Gauvin, L., Richard, L., Kestens, Y., Shatenstein, B., Daniel, M., Moore, S.D., Mercille, G., & Payette, H. (2012). Living in a well-serviced urban area is associated with maintenance of frequent walking among seniors in the VoisiNuAge study. *The Journals of Gerontology, Series B: Psychological Sciences and Social Sciences, 67(1)*, 76–88, doi:10.1093/geronb/gbr134. Advance Access published on January 6, 2012

Living in a Well-Serviced Urban Area Is Associated With Maintenance of Frequent Walking Among Seniors in the VoisiNuAge Study

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Objective. This paper examined whether or not closer proximity to local services and amenities was associated with maintenance of more frequent walking over time among urban-dwelling seniors over and above individual-level characteristics.

Method. A sample of 521 adults who were part of the VoisiNuAge study and who resided in a large North American urban area reported on the frequency of walking outside the home over a 3-year period and on their health, sociodemographic characteristics, social support and resources, and perceptions of different features of their residential environment. Information about the distance between their home and 16 services and amenities was obtained from a geographic information system. Seniors were then classified into quartiles of proximity (Q1, Q2, Q3, Q4).

Results. Unadjusted and adjusted ordinal growth curve models showed that closer proximity to services and amenities was associated with greater likelihood of frequent walking at all times throughout the 3-year period.

Discussion. Findings are consistent with the notion that environments may act as buoys for the maintenance of important health behaviors. Future experimental and quasi-experimental research is required to explore whether or not the environment can play a causal role in influencing patterns of walking over time.

Key Words: Activity levels—Cohort analysis—Epidemiology—Health promotion—Living environments—Longitudinal methods—Multi-level models—Observational studies—Physical activity—Walking.

PHYSICAL activity is an important determinant of successful aging (J. Baker, Meisner, Logan, Kungl, & Weir, 2009; Peel, McClure et al., 2005). Yet, like populations in most industrialized nations, many older adults do not cumulate sufficient amