Another study in Alberta also reported that more transport walking occurred in adults that lived in highly walkable neighbourhoods (Jack & McCormack, 2014).

Measuring Walkability

Neighbourhood walkability can be assessed objectively and/or subjectively measured. Objective measures include observational checklists or GIS databases on physical attributes of neighbourhoods (e.g., street connectivity, sidewalk conditions, pedestrian amenities, aesthetics) at a low cost (Lotfi & Koohsari, 2009). One important limitation of these measures is that to assess perceived attributes such as safety from crime and safety from traffic in a neighbourhood (Lovasi et al., 2013). Subjective walkability, however, questions respondents about various features of the built environment in their neighbourhood. One benefit of subjective walkability measures is that residents who live in that particular neighbourhood are assessing the neighbourhood as opposed to a third party.

The NEWS

A well-known perceived walkability questionnaire, the Neighbourhood Environment Walkability Scale (NEWS), was developed in the United States of America (Saelens, Sallis, Black, et al., 2003). Eight subscales comprise the NEWS: residential density (e.g., types of residences such as houses versus apartments), land use mix-diversity (e.g., variation in the types of stores, places, facilities, etc.), land use-access (e.g., the ease of going to various places, stores), street connectivity, facilities for pedestrians (e.g., sidewalks, trails, etc.), aesthetics, traffic safety, and crime from safety. These have been found to be associated with walking behaviours (Saelens, Sallis, Black, et al., 2003).

The validity of the NEWS has been well established. Adequate factorial validity (Cerin et al., 2009), construct validity (Cerin et al., 2006), and criterion validity (Saelens, Sallis, Black, et al., 2003) of the NEWS has reported. Recently, the NEWS has been validated using a Confirmatory Factor Analyses (CFA) with data from 12 countries that include Hong Kong, New Zealand, Brazil, and the Czech Republic; most studies have compared the NEWS scores to walking behaviour (Cerin et al., 2013). The NEWS is also related to physical activity. For example, individuals who live in neighbourhoods with high walkability reported 70 minutes more of physical activity compared to low walkability neighbourhoods (Saelens, Sallis, Black, et al., 2003). The reliability for the NEWS is also adequate. Test-retest reliability intraclass correlations (ICC) ranged from 0.58 to 0.80 across the eight subscales for the NEWS (Saelens, Sallis, Black, et al., 2003).

Limitations of the Current Literature

There have been several adaptations of the NEWS such as the abbreviated NEWS (NEWS-A; Cerin et al., 2006), the NEWS for Australia (Leslie et al., 2005), the NEWS for Chinese Seniors (Cerin et al., 2010), the NEWS for Africa (Oyeyemi et al., 2014), the NEWS for Poland (Jaskiewicz & Besta, 2016), the NEWS for India (Adlakha, Hipp, & Brownson, 2016), and the NEWS for Iran (Hakimian & Lak, 2016).

However, these adaptions of the NEWS have designed for use in locations with warm climates. The weather during different seasons can influence the amount of neighbourhood walking (Tucker & Gilliland, 2007). Second, to our knowledge, a perceived walkability questionnaire that incorporates seasonal variability does not currently exist. In northern climates, there is need for a walkability survey that incorporates winter walkability.

Objectives

The main goals of this thesis were to adapt the NEWS for use in Canada and other northern climates, and to examine the reliability and validity of the adapted measure, the NEWS-North. We followed the adaption steps outlined by the original authors of the NEWS (via personal email correspondence from April 2012 to March 2014). First, focus groups provided feedback on the NEWS and an expert panel verified the changes. Next, we conducted a large pilot test in Ottawa, Ontario to examine evidence for validity based on internal structure (i.e., factor analysis and internal consistency) as well as test-retest reliability. The third phase involved the examination of both the construct validity and convergent validity that also used the pilot study data. In this paper, we report on the Phase Two results. Specifically, this paper had three study objectives:

- The assessment of the factorial validity of the NEWS-North
- The assessment of the internal consistency of the NEWS-North factors (reliability)

- The examination of the test-retest reliability of the NEWS-North factors (reliability)

An additional objective was to examine and report any differences on the NEWS-North as a function of season and recruitment (i.e., resident versus student) from the pilot study.

Method

Participants

Ottawa participants were recruited from two sources: (a) students at the University of Ottawa who participated in the Integrated System of Participation in Research (**ISPR**), and (b) other Ottawa residents. All participants had to have lived at their current home address in Ottawa for more than one year in order to ensure their familiarly with their neighbourhood. Eligibility requirements included that participants: 1) be at least 18 years or older, were fluent in English, and 2) that only one person in their household completed the study.

The demographics of participants at both Time One (N = 434) and Time Two (N = 80 for test-retest reliability) can be found in Table 1. A map of participants' neighbourhoods can be found in Figure 1b (at Time One) and 1c (at Time Two). The total number of participants in each neighbourhood can be found in Table 2.

At Time One, a final sample of 434 participants (n = 224 students and n = 210 residents) participated in this study; a total of 65 neighbourhoods were represented. The majority of the participants were 18 to 24 years of age (50.5 %), completed high school (49%) or had completed an undergraduate degree (20.3%), had no children in their household (78.8%), reported no physical disabilities (97%), and were female (71.9%). Although the data collection occurred throughout the year, the largest participation occurred in the winter months (i.e., January to April; 47.9%) followed by the fall months (September to December; 35.3%) then summer months (May to August; 16.8%). Nearly one-third of participants reported living at their current address for 11 years or more (31.1%), followed by 30.9% between 1 to 3 years, 23.4% between 6 to 10 years, and 14.5% between 4 to 5 years. The most popular method of transportation to school for students was public transport (74.7%), followed by walking (13.5%), while other participants reported that their transportation for work consisted of either public transport (36.2%) or driving (31.8%). The time taken to complete the NEWS-North ranged from 9 minutes to 45 minutes (*M*= 14.96, *SD*= 6.33). The 434 participants came from 65 Ottawa neighbourhoods with residents in Orleans Avalon/Notting Gate (7.6%), Centretown (7.4%), and the Glebe/Dows Lake (4.0%) being the most common.

At Time Two, eighty participants (*n* = 59 residents; *n* = 21 students) who lived in 41 neighbourhoods completed the follow-up three weeks later. In terms of the highest level of education, some of the participants completed only high school (33.8%); others completed an undergraduate degree (28.7%), or a graduate degree (17.5%). The length of time at their current address varied from 11 years or more (21.3%), 6 to 10 years (32.5%), to 4 to 5 years (17.5%), and 1 to 3 years (28.7%). Public transport (37.7%), and walking (19.7%) were the most popular methods of transportation for work. The time taken to complete this follow-up ranged from 9 minutes to 33 minutes (*M*= 13.44 *SD*= 5.40). These 80 participants came from 41 neighbourhoods with participants from Centretown (10.0%), Lowertown (6.3%), Orleans Avalon/Fallingbrook (6.3%), and Elmvale/Riverview (5.0 %) being the most common. Similar results were found in Time One for age, physical disabilities, presence of children, gender, term participated, and method of transportation for school.

A total of 53 neighbourhoods were represented with the majority of participants from Centretown (12.4%) and Sandy Hill (11.6%). The majority of the participants were 18 to 24 years of age (44.2 %), completed high school (34.6%), had no children in their household

(72.3%), were without a physical disabilities (95.5%), did not own a dog (71.6%), and were female (74.4%). During data collection, the majority of participants that were excluded were from the winter term (58.3%) followed by the fall (28.2%). Public transportation was the most common method of transportation to school (71.9%) followed by walking (14.6%). Driving (35.7%) and public transportation (29.6%) were mostly commonly used transportation for work.

In total, 156 participants (*n*= 90 residents; *n* = 66 students) were excluded from analysis in this paper; 54 for living at their address for less than a year, and 102 multivariate data).

Material

Sociodemographic questionnaire. Nine items assessed demographic questions including the participant's method of transportation (e.g., work versus school, if applicable), age, gender, presence of children, physical disability, and highest education attained. Participants were also asked to provide their Ottawa six digit postal code.

Our adapted questionnaire. The NEWS-North is a 70-item self-report questionnaire adapted from the NEWS (Saelens, Sallis, Black, et al., 2003). The NEWS-North contains nine subscales assessing neighbourhood walkability: (A) land use mix-access (e.g., "generally, stores are within easy walking distance of my home"), (B) street connectivity (e.g., "there are walkways in my neighbourhood that connect dead ends to other streets or trails"), (C) walking facilities (e.g., "there are sidewalks on most of the streets in my neighbourhood"), (D) winter walking (e.g., "the sidewalks in my neighbourhood are cleared quickly after a winter storm"), (E) aesthetics (e.g., "there are trees along the streets in my neighbourhood"), (F) traffic safety (e.g., "many drivers exceed the posted speed limits while driving in my neighbourhood"), (G) crime safety (e.g., "my neighbourhood streets are well lit at night"), (H) residential density (e.g., "how common are detached single-family residences in your immediate neighbourhood"), and (I) land use mix-diversity (e.g., participants are asked to rate the approximate distance for each business or facility listed). In this paper, these subscales are denoted as *section A*, *section B*, *section C*, *section D*, *section E*, *section F*, *section G*, *section H*, and *section I* respectively (see Appendix A). Except for two subscales (*section H* and section *I*), the NEWS-North is rated on a 4-point scale ranging from 1 (*strongly disagree*) to 4 (*strongly agree*). In addition, a *not applicable* option was included for both *section C* (four items) and *section* D (four items). All items in *section I* and nine items in the remaining sections were reverse coded. Eight subscales were scored by taking the mean of the items with the exception of one subscale (*section H)* whose score was based on a weighted formula. A higher mean score for each section denotes higher walkability.

Data Source. This study used publically available walkability data from the Ottawa Neighbourhood Study (ONS), which was established in 2006 to in Ottawa to understand differences in health and the determinants of health across Ottawa neighbourhoods (Ottawa Neighbourhood Study, 2013). The ONS has become a popular resource for information on Ottawa's neighbourhoods. Full Ottawa neighbourhoods profiles and more information on the ONS study can be found on their website (www.neighbourhoodstudy.ca). At the time we conducted the pilot test survey, the ONS identified 103 urban neighbourhoods, including a greenbelt area (see Figure 1a), The ONS incorporated several methods of defining a neighbourhood boundary in Ottawa that included physical boundaries, real estate maps, and knowledge from both the community and the City of Ottawa (Ottawa Neighbourhood Study, 2013).

Procedure

The validity of the internal structure (i.e., factor analysis) and reliability (internal consistency and inter-rater reliability) of the NEWS-North was examined using data from the online pilot test of the NEWS-North in Ottawa, Canada. Permission was granted from the University of Ottawa Research and Ethics Board to conduct this study.

To be eligible for this study, participants had to be at least 18 years or older with internet access, fluent in English and have lived in an Ottawa neighbourhood for at least a year. Furthermore, only person per household could participate. Duplications in Internet Protocol (IP) addresses, last names, and contact information were checked to ensure that we had only one participant per household.

Participants were recruited in one of three seasons: winter (January 1 to April 31), summer (May 1 to August 31), or fall (September 1 to December 31). The beginning of recruitment coincided with the academic sessions at the University of Ottawa to maintain consistency of when the data was collected.

The recruitment for participants in the pilot study consisted of two methods. Students at the University of Ottawa were recruited through the online ISPR recruitment system. ISPR is an online research participation sample that consists of university students that are enrolled in introductory courses willing to participate in research to further their understanding of psychological research. The School of Psychology at the University of Ottawa operates ISPR. We used an ISPR online recruitment poster that described the study. Interested participants clicked on the external link to be directed to the study. Students who had completed the ISPR pre-screen questionnaire and met the eligibility requirements received an invitation email that contained the same external link to this study's webpage. Ottawa residents were recruited through newspaper advertisements and posters distributed around community centres, libraries, etc. and social media.

The recruitment material directed interested participants to external websites for students (*url 1*) and residents (*url 3*). The consent form explained the eligibility requirements and all other necessary information to ensure informed consent and briefly introduced the follow-up study option. Prior to the commencement of the study, participants had to click the “yes, I consent” option to continue. Participants who chose the “no, I do not consent” were immediately directed to the end of the study webpage and were thanked for their time. Participants were asked to complete a series of demographic questions, which included their postal code, and then were given the NEWS-North. Students received one point toward their ISPR account for their participation. All other Ottawa residents were offered a chance to win one of six prizes in a draw.

At the end of the initial study (Time One), participants were given details of a possible follow-up study (to assess test-retest reliability) and the option to take that study in the future (Time Two). Interested participants provided their contact information. For the completion of the follow-up study, students received an additional half point towards their ISPR grade, while residents were offered another ballot to win a prize in the draw. If residents declined to participate in the follow-up online study, participants were directed immediately to the draw entry page. If students declined, participants were directed to the end of the study and thanked for their participation.

Interested participants received an email with instructions approximately three weeks after the completion date of the initial study for test-retest reliability. Participants were directed to a separate follow-up webpage based on whether they were students (*url 2*) or residents (*url 4*). Participants were assigned a unique four-digit code. This code allowed for the data from the completed initial and follow-up survey to be linked. Participants were directed to the follow-up consent form where consent was obtained and the unique code was entered prior to the commencement of the follow-up questionnaire. Those participants with valid codes were directed to the NEWS-North questionnaire, while others without a code were redirected and thanked for their time.

After the data collection was completed, the researcher pulled six names out of a hat to determine the winners of the draw for residents. If a participant had been selected as a winner of a prize, they were contacted either by phone or e-mail.

The ONS holds a database that links postal codes to Ottawa neighbourhoods. The postal code provided by the participant was linked to the ONS neighbourhood postal code data file to identify which neighbourhood each participant lived in.

Data Analysis

Data screening. Participants' data were screened to ensure that they met all study criteria. Before data screening, 825 participants (residents n = 457; students n = 368) completed the initial online study. However, 83 participants were removed due to the fact that more than 50 percent of their responses were missing (residents n = 81; students n = 2), another 56 participants were lost because they had lived at their current address for less than a year (residents n = 44; students n = 12), 15 participants lived in Quebec, and six more participants were removed due to duplication (residents n = 4; students n = 2). To ensure quality responses within the data, participants whose survey completion time was eight minutes or less were also removed. This resulted in the removal of an additional 128 (residents n = 60; students n = 68) participants.

To assess test re-test reliability, the follow-up initially recruited 244 participants (residents n = 163; students n = 81) for this optional component. Thirty-eight of these participants were ineligible and removed due to over half missing data in the dataset (residents n = 2; students n = 36), two were duplicated entries (residents n = 2; students n = 0), and 106 were removed due to a response time of eight minutes or less (residents n = 88; students n = 18).

Data cleaning. Before formal analyses began on the NEWS-North, responses at both Time One and Time Two were examined for errors using descriptive statistics in Statistical Package for the Social Sciences (SPSS) 23®. Individual items were reverse recoded in *section A* (items 4 and 5), *section C* (item 2), *section D* (items 3, 5, and 7), *section F* (items 1, 2, and 5), and *section I* (all items) at both Time One and Time Two. Missing data were resolved in two ways. First, data missed by participants were coded as system missing. Second, items with the *not applicable* option were recoded into the lowest rated value of the Likert scale (i.e., strongly disagree) to reduce the elimination of participants from formal analysis. The number of missing cases across all items varied between zero to eight at Time One and zero to three at Time Two.

Univariate outliers at both Time One and Time Two were assessed using the absolute z-score limit of 3.29. However, univariate outliers were due to a small number of responses in a response category compared to a large number of responses that were distributed among the categories that remained. All initially identified outliers were kept for formal analysis.

Neighbourhood classification. The postal code provided by the participant was linked to the ONS neighbourhood postal code data file. Participants who completed the questionnaire but gave a partial Ottawa postal code of three digits were still included but their neighbourhood was coded as missing since a particular neighbourhood could not be accurately categorized.

The internal structure of the NEWS-North. The internal structure of the NEWS-North was examined using a multilevel exploratory factor analyses (MEFA) to assess the factorial validity of the NEWS-North.

MEFA. The goal of the MEFA was to determine whether the 42 items of the NEWS-North loaded onto their proposed seven subscales due to the exploratory nature of the NEWS-North in the preliminary testing stages. The MEFA used items only with the same Likert scale, thus *section H* (i.e., residential density) and *section I* (i.e., land use mix diversity) were omitted from further analyses. In this dissertation, we followed the adaptation protocol that had excluded those two subscales due to being different scales (Sallis et al., 2015). These exclusions have also been done in previous studies that excluded both subscales (Cerin et al., 2009; Starnes et al., 2014). In addition, the weighted scoring of *section H* combined with the 5-point Likert scale would have made the results difficult to analyze with such diversity of housing in Ottawa. The number of items in *section I* would have dominated the factor analysis along with this subscale being rated on a different 5-point Likert. .A previous Canadian study included a dichotomized *section H* into an EFA as a one item measure, although section I had also been excluded (McCormack et al., 2013). Due to the exploratory stage of the NEWS-North, a multilevel confirmatory factor analysis (MCFA) was not used. However, later development stages of the NEWS-North will include a MCFA.

To prepare the data for multilevel factor analysis in SPSS 23®, we first restructured the data using variables to cases. Next, we calculated average item scores for each neighbourhood. Then, the dataset was restructured back to its original form, saving the mean item scores for each neighbourhood. We then calculated the residuals for each item; these were based on the difference between each person's item score and the average item score for his/her neighbourhood. Note that participants who were missing scores on a particular item were removed in the process of data restructuring and calculating residuals.

Next, we checked assumptions of Exploratory Factor Analyses (EFA). The skewness and kurtosis of each item were below the critical values of one for skewness and two for kurtosis. Next, we assessed multivariate outliers using Mahalanobis Distance; these were calculated by regressing each residual item score on participant ID. Participants with Mahalanobis Distance above the critical value of 73.40 (40 df) were removed. We repeated this regression and removed additional outliers. In total, 102 people who had missing data or who were multivariate outliers were removed; the total final sample size was 536.

We conducted multivariate EFA in SPSS 23® using maximum likelihood extraction with direct oblimin rotation. The final sample size used in the MEFA was 434. Five, Six and seven factor solutions were compared.

We assessed factorability of the correlation matrix using the Kaiser-Meyer-Oklin (KMO) The KMO value was 0.79, which as well above the cut-off of 0.60 (Kaiser, 1974). Thus, we deemed that this correlation matrix was factorable.

All three models were compared on (a) eigenvalue values over 1 for each factor and the total variance explained, (b) the scree plot as a visual display of where the data points “bend” also known as the *elbow* that visually denotes the appropriate number of factors, (c) extracted communalities (i.e., the variance of each item), (d) the theoretical sense of loadings in pattern matrix, and (e) the residual matrix (this matrix should have no more than 20% of residuals of .05 or greater and no residuals over 0.100). We removed item E2 from the formal analyses due its poor loadings (less than .200) on any factor across the three factor models. The final analysis used 41 items from seven factors of the NEWS-North.

Reliability of the NEWS-North. To assess the reliability of the NEWS-North, both the internal consistency and test retest reliability was performed.

Internal consistency. Cronbach's alpha was calculated to measure the internal consistency of the NEWS-North's seven factors, and the analysis was performed using SPSS 23®. Values over 0.70 were considered acceptable (DeVellis, 2003). The total number of participants was 434.

Test- retest reliability. During the online testing, both Ottawa residents and university students were given the option to participate in a follow-up study three weeks later; data from these participants was used to assess test-retest reliability. The test-retest reliability was evaluated by correlating the NEWS-North subscale scores given by the same participants at two different instances in time using SPSS 23®. The mean score of each subscale was calculated from the items included in each specific subscale.

To assess test-retest reliability of each subscale, we assessed the consistency between the participant's rating at both the initial and follow-up as measured by the ICC. We used a two-way random model. The option of *absolute agreement* was selected to examine the agreement. An additional option, an ANOVA (F test), was used to examine whether there was a difference between the initial and follow-up responses. ICC values were classified as poor if they were lower than 0.50, moderate for values between 0.50 to 0.75, and high for values greater than 0.75 (Portney & Watkins, 2009). The ICC analysis was conducted on each of the seven factors. Eighty participants were included in this analysis.

Further Analyses. Three further analyses were performed: a descriptive analysis to summarize the participant demographics, an analysis of variance (ANOVA) to assess the relationship between scores on the NEWS-North subscales and season, and a t-test to compare responses from students and Ottawa residents.

Sample characteristics. Descriptive statistics were used to examine the characteristics of the sample at Time One and Time Two.

ANOVA. A one-way between-group ANOVA was conducted to examine whether there were differences in scores on the seven subscales of the NEWS-North by season (i.e., all three data collection periods).

In the ANOVA analysis, selected options included descriptive statistics, Levene's test for homogeneity, and the Tukey Honest Significant Difference (HSD) Post Hoc test with a significance of .05. The total number of participants in each of the seven sections of the NEWS-North was 434. This analysis was performed using SPSS 23®. Eta squared was used to calculate effect size in a statistically significant ANOVA result and then converted to Cohen's *d*. The magnitude of effect size was classified as .01 for small, .06 for moderate, and .14 for a large effect (Cohen, 1988).

Independent sample t-test. An independent two-sided t-test in SPSS 23® was used to determine whether there were any significant differences in perceptions between Ottawa residents and to university students in the seven subscales of the NEWS-North. In this test, the independent variable (i.e., mean score of each the seven NEWS-North section) and dependent variable (i.e., participant classification) were used. Levene's test of equal variances was used to test the assumption of equal variances. The confidence interval (CI) used in this test was 95%. The total number of participants in each section examined was 434. Eta squared was calculated as the effect size for statistically significant independent sample t-test results. Eta squared was then coverted to Cohen's *d*. Effect sizes were classified as .01 for small, .06 for moderate, and .14 for a large effect (Cohen, 1988).

Results

The Internal Structure of the NEWS-North

MEFA. The correlation matrix was amenable to a factor analysis, as judged by a KMO value of 0.79, which is well above the 0.60 (Kaiser, 1974) recommend value. In addition, the significance of the Bartlett's Test of Sphericity (χ^2 [820] = 4591.99, $p < .001$) also verified the use of a MEFA.

We first conducted an EFA with no constraints but the number of factors suggested was too large. Next, we limited the factors and compared the eigenvalues. A 5- and 6- factor analyses was performed to determine if there was an improvement in the fit. An 8-factor was also conducted but the fit worsened (results not shown).

As mentioned previously, we tested a 5-factor, 6-factor, and 7-factor solution. The MEFA first began with a 7-factor model solution to represent the seven proposed subscales of the NEWS-North. We found that 34 factors had an eigenvalue greater than one. However, factors 10 through 34 explained less than three percent of the variance. An inspection of the Scree plot revealed a bend in the data around the 5-factor solution (see Figure 2).

The 7-factor solution explained 44.60% of the total variance. Twelve percent of the residuals had a value of .05 or greater, which meets the requirement of no more than 20% of residuals of .05 or greater in each item. We found three residual correlations that were greater than 0.10. Upon inspection of the pattern matrix, all factors had at least three items with loadings greater than 0.30. Although not all items loaded on their predetermined subscales, the solution made theoretical sense.

Next, a 6-factor solution was examined. The total variance explained in the model was 41.19%. There were five items with residuals greater than .10. Sixteen percent of the residuals had values greater or equal to .05, which is below the 20% cut-off. However, inspection of the pattern matrix revealed that factor loadings for items that belonged to *section C* were scattered across five factors and did not fit well with the other high loading items within those factors.

Finally, a 5-factor solution was examined to determine whether the 41 items would be better explained by reducing the number of factors despite each factor with an eigenvalue over 1. However, the 5-factor solution only explained 37.31% of the total variance. Moreover, there were 10 residuals greater than 0.10 and 21% percent of residuals were greater than .05. Finally, some item loadings for the 5-factors were low.

Upon careful consideration, we selected the 7-factor model because it explained more variance, had lower residual correlations, and the solution made sense. Of the 41 items, two items (A4 and B1) did not load highly onto any factor and were removed from further analyses. Table 3 depicts the factors and the highest item loading for each factor.

In this paper, Factor 1 will be referred to as *safety from traffic* (6 items: F1, F2, F3, F5, F6, A5); Factor 2 will be referred to as *aesthetics* (5 items: E1, E3, E4, E5, & E6); Factor 3 will be referred to as *land use-access* (5 items: A1, A2, A3, B2, B3); Factor 4 will be referred to as *winter walking* (7 items: D1, D2, D3, D4, D5, D7, D8); Factor 5 will be referred to as *safety from crime* (4 items: G1, G2, G4, G5); Factor 6 will be referred to as *sidewalks* (6 items: C1, C3, C5, C6, F4, G3); and Factor 7 will be referred to as *pedestrian/bike comfort* (6 items: C2, C4, C7, C7, C9, D6) when presenting the remaining results from the analyses. The proposed NEWS-North from the MEFA can be found in Appendix A.

Reliability

Internal consistency. Cronbach's alpha was calculated for each factor. We found that the safety from traffic (α = .75), land use-access (α = .75), and *aesthetics* subscale (α = .74) had the highest internal consistency, while the *sidewalk* subscale had the lowest (α = .53). The remaining subscales showed adequate reliabilities: *winter walking* (α = .65), *safety from crime* (α = .65), and *pedestrian/bike comfort* (α = .60).

Test- retest reliability. We found high test-retest reliability for six of the seven subscales. Furthermore, we found that each person's score on those six subscales were not significantly different between Time One and Time Two. High reliabilities were found for *safety from traffic* (ICC= .93, 95% CI .89, .95), *pedestrian/bike comfort* (ICC= .93, 95% CI .88, .95), *land use-access* (ICC= .90, 95% CI .84, .94), *sidewalk* (ICC= .88, 95% CI .81, .92), *winter walking* (ICC= .87, 95% CI .80, .92), and *aesthetics* subscale (ICC= .88, 95% CI .82, .93).

However, despite a high degree of reliability, there was a significant difference reported between the initial completion and the follow-up in *safety from crime* (ICC= .85, 95% CI .77, .90; F [1, 79] = 3.98, p = 0.05).

Further Analyses

ANOVA. A one-way between-groups ANOVA categorized participants into three groups according to the season in which the NEWS-North was completed (Group 1: summer months between May to August; Group 2: fall months between September to December; Group 3: winter months of January to April). Levene's Test for homogeneity was not violated. When the ANOVA was significant, the Tukey HSD post hoc test was used to determine which groups differed and to calculate their effect sizes. Results from the ANOVA can be found in Table 4.

There was a significant difference across seasons for the *traffic safety* subscale (F [2, 433]= 25.53, $p < .001$) and *sidewalks* subscale (F [2, 433]= 5.85, $p = .003$). However, the mean differences between groups were quite small.

Group differences on the *traffic safety* subscale had a large overall effect ($d = .70$), although the mean differences between groups were quite small. The mean score for the winter ($M = 15.23$, $SD = 3.58$) was significantly different from scores in both the summer (M =16.52, $SD = 4.01$) and the fall ($M = 17.89$, $SD = 3.10$). However, scores in the summer months were not significantly different from those in the fall months. For the *sidewalks* subscale, the overall effect was large ($d = .35$) for the fall ($M = 17.80$, $SD = 3.50$) was significantly different from the winter ($M = 16.67$, $SD = 3.06$) but the mean differences between groups were quite small. There were no significant differences ($p > .05$) for season in the remaining five subscales.

T-test. Two-sided independent sample t-tests examined whether residents and students differed in their perceptions of neighbourhood walkability for each of the seven factors of the NEWS-North. Equal variances were assumed unless otherwise noted.

We found that both the *traffic safety and sidewalks* subscales violated Levene's Test for homogeneity. Thus, equal variances were not assumed. We also found statistically significant differences between residents and students on the *traffic safety* (t [432]= 9.98, $p < .001$) and *sidewalks* (t [432]= 5.31, $p < .001$) subscales, but the mean differences between groups were again quite small.

In the *traffic safety* subscale, scores for students ($M = 17.93$, $SD = 2.99$) suggested they perceived slightly more safety from traffic than residents ($M = 14.73$ $SD = 3.64$). However, the magnitude of difference between the means (M_{diff}= 3.20, 95% CI 2.57, 3.84) was small despite a large effect ($d = .96$). However, in the *sidewalks* subscale, students ($M = 18.00$, $SD = 3.26$)

perceived slightly better sidewalk attributes than residents (*M* = 16.39, *SD* = 3.08). However, the magnitude of difference between the means (M_{diff}= 1.61, 95% CI 1.02, 2.22) was small despite a large effect size (*d* = .49).

Two marginally significant differences were also found for both the *winter walking* (*t* [432] = 1.93, *p* = .054) and *crime safety* (*t* [432] = -1.75, *p* = .081) subscales, although the mean differences between the groups was small despite a large effect size (*d* = .22). Students (*M* = 15.91, *SD* = 3.55) perceived better walking conditions in the winter compared to residents (*M* = 15.23, *SD* = 3.80). However, residents (*M* = 12.64, *SD* = 2.08) perceived higher safety from crime compared to students (*M* = 12.29, *SD* = 2.18).

Discussion

To our knowledge, this is the first time that a perceived walkability questionnaire was developed for use in northern climates. The overall goal of this study was to examine the reliability and validity of the NEWS-North after pilot testing in a truly multi-seasonal location such as Ottawa, Canada. The goal of this paper was to examine the NEWS-North on (a) validity based on its internal structure (i.e., factorial validity); and (b) the reliability of each factor/subscale (i.e., internal consistency and test-retest reliability). In addition, we also examined differences as a function of season and recruitment (i.e., resident versus student) to aid in the interpretation of our findings. Important results from each objective in this study that are further discussed below.

Objective 1: Internal structure validity assessed using factorial validity

The factorial structure of the NEWS-North was examined using a MEFA to account for the fact that people were clustered into neighbourhoods.

In this paper, a 7-factor model had the best fit for the NEWS-North. The NEWS-North differed in several ways from other adaptations of the NEWS. First, we incorporated a *winter walking* subscale to assess winter walkability. Seven of eight items on *section D* loaded together on the *winter walking* subscale. This is an important addition as previous literature has shown that weather (Trost et al., 2002) and cold temperatures (Juvani et al., 2005) have affected walking.

Second, the MEFA of the NEWS-North divided *section C* into two unique subscales: *sidewalks* and *pedestrian/bike comfort*. For the *sidewalks* subscale, four of the items from *section C* specifically dealt with sidewalks (e.g., on most streets, well maintained, separates from the road, free from obstacles). The importance of sidewalks to neighbourhood walkability has been found. For example, pedestrians often use sidewalks for walking regardless of the type of walking, such as transport or recreation (Pikora et al., 2006). The addition of item F4 ("the pedestrian signals in my neighbourhood give me enough time to walk across the street") in this subsection is relevant because pedestrian crossings are not found when there are no sidewalks. The relationship of item G3 ("I often see and speak to other people when I am walking in my neighbourhood") to this section may have been due to the fact that sidewalks often facilitate interactions.

For the *pedestrian/bike comfort* subscale, the remaining five items of s*ection* C grouped together along with an additional item from *section D*. Item C9 ("I feel safe walking on most streets in my neighbourhood that don't have sidewalks") and D6 ("most streets WITHOUT sidewalks in my neighbourhood are safe to walk on in the winter") had very similar loadings. It is not surprising that both items loaded onto the *pedestrian/bike comfort* subscale. Pedestrian trails have been shown to promote walking (Huston et al., 2003). It is possible that participants often used bike trails and pedestrian trails for walking. In Ottawa, the bike trail by the Rideau Canal is often shared between walkers and cyclists.

Third, we combined *section A* and *section B* from the NEWS-North to form the *land-use access* subscale. These five items are all relevant to the residential density of the neighbourhood in which the respondent lives. Items B2 ("The distance between intersections in my neighbourhood is usually short") and B3 ("there are many alternative routes for getting from place to place in my neighbourhood") refer to a high level of street connectivity which strongly corresponds to urban environments. Items A1 ("generally, stores are within easy walking distance of my home"), A2 ("there are many places to go within easy walking distance of my home"), and A3 ("it is easy to walk to a transit stop from my home") are also common features in dense urban environments.

Although the item A4 ("streets in my neighbourhood are hilly, making my neighbourhood difficult to walk in") was removed due to the lack of hills in Ottawa, it could be used as a single item especially for neighbourhoods that have a variety of hills. Hills are an important limiting factor of walking due to the increased risk for fatigue and/or injury (Ainslie et al., 2003). In addition item B1 ("there are walkways in my neighbourhood that connect dead-ends to other streets or trails") was also removed. Approximately 70.7% of participants agreed that dead-ends streets were connected by walkways. This is common in many Canadian cities (Lucy & Phillips, 2006) and therefore may not be a useful item in assessing walkability.

Objective 2: Reliability assessed using internal consistency

At Time One, Cronbach's alpha for the seven factors of the NEWS-North ranged from 0.60 (*pedestrian/bike comfort* subscale) to .75 (both *safety from traffic and land use-access* subscales). Others have also reported good Cronbach's alpha values for other adaptations of the

NEWS that have ranged from 0.64 to 0.86 based on eight subscales (Oyeyemi et al., 2013). Overall, the internal consistency results indicated acceptable internal consistency for the NEWS-North as most subscales had Cronbach's alpha values over 0.70 (DeVellis, 2003).

In the NEWS-North, the *sidewalk* subscale had the lowest (α = .53) internal consistency. The removal of item G3 ("I often see and speak to other people when I am walking in my neighbourhood") would have increased the internal consistency to .64. It is possible that the low alpha may be due to the mix of both students and residents, where students could be less likely to talk to people (i.e., headphones). Item G3 was retained because it loaded the highest onto the *sidewalk* subscale & our walkability experts (Study One) confirmed its importance in the measure.

Objective 3: Reliability assessed using test-retest reliability

The test-retest reliabilities of the seven subscales of the NEWS-North were high (ICC= .88 to .93). Previous research with the original NEWS has shown similar moderate to high reliability from 0.58 to 0.80 (Saelens, Sallis, Black, et al., 2003). ICC values were also similar to those of other adaptions of the NEWS. These included 0.52 to 0.77 on the NEWS-Australia (Cerin et al., 2010), 0.59 to 0.91 on the NEWS-Africa (Oyeyemi et al., 2013), and on the NEWS-India 0.85 to 0.98 (Adlakha et al., 2016).

In this paper, we found that six of the seven factors in the NEWS-North had high ICC values that ranged from 0.88 (*aesthetics* subscale) to 0.93 (*safety from traffic* subscale) and no differences between Time One and Time Two. However, although the *safety from crime* subscale had an ICC of 0.85, differences between Time One and Time Two were significant.

Objective 4: Further analyses

Season. There was a difference between walkability perceptions as a function of season that the participant completed the NEWS-North (i.e., winter: January 1 to April 31, summer: May 1 to August 31, or fall: September 1 to December 31) for both the *traffic safety* subscale and *sidewalks* subscale. However, the actual mean difference between seasons was small.

Participants who completed the NEWS-North in the winter rated the *traffic safety* more poorly than those who completed the survey in the summer and fall seasons. The seasonal effect of higher perceived safety in the fall versus winter in this paper is consistent with previous research. One study reported that during daylight savings time (March to November), fewer pedestrian-related fatal crashes occurred when compared to standard time (Ferguson, Preusser, Lund, Zador, & Ulmer, 1995). There are several possible reasons for this result. First, it is possible that the fewer pedestrian-related fatalities is a result of the increased visibility for drivers from daylight during the most active times of the day for vehicular traffic. Secondly, the reduced daylight during typical driving times may add to the fatigue and alertness of drivers. Thirdly, the likelihood of difficult road and driving conditions may be higher during the winter months, leading to increased risk of pedestrian-related fatalities. In the case of Ottawa, the streets and sidewalks are clear of snow and snow banks during the summer months thus making it easier for participants to cross roads and provide better visibility of road sign and pedestrians for drivers.

Those who participated in the fall rated the *sidewalks* subscale more favourably than those that completed the NEWS-North in the winter. This is not surprising, as several studies have reported that frigid temperatures and slippery walking surfaces often limit the amount of walking (Li et al., 2012; Ripat et al., 2010; Spinney & Millward, 2011). Our finding is consistent with research that reported that greater walking occurs during the warmer months as opposed to the winter (Shephard & Aoyagi, 2009; Yang et al., 2011).

Recruitment. We found two statistically significant differences and two marginally significant differences between residents and students.

We found statistically significant differences between residents and students on two scales although the mean difference was small. In the *traffic safety* subscale, students perceived slightly more safety from traffic than residents. It is possible that students perceived higher neighbourhood traffic safety than residents because they may be more likely to neglect the use of specified pedestrian traffic crossings and simply cross streets when convenient. Another possibility is that a large number of students who participated may live near campus or public transport stations reducing the number of busy streets to cross, as opposed to residents who may have a longer commute.

In the *sidewalks* subscale, students perceived slightly better sidewalk attributes than residents. It is possible that students attending the University of Ottawa live in neighbourhoods that are more centrally located downtown where walkability is often higher including more pedestrian signals and better sidewalk maintenance. Another possibility is that students may also be less affected by sidewalk obstacles (e.g., garbage bins), as they may carry limited personal items to and from classes, or that fewer students have the need to grocery shop as often as non-student residents if their parents do such tasks or they make more use of the food options at their university.

Two marginally significant differences with large effects but small mean differences were also found for both the *winter walking* and *crime safety* subscales. In terms of the *winter walking* subscale, students perceived better walking conditions in the winter compared to residents. It is possible that students' higher perceptions of winter walking conditions may be due to their timetable for courses, and to the fact that most courses have start times later than 10: 00 a.m. On the other hand, working residents leave for work in the early morning hours around the same time city crews start to clear snow. It is possible that after 10 o'clock, crews will have had time to clear snow, sprinkle salt on walkways.

In terms of the *crime safety* subscale, residents perceived higher safety from crime than students. It is possible that the inclusion of an artificial light item (G1: "my neighbourhood streets are well lit at night") may contribute to the marginal significance between participants. A frequency analysis showed that both students and residents perceived their neighbourhood as well-lit and generally safe for walking. It is possible that students may perceive artificial light differently than other residents. For example, students may have felt that although their neighbourhood was well lit, it may have attracted unwanted attention to things that they carry (e.g., laptop bags). In addition, it is also possible that street lamps introduce shadows, which reduce the ability to see detail from the difference in contrast between a lit area (e.g., on the sidewalk) and shaded areas (e.g., figures around bushes away from the luminescence) at night. Furthermore, students may live in neighbourhoods that are more likely to be unsafe. In contrast, students rated item G2 ("walkers and cyclists on the streets in my neighbourhood can be easily seen by people in their homes") higher than residents. This could be due to the fact that students move around the neighbourhood more frequently or to the type of housing that students tend to live in.

Strengths

There were several strengths in this study. First, to our knowledge this is the first perceived walkability questionnaire to include winter walkability. The NEWS-North incorporates questions that assess walkability in all four seasons (Takacs & Kristjansson, 2017).

Second, participants of all levels of physical activity were recruited to participate since it offered a unique perspective and helped to ensure that we encompassed aspects of walkability that everyone encounters. Good neighbourhood walkability has been shown to have a positive impact on residents that are healthy (Boone-Heinonen et al., 2009) or chronically ill (Hajna, Ross, et al., 2016).

Third, we recruited participants from 103 neighbourhoods. Of those 103 neighbourhoods, people from 65 neighbourhoods participated in this study, whereas previous research has included a much smaller number of neighbourhoods. For example, eight highly walkable neighbourhoods and eight poorly walkable neighbourhoods were recruited for the NEWS for Australia (Cerin, Leslie, Owen, & Bauman, 2008).

Fourth, we used a multilevel factor analysis, which accounts for the variance in the dependent variable from nested data (Steenbergen & Jones, 2002). Moreover, this ecological approach in physical activity research of residents in neighbourhoods is encouraged to better understand the complexities of maintaining health (Sallis & Owen, 2002).

Fifth, Ottawa's weather has four distinct seasons, like many cities in North America. To accurately assess the NEWS-North for the season variability, our perceived questionnaire collected data for an entire year to examine the role of season on perceived neighbourhood walkability.

Sixth, our sample included a range of participants, including those who were attending school, working, parenthood, etc. It was important to pilot test the NEWS-North with a diverse sample in order to obtain an eclectic perspective on walkability.

Seventh, our study only included participants who had been at the same address for longer than a year. Many participants at Time One had lived at the same address for an extended period of time (i.e., 31.1% for 11 or more years, 30.9% for 1 to 3 years). A benefit of these durations is that each participant is an expert in conditions in their neighbourhood. Research has shown that moving to a neighbourhood with different level of neighbourhood walkability can increase over time (Wasfi et al., 2015) or decrease over time (Wasfi, Dasgupta, Orpana, et al., 2016) a resident's health.

Limitations

This study was not without its limitations. First, this study was only conducted in English. We excluded participants who identified as not fluent in English. This may have limited perspectives in walkability due to cultural differences.

Second, using social media as a form of recruitment may have also limited the sample. It may have resulted in the inclusion of residents with strong opinions and those who were comfortable with Twitter and the exclusion of those who did not use social media.

Third, there were more participants who were residents of neighbourhoods located within Ottawa's greenbelt than outside it. Those participants living in rural or suburban Ottawa may have very different neighbourhood walkability, and the NEWS-North may have not fully captured their walkability challenges or barriers.

Fourth, the definition used to categorize neighbourhoods was based on the ONS. It is possible that the residents' definitions of neighbourhood may have differed especially those that were close to the boundary of another neighbourhood.

Fifth, this paper did not assess the NEWS-North using a MCFA, but a MEFA was used because this is the first time that the internal validity of the NEWS-North has been assessed. The benefit of a MCFA for a new measure is to confirm whether the proposed items belong on the intended subscale. As this paper used an exploratory approach, the results must be interpreted with caution until a time where further analyses can confirm the NEWS-North subscales.

Sixth, the NEWS-North was unable to validate both the *land use mix diversity* and *residential density* subscales in the present paper. Thus, the entire eight subscales of the NEWS-North was not fully examined.

Lastly, a number of outliers were removed that may have decreased the power of our results. It is possible that other statistical options may have been implemented to retain a larger sample size (e.g., Windsorize outliers).

Future Research on the NEWS-North

We recommend the development of a French version of the NEWS-North. Furthermore, in recruiting participants, we suggest that researchers use more print recruitment advertisements/ announcement in newspapers, and connect more with suburban community centers to help distribute the call for recruitment. It may also be useful to remove participants who are located along the neighbourhood border. It is possible that their perceptions would often include perceptions on the adjacent neighbourhood too. Differences in perceptions of walkability within versus across neighbourhoods have been reported (Cerin et al., 2006).

In addition, validating the *land use mix diversity* subscale on the NEWS-North in the future is recommend. There are several ways of validating this subscale in the future, for example, using GIS data obtained from the postal codes provided by participants of their neighbourhood. One option would be to average the 'center' of each neighbourhood to calculate the distance (plus the average duration to walk within that neighbourhood) to walk to various shopping stores. Another option would be to identify high versus low walkable neighbourhoods that participated and aggregate their scores on this domain where high domain scores would coincide with highly walkable neighbourhoods. Examining the 'land use mix diversity' is important to use in future research as this domain has the ability for change as amenities are easy walking distance one may walk more, Moreover, greater diversity of amenities (objective measured) have been linked to greater walking (Glazier et al., 2014). Similarly, *residential density* subscale could be validated using a similar GIS method.

In regard to seasonal differences, future researchers may want to try to have more of an even participant distribution as our largest sample was in the winter (our study at Time One had Summer n = 73, Fall n =153, and Winter n = 208). It may be useful to recruit a larger group of long-term residents and re-test the NEWS-North. Residents will be more directly affected by political budgets improving walkability to their neighbourhood compared to students. Students will likely be moving to a neighbourhood of their own once their schooling is complete. The goal of obtaining data from long term permanent residents and those that chose the neighbourhood would be more meaningful as they are invested to that neighbourhood.

Conclusion

This study found that the NEWS-North had acceptable internal structure (i.e., factorial validity) and reliability (i.e., internal consistency and test-retest reliability). The next step is to assess convergent validity of the NEWS-North. The results of this study are important as the NEWS-North has promising reliability and validity. The NEWS-North is not only accessible for researchers to examine neighbourhoods and walkability in northern climates, but also at the municipal level for city policy and planning. The NEWS-North could be used to identify sections of the city that either promote walkability or hinder walkability in a given neighbourhood especially in the winter by identifying neighbourhood sidewalks that need additional snow removal. This data in turn could be used to set aside a budget to help neighbourhoods become more walkable by improving or installing sidewalks.

Table 1

*Sample Characteristics of Participants of the NEWS-North study at Time One and Time Two**

	Time One[a]	Time Two[b]
Variable	*n*	*n*
Participant		
Student	224	21
Resident	210	59
Term		
Summer	73	11
Fall	153	17
Winter	208	52
Gender		
Female	312	52
Male	121	28
Other	1	--
Age (years)		
18-24	219	19
25-30	66	13
31-40	68	17
41-50	40	14
51-60	23	10
61-70	15	6
71-80	2	1
81+	1	--
Highest Education		
Did not complete high school	3	1
Completed high school	212	27
College diploma or trades certificate	43	10
Undergraduate degree	88	23
Graduate degree	75	14
Professional degree (e.g., M.D.)	12	5
Children		
None	342	58
1	34	6
2	35	7
3	18	6
4	5	3
Time at Current Address		
1 to 3 years	134	23
4 to 5 years	63	14
6 to 10 years	102	26
11+ years	135	17

Variable	Time One[a] *n*	Time Two[b] *n*
Transport for School		
Not Applicable	149	43
Walk	38	4
Bike	7	3
Public transport	210	25
Drive	17	2
Other	9	1
Drive & public transport	7	--
Drive & walk	2	1
Transport for Work		
Not Applicable	93	18
Walk	61	12
Bike	34	11
Public transport	123	23
Drive	108	11
Other	14	4
Bike & public transport	4	--
Bike & drive	4	2
Bike & walk	3	2
Drive & walk	1	--
Public transport & walk	1	--
Public transport & drive	1	--
Physical Disabilities		
No	418	76
Yes	13	4

Note. *based on completed answers from participants
[a] At Time One, $N = 434$
[b] At Time Two, $N = 80$

Table 2

Neighbourhoods of Participants in the Pilot Study in Ottawa, Canada

Neighbourhood	Time One *n*	Time Two *n*
Orleans Avalon – Notting Gate –Fallingbrook – Gardenway South	32	5
Centretown	31	8
Glebe –Dows Lake	17	2
Sandy Hill	16	--
Stonebridge – Halfmoon Bay – Heart's Desire	14	1
Elmvale – Eastway – Riverview – Riverview Park West	13	4
Lowertown	12	5
Orleans North West	12	2
Hintonburg – Mechanicsville	11	3
West Centertown	11	2
Hunt Club Park	10	1
Old Ottawa South	10	2
Kanata Lakes –... – Kanata North Business Park	8	1
Vanier North	8	3
Westboro	8	--
Barrhaven	7	1
Bayshore – Belltown	7	3
Bridlewood – Emerald Meadows	7	2
Greenboro East	7	2
Ledbury – Heron Gate – Ridgemont	7	1
Orleans Village – Chateauneuf	7	2
Riverside South – Leitrim	7	2
Rothwell Heights – Beacon Hill North	7	--
Whitehaven – Queensway Terrace North	7	2
Billings Bridge – Alta Vista	6	--
Braemar Park – Bel Air Heights – Copeland Park	6	--
Byward Market	6	2
Overbrook – McArthur	6	1
Carlington	5	--
Chapman Mills – Rideau Crest – Davidson Heights	5	--
Cityview – Crestview – Meadowlands	5	--
Hunt Club East – Western Community	5	1

Neighbourhood	Time One n	Time Two n
Hunt Club Woods – Quintarra – Revelstoke	5	--
Iris	5	1
Stittsville	5	1
Chatelaine Village	4	1
Cummings	4	1
Hawthorne Meadows – Sheffield Glen	4	1
Playfair Park – Lynda Park – Guildwood Estates	4	1
Queenswood Heights	4	1
Tanglewood	4	2
Vanier South	4	1
Wateridge Village	4	2
Beacon Hill South – Cardinal Heights	3	--
Carleton Heights – Rideauview	3	--
Chapel Hill North	3	--
Chapel Hill South	3	--
Emerald Woods – Sawmill Creek	3	2
Glen Cairn – Kanata South Business Park	3	
Laurentian	3	1
Lindenlea – New Edinburgh	3	2
Old Ottawa East	3	--
Qualicum – Redwood Park	3	1
Riverside Park	3	2
Woodroffe – Lincoln Heights	3	--
Woodvale – Craig Henry – Manordale – Estates of Arlington Woods	3	--
Blackburn Hamlet	2	--
Centrepointe	2	1
Civic Hospital – Central Park	2	--
Hunt Club Upper – Blossom Park – Timbermill	2	--
Rockcliffe Park	2	--
Skyline – Fisher Heights	2	--
Bells Corners East	1	--
Carlingwood West – Glabar Park – McKellar Heights	1	1
Wellington Village	1	--

Note. At Time One, 18 participants did not provide full postal codes ($N = 421$). At Time Two, all participants had provided full postal codes ($N = 80$).

Table 3

Factor Loadings of the Final 7-Factor Solution of the NEWS-North

	Factor						
Abbreviated Item	1	2	3	4	5	6	7
A1. Stores are within easy walking distance.	-.05	.07	**.80**	.08	-.08	.11	-.02
A2. There are many places.	.02	-.04	**.82**	.08	.02	.11	-.13
A3. It is easy to walk to a transit stop.	-.13	-.06	**.33**	-.08	-.09	-.04	.06
B2. Distance between intersections is short.	.04	.03	**.28**	-.06	.02	-.05	-.01
B3. Alternative routes.	.08	-.16	**.43**	.04	-.01	-.06	.06
C1. There are sidewalks on most of the streets.	.09	.09	.21	-.11	-.03	**-.48**	.01
C2. Sidewalks sometimes end.	.17	-.02	.01	-.02	.10	.10	**.25**
C3. The sidewalks are well maintained.	.06	-.06	.09	-.18	-.09	**-.58**	.04
C4. Pedestrian trails are easy to walk to.	-.04	-.12	.07	-.07	.02	-.14	**.35**
C5. A strip that separates the road.	.03	.01	-.02	-.10	.02	**-.32**	-.04
C6. The sidewalks are free from obstacles.	.22	-.03	.05	-.07	-.08	**-.31**	.08
C7. There are benches to rest.	.03	-.18	.05	-.11	.08	-.18	**.23**
C8. There are bicycle trails that are easy to bike to.	-.12	-.33	-.08	-.11	.06	-.11	**.40**
C9. Safe walking on streets without sidewalks.	.27	-.01	.01	.13	-.28	.09	**.52**
D1. The sidewalks are cleared quickly.	.01	.03	-.05	**-.57**	-.14	-.27	-.01
D2. Pedestrian trails are cleared quickly.	.01	-.01	.09	**-.74**	-.03	-.07	-.15
D3. The sidewalks are often slippery in the winter.	.18	.02	-.10	**-.42**	-.06	.31	.11
D4. There are places to get out of the wind.	-.06	.02	.42	**-.26**	.07	-.11	.07
D5. Snow banks and pedestrians.	.24	.26	.08	**-.26**	-.13	-.13	.06
D6. Streets WITHOUT sidewalks are safe.	.08	.24	.06	-.04	-.23	.12	**.50**
D7. Snow from driveways/road on sidewalks.	.23	-.04	-.04	**-.24**	-.06	.22	-.01
D8. Bicycle trails are cleared after a winter storm.	-.08	-.02	.06	**-.50**	.03	-.09	.04
E1. There are trees along the streets.	.09	**-.40**	.11	.04	.03	-.05	-.02
E3. Interesting things to look at while walking.	-.03	**-.57**	.19	-.06	-.03	.15	.06
E4. My neighbourhood is generally clean.	.25	**-.47**	-.14	-.01	-.19	-.13	-.03
E5. There are many attractive natural sights.	-.02	**-.74**	-.01	-.03	-.10	.11	.09
E6. There are attractive buildings/homes.	.01	**-.65**	-.03	.01	-.20	.01	.01
F1. Traffic makes it difficult or unpleasant.	**.58**	-.06	.06	.06	-.01	-.08	.16
F2. Drivers exceed the posted speed limits.	**.59**	-.02	-.03	-.07	.01	-.07	-.04
F3. Enough crosswalks and pedestrian signals.	**.29**	-.09	.13	-.02	-.10	-.29	.18
F4. Pedestrian signals give me enough time.	.10	-.09	.02	.04	-.20	**-.29**	.29
F5. There are a lot of exhaust fumes.	**.55**	-.14	-.08	.02	-.07	.06	.03
F6. Most DRIVERS are courteous.	**.50**	-.09	.02	-.09	-.13	-.19	.08
G1. My neighbourhood streets are well lit at night.	-.21	-.08	.03	-.10	**-.46**	-.21	-.02
G2. Walkers and cyclists can be easily seen.	.09	-.08	.14	.01	**-.37**	-.11	-.03

Abbreviated Item	Factor 1	2	3	4	5	6	7
G3. See and speak to other people.	-.02	-.20	.04	-.07	-.20	**.27**	-.09
G4. Safe walking during the day.	.06	-.14	-.01	.04	**-.52**	.11	.02
G5. Safe walking at night.	.01	.04	-.01	-.05	**-.78**	.12	.10

Note. The final factor loadings that belong to a specific factor are **bolded**.

Items with low factor loading values (< .30) were retained because of importance conformed by the content experts (via Study One). In addition, the low factor loading may be due to the fact that our study was done in only one city. For example, items loadings were low because not a lot of variability compared to if numerous cities tested. Of those items with low factor loadings, the factor it loaded onto 'fit' better as a whole to that factor.

Table 4

*Difference be*tween season and the NEWS-North

	Term		
NEWS-North Subscale	Summer	Fall	Winter
Traffic safety **(p < .001)**	***M*= 16.52, *SD*= 4.01**	*M*= 17.88, *SD*= 3.09 **(p = .017)**	*M*= 15.23, *SD*= 3.58 **(p =.019)**
Aesthetics (p = .549)	*M*= 15.65, *SD*= 3.00	*M*=15.39, *SD*= 2.84	*M*= 15.22, *SD*= 3.05
Land Use/ Access (p =.460)	*M*=15.52, *SD*=3.08	*M*=15.91, *SD*=3.05	*M*=16.03, *SD*= 3.75
Winter (p =.398)	*M*=15.13, *SD*=4.00	*M*=15.84, *SD*=3.43	*M*=15.55, *SD*= 3.75
Crime Safety (p =.147)	*M*= 12.71, *SD*= 2.23	*M*=12.20, *SD*= 2.12	*M*=12.56, *SD*=2.09
Sidewalks **(p = .003)**	*M*= 17.57, *SD*=3.14	***M*=17.79, *SD*= 3.50**	*M*= 16.67, *SD*= 3.05 **(p = .003)**
Pedestrian/Bike comfort (p = .295)	*M*= 17.01, *SD*= 3.09	*M*= 17.11, *SD*= 2.82	*M*= 16.63, *SD*=3.47

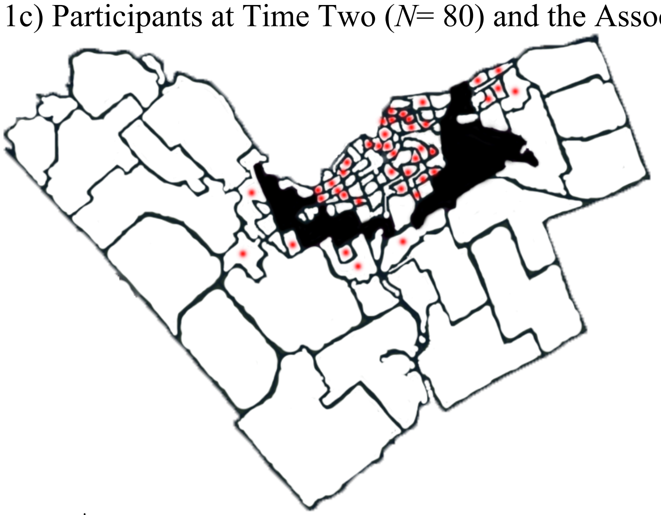
Note:
p < .05 is significant and is in ***bold***
** denotes the term which is significantly different from the other term(s) that is being compared*

Figure 1. Neighbourhood Boundaries and Participation *

1a) The ONS Neighbourhood Boundaries

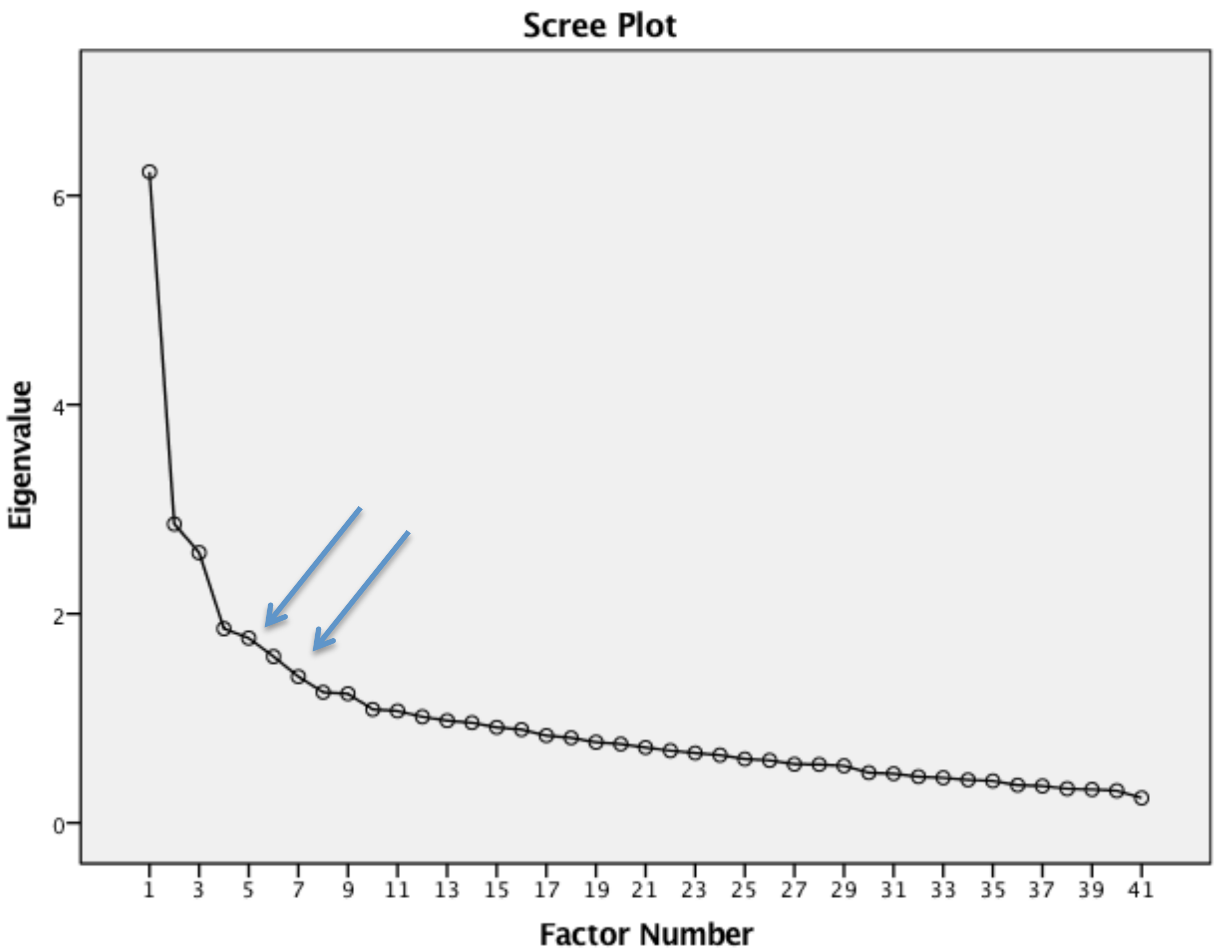
1b) Participants at Time One (*N*= 432) and the Associated Neighbourhoods denoted by the dot.

1c) Participants at Time Two (*N*= 80) and the Associated Neighbourhoods denoted by the dot.



Note. * Data source Ottawa Neighbourhood Study (2013). Greenbelt denoted by black as the fill colour.

Figure 2. MEFA Scree Plot of the factors suggested based on the 41 items of the NEWS-North



Arrows denote the “elbow” bend.
Scree plot image generated directly from the SPSS 23® program.

Appendix

NEWS-North: 7 subscales identified using the MEFA

Factor 1: Safety from Traffic

F1. There is so much traffic along nearby streets that it makes it difficult or unpleasant to walk in my neighbourhood.

1	2	3	4
Strongly Disagree	Somewhat Disagree	Somewhat Agree	Strongly Agree

F2. Many drivers exceed the posted speed limits while driving in my neighbourhood.

1	2	3	4
Strongly Disagree	Somewhat Disagree	Somewhat Agree	Strongly Agree

F3. There are enough crosswalks and pedestrian signals to help walkers cross busy streets in my neighbourhood.

1	2	3	4
Strongly Disagree	Somewhat Disagree	Somewhat Agree	Strongly Agree

F5. When walking in my neighbourhood, there are a lot of exhaust fumes (such as from cars, buses).

1	2	3	4
Strongly Disagree	Somewhat Disagree	Somewhat Agree	Strongly Agree

F6. Most DRIVERS in my neighbourhood are courteous and concerned for pedestrian safety.

1	2	3	4
Strongly Disagree	Somewhat Disagree	Somewhat Agree	Strongly Agree

A5. There are physical barriers (e.g., rivers or busy streets) in my neighbourhood that limit the number of routes for getting from place to place.

1	2	3	4
Strongly Disagree	Somewhat Disagree	Somewhat Agree	Strongly Agree

Factor 2: Aesthetics

E1. There are trees along the streets in my neighbourhood.

1	2	3	4
Strongly Disagree	Somewhat Disagree	Somewhat Agree	Strongly Agree

E3. There are many interesting things to look at while walking in my neighbourhood.

1	2	3	4
Strongly Disagree	Somewhat Disagree	Somewhat Agree	Strongly Agree

E4. My neighbourhood is generally clean (e.g., free from litter).

1	2	3	4
Strongly Disagree	Somewhat Disagree	Somewhat Agree	Strongly Agree

E5. There are many attractive natural sights in my neighbourhood (such as well landscaped yards, parks and trees).

1	2	3	4
Strongly Disagree	Somewhat Disagree	Somewhat Agree	Strongly Agree

E6. There are attractive buildings/homes in my neighbourhood.

1	2	3	4
Strongly Disagree	Somewhat Disagree	Somewhat Agree	Strongly Agree

Factor 3: Land Use-Access

A1. Generally, stores are within easy walking distance of my home.

1	2	3	4
Strongly Disagree	Somewhat Disagree	Somewhat Agree	Strongly Agree

A2. There are many places (e.g., coffee shops, restaurants, recreation) to go within easy walking distance of my home.

1	2	3	4
Strongly Disagree	Somewhat Disagree	Somewhat Agree	Strongly Agree

A3. It is easy to walk to a transit stop (e.g., bus, train) from my home.

1	2	3	4
Strongly Disagree	Somewhat Disagree	Somewhat Agree	Strongly Agree

B2. The distance between intersections in my neighbourhood is usually short (100 meters or less).

1	2	3	4
Strongly Disagree	Somewhat Disagree	Somewhat Agree	Strongly Agree

B3. There are many alternative routes for getting from place to place in my neighbourhood. (I don't have to go the same way every time.)

1	2	3	4
Strongly Disagree	Somewhat Disagree	Somewhat Agree	Strongly Agree

Factor 4: Winter walking

D1. The sidewalks in my neighbourhood are cleared quickly after a winter storm.

1	2	3	4	N/A
Strongly Disagree	Somewhat Disagree	Somewhat Agree	Strongly Agree	Not applicable means no

sidewalks in my neighbourhood

D2. The pedestrian trails in my neighbourhood are cleared quickly after a winter storm.

1	2	3	4
Strongly Disagree	Somewhat Disagree	Somewhat Agree	Strongly Agree

D3. The sidewalks in my neighbourhood are often slippery in the winter.

1	2	3	4	N/A
Strongly Disagree	Somewhat Disagree	Somewhat Agree	Strongly Agree	Not applicable means no sidewalks in my neighbourhood

D4. There are places to get out of the wind (e.g., shops, bus shelters, public buildings) while walking in my neighbourhood.

1	2	3	4
Strongly Disagree	Somewhat Disagree	Somewhat Agree	Strongly Agree

D5. Snow banks in my neighbourhood make it difficult for drivers to see pedestrians.

1	2	3	4
Strongly Disagree	Somewhat Disagree	Somewhat Agree	Strongly Agree

D7. In my neighbourhood, snow from driveways or the road is often put onto the sidewalks.

1	2	3	4	N/A
Strongly Disagree	Somewhat Disagree	Somewhat Agree	Strongly Agree	Not applicable means no sidewalks in my neighbourhood

D8. The bicycle trails in my neighbourhood are cleared quickly after a winter storm.

1	2	3	4	N/A
Strongly Disagree	Somewhat Disagree	Somewhat Agree	Strongly Agree	Not applicable means no sidewalks in my neighbourhood

Factor 5: safety from crime

G1. My neighbourhood streets are well lit at night.

1	2	3	4
Strongly Disagree	Somewhat Disagree	Somewhat Agree	Strongly Agree

G2. Walkers and cyclists on the streets in my neighbourhood can be easily seen by people in their homes.

1	2	3	4
Strongly Disagree	Somewhat Disagree	Somewhat Agree	Strongly Agree

G4. I feel safe walking in my neighbourhood during the day.

1	2	3	4
Strongly Disagree	Somewhat Disagree	Somewhat Agree	Strongly Agree

G5. I feel safe walking in my neighbourhood at night.

1	2	3	4
Strongly Disagree	Somewhat Disagree	Somewhat Agree	Strongly Agree

Factor 6: Sidewalks

C1. There are sidewalks on most of the streets in my neighbourhood.

1	2	3	4
Strongly Disagree	Somewhat Disagree	Somewhat Agree	Strongly Agree

C3. The sidewalks in my neighbourhood are well maintained (paved, even, and have few cracks).

1	2	3	4	N/A
Strongly Disagree	Somewhat Disagree	Somewhat Agree	Strongly Agree	Not applicable means no sidewalks in my neighbourhood

C5. There is a strip (grass/dirt/ concrete) that separates the road from the sidewalks in my neighbourhood.

1	2	3	4	N/A
Strongly Disagree	Somewhat Disagree	Somewhat Agree	Strongly Agree	Not applicable means no sidewalks in my neighbourhood

C6. The sidewalks in my neighbourhood are free from obstacles (parked bicycles, electricity boxes, garbage bins).

1	2	3	4	N/A
Strongly Disagree	Somewhat Disagree	Somewhat Agree	Strongly Agree	Not applicable means no sidewalks in my neighbourhood

F4. The pedestrian signals in my neighbourhood give me enough time to walk across the street.

1	2	3	4
Strongly Disagree	Somewhat Disagree	Somewhat Agree	Strongly Agree

G3. I often see and speak to other people when I am walking in my neighbourhood.

1	2	3	4
Strongly Disagree	Somewhat Disagree	Somewhat Agree	Strongly Agree

Factor 7: Pedestrian & Bike comfort

C2. Sidewalks in my neighbourhood sometimes end in the middle of a block.

1	2	3	4	N/A
Strongly Disagree	Somewhat Disagree	Somewhat Agree	Strongly Agree	Not applicable means no sidewalks in my neighbourhood

C4. There are pedestrian trails in or near my neighbourhood that are easy to walk to.

1	2	3	4
Strongly Disagree	Somewhat Disagree	Somewhat Agree	Strongly Agree

C7. There are benches to rest on in my neighbourhood.

1	2	3	4
Strongly Disagree	Somewhat Disagree	Somewhat Agree	Strongly Agree

C8. There are bicycle trails in or near my neighbourhood that are easy to bike to.

1	2	3	4
Strongly Disagree	Somewhat Disagree	Somewhat Agree	Strongly Agree

C9. I feel safe walking on most streets in my neighbourhood that don’t have sidewalks.

1	2	3	4
Strongly Disagree	Somewhat Disagree	Somewhat Agree	Strongly Agree

D6. Most streets WITHOUT sidewalks in my neighbourhood are safe to walk on in the winter.

1	2	3	4
Strongly Disagree	Somewhat Disagree	Somewhat Agree	Strongly Agree

Chapter 4: Study 3

The Convergent Validity of the NEWS-North: A Pilot Test

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Abstract

Objective: The NEWS-North was developed in Canada to assess walkability in more northern climates. It has shown good test-retest reliability, internal consistency, and factorial validity. The aim of this paper is to examine the convergent validity of seven subscales of this adapted walkability measure for Northern climates.

Method: We collected data from 432 participants using an online survey. The data collected was part of the pilot test of the NEWS-North. In this pilot test, we asked about walking behaviour and sought to assess how well the seven subscales of the NEWS-North predicted walking behaviour. We also compared item and subscale scores for participants living in neighbourhoods to conceptually similar concepts from an observed walkability scale. To do this, we used a two-level Hierarchical Linear Modeling (HLM) with spatial dependency analyses. The individual level (Level One) comprised each subscale of the NEWS-North and relevant control variables. Level Two comprised the neighbourhood walkability for each of 64 neighbourhoods as assessed using objective data from both Frank's walkability index (Frank et al., 2010) and the Ottawa Neighbourhood Study (ONS) walkability scale (Lafontaine et al., 2017) using relevant control variables. In addition, interaction variables for each individual-level variable and season were examined to determine whether season influenced the relationship between walking behaviours and scores on the NEWS-North.

Results: At the individual level, only the *sidewalk* subscale from the NEWS-North, predicted walking behaviour with and without the inclusion of control variables. A significant negative interaction between season and *traffic safety* subscale was also found. At the neighbourhood level, two subscales from the objective data (i.e., the *sidewalk* subscale and the *land use access* subscale measured by Frank's index) predicted walking behaviour with and without controlling

for income. Finally, the correspondence between the individual level (i.e., the NEWS-North) and the neighbourhood level (i.e., the ONS walkability scale and Frank's index) on six conceptually similar subscales of the measurement was significant in three subscales and marginally significant in one.

Conclusion: Some convergent validity was found for the NEWS-North in the large pilot test Ottawa, Canada. Implications for future research are discussed.

The Convergent Validity of the NEWS-North: A Pilot Test

High neighbourhood walkability refers to a pedestrian friendly neighbourhood that is safe, has a higher density of desirable destinations that are in close proximity, and a pleasant overall experience of walking (Talen & Koschinsky, 2014b). Furthermore, a walkable neighbourhood is characterized by better street connectedness, a higher number of sidewalks, greater diversity of walking destinations, better aesthetics, and better safety from traffic (Lo, 2009). The benefits of a walkable neighbourhood include higher housing value, fewer foreclosures, fewer property crimes (Gilderbloom, Riggs, & Meares, 2015), and most importantly better health and a reduction in medical health care costs (Tsuji et al., 2003). Studies related to walkability in the literature have reported significant associations with walking behaviours when measured subjectively, objectively, or a combination of the two measurements.

Neighbourhood Walkability: Subjective Measurement

Subjective neighbourhood walkability assessments are based on perceptions of neighbourhood residents. Data on subjective walkability are obtained by questionnaires, focus groups, or structured interviews. A recent systematic review found that Dutch adults who perceived higher neighbourhood walkability walked more (Friederichs, Kremers, Lechner, & de Vries, 2013).

Greater walking frequency was found among Kuala Lumpur residents with no mobility issues with higher perceived sidewalk presence, better sidewalk maintenance (e.g., free from street furniture, wide, not crumbling), greater perceived safety from crime, and more pleasant weather from results obtained by a questionnaire (Ariffin & Zahari, 2013). The top barriers to walking included greater crime-related risk, distance to walking destinations, and poor weather (Ariffin & Zahari, 2013). In Alberta, Canada, middle-aged adults (average age of 36 years) without mobility problems who participated in focus groups, also reported that greater neighbourhood walkability as defined by the presence and maintenance of sidewalks, warm weather, and safety from traffic (e.g., crosswalks and reduce automobile speeds) influenced their walking behaviours (Montemurro et al., 2011).

Neighbourhood Walkability: Objective Measurement

Data on objective walkability is obtained by using methods such as walkability audits of neighbourhoods by trained researchers or secondary data sources, such as Geographic Information Systems (GIS) databases. In Sweden, a GIS based objective walkability index used three variables (i.e., residential density, street connectivity, and land use mix-diversity of destinations). Using this index, Sundquist et al. (2011) found that adults aged 20 to 65 years without walking impairment who lived in a walkable neighbourhood (i.e., greater residential density, street connectivity, and land use mix-diversity of destinations) were more likely to walk for transportation and leisure compared to those who lived in less walkabile neighbourhoods (Sundquist et al., 2011). Among Australian adults aged 20 to 65 years who are able to walk without assistance, those who lived in neighbourhoods with greater objectively walkability (i.e., residential density, street connectivity, net retail area, and land use mix-diversity of destinations) had higher levels of transportation walking (Owen et al., 2007a).

Combining Both Approaches

Many experts recommend that walkability be measured both objectively and subjectively due to inconsistencies when a single measure is used (Brownson et al., 2004). One study examined the relationship between land use mix-proximity to destinations and overall transportation walking in Australian adults, aged 20 to 65 years without walking assistance, using both subjectively (i.e., self-report) and objectively (i.e., GIS) obtained measurements

(Cerin, Leslie, du Toit, Owen, & Frank, 2007). They found that greater transportation walking was reported with higher subjective and objective land use mix-proximity to destinations (Cerin, Leslie, du Toit, et al., 2007). Another study examined the relationship between neighbourhood walkability and self-reported transportation or leisure walking, measured both objectively (i.e., GIS) and subjectively (i.e., a questionnaire) using three variables, (i.e., residential density, land use mix-diversity of destinations, and street connectivity) in middle to older aged Swedish adults (Arvidsson et al., 2012). Those middle aged and older adults who lived in areas with high subjective neighbourhood walkability walked more minutes per week walking for transportation (41.50 minutes) and leisure (21.80 minutes) than those adults living in areas with low walkability (Arvidsson et al., 2012). Those middle aged and older adults living in neighbourhoods with high objective neighbourhood walkability walked 35 minutes more for transportation and 10.50 minutes more for leisure than those adults living in neighbourhoods with low objective walkability (Arvidsson et al., 2012).

Agreement Between Objective and Subjective Measurements

The level of agreement between objective and subjective measurement is mixed. Some studies have found good concordance between measurements. In Australia, Gebel, Bauman, and Owen (2009a) reported moderate agreement (Kappa= 0.35) between GIS based neighbourhood walkability based on four physical neighbourhood environment variables (street connectedness, land use mix-diversity of destinations, net retail area, and residential density) and self-reported data from adults aged 19 to 65 years using census tracts to define neighbourhoods. The Swedish study described above reported similar results (Kappa = 0.34), although the land use mix-diversity of destinations data was omitted due to the lack of data (Arvidsson et al., 2012). However, others have found little concordance between measurements. For example, low agreement (Kappa < .20) was reported between self-reported and systematic observational data of six neighbourhood environment variables (i.e., sidewalk existence, obstructions on sidewalks, aesthetics, presence of malls, presence of parks, and presence of trails), in a study with older American adults using street boundaries to define neighbourhoods (Michael , Beard, Choi, Farquhar, & Carlson, 2006). Interestingly, Jack and McCormack (2014) found that adults perceived aesthetics, safety from traffic, and safety from crime were more negative in neigbourhoods that were rated objectively as highly walkable in Calgary, Alberta.

Some of the inconsistent results are likely due to lack of a consistent neighbourhood boundary definition between studies (Bailey et al., 2014b). Definitions of neighbourhoods can vary from 1-mile buffers, geographic units, census tracts, or postal codes for examining neighbourhoods and health. Each neighbourhood definition can produce different results (Flowerdew, Manley, & Sabel, 2008). Moreover, using a single operational definition of neighbourhood can be troublesome due to differences between residents' perceptions of neighbourhoods and the neighbourhood boundary defined by the researcher. For example, census tracts used by researchers may not always match the residents' perceptions of their neighbourhood boundary (Coulton, Korbin, & Su, 2001). It has been suggested that defining a neighbourhood should involve the consideration of several definitions, such as census tracts, the feedback of residents (Weiss, Ompad, Galea, & Vlahov, 2007), and the inclusion of physical boundaries (Flowerdew et al., 2008) to produce a comprehensive neighbourhood boundary definition.

Neighborhood Walkability at Multiple Levels

Ecological models are often used to better understand the variables related to physical activities of residents, including walking (Sallis & Owen, 2002). An ecological model also acknowledges and aims to understand how multiple levels with their associated variables interact to influence physical activity (Richard et al., 2010).

Ecological models related to walking behaviours often include an individual level and a neighbourhood level (Sallis & Owen, 2002). At the individual level, variables such as age, gender, income, or perceived walkability may be included. At the neighbourhood level, information about the neighbourhood environment can include physical characteristics (e.g., intersection density, proximity to parks and green space) and social characteristics (e.g., safety from crime, neighbourhood socioeconomic status). The literature on individual variables, neighbourhood walkability, and walking behaviour will be briefly discussed herein.

Individual-level variables, neighbourhood walkability, and walking. At the individual level, researchers have examined the impact of dog ownership, children in a household, age and gender on neighbourhood walkability and walking behaviours.

In Victoria, British Columbia, adults aged 20 to 80 years who owned a dog reported walking a weekly average of 300 minutes while those who did not own a dog reported walking for 168 minutes (Brown & Rhodes, 2006). In Calgary, Canada, street connectivity, pedestrian infrastructure, and overall neighbourhood walkability were subjectively rated higher among non-dog owners by adults' aged 18 years or older when compared to residents who walked their dog (McCormack, Graham, Christian, Toohey, & Rock, 2016).

Owen et al. (2007b) found that having at least one child in the household for adult women was negatively associated with walking for transportation. This study also reported that older adults without children reported greater recreation walking (Owen et al., 2007b). High objective walkability was related to greater walking for transportation, but the relationship between objective neighbourhood walkability and recreational walking was not significant (Owen et al., 2007b).

Neighbourhood-level variables, neighbourhood walkability, and walking. The association between neighbourhood walkability and walking frequency is mixed and varies by the type of walking. A recent study by Clark, Scott, and Yiannakoulias (2014) found that residents aged 15 years or older who lived in walkable neighbourhoods (characterized by population density, land use mix-diversity to destinations, street connectivity, retail floor area ratio, and pedestrian infrastructure) were more likely to walk for transportation in Halifax, Nova Scotia. However, a study by Hanibuchi, Nakaya, Yonejima, and Honjo (2015) found that Japanese adults aged 20 to 89 years who lived in neighbourhoods with higher objective walkability (characterized by population density, road density, access to parks, and access to retail areas) was not associated with walking behaviour for recreation.

Both levels, neighbourhood walkability, and walking. In Portland, Oregon, a study by Li et al. (2005) examined the walking activity of older American adults (mean age of 74 years) in relation to both objective and subjective neighbourhood walkability. Objective walkability was based on four physical neighbourhood characteristics (i.e., household density, density of places of employment, street intersections, and green/open space for recreation) while the subjective walkability index was created from six items: four single items (recreation facility access, diversity of recreational facilities, street intersections, and green/open space for recreation) and two items related to safety, one for traffic and the other for walking (Li et al., 2005). Residents who lived in high walkability neighbourhoods (measured objectively across all four variables) reported more walking activity (Li et al., 2005). A positive association was only found for two subjective items (i.e., safety for walking and diversity of recreational facilities) while the other items were not significant (Li et al., 2005).

Neighbourhood Walkability in Canada

A longitudinal study by Wasfi, Dasgupta, Eluru, et al. (2016) reported that adults aged 45 to 84 years at baseline who lived in highly walkable neighbourhoods increased utilitarian walking between 1996 to 2007, and participants who moved to neigbourhoods that were more walkable also reported more utilitarian walking. Similar results on physical activity and neighbourhood walkability have been reported in several cross-sectional studies. For example, Canadian residents aged 18 to 79 years who lived in high walkability neighbourhoods in urban areas reported more physical activity than those who lived in low walkability neighbourhoods (Thielman, Manson, Chiu, Copes, & Rosella, 2016). Across Ontario, adults aged 20 years or older who lived in highly walkable neighbourhoods reported more utilitarian walking as a leisure activity and were less likely to be obese or overweight (Chiu et al., 2015). A recent study across 15 municipalities in Southern Ontario found that adults reported higher daily walking and modest increases in walking if they lived in high walkable neighbourhood (Creatore et al., 2016). A study in Calgary, Alberta, found that greater transportation walking was reported in adults who lived in highly walkable neighbourhoods (Jack & McCormack, 2014). Similarly, greater physical activity was reported in adults who lived in neighbourhoods that were more walkable in Montreal, Quebec (Hajna, Kestens, et al., 2016).

Subjective Walkability Questionnaire

The Neighbourhood Environment Walkability Scale (NEWS), which was developed in the United States of America (Saelens, Sallis, Black, et al., 2003) is a well-known, validated measure of subjective walkability. The NEWS assesses both social and physical categories of a neighbourhood environment in a total of eight subscales. Five physical neighbourhood categories include residential density, land use mix (accessibility and proximity), street connectedness, and walking infrastructure (e.g., sidewalks). Three social neighbourhood categories include aesthetics, traffic safety, and crime safety.

The NEWS has shown good convergent validity. Several studies have reported that residents who lived in objectively high walkable neighbourhoods had higher subscale scores compared to neighbourhoods with low walkability (Leslie et al., 2005; Saelens, Sallis, Black, et al., 2003). In addition, adequate construct validity of the NEWS was reported when factorial validity and criterion validity (i.e., self-reported walking) were assessed (Cerin et al., 2006). Several adaptations of the NEWS in the last decade have included the NEWS- abbreviated (Cerin et al., 2006), NEWS-Australia (Leslie et al., 2005), NEWS-Chinese for Seniors (Cerin et al., 2010), and NEWS-India (Adlakha et al., 2016).

A current limitation of the NEWS is that the majority of studies have been conducted in warmer climates. However, we know that seasonal changes in northern climates may impact walking behaviours. For example, residents in Nova Scotia reported that as the temperature increases so did their walking (Clark et al., 2014). Miranda-Moreno and Lahti (2013) examined the relationship between land use mix and pedestrian volumes during winter months (December to March, below zero degrees Celsius) and temperate months (April to November above zero degrees Celsius) in Montreal, Quebec. They reported that in the winter months, weather related to precipitation and wind decreased pedestrian volume (Miranda-Moreno & Lahti, 2013). At the time of this paper, however, we do not know of any subjective walkability questionnaire for use in northern climates.

Our operational definition of walkability is based on previous walkability framework (Grant et al., 2010; Marshall et al., 2009; Mehta, 2008; Montemurro et al., 2011) and includes aspects of the built environment (i.e., social and physical) such as aesthesis, safety traffic, presence/diversity of retail, street connectivity, residential density, and quality of sidewalks. Our operational definition of walkability also incorporates winter walking.

Objectives

The overall goal of this work was to adapt the NEWS to include a subscale on winter weather and to assess its validity and reliability. We followed a three-phase adaption process. In the first phase, the adapted questionnaire, the NEWS-North, was developed (Takacs & Kristjansson, 2017). The second phase included assessing reliability (i.e., test-retest reliability and internal consistency of each scale) and factorial validity (Takacs & Kristjansson, 2017). Finally, in the third phase, we assessed convergent validity by comparing the NEWS-North subscales to self-reported walking behaviour and to aspects of objectively measured walkability. In the present paper, we report on phase three of the adaption process. The objectives of this study included:

- The examination of the relationship between each of the seven subscales[7] of the NEWS-North and walking behaviour.
- The examination of the relationship between the six subscales[8] of the adapted questionnaire and objectively observed walkability.

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[7] The NEWS-North was adapted with a final nine subscales. However, seven subscales were examined in the MEFA (Takacs & Kristjansson, 2017) since two subscales were excluded.
[8] Only six objective subscales were compared instead of seven due to the fact at the time of this dissertation objective data on the winter subscale was unavailable.

Method

Overview

The convergent validity for the NEWS-North was assessed in two ways: (a) by comparing scores on NEWS-North subscales to self-reported walking behaviour, and (b) by comparing NEWS-North subscale scores to items from an observational walkability measure that created an equivalent subscale. We gathered data on the NEWS-North and walking behaviour from an on-line pilot test in Ottawa Canada. Two raters gathered data for the observed walkability measure for each neighbourhood in the summer of 2015.

Participants

Participants living in Ottawa, Canada were eligible to participate in this pilot test study if they satisfied the following requirements: had lived at their current home address in Ottawa for more than one year, were aged at least 18 years or older, and were fluent in reading and writing English. Only one person per household was allowed to participate. Students at the University of Ottawa were recruited using the university's participant recruitment system, while Ottawa residents were recruited through social media and poster distribution advertising the study in various locations (e.g., libraries). Four hundred and fourteen participants (i.e., residents n = 201; students n = 214) in 64 Ottawa neighbourhoods completed the pilot test and remained in the dataset after data screening and cleaning.

Materials

Demographic questionnaire. Eleven items were used to assess demographics. Participants were asked about their mode of transportation for work and/or school (if applicable), age, highest education level attained, length at current address, gender, physical disabilities, number of children, and dog ownership status. Participants were also asked to provide their full postal code. The season (i.e., winter term: January 1 to April 31, summer term: May 1 to August 31, or fall term: September 1 to December 31) in which the participant completed the perceived walkability measure was also recorded.

Subjective data: Adapted neighbourhood walkability questionnaire. The NEWS for northern climates (NEWS-North) is a 70-item self-report questionnaire that contains nine subscales: land use mix-accessibility of destinations (5-items, referred to as *Section A*), street connectivity (3-items, referred to as *Section B*), walking infrastructure (9-items, referred to as *Section C*), winter walking (8-items, referred to as *Section D*), aesthetics (6-items, referred to as *Section E*), traffic safety (7-items, referred to as *Section F*), safety from crime (5-items, referred to as *Section G*), residential density (6-items, referred to as *Section H*), and land use mix-proximity of destinations (22-items, referred to as *Section I*). Items are rated on a 4-point scale ranging from 1 (*strongly disagree*) to 4 (*strongly agree*) with two exceptions. The "residential density" section is rated from 1 (*none*) to 5 (*all*) for the types of homes in a neighbourhood (e.g., single family), while the "land use proximity" to destinations in neighbourhoods (e.g. grocery stores) section is rated from 1 (*31 minutes or more/ don't know*) to 5 (*1 to 5 minutes*). Two subscales included a *not applicable* option related specifically to sidewalks for "walking infrastructures" (3-items) and "winter walking" (5-items) subsections. Twenty-one items within five subscales of the NEWS-North were reverse coded. The subscale score was calculated by the mean of the items; a higher mean score on each subscale denoted higher walkability.

We used a multilevel exploratory factor analysis (MEFA) to examine the seven subscales with the same Likert scale; thus both *section H* and section I were excluded. In this dissertation, we followed previous studies and the adaptation protocol (Sallis et al., 2015) that excluded both subscales (Cerin et al., 2009; Starnes et al., 2014). In addition, the weighted scoring of *section H* combined with the fact that different Likert scales were used in the rest of the measure would have made the results difficult to analyze .

The MEFA model was as a 7-factor model with 39 items, and was selected on the basis of low residuals and interpretability. Factor 1 (originally *section F*) is still referred to as *safety from traffic* in this paper and consists of items F1, F2, F3, F5, F6, and A5. Factor 2 (originally *Section E*) is referred to as *aesthetics*, consisting of items E1, E3, E4, E5, and E6. Factor 3 (originally *Section A* and *Section B*) is referred to as *land-use access* and consists of items A1, A2, A3, B2, and B3. Factor 4 (originally *Section D*) is *winter walking*, and comprises items D1, D2, D3, D4, D5, D7, and D8. Factor 5 (originally *Section G*) is referred to as *safety from crime* and consists of items G1, G2, G4, and G5. In the MEFA, *Section C* was divided into two factors. Factor 6 is *sidewalks,* consisting of items C1, C3, C5, C6, F4, and G3. Factor 7 is referred to as *pedestrian/bike comfort,* consisting of items C2, C4, C7, C8, C9, and D6.

Objective data: Ottawa neighbourhoods. The objective data for the Ottawa neighbourhoods used in this paper was obtained from Ottawa Neighbourhood Study (ONS). The ONS provides users with comprehensive information on neighbourhood characteristics for 103 neighbourhoods; this is publicly accessible data (Ottawa Neighbourhood Study, 2013). For the purposes of the present study, of the 103 ONS defined neighbourhoods, only 73 urban and suburban neighbourhoods had data on objective walkability because of the difficulty of assessing walkability in more rural areas. Specifically, the concept and measurement of walkability is different in rural areas.

Defining Ottawa neighbourhood boundaries. The first step was the identification of Ottawa neighbourhoods, which participants resided in. To identify residents within a specific neighbourhood boundary defined by the ONS, a database of postal codes mapped within each defined ONS neighbourhood boundary was created by the ONS. The postal code provided by participants was identified in ONS database and matched to a neighbourhood currently defined by the ONS.

Objective neighbourhood characteristics. The ONS profiles provide information on neighbourhoods. Complete neighbourhood profiles can be viewed online (www.neighbourhoodstudy.ca). Four neighbourhood-level demographic variables were selected from the ONS: neighbourhood resident employment, rated on a 4-point Likert scale from *1* (less than 50% employed) to *4* (70% to 79% employed), median resident income after tax, rated on a 3-point Likert scale from *1* ($20,000 to $29,000) to *3* ($40,000 to $49,000), the percentage of neighbourhood households owned was rated on a 4-point Likert scale from *1* (under 20% of households owned) to *4* (above 80% households owned), and the prevalence of neighbourhood marital status rated dichotomously (single/never married vs. married/common law). These variables all came from the 2011 National Household Survey. We also used variables from two walkability scales: Frank's walkability index (Frank et al., 2010) and the ONS walkability scale (Lafontaine et al., 2017).

To calculate Frank's walkability index (Frank et al., 2010) in Ottawa, we combined four items that were measured using GIS data. These four variables included: land use mix-diversity, intersection density, residential density, and retail floor area (Frank et al., 2010). A higher score denotes higher neighbourhood walkability. Data sources used by the ONS to create the walkability index included data from the City of Ottawa Zoning Data, Roads, and Statistics Canada. This walkability index was comparable to the *land use-access* subscale of the NEWS-North developed from an earlier MEFA.

We also included items from an observed walkability scale (Lafontaine et al., 2017) that was completed in 73 Ottawa neighbourhoods by the ONS team in the summer (May to August) of 2015. The neighbourhood walkability scaled comprised ratings of aesthetics (29-items), parks (33-items), and overall walkability (21-items). The ONS team developed the three scales after extensive literature reviews. A higher score denotes a better aesthetics, more parks, and higher overall walkability in a neighbourhood. Each item in the questionnaire was operationally defined and accompanied with photos to demonstrate each rating point on the Likert scales. The two observers received two weeks of training by a team leader of the ONS to audit neighbourhoods with iPads®. After the training was completed, both of the trained observers were tested on their coding accuracy. Then, both were sent to the same Ottawa neighbourhoods at the same time with iPads to separately rate five randomly selected block faces in the neighbourhood on 83 items. The ratings from the two raters were averaged for each block face; next a neighbourhood average (of the five block faces) was calculated. Inter-rater reliability for the ONS walkability subscales ranged from .40 to .77 (Lafontaine et al., 2017).

Of the 83 items rated by these observers from the ONS, only 21 items were equivalent to 21 items on the NEWS-North in five subscales from the MEFA: *safety from traffic*, *aesthetics*, *safety from crime*, *sidewalks*, and *pedestrian/bike comfort*. Higher scores on each of the items correspond to the promotion of neighbourhood walking. If more than one NEWS-North items were similar to an ONS item, the items were averaged. See Appendix A for item comparisons.

Walking behaviour. Due to time constraints and financial limitations, a subjective measure of walking frequency was used rather than an objective measure (e.g., accelerometer). The Longitudinal Aging Study Amsterdam Physical Activity Questionnaire (LAPAQ; (Stel et al., 2004) is a four item self-report measure specifically designed to assess the frequency of walking in adults. One item assessed whether walking is used for daily activities (e.g., "Do you walk outside"), and one item asked about recent walking (e.g., "did you walk during the past two weeks"). Another item asked adults about their walking frequency (e.g., "How many times did you walk during the past 2 weeks"), and one item assessed the time taken for usual walks (e.g., "How long do you usually walk each time"). The first two items were rated on a dichotomous scale (i.e., no or yes) while the remaining items were open-ended. The LAPAQ has good construct validity, with a correlation of .50 between the score and a walking diary, and a correlation of .56 with pedometer measures (Stel et al., 2004). More recently, the LAPAQ has also been found to have acceptable construct validity (Hoogendijk et al., 2016).

The total score (minutes walking over the past two weeks) on the LAPAQ was calculated by multiplying the frequency of walking by minutes of walking each time those participants who answered 'yes' to both walking outside and walked during the past two weeks questions. Participants who answered 'no' to either or both questions received a total walking score of zero. A higher score denotes more minutes walked.

Procedure

Subjective data. The University of Ottawa Research and Ethics board approved our study. Eligibility for participation in the study included satisfying all the following requirements: being at least 18 years of age or older, being fluent in English, having lived at least one year at the current residential address, and being the only person in their household to participate.

Participants were recruited and participated in the study during the period from May 2014 to April 2015. We used different methods of recruiting for University of Ottawa students and other Ottawa residents. Students attending the University of Ottawa were recruited through a recruitment portal, Integrated System of Participation in Research (ISPR), through use of a general recruitment poster and a pre-screen questionnaire. Students who were successfully pre-screened received an email inviting them to participate. Ottawa residents were recruited using various methods: newspaper advertisements, recruitment posters in neighbourhoods (e.g., community centres and libraries), and social media.

Interested participants from the University of Ottawa who were recruited using ISPR were directed to *URL 1*, while all recruitment methods used for Ottawa residents were directed to *URL 3*. Separate websites were used to track participation and to identify whether additional recruitment methods (e.g., tweets and emails) were needed. The consent form explained the eligibility requirements, and gave an overview of the study with enough information to ensure informed consent. To proceed with the study, participants had to click the “yes, I consent” option to continue. Those participants who chose the “no, I do not consent” were immediately directed to the end of the study webpage where they were thanked for their time.

Both recruitment methods asked participants to complete the same online questionnaire that included a series of demographic questions (e.g., their residential postal code) followed by the NEWS-North. Participants also completed a walking frequency questionnaire. The postal code provided by the participant was linked to the ONS postal code data file.

Students received a half point toward their ISPR account for their participation and Ottawa residents were offered a chance to win one of six prizes available in a draw that included six gift certificates: one grand prize ($125 grocery gift card), two first place prizes ($50 Chapters gift card), and three second place prizes ($30 movie gift card). The draw for Ottawa residents occurred after data collection was completed. The lead researcher pulled six names randomly out of a hat to determine the winners. Residents selected as prizewinners were contacted either by phone or e-mail and asked a skill-testing question. Winners had 14 days to claim the prize awarded. Failure to respond resulted in additional names being selected until the prizes were awarded.

At the conclusion of data collection, the NEWS-North data was prepared for analyses. A total score was calculated for each of the seven factors on the NEWS-North as well as the ONS equivalent subscale factors.

Objective data. Data on the NEWS-North, demographic and walking behaviour was linked to the ONS walkability data by matching participants' postal codes to the ONS neighbourhood postal code data file (which contained all postal codes in the Ottawa municipality). Each postal was categorized into one of 103 defined neighbourhoods by the ONS.

Neighbourhood-demographic variables. The four neighbourhood-level demographic variables (i.e., neighbourhood employment, neighbourhood resident income after tax, percentage of households owned in a neighbourhood, and neighbourhood marital status,) were obtained from the ONS profiles webpage (www.neighbourhoodstudy.ca). In this paper, we only used neighbourhood resident income after-tax variable as a control variable in the neighbourhood level analyses. The remaining variables were used to describe the neighbourhoods that participated.

Neighbourhood boundaries: Assessing and correcting for spatial autocorrelation. We examined the influence of any shared boundaries between the neighbourhoods in our study. A spatial analysis in HLM was performed to account for shared boundaries in predicting walking across neighbourhoods. This was done by adding a correction term to reduce the systematic error variance across neighbourhoods. This term consists of the residuals vector, average dependent variable correlation, and a spatial weight matrix that describes which neighbhourhoods are spatially connected to each other.

Convergent validity: Relationship of NEWS-North items to equivalent ONS items. The lead researcher and her supervisor identified ONS walkability items that were conceptually similar to NEWS-North items. An additional expert in geographic information systems (GIS) in the Faculty of Geography at the University of Ottawa and the co-lead investigator of the ONS was consulted to confirm the pairing. Overall subscale scores from these the ONS data was created.

Data Analysis

Our two-level analysis was performed using Hierarchical Linear Modeling (HLM) software. For the analyses at both levels, the data was assessed with and without the selected control variables chosen for in this paper. Subjective data (i.e., NEWS-North data) and selected control variables (i.e., gender, dog ownership, and season) correspond to the individual-level, and were entered at the first level. Objective walkability data (i.e., the ONS data) that controlled for resident median income after-tax corresponded to the neighbourhood-level, and were entered at the second level. The remaining variables were used to describe the participants at the individual level and neighbourhoods at the neighbourhood level.

Multi-level model justification check. To perform the multilevel modeling, we used the student version of HLM 7 for Windows® (Scientific Software International, 2016), with the capability for spatial dependency analyses. The inclusion of spatial dependency in HLM is to assess spatially auto correlated data, and is important for use in analyses with neighbourhoods that share common boundaries (Raudenbush, Bryk, Cheong, Congdon, & du Toit, 2011). Before formal analyses, two justification checks were performed to ensure that using HLM was appropriate. First, to determine whether or not there is variance in the dependent variable (i.e., walking) from neighbourhood to neighbourhood. Second, the Intraclass Correlation (ICC) was calculated to examine whether there is a substantial difference in variance of walking between neighbourhoods and the individual-level. In HLM, the ICC is calculated as the 'ratio of the between study variance to the total variance' (Grace-Martin, n.d.). It is used to determine whether multilevel analysis is needed (Garson, 2013). If the ICC is high, then the means of the clusters are significantly different and there is little variance within the clusters (Garson, 2013). In this study, a difference at the neighbourhood-level was considered substantial if it produced a value greater than 10%. The independent variables for both Level One and Level Two were entered into HLM centered around the grand mean. However, the interaction variables created have already been centered on the mean.

Main analyses. To aim of this paper is to predict overall walking frequency from the NEWS-North subscales across 64 neighbourhoods through four HLM analyses. The frequency of walking behaviour in minutes over the past two weeks is the dependent variable in this paper. The first analysis was designed to determine whether any of the seven factors of the NEWS-North (at the individual level) predicted walking both with and without the control variables (i.e., dog ownership, gender, and season). The second analysis examined interactions at the individual-level. This which was initially done by running a univariate analysis of variance to identify significant interactions between season (summer/fall term compared to winter term) and each individual-level variable. Only the significant interactions were then analyzed in HLM. A third analysis was done to determine whether the equivalent six factors from the ONS at the neighbourhood-level predicted walking. *Winter walking* was excluded from this third analysis due to unavailability of data at the neighbourhood-level. Similarly, the third analyses examined with and without controlling for resident median income after tax. Effect sizes for analyses one through three are denoted as R-squared and explained the percentage of the total variance within this data that controlled for spatial dependency. The effect size was calculated by the total variance of the dependent (i.e., within and between variance) variable value controlling for spatial dependencies subtracted by the value total variance of an independent variable then divided by the total variance of the dependent variable. In this paper, R-squared is considered very small between the values of 0 to .01, .01 to .09 as small, moderate between the values of .09 to .25, and large for values greater than .25. Finally, the fourth analysis was performed to check the agreement between the NEWS-North subscales and similar ONS walkability subscales. See Appendix B for a list of the way in which variables were coded in this paper.

Reliability between the ONS trained observers. The inter-rater reliability across 64 neighbourhoods was calculated for each of the five ONS subscales that were equivalent to the NEWS-North subscales: *safety from traffic*, *aesthetics*, *safety from crime, sidewalks*, and *pedestrian/bike comfort* subsections. We used an ICC to estimate this reliability. A two-way mixed model was selected as the study had fixed raters. ICC values were classified as poor if less than 0.50, moderate for values between 0.50 to 0.75, and high for values greater than 0.75 (Portney & Watkins, 2009).

Data screening. Both individual-level and neighbourhood-level data were screened. Each level and the data screening techniques used are discussed below.

Individual-level data. Eight hundred and twenty-five participants completed the online pilot test. However, 289 participants were removed due to study ineligibility that included living at their address for less than a year (n = 56), lived in Quebec (n = 15), household duplications (n = 6), more than half of the data responses missing in the pilot study (n = 84) and response times of eight minutes or less (n = 128) to ensure quality responses. An additional 102 participants were removed either because they were multivariate outliers in the MEFA or because they had data missing on one or more items. Finally, 20 participants were also removed due to lack of data at the neighbourhood level. For this paper our final sample is 414.

Neighbourhood-level data. Of the 103 neighbourhoods defined by the ONS, 73 neighbourhoods had objectively measured data across the three questionnaires used by the ONS. However, only 64 neighbourhoods were used in this study due to the fact that no residents from the remaining nine neighbourhoods participated.

Data cleaning. Prior to the main analyses, a series of data cleaning processes occurred at both levels. First, we assessed descriptive statistics in Statistical Package for the Social Sciences (SPSS) 23® to determine any coding errors. Additional steps were performed to examine the spatial dependency data and the dependent variable.

Individual-level data. For the NEWS-North, eight items were reverse coded (i.e., A5, C2, F1, F2, F5, D3, D5, and D7). The *not applicable* Likert option was originally coded as 777 as missing data. However, a missing value analysis revealed that two items (C3 and C5) had the largest number missing (i.e., over 25 missing) in 21 neighbourhoods. Upon an additional frequency analysis, the majority of the missing value responses were attributed to participants that selected the *not applicable* option. Items coded originally as *not applicable* were recoded to the lowest rating on the 4-point Likert scale (i.e., strongly disagree) for the main analyses. The mean subscale scores for the 7-factor model were examined for outliers greater than 3.29 standard deviations. Those outliers identified were Winsorized to the next most extreme value.

The demographic items self-reported by participants were also examined for outliers with z-scores above 3.29. Of the 414 participants, one participant who identified as “other” in the gender variable was subsequently removed from further analyses. In addition, season was recoded as *summer term/fall term* versus *winter term* as opposed to comparing all three terms separately. The dichotomization of these three variables to investigate whether they predicted walking was necessary because HLM does not assume that higher numbers represent different categories in categorical variables.

Neighbourhood-level data. Seven of the items in the ONS walkability data were reversed recoded prior to creating subscale scores. A higher score indicates greater walkability. We used frequencies to check our reverse coding in SPSS 23®. The resident median income after-tax variable obtained from the ONS database was also examined for any coding irregularities (i.e., values outside of the minimum and maximum values). For the ONS walkability scale and the resident median income after-tax variable, outliers that were greater than 3.29 standard deviations were Winsorized to next most extreme value.

Spatial dependency data. The shared boundaries between the 64 neighbourhoods were assessed by creating two independent files, which were later compared to ensure accuracy. Each neighbourhood that participated in the study was coded from 1 to 64 in SPSS 23® to avoid potential software issues. Shared boundaries[9] for each neighbourhood were assessed by using the interactive map on the ONS website. The total number of shared boundaries was tallied. A total of 268 shared boundaries were found in this paper.

To ensure the accuracy of the spatial dependency data, a second rater reviewed each file to ensure that all shared boundaries were recorded and the correct neighbourhood number was recorded. Both files were then examined using a series of algorithms in Excel to ensure both data files matched. In addition, several algorithms were also used to confirm that the tallied value was correct.

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[9] Shared boundaries in this thesis was not based on weighted values due to the new version of the HLM program that only accounted for rook contiguity

Dependent variable. A total walking frequency score from past two weeks was created from multiplying the number of times walked with the number of minutes of walking reported. This was carried out for 430 participants. The walking frequency score for participants over the past two weeks had a skew of 2.29 and kurtosis of 7.39 and underwent a square root transformation. The transformation improved both the skewness (.547) and kurtosis (.217) dramatically. Five participants were removed due to z-scores above 3.29. Using a cut-off of a total of 2600 minutes in the last 14 days (i.e., approximately 3 hours of walking a day) resulted in 11 additional removals for a final sample of 414 participants.

Results

Justification Checks for HLM

Our first HLM justification check examined dataset for variance in our dependent variable (i.e., walking), which was statistically significant indicating that there was enough variance in our dependent variable from neighbourhood to neighbourhood to justify using HLM, χ^2 (63) = 150.55, $p < .001$. The second HLM justification check examined whether more than 10% of the variance in our dependent variable between neighbourhoods existed. In our dataset, the ICC value was 0.1706. Thus, 17.06% of the variance in time walking is attributed to the neighbourhood level. As this is above the cut-off of 0.10, a multi-level analysis was performed.

Trained Observers' Inter-Rater Reliability for the ONS Subscales

We conducted inter-rater reliability analyses for the ONS subscales that were similar to NEWS-North factors (i.e., *safety from traffic*, *aesthetics*, *safety from crime, sidewalks*, and *pedestrian/bike comfort* subsections) to determine the agreement between the two ONS trained observers. We found high agreement, with ICC values greater than 0.75 (Portney & Watkins, 2009), across all five subscales: *safety from traffic* (ICC= .96, 95% CI .94, .98), *aesthetics*

(ICC= .99, 95% CI .98, .99), *safety from crime*(ICC= .95 , 95% CI .91, .97), *sidewalks* (ICC= .99, 95% CI .99, .996), and *pedestrian/bike comfort* (ICC= .99, 95% CI .98, .99).

Participant Sample Characteristics

Participant characteristics can be found in Table 1. Approximately 50.2% of participants completed the pilot study in the summer (May to August) or fall (September to December) terms compared to the 49.80% that participated in the winter months (January to April). The majority of participants were 18 to 24 years of age (50.50%), followed by 31 to 40 years olds (15.90%). In addition, many participants were female (71.70%), did not own a dog (75.20%), had no children (79.20%), and had no physical disability (97.10%). The majority of participants had lived at their current residential address for either 1 to 3 years (30.60%) or 11 years or more (30.60%). Nearly half of the participants listed their highest education level as completion of high school (48.90%); more than 20% had at least an undergraduate degree (21.10%). The main method for transportation to school and/or work was by public transportation for both school (75.9%) and work (36.8%).

Of those 176 participants excluded from analysis (102 due to multivariate outliers; 56 due to less than one year at their current address; 20 due to objective data being unavailable), the majority of the participants were 18 to 24 years of age (44.9 %), completed high school (36.6%) or had completed an undergraduate degree (21.7%), had no children in their household (70.9%), reported no physical disabilities (95.5%), were residents (56.3%) opposed to ISPR, and were female (75.0%). The largest participation occurred in the winter months (i.e., January to April; 52.8%) followed by the fall months (September to December; 30.7%) then summer months (May to August; 16.5%). The most popular method of transportation to school for students was public transport (69.47%) followed by walking (13.5%), while other participants reported that their transportation for work consisted of either public transport (28.7%) or driving (38.8%). The 176 excluded participants came from 57 Ottawa neighbourhoods with residents in Centretown (10.7%), Sandy Hill (10.1%), and Bayshore (6.0%) being the most common.

Ottawa Neighbourhood Characteristics

Demographics at the neighbourhood-level can be found in Table 2. Of the 414 participants, 7.70% were from Orleans Avalon-Notting Gate, 7.50% from Centretown, 4.10% from Glebe-Dows Lake, 3.90% from Sandy Hill, 3.40% from Stonebridge- Halfmoon Bay, and 3.10% from Elmvale.

Overall, the Ottawa neighbourhoods are demographically and socially diverse. Neighbourhoods with the highest household ownership were Riverside South- Leitrim (96.10%), Queenswood Heights (95.90%), and Stittsville. Neighbourhoods with the highest number of tenant households were Lowertown (79.20%), Centretown (77.30%), and Sandy Hill (75.70%).

The median resident after-tax income ranged from \$21,380 (Ledbury neighbourhood) to \$49,654 (Wellington Village neighbourhood). The median after-tax income category included 16 neighbourhoods within the \$20,000 to \$29,999 category, 31 neighbourhoods within the \$30,000 to \$39,999 category, and 17 neighbourhoods within the \$40,000 to \$50,000 category.

The percentage of employed residents ranged from 46% to 77.60%. The neighbourhoods with the highest percentage of employed residents included Riverside South- Leitrim (77.60%), Orleans Avalon (73.80%), Chapman Mills (72.60%), and Stonebridge (72.50%). The lowest percentages of employed residents were in the Wateridge Village (49.30%) and Woodroffe-Lincoln Heights (46%) neighbourhoods.

The percentage of married people in neighbourhoods ranged from 38.80% (Hintonburg-Mechanicsville) to 73.30% (Riverside South - Leitrim). Kanata Lakes-Marchwood Lakeside

(70.20%), and Stittsville (67.60%) neighbourhoods also had a high percentage of married residents. The percentage of single or never legally married people ranged from 38.40% (Vanier South) to 54.50% (Sandy Hill). Both the Byward Market (51.20%) and Centretown (50.90%) neighbourhoods also had large rates of single or never legally married residents.

Results accounting for Neighbourhood Spatial Dependence

Results from the spatial dependency analyses can be found in Table 3. Our dataset met the recommended HLM guidelines for each independent variable at each level that included: (a) achieving convergence with less than 2000 computational iterations of the program, and (b) having a reliability greater than .05. In our dataset, iterations ranged from 62 to 184, and the reliability ranged from .28 to .53 for the independent variables in our 2-level HLM.

Spatial dependency of walking behaviour in our data set. Participants in the study spent an average of 200.51 minutes walking over the past 2 weeks (standard error of 1.05, $p < .001$). The within-neighbourhood variance in walking was 82.22. We used the average Level Two variance to estimate the between-neighbourhood variance after controlling for spatial dependence. The average Level Two variance is calculated for each neighbourhood and includes the variance of the dependent variable (i.e., walking after controlling for spatial dependence) across that neighbourhood and its contiguous neighbourhoods, which is averaged across those two variances. The between-neighbourhood variance in this data set is 13.76. However, the between-neighbourhood variance not controlling for spatial dependence is 40.83.

The spatial dependence correlation for this data set uses the goodness of fit that compares with and without spatial dependency; this statistic was χ^2 (1) = 9.41, p =.003, ρ = .67. This indicates that spatial dependency analyses should be used. The rho value refers to whether or not neighbourhoods that are in close proximity have similar values on the dependent variable (i.e., walking) whose value in this paper is .67, also denotes a strong spatial autocorrelation that reaffirms the use of spatial dependency analyses.

Individual-level walking behaviour. In terms of the NEWS-North subscales, only the *sidewalks* subscale was a marginally significant predictor of walking. Without control variables, for every unit increase in the *sidewalks* subscale, there was a decrease of 8.13 extra minutes in walking over the past two weeks (approximately 0.58 extra minutes per day, $p = .061$); the effect size was small (*R-squared* = .02). However, when controlling for dog ownership, gender, and season there was a decrease of 8.41 extra minutes in walking over the past two weeks (approximately 0.60 extra minutes per day, $p = .053$) for every unit increase in the *sidewalk* subscale, although the effect size was very small (*R-squared* = .02).

Neighbourhood-level. At the neighbourhood-level, two of the six equivalent subscales predicted walking behaviour with and without controlling for resident median income after tax in neighbourhoods.

Without the inclusion of the control variable, the *sidewalks* subscale from the ONS was marginally significant although the overall effect size was small (*R-squared* =.04). For every 1-unit increase in the *sidewalks* subscale, there was an increase of 13.23 extra minutes in walking over the past two weeks (approximately 0.95 extra minutes per day, $p = .059$). However, when controlling for the after-tax income the *sidewalks* subscale was significant. Specifically, for every 1-unit increase in the *sidewalks* subscale, there was an increase of 19.12 extra minutes in walking over the past two weeks (approximately 1.37 extra minutes per day, $p < .001$; *R-squared* =.07).

The *land use access* subscale equivalent (i.e., GIS), Frank's walkability index (Frank et al., 2010), was significant in both analyses. For every 1-unit increase in Frank's walkability index (Frank et al., 2010), there was also an increase of 19.12 minutes in walking over the past two weeks (approximately 1.37 extra minutes per day, $p < .001$, *R-squared* =.07) without controlling for income after tax. Similar results were found when controlling for resident income after tax. There was an increase of 18.23 minutes in walking over the past two weeks (approximately 1.30 extra minutes per day, $p < .001$, *R-squared* =.08), for every 1-unit increase in Frank's walkability index (Frank et al., 2010).

In addition, a marginally significant effect was found for median income after taxes such that for every 1-unit increase in the income category, there was a decrease of 41.50 minutes in walking over the past two weeks (approximately 2.96 minutes per day, $p = .082$) but the effect size was small (*R-squared* =.03).

Interaction terms. The interaction between season and the *traffic safety* subscale ($p = .004$) had a negative but significant effect without the inclusion of the control variables. During the winter term, the relationship between the *traffic safety* subscale and walking was more strongly negative than in the summer/fall term. In other words, as perceptions in the *traffic safety* subscale increased, the amount of total walking in the past two weeks reported was decreased although the effect size was very small (*R-squared* = .01). Similarly, a negative but significant effect between season and the *traffic safety* subscale ($p = .007$) was found controlling for gender and dog ownership.

Agreement between individual-level and neighbourhood-level subscales. The agreement between six subscales in the NEWS-North and their conceptually related subscales from the observer rated ONS walkability scale is determined whether or not significance is obtained. Of the six comparable subscales, only three NEWS-North subscales were significantly correlated with their conceptually related subscales from the objective data. There was significant agreement between in both datasets in the *aesthetics* scales ($p < .001$); the agreement between both *pedestrian/bike comfort* scales was also significant ($p = .017$); and significant agreement in the *land-use access* subscale measured by Franks ($p < .001$). Marginally significant agreement was also found for the *safety from traffic* ($p = .062$) subscale. However, both the *safety from crime* ($p = .53$) and *sidewalks* ($p = .54$) subscales were not significantly correlated with their comparable ONS measure.

Discussion

The goal of this paper was to examine the convergent validity of the NEWS-North in two ways (a) the predictability of walking for each of the seven sections of the NEWS-North at the individual level; and (b) the relationship between the comparable six sections of the subjective NEWS-North (i.e., individual level) with the objectively measured walkability (i.e., at the neighbourhood level).

Individual-level Predictors

NEWS-North subscales. The *sidewalks* subscale was a marginally significant predictor of walking behaviour both with and without the inclusion of the control variables. In both cases, every 1- unit increase in the *sidewalks* score was related to a decrease in minutes walking per day over the past two weeks. This finding is inconsistent with previous research that pedestrian infrastructures are important for walking (Saelens & Handy, 2008). Shay, Rodriguez, Cho, Clifton, and Evenson (2009) reported that people who lived in neighbourhoods with a variety of walking infrastructure, such as desirable sidewalks conditions (e.g., presence and width), crossing aids, and crosswalks in their neighbourhood would walk more. Moreover, better sidewalk maintenance is related to more walking in both adults (Kirchner, Gerber, & Smith, 2008; Perez et al., 2016) and older adults (Gallagher et al., 2010). However, a focus group by

Ferrer, Ruiz, and Mars (2015) found that some participants reported that sidewalk cafés, and restaurant patios were seen as obstacles. It is possible that due to the majority of participants that reside in centralized urban neighbourhoods perceived a lot of patios and food trucks that obstructed their ability to walk. Moreover, many of the participants were students who walk regardless of sidewalks to get to class.

The *winter walking* subscale on the NEWS-North was not a predictor of walking. It is possible that this is due to the fact that this section was given to all respondents regardless of season, thus the ability for them to recall in the summer/fall could have been less accurate when compared to actually completing the category in the actual winter. Another reason may be that students, in particular, have similar walking behaviours regardless of the weather (Mitra & Faulkner, 2012; Motoaki & Daziano, 2015). For the participants who completed the survey in the winter term, a stratified analysis also examined whether the *winter walking* subscale on the NEWS-North predicted walking (i.e., January to April). However, the *winter walking* subscale was again not significant.

Neighbourhood-level Predictors

NEWS-North comparable subscales measured objectively. Of the six equivalent ONS subscales of the NEWS-North, two subscales predicted walking behaviours with analyses and without controlling for resident median income after tax. However, the overall effect sizes of these predictors were small.

The *sidewalk* subscale equivalent reached marginal significance in the model without other control variables and was significant when controlling for resident income after tax. Specifically, for every 1-unit increase in neighbourhood sidewalk quality and presence, participants were likely to walk approximately 0.95 extra minutes per day over the past two weeks (without control variable) versus 1.37 extra minutes per day over two weeks (while controlling for income after tax).

The *land use access* equivalent subscale, based on by Frank's walkability index (Frank et al., 2010), was a significant predictor of walking but the effects were small. For every 1-unit increase in the Frank's walkability index in a neighbourhood, an increase of only 1.37 extra minutes per day in walking, and 1.30 extra minutes per day in walking when controlling for income after tax. Our finding is inconsistent with previous literature that show larger effects. Adults who live in highly connected neighbourhoods tend to report higher levels of physical activity (King et al., 2011; Siqueira Reis, Hino, Ricardo Rech, Kerr, & Curi Hallal, 2013). The small increase per day in the minutes spent walking may be due to the fact that some neighbourhoods with very different walkability indices may be physically very close to each other. Furthermore, people of working age often spend much of their day in neighbourhoods in which they work. This would have the effect of blurring the differences between residential neighbourhoods.

Resident median income after tax variable. The median income after tax in a neighbourhood was only marginally significant for predicting walking behaviour. For every 1-unit increase in median income, participants were likely to walk 2.96 less minutes per day over the past two weeks. This decrease is quite small.

Agreement between Individual-level and Neighbourhood-level Subscales

There was significant agreement between the individual level and the neighbourhood level for both *aesthetics* and *pedestrian/bike comfort* subscales and marginally significant agreement for the *safety from traffic* subscales. The correspondence in aspects of walkability between objective and subjective measures from previous cross-sectional studies have been mixed. Some researchers have found poor agreement (Macdonald, Kearns, & Ellaway, 2013; McGinn, Evenson, Herring, Huston, & Rodriguez, 2007); while other researchers have found moderate agreement (Gebel et al., 2011) between GIS and subjective measures of walkability. A study by Bailey et al. (2014a) found high agreement between neighbourhood audits and self-reported walkability. In our data, agreement on the *pedestrian/bike comfort* subscale may have been hindered by the fact that several items in the NEWS-North (e.g., “sidewalks in my neighbourhood sometimes end in the middle of the block”) had no comparable item in the ONS.

It is not surprising that there was agreement between the two levels on the *aesthetics* subscale as items included the presence of litter and trees, which are easy to asses. Similarly, residents may be adept at recalling whether or not benches and trails are present in their neighbourhood. In regards to the *safety from traffic* subscale, the items included between the two levels were nearly identical.

Interactions

The relationship between walking and perceived traffic safety varied according to season. In the winter term, in comparison to summer or fall, we found that walking time decreased more with increases in traffic safety but the effect size was very low. It is possible that participants who feel less safe from traffic in the winter took longer routes to feel safer such as using connecting buildings and malls. It is also possible that participants who feel safer from traffic in the winter still use their same route but underestimated their total time walking. When controlling for owning a dog and gender, the negative interaction slightly decreased but remained negative.

Strengths

Development of the NEWS-North is an important contribution to the field of the built environment and health. Researchers in northern climates can use the NEWS-North to assess subjective walkability in all seasons, including winter. Convergent validity of the NEWS-North was examined in two ways: (a) whether each section of NEWS-North predicted walking, and (b) the comparison between NEWS-North subscales and objectively measured walkability. Other adaptations have examined validity only at the individual level. For example, construct validity (i.e., comparing the adapted questionnaire scores of residents who live in identified high versus low walkable neighbourhoods) and concurrent validity (i.e., the relationship between the adapted questionnaire and self-reported physical activity) was assessed for the NEWS-Africa at the individual level (Oyeyemi et al., 2013).

Secondly, this paper used updated objective databases for Ottawa neighbourhoods maintained by the ONS. Often objective data bases are incomplete (Bodea et al., 2008) and can be unreliable due to irregular updates (Lee & Talen, 2014). The inter-rater reliability for the ONS subscales was high. In addition, the objective databases that included various neighbourhood variables were obtained recently, in 2015.

These results also highlight the importance of examining datasets for spatial dependencies. If spatial dependencies are present but ignored in the HLM, standard errors are often underestimated while providing a poor goodness of fit when compared to HLM analyses conducted with spatial dependencies (Raudenbush et al., 2011). In addition, data sets that demonstrate spatial dependency (i.e., nearby neighbourhoods are similar compared to further neighbourhoods on a dependent variable) should use spatial dependency analyses in order to avoid misleading results (Park & Kim, 2014).

Limitations and Future Research

Despite the strengths of this study, there are some limitations. First, the majority of the significant and marginally significant results at both the individual and neighbourhood level had small effect sizes. Moreover, the majority of the results were small (e.g., 0.95 minutes to 2.96 minutes spent walking per day over the past two weeks).

Second, in both of our analyses (i.e., control variables versus without) the majority of subscales did no predict walking behaviour. At the individual level, six of seven of the NEWS-North subscales did not predict walking in Ottawa, Ontario. Similarly, four of the six observed walkability subscales of the ONS were not significant at the neighbourhood level. At both levels, the *sidewalk* subscale was only marginally significant in most cases. It is possible that the study may have been underpowered as only 64 of the 74 neighbourhoods that had objective data available were included. Furthermore, the fact that half of the sample comprised students may also be relevant as students may be more likely to walk, regardless of neighbourhood conditions (Norzalwi & Ismail, 2011). Only when controlling for resident median income after tax, at the neighbourhood level, did the *sidewalk* subscale reach significance. Previous research has found that higher income has been related to better quality of sidewalks in neighbourhoods and greater presence of sidewalks in neighbourhoods (Boehmer, Hoehner, Deshpande, Brennan Ramirez, & Brownson, 2007).

Third, the NEWS-North and ONS subscales were not identical in terms of the number of items and topic covered. For example, in the *pedestrian and bike comfort* section, the ONS had three items that were comparable to the six items on the NEWS-North. Items shared between the two measures included the presence of pedestrian paths, benches, and bicycle trails. However, the NEWS-North contained additional items not present in the ONS such as sidewalk continuity, safety walking on streets without sidewalks, and safety of walking in the winter on streets without sidewalks.

Fourth, in the current paper, the *winter walking* subscale of the NEWS-North could not be compared to an ONS subscale. However, wintry conditions in Canadians have been shown to influence walking behaviours of adults (Merchant et al., 2007).

Fifth, this pilot test only included English-speaking participants. Thus, we may have excluded recent immigrants who do not speak English well. Some francophones too, may have felt uncomfortable completing a survey in English, so it is likely that we missed potential participants. Lastly, the results presented in this paper are only generalizable to our demographic group who were largely female, had no children, nor owned a dog.

Sixth, the use of the measure used to assess walking behaviour may not have been ideal due to the short assessment duration of participants walking over the past two weeks. We could have used an additional measurement tool (e.g., pedometer) for assessing walking but were unable due to financial restrictions.

Finally, we removed a number of participants due to short (and unrealistic) completion times, being a multivariate outlier and having missing data. We could have used multiple imputation for some of the missing people in order to bring up the sample size, but felt that this would result in over fitting, especially for the factor analysis. It is recommended that in further research on the NEWS-North, researchers Windsorize outliers rather than removing them from the dataset. In addition, we recommend that researchers use a walking questionnaire that assesses both walking frequency and walking duration separately as opposed to combining them.

Future research involving the NEWS-North would benefit from a comparison to objective data in all 103 neighbourhoods in Ottawa. Future research may test the NEWS-North in a more wintry area such as the Yukon or Northwest Territory. It is important to adapt the NEWS-North for Canadian francophones, because the official languages of Canada are English and French.

Conclusion

Our adapted walkability questionnaire for northern climates, the NEWS-North, included seasonal variability during data collection as well as new items in the questionnaire. At the individual level, the *sidewalk* subscale of NEWS-North was mostly a marginal predictor of walking with and without controlling for dog ownership, season, and gender. At the neighbourhood level, the *land use access* equivalent subscale was a significant predictor of walking with and without controlling for median income after tax. Of the six similar ONS subscales in the NEWS-North and ONS, *aesthetics*, *land use access*, and *pedestrian/bike comfort* had significant matching between objective and subjective data, and marginal significance was also found for the *safety from traffic* subscale. Overall, some convergent validity was found for the NEWS-North in the current pilot test. We believe that more validation studies are required before the News-North is ready to use.

Table 1

Sample Characteristics of Participants

Variable	*n*
Participant (*N* = 414)	
Student	213
Resident	201
Term (*N* = 414)	
Summer or Fall	208
Winter	206
Gender (*N* = 413)	
Male	117
Female	296
Age in years (*N* = 414)	
18 to 24	209
25 to 30	64
31 to 40	66
41 to 50	40
51 to 60	20
61 to 70	12
71 to 80	2
81+	1
Highest Education (*N* = 413)	
Did not complete high school	2
Completed high school	202
College diploma or trades certificate	41
Undergraduate degree	87
Graduate degree	69
Professional degree (e.g., M.D.)	12
Dog Owner (*N* = 412)	
No	310
Yes	102
Children (*N* = 414)	
None	328
1 child	31
2 children	34
3 children	16
4 children	5
Current Address (*N* = 414)	
1 to 3 years	128
4 to 5 years	63
6 to 10 years	95
11+ years	128

Variable	*n*
Transport for School ($N = 410$)	
Walk	37
Bike	7
Public Transport	202
Drive	15
Other	5
Not Applicable	144
Transport for Work ($N = 413$)	
Walk	59
Bike	34
Public transport	120
Drive	99
Other	14
Not Applicable	87
Physical Disabilities ($N = 411$)	
No	399
Yes	12

*based on completed answers from participants

Table 2

Ottawa Neighbourhoods and Neighbourhood Characteristic Variables

	Pilot Study	ONS Neighbourhood Characteristics			
Ottawa Neighbourhood	*n*	% HTO	MRI	% MS [A]	% E
Barrhaven	7	94.6	37288	61.3	71
Beacon Hill South – Cardinal Heights	3	74.6	32252	49.6	60.3
Bells Corners East	1	88	34056	53.8	54.8
Billings Bridge – Alta Vista	6	65.7	34322	53.5	60
Blackburn Hamlet	2	76.4	35076	58.9	59.8
Braemar Park – … – Copeland Park	6	67.3	31400	55.6	64.2
Bridlewood – Emerald Meadows	7	92	41141	66.7	69.6
Byward Market	6	35.1	35899	**51.2**	66.5
Carleton Heights – Rideauview	3	52.7	23940	44	58.2
Carlington	5	32	22962	41.7	54.8
Carlingwood West – …– McKellar Heights	1	84.5	39878	56.5	59.4
Centrepointe	2	78.8	43282	56.5	65.5
Centretown	31	22.7	35998	**50.9**	71
Chapel Hill North	3	85.9	40377	65.3	65
Chapel Hill South	3	94.6	41329	66.2	69.7
Chapman Mills – … – Davidson Heights	5	89.5	42195	65.9	72.6
Chatelaine Village	4	93	37453	62.2	70.2
Cityview– Crestview – Meadowlands	5	69.2	29222	51.3	59.6
Civic Hospital – Central Park	2	67.2	38639	55.3	63.9
Cummings	4	43.5	35360	45.2	55.4
Elmvale – …– Riverview Park West	13	48.4	30561	49	64.5
Emerald Woods – Sawmill Creek	3	47.5	27329	51.4	55.6
Glebe – Dows Lake	17	56.4	47077	52.8	68.8
Glen Cairn – Kanata South Business Park	3	87.5	33597	61.7	68.7
Greenboro East	7	78.7	33097	53.4	70.1
Hawthorne Meadows – Sheffield Glen	4	39.2	24530	44.2	64.5
Hintonburg – Mechanicsville	11	36.7	30496	38.8	64.2
Hunt Club East – Western Community	5	62.2	31054	51	60.8

Ottawa Neighbourhood	Pilot Study	ONS Neighbourhood Characteristics			
	n	% HTO	MRI	% MS [A]	% E
Hunt Club Park	10	83.1	32130	53.8	64.8
Hunt Club Upper –… – Timbermill	2	81.3	32922	57.7	66.7
Hunt Club Woods – Quintarra – Revelstoke	5	92.8	42065	63.3	56.2
Iris	5	55.6	31280	49.9	62.4
Kanata Lakes – …– Kanata North Business Park	8	95.4	42651	70.2	69.9
Laurentian	3	56.8	37555	56.8	60.2
Ledbury – Heron Gate – Ridgemont	7	30.1	21380	42.4	55.9
Lindenlea – New Edinburgh	3	47.5	46050	52.5	62.7
Lowertown	12	20.8	26304	**47.2**	61.5
Old Ottawa East	3	31.2	28268	**50.8**	69.1
Old Ottawa South	10	78.6	46230	59.6	70.9
Orleans Avalon – … – Gardenway South	32	94.3	43189	64	73.8
Orleans North West	12	88.9	40019	60.3	65.3
Orleans Village Chateauneuf	7	87.9	39864	60.3	68.7
Overbrook – McArthur	6	39.7	25117	42.1	53.3
Playfair Park – Lynda Park – Guildwood Estates	4	72.5	36127	57.4	54
Qualicum – Redwood Park	3	73.1	35831	55	62.3
Queenswood Heights	4	95.9	39106	63.8	66.6
Riverside Park	3	58.1	31324	50.5	54.8
Riverside South – Leitrim	7	96.1	47901	73.3	77.6
Rockcliffe Park	2	75.9	43788	60.4	61
Rothwell Heights – Beacon Hill North	7	82.3	38558	59.3	55.5
Sandy Hill	16	24.3	25023	**54.5**	63.9
Skyline – Fisher Heights	2	49.1	28953	50.2	57
Stittsville	5	95.8	41850	67.6	67.9
Stonebridge – Halfmoon Bay – Heart's Desire	14	92.8	40533	67.3	72.5
Tanglewood	4	69	30252	52.6	63.2
Vanier North	8	40.2	28848	40.9	58.7
Vanier South	4	29	22436	**38.4**	54
Wateridge Village	4	37.1	28643	41.3	49.3
Wellington Village	1	82.9	49654	63.4	69.7
West Centertown	11	25.6	23332	**43.8**	62.2

	Pilot Study	ONS Neighbourhood Characteristics			
Ottawa Neighbourhood	*n*	% HTO	MRI	% MS [A]	% E
Westboro	8	50.8	39276	52	65.3
Whitehaven – Queensway Terrace North	7	51.7	28943	47.8	57.1
Woodroffe – Lincoln Heights	3	45.7	33715	42.9	46
Woodvale – … – Estates of Arlington Woods	3	63.8	32632	56.3	60.5

Note. Data source Ottawa Neighbourhood Study (2013).
HTO= percentage of Household Tenure Owned; MRI= Median Resident after-tax Income; MS= percentage Marital status; E= percentage of employment

[a] The percentage of marital status, unless otherwise specified refers to married/ common-law. Single-never legally married is denoted by bold.

Table 3

Predictors of Walking at the Individual level, Neighbourhood level, and Interactions (N=434)

Level and Variable	*Coefficient*	Standard Error	*p*
Individual Level (no control variables)			
Gender variable	0.57	1.04	0.585
Own dog variable	1.81	1.09	0.100
Season [a] variable	-0.33	0.96	0.734
Factor 1 traffic	-0.20	0.13	0.131
Factor 2 aesthetics	0.16	0.16	0.335
Factor 3 land use access	0.12	0.18	0.499
Factor 4 winter	-0.07	0.13	0.604
Factor 5 crime	0.11	0.23	0.621
Factor 6 sidewalks	-0.29	0.15	0.061
Factor 7 pedestrian and bike	0.03	0.15	0.821
Individual Level (control variables [b])			
Factor 1 traffic	-0.21	0.14	0.114
Factor 2 aesthetics	0.14	0.16	0.391
Factor 3 land use access	0.11	0.18	0.519
Factor 4 winter	-0.03	0.13	0.793
Factor 5 crime	0.12	0.23	0.608
Factor 6 sidewalks	-0.30	0.15	0.053
Factor 7 pedestrian and bike	0.04	0.15	0.767
Individual Level Interaction (no control variables)			
Season by Factor 1 interaction [c]	-0.76	0.26	0.004
Individual Level Interaction (control variables [2])			
Season by Factor 1 interaction [c]	-0.72	0.27	0.007
Neighbourhood Level (no control variable)			
Factor 1 traffic equivalent	0.87	0.90	0.336
Factor 2 aesthetics equivalent	-0.22	0.51	0.664
Factor 3 land use access equivalent	0.66	0.16	< .001
Factor 5 crime equivalent	-0.78	0.57	0.179
Factor 6 sidewalks equivalent	0.46	0.24	0.059
Factor 7 pedestrian and bike equivalent	-0.69	0.47	0.143
Resident median income after tax variable	-1.55	0.88	0.082
Neighbourhood Level (with control variable [d])			

Level and Variable	*Coefficient*	Standard Error	*p*
Factor 1 traffic equivalent	1.14	0.87	0.199
Factor 2 aesthetics equivalent	0.49	0.63	0.444
Factor 3 land use access equivalent	0.63	0.16	< .001
Factor 5 crime equivalent	-0.70	0.58	0.230
Factor 6 sidewalks equivalent	0.66	0.18	< .001
Factor 7 pedestrian and bike equivalent	-0.67	0.45	0.147

Note. The p-value identifying statistical significance used was $p <. 05$
The coefficient is related to the total walking behaviour (the dependent variable) over the past two week. The actual minutes walking over the past two weeks are presented in the results section for the significant variables as the coefficient is calculated into a meaningful value.

[a] season (coded summer/fall vs. winter).
[b] at the individual level, controlling for gender, dog ownership, and season.
[c] season (summer/fall vs. winter) by traffic safety.
[d] at the neighbourhood level, controlling for resident median income after tax variable.

Appendix A

Selected Item Comparisons from the ONS and NEWS-North

NEWS-North item	ONS Item Photo scale	Spearman's Rank Correlation	*p*
C3. The sidewalks in my neighbourhood are well maintained (paved, even, and have few cracks).	Quality sidewalks (Aesthetics subscale)	.033	.782
C4. There are pedestrian trails in or near my neighbourhood that are easy to walk to.	Quality of paths & trails (Parks subscale)	.097	.411
C5. There is a strip (grass/dirt/ concrete) that separates the road from the sidewalks in my neighbourhood	Proximity to traffic (Walkability subscale)	.125	.284
C8. There are bicycle trails in or near my neighbourhood that are easy to bike to.	Quality of paths & trails (Parks subscale)	.042	.725
E1. There are trees along the streets in my neighbourhood	Quantity of trees (Aesthetics subscale)	.052	.658
F3. There are enough crosswalks and pedestrian signals to help walkers cross busy streets in my neighbourhood.	Intersection safety (Walkability subscale)	.051	.667
F5. When walking in my neighbourhood, there are a lot of exhaust fumes (such as from cars, buses).	Unpleasant smells (Parks subscale)	.010	.934
G2. Walkers and cyclists on the streets in my neighbourhood can be easily seen by people in their homes.	Proximity of houses to street (Walkability subscale)	.157	.181
G3. I often see and speak to other people when I am walking in my neighbourhood.	Amount of people walking (Walkability subscale)	.006	.961
G4. I feel safe walking in my neighbourhood during the day.	Hiding places (Walkability subscale)	.067	.571
G5. I feel safe walking in my neighbourhood at night.	Hiding places (Walkability subscale)	.130	.269

Appendix B

Variables Coded as Categories in HLM

Items	Coded Category
Individual-level	
Season	0: summer or fall term 1: winter term
Gender	0: male 1: female
Dog Ownership	0: no 1: yes
Neighbourhood level	
Median income after tax	1: $20,000 to $29,000 2: $30,000 to $39,000 3: $40,000 to $49,000

* Note: the variables that do not appear in this table are those with continuous values

Chapter 5: General Discussion

The objectives of this dissertation were to adapt the NEWS for use in Canada and other northern climates and to assess the reliability and validity of the adapted measure. In the first study, an initial draft of the NEWS-North was created through feedback received from three focus groups in Ottawa, Ontario then sent to an expert panel for a content validation assessment. The final NEWS-North version encompassed feedback from both the walkability experts and Ottawa residents. In the second and third studies, the finalized NEWS-North was pilot tested in an online survey in Ottawa, Canada. In this chapter, the main findings from each of the three studies are summarized. The implications of this dissertation, applied uses, strengths, future research, limitations, and an overall conclusion are also discussed.

Summary of our Results

In the first study, we first recruited Ottawa residents to participate in one of three focus groups that were formed to help us adapt the NEWS for use in northern climates. Two coders conducted qualitative analysis of transcripts from these groups; these analyses were used to create an initial draft of the NEWS-North. Several modifications were made: changing from American to Canadian phrasing, shorter and more precise subscale titles, beginning with more interesting subscales and adding a section on winter walkability.

We changed several items that used American phrasing (i.e., distance of football fields) and imperial units (i.e., miles per hour) to Canadian concepts and wording. Accurate wording of neighbourhood characteristics and features is paramount to avoiding misinterpretation (Foster, Tonkyn, & Wigglesworth, 2000). We also developed shorter and more precise subscale titles. Third, we rearranged the order of some subscales as the groups had suggested that the NEWS-North begin with interesting subscales to get participants inclined to demonstrate more active participation in the study. This result is consistent with Tourangeau (2004) who reported that participants often expect the subscale with a positive category to be presented first. Finally, we added a winter walkability section.

An expert panel of 11 walkability experts then reviewed the initial draft of the NEWS-North and completed content validation assessment. We examined both the quantitative and qualitative feedback from the content validation to examine whether or not each subscale included in the initial NEWS-North draft was important for assessing neighbourhood walkability; this was rated on a 4-point Likert scale. The content validation also included three questions on whether the subscales were missing any items, whether any current items could be removed, or if any current items were problematic), and an open-ended question asking there was any other suggestions. Two raters analyzed both the qualitative (i.e., descriptive analysis) and quantitative (i.e., tallied respondent options for each item in the subscale) feedback from the content validation separately. A third rater reviewed the content from both raters and moderated discussions on inconsistencies. The NEWS-North was revised on the basis of these suggestions.

The initial NEWS-North draft included eight of the original subscales of the NEWS (Saelens, Sallis, Black, et al., 2003) with the exclusion of winter walking. Quantitative analyses indicated that all of the nine subscales on the initial NEWS-North draft were rated from “very important” to “somewhat important” by the expert panel. Three of the nine subscales from the initial NEWS-North draft have also been consistently found in previous research to promote walking. These include residential density (Durand et al., 2011; Rodríguez et al., 2009; Wilson et al., 2012), street connectivity (Frank et al., 2012; Owen et al., 2004), and personal saftey from crime (Evenson et al., 2012; Shenassa et al., 2006; Wilbur et al., 2003). Five subscales of the initial NEWS-North draft have had mixed results in the literature. These included: aesthetics

(Humpel et al., 2002; Saelens & Handy, 2008), safety from traffic (Bentley et al., 2010; Sugiyama et al., 2012; Trost et al., 2002), land use mix diversity and proximity of destinations (Ball et al., 2001; Oliver et al., 2011), and pedestrian infrastructure (Huston et al., 2003; Lovasi et al., 2008). Finally, the inclusion of a winter walkability subscale was rated "very important" by 81.82% of experts and 18.18% of them rated them 'somewhat important' due to the challenges related to walking for pedestrians in the winter. This is consistent with previous research that has reported hazards of walking in the winter including icy conditions (Juvani et al., 2005) and greater likelihood of injury due to falls or slips (Ripat et al., 2010).

Following advice from the experts, five items from the initial draft were removed and two items combined, and five items were added to the questionnaire. Despite the suggestion to restructure two subscales (i.e., *land use mix-diversity* and *residential density*) from the focus groups, the experts disagreed with the substantial restructuring idea overall in order to maintain similar structure to allow for future comparisons. Overall, the adaptations of the NEWS led to important decisions regarding the format for the NEWS-North draft that was pilot tested in Ottawa, Canada.

In Study Two and Study Three, we pilot tested the finalized version of the NEWS-North. Participants were recruited from both the University of Ottawa (e.g., through the recruitment system, ISPR) and neighbourhood residents (e.g., social media).

In Study Two, we used data from the pilot test to conduct a MEFA to examine the factorial validity. We also conducted an internal consistency analysis (i.e., Cronbach's alpha) on subscales with the same Likert rating. The MEFA produced a 7-factor solution model. Four subscales were substantially modified. We combined *street connectivity* and *land use mix-access* subscales of the NEWS into one subscale termed *land use-access* (for the ability to access land uses through street connectivity) with a total of 5 items versus the original 11 items. Another factor included a *winter walkability* subscale that retained all but one item originally created for the subscale. We also divided *pedestrian infrastructure* features into two distinct factors: *sidewalks* subscale and *pedestrian/bike comfort* subscale. A few additional items from other subscales were included in those two distinct factors. Items grouped in the *sidewalks* subscale were specifically geared toward the qualities of sidewalks, such as obstacles (e.g., garbage bins), maintenance, and interaction with others (e.g., residents and/or pedestrians) while out walking. In comparison, the items grouped into the *pedestrian/bike comfort* subscale were related to the ability to comfortably walk or bike in a neighbourhood. These included items such as whether benches were available to rest, the ease of accessing pedestrian trails and bike trails, and feeling safe walking in neighbourhoods without sidewalks. However, the *safety from traffic* subscale, *aesthetics* subscale, and *safety from crime* subscale remained relatively intact on the basis of the factor analysis. The NEWS-North subscales of the 7-factor solution model had three subscales that had 'good internal consistency (Cronbach's alpha value of 0.70 or higher; DeVellis, 2003), while one subscale had an value of .53 and the remaining subscales were adequate with values that ranged from .60 to .65. Overall the results showed promising internal consistency for the first examination of the NEWS-North.

A series of two-way random model ICC analyses were used to examine test-retest reliability for each subscale in the 7-factor solution model. The majority of ICC values in the NEWS-North were high based on an ICC value greater than 0.75 (Portney & Watkins, 2009). The NEWS-North ranged from .88 to .93 with no differences between Time One and Time Two. The only significant difference between Time One and Time Two in the NEWS-North was the *safety from crime* subscale, despite a high ICC of 0.85.

In Study Three, we examined the pilot study data in 64 Ottawa neighbourhoods using HLM, accounting for spatial dependency. The overall objective of this study was to examine the convergent validity of the NEWS-North in two ways. First, the ability of the seven subscales from the MEFA of the NEWS-North to predict walking behaviour over the past two weeks was assessed. At the individual level, this analysis was conducted both with control variables included (i.e., dog ownership, gender, and season) and without the control variables included. In both analyses, the results indicated that of the seven subscales, only a marginally significant relationship for the *sidewalks* subscale was found on the NEWS-North. Overall, for every 1-unit increase in the *sidewalks* subscale, there was a very small decrease in the minutes spent walking per day (i.e., 0.60 minutes less with control variables included and 0.58 minutes without the inclusion of control variables) although the effect size was small. Our result is similar to the findings of Cerin et al. (2013), who found that items within the sidewalk subscale were generally problematic (e.g., "grass/dirt separating sidewalks and traffic"). This relationship may be due to a combination of factors. It is possible that the majority of neighbourhoods in Ottawa without sidewalks have very low traffic volume. More specifically, it is possible for a neighbourhood to be walkable without sidewalks if the amount of traffic is low. Also at the individual level, the interaction variable assessed with and without controlling for variables was similar. Overall, a significant negative interaction between the *safety from traffic* subscale and term revealed that during the winter term (i.e., January to April), minutes spent walking over two weeks decreased when the participants had better perceptions of traffic safety.

At the neighbourhood level, the *land use access* subscale equivalent (assessed by Frank's score) was a significant predictor of walking before and after controlling for resident median income in neighbourhoods. Our result is consistent with previous literature, which has reported that greater access to destinations and diversity of destinations increased walking behaviours (King, Bentley, Thornton, & Kavanagh, 2015). The *sidewalk* subscale equivalent was also a predictor of walking behaviours. However, at the neighbourhood level, there was an increase in the minutes spent walking over two weeks when compared to the individual level that had a decrease for every 1-unit increase in the *sidewalk* subscale.

Second, an additional analysis was conducted to examine the agreement between the NEWS-North and observer ratings on relevant subscales. The majority of the subscales in the NEWS-North had corresponding measurements with the ONS between the subjective and objective measures of the latent factor. These included *land use-access*, *aesthetics*, *pedestrian/bike comfort*, and *safety from traffic*. However, despite the lack of agreement between objective and subjective walkability for *safety from crime* subscale and *sidewalk* subscale, both may be measuring some slightly different aspects, but may still be important in influencing walking behaviours.

Implication of our Results

Several studies in Canada have examined physical neighbourhood environments and walking behaviours of adults through walkability-derived indices (Booth et al., 2013) and Walk Score (Chiu et al., 2016a; Hajna, Kestens, et al., 2016), which are derived from objective means like GIS. In contrast, some subjective walkability assessments (Grant et al., 2010; Montemurro et al., 2011) have been assessed by focus groups. However, until now, there was no perceived walkability questionnaire tailored for Canadians and cities with similar northern climates. Montemurro et al. (2011) noted that both objective and subjective walkability measures should include the effect of season due to changes reported in the winter for Canadians.

Findings from our three studies suggest that the NEWS-North has promise as an instrument to assess walkability in northern climates.

The initial validity and reliability evidence obtained in this dissertation of the NEWS-North is promising. The content validation of the experts helped us to adapt the NEWS into user-friendly questionnaire and for use in Canada and other northern climates. The examination of stakeholders and experts allowed us to gain insight on the barriers to walking in neighbourhoods with changes in seasonal climate. Not surprisingly, the experts noted winter walkability as a barrier to walking.

In this dissertation, a MEFA followed by the internal consistency analyses for each of the factors provided some evidence for validity based on the internal structure. Based on the MEFA, we retained the subscale structure for three of the original NEWS subscales, including *safety from traffic*, *aesthetics*, and *safety from crime*. However, the four remaining factors included items from two or more subscales of the NEWS.

The *land use-access* subscale of the NEWS-North combined two of the original NEWS subscales (i.e. *street connectivity* and *land use mix-access*). It is possible that this difference may have been due to the fact that two items (A5, B1) of the NEWS-North did not load on any factor and were subsequently removed from further analyses. This may also be due to the fact that the NEWS-North contained only three of the seven original items for *land use mix-access* and three of the five original items for the *street connectivity*.

Items from the original NEWS subscale *pedestrian infrastructure* formed two new factors (i.e., *sidewalks* subscale and *pedestrian/bike comfort* subscale). It is possible that both the modifications to the original items and/or the inclusion of additional new items are responsible for these particular differences between the NEWS-North and the NEWS.

In the *sidewalks* subscale, the original NEWS item “there are crosswalks and pedestrian signals to help walkers cross busy streets in my neighbourhood” was modified to “the pedestrian signals in my neighbourhood give me enough time to walk across the street.” This changed the meaning of the item from assessing the presence of crosswalks and pedestrian signals to whether there is enough time to cross a road. The addition of a new item “the sidewalks in my neighbourhood are free from obstacles (parked bicycles, electricity boxes, garbage bins)” extended the questionnaire to include potential obstacles that cause barriers to walkers.

In the *pedestrian/bike comfort* subscale, the original item “there are bicycle or pedestrian trails in or near my neighbourhood that are easy to get to” was modified so that ‘bicycle’ and ‘pedestrian trails’ each had their own item. In addition, the remaining four items (C2, C7, C9, D6) were created in this dissertation.

The *winter walking* subscale was completely new. For the *winter walking* subscale on the NEWS-North, the content validity evidence initially provided support for the *winter walking* subscale subscale as did the fact that most of the winter walkability items loaded on the same factor in the MEFA.

The majority of the seven factors had good to moderate internal consistency, which provides more evidence for validity based on internal structure. All of the seven factors of the NEWS-North had high test-retest reliabilities as ICC values were greater than 0.75 (Portney & Watkins, 2009).

Overall, findings from this dissertation support the use of the ecological model originally conceptualized by Bronfenbrenner (1986, 2004). In this dissertation, the proposed model in the paper adapted from Fitzgerald and Spaccarotella (2009) ecological perspective included the importance of considering seasonal neighbourhood barriers when assessing perceived walkability.

The *winter walking* subscale of the NEWS-North did not predict walking behaviours in this sample, which is inconsistent with some previous research (Shephard & Aoyagi, 2009; Trost et al., 2002; Wu, Luben, Wareham, Griffin, & Jones, 2017). For example, a study by Wu et al. (2017) reported that adults spent less time walking in colder temperatures with high precipitation. Spinney and Millward (2011) reported that weather affected physical activities in respondents who carried a Global Positioning System (GPS) data logger over a period of two days in Halifax, Nova Scotia. On the other hand, a recent study used an overall weather score based on a point allotment system; however no significant relationship between walking activity and season during the period of December 2002 to July 2003 was found (McGinn, Evenson, Herring, & Huston, 2007). In our study, the non-significant relationship between walking behaviour and the winter walking subscale of the NEWS-North may be due to several of the following possibilities. First, our study assessed walking behaviour subjectively over a short period of time (two weeks). Second, it may be due to the fact that half of the data was collected during the fall and spring. This may have made recollection of winter conditions more difficult. Moreover, another possibility for this non-significant relationship is due to the fact that many students are limited to walking as a result of their economic situation regardless of the weather.

We found a significant interaction between the season when NEWS-North was completed and the *safety from traffic* subscale of the NEWS-North with and without accounting for control variables (e.g., gender and ownership of a dog). During the winter months (i.e., January to April), participants who perceived less safety from traffic walked more than those who perceived greater safety. This result is somewhat counterintuitive, as other research has shown higher walking in neighbourhoods with higher perceived traffic safety (Li et al., 2005).

Interestingly, previous research has shown that weather's effect on self-reported walking is mixed (Chan & Ryan, 2009; Tucker & Gilliland, 2007). For example, Wilcox, Castro, King, Housemann, and Brownson (2000) reported that weather was not related to self-reported physical activity in the past two weeks for American women. However, Japanese residents who lived in low walkable neighbourhoods perceived bad weather as a greater hindrance than those living in high walkability neighbourhoods (Lee et al., 2007).

Support for convergent validity of the NEWS-North arises from the significant levels of agreement between three subscales (i.e., two NEWS-North subscales and the ONS walkability scores on these constructs; and the *access to destinations* subscale on the NEWS-North and Frank's score). We also found a marginally significant agreement for one subscale. This is important for several reasons. First, the data from the ONS and their corresponding NEWS-North subscales were measuring the same latent factor, which strengthens our preliminary results. Second, previous research has focused on objective and subjective measures based on physical neighbourhood attributes (Arvidsson et al., 2012; Lotfi & Koohsari, 2009). Saelens, Sallis, Black, et al. (2003) had highlighted the need for more objective and subjective measures to assess various neighbourhood characteristics of neighbourhood walkability.

This dissertation highlights the importance of examining a dataset using spatial dependency analyses in order to be sure that the analysis is appropriate. In our dataset, nearby neighbourhoods had a similar value on the dependent variable, which was confirmed by a significant moderate correlation of .67. Moreover, the use of spatial auto-correlated analyses is encouraged in ecological models (Legendre, 1993). Griffith (1987) reported that moderately positive spatial auto-correlations are typically found in the majority of social science research examining neighbourhoods. Variables such as population density and number of families with children in neighbourhoods are known to demonstrate spatial auto-correlation (Griffith, 1987). However, several of the adaptations of the NEWS analysis including the NEWS-Africa (Oyeyemi et al., 2014) and the Chinese abbreviated NEWS(Cerin, Macfarlane, et al., 2007) have not included a spatial dependency analysis. Results from analyses without spatial auto-correlation may be prone to errors in parameter estimates (Dormann, 2007).

Strengths

The research carried out through dissertation has several strengths. First, we followed a clear and rigorous adaptation protocol developed by the original authors of the NEWS. The protocol included clear instructions as well as a combination of qualitative (i.e., focus groups) and quantitative (i.e., pilot testing) methods to adapt the NEWS.

Second, this dissertation took an ecological model perspective that investigated aspects at the individual level, neighbourhood level, and the interaction of season to examine the walkability in adults. The inclusion of a theoretical model is important to understand the interaction between multiple variables in the influence of walking behaviours (Richard et al., 2010). The adaptation of the ecological model of Fitzgerald and Spaccarotella (2009) was instrumental in the development, framework, and execution of this dissertation.

Third, our analyses included all across Ottawa urban and suburban neighbourhoods to examine convergent validity. Previous NEWS adaptations have focused on neighbourhoods that compared only the high and low walkable neighbourhoods that had reported more significant results across subscales (Adlakha et al., 2016; Cerin et al., 2008; Oyeyemi et al., 2014; Oyeyemi et al., 2013) compared to the NEWS-North. It is possible that due to the NEWS-North being tested across Ottawa resulted in less significant results than those studies that examined extreme ends of neighbourhood walkability.

Fourth, at the time of this dissertation, to our knowledge, there is no perceived walkability that included seasonal barriers for use in Canada or other northern climates.

Limitations and Future Research

This dissertation is not without its limitations. First, residents' self-selection into neighbourhoods was not controlled for in this study. In other words, there is uncertainty regarding whether residents spend more time walking in walkable neighbourhoods, and also if walkable neighbourhoods attract residents who walk more (Mokhtarian & Van Herick, 2016). Future research on the NEWS-North should take into account self-selection bias. For example, a future study could include a map of a city, where participants could indicate the extent of their perceived neighbourhood and the areas where they walk.

Second, this questionnaire was limited to participants who were fluent in English. The development of a French version of the NEWS-North would be particularly useful in Canada, where the official language spoken is English and French. Furthermore, the inclusion of photos for each option on the Likert rating options for subscale of the NEWS-North to provide contextual imagery to standardize operational definitions across participants.

Third, winter walking was included in the NEWS-North, but we were unable to compare results from this scale to an objective measure of winter walkability. In the future, we would suggest that researchers perform this comparison.

Fourth, this dissertation examined convergent validity based on self-reported walking. Self-reported information has limitations including reporting less walking (Kitchen et al., 2011) and less reliable recollection of the past (Sallis & Saelens, 2000). While the use of a four-item questionnaire was used to assess walking behaviours, it was not adequate due to the short walking behaviour assessment period of two weeks. In the future, the use of an accelerometer of seven days (see Saelens, Sallis, Black, et al., 2003) rather than a self-report should be considered.

Fifth, the objective data from the ONS obtained from a combination of secondary sources as well as trained observers were matched to the subjective data of the NEWS-North, and had agreement on four of the seven subscales from the 7-factor model solution. Previous research has reported that the agreement between objective and subjective measures on neighbourhood walkability range from lack of agreement (Macintyre, Macdonald, & Ellaway, 2007; McGinn, Evenson, Herring, Huston, et al., 2007) to concordance (Arvidsson et al., 2012). It is possible that the differences reported in the literature are due to the variation of how neighbourhood walkability is measured and compared between objective and subjective data. Future development of the NEWS-North, partnered with the ONS, could involve objectively and subjectively comparing the NEWS-North across Ottawa neighbourhoods. For example, the ONS could have trained observers' rate neighbourhoods using the NEWS-North. Thus, the items on both measures would be identical as opposed to using the equivalent items.

Sixth, we assumed that self-reported walkability is a predictor of walking despite the observation study designs used and the largely cross-sectional evidence that was reviewed. Longitudinal studies can examine the relationship between walkability and self-reported walking. For example, adults who perceived a higher walkable neighbourhood showed increased self-reported walking (Chor et al., 2016).

Seventh, future research testing the NEWS-North could use two separate random samples. In particular, a sample to examine an exploratory analyses (e.g., MEFA) and a different sample to explore the structure (e.g., MCFA) opposed to using the same sample to confirm the structure of the NEWS-North. Unfortunately, due to the combination of thesis time and financial constraints this possibility of two separate random samples was not an option.

Finally, the NEWS-North is not ready to be used in mainstream research. More testing and revisions are still needed. Additional testing could include a larger resident sample from specific low and high neighbourhoods as opposed to a spectrum of neighbourhoods, shortening the number of items, as well as revisions based on a CFA and additional screening by another expert panel. Moreover, we recommend the use of a more objective walking measure such as a pedometer. We also recommend that further research on the NEWS-North be carried out in the winter.. The results in this dissertation were also based on a cross-sectional sample that was mostly comprised of women, did not own a dog, and did not have a child in their household. In the future, a longitudinal study with a greater variability in the sample would provide greater generalizability.

Future Applied Uses of the NEWS-North

There are several potential applications of the NEWS-North contingent on additional testing as the NEWS-North is not ready for use.

Community interventions. A community that is interested in increasing overall physical activity in their neighbourhood could use the NEWS-North to identify perceived barriers to walking for its residents at baseline. Interventions can be constructed based on the barriers identified. Following a successful introduction of the intervention, the NEWS-North can be redistributed to examine whether perceptions of a neighbourhood have improved.

Take for example, perceived high crime identified by the NEWS-North. Interventions could include the implementation of anti-crime programs such as Block Parents or Neighborhood Watch programs. A retest would be conducted at a later time to determine if there was an improvement in residents' perceived crime. Additional interventions would be aimed at both changing residents' perceptions and the physical environment. For example, one could both produce commercials aimed at residents' perceptions and interventions changing the physical environment (e.g., parking with emergency posts).

Government: Neighbourhood walkability and governing decisions and policies. The goal of city planners is to create and promote walkable neighbourhoods in a city that encourages sustainable, and healthy transportation options with minimal environment impact (Ariffin & Zahari, 2013). For example, ministries across Ontario, Canada have developed a plethora of polices aimed at the design and enhancement of creating a walkable neighbourhood (Bergeron & Lévesque, 2012). The NEWS-North has the ability to be implemented for government use. For example, using the NEWS-North to identify improvements from residents' perspectives directly who lives in a neighbourhood that has been granted funding towards infrastructure and services that promote walking. Improvements could range from the installation of sidewalks, to snow removal, or improved urban designs such as greater street connectivity.

Regarding urban policies, perceived winter walkability can identify barriers that are blocking residents from walking in the winter (e.g., no sidewalks, snow banks too high). Other policies include snow bank height to ensure that pedestrians are safe and seen by traffic as well as better snow clearance and salting of sidewalks. Similarly for public health interventions, the winter walkability of the NEWS-North has the potential to improving walking behaviours in neighbourhoods. For example, raising awareness of alternatives routes for walking (e.g., Hall/mall walkers for older adults to walk in hallways in winter), and additional access to programs (e.g., in the Bytown neighbourhood, walkers walk all year competitively as a group activity).

However, at this current time, governments and researchers should refrain from using the NEWS-North for monitoring perceptions of walkability.. The walking measure used was not ideal (i.e., only 4 items). Furthermore, we defined the three seasons according to the university academic terms. In addition, during the various seasons, the amount of precipitation was not measured when a snowfall occurred nor did the participant completed their walking measure that same/next day of the storm. Thus, on some days that participants completed questionnaires, the city may not have been experiencing winter weather. Moreover, it is also likely that our definition of 'season' was too broad making it difficult to find associations.

Conclusion

Physical activity, like walking, is an important to maintain a healthy lifestyle (Foster-Schubert et al., 2012). The NEWS-North was adapted for use within Canada and other cities with northern climates. Overall, the NEWS-North has shown good validity based on the content assessment and based on internal structure. In addition, the NEWS-North has shown high test-retest reliability for each of the subscales and some validity based on relations to external structure. More research relating the winter walkability section to winter walkability is needed.

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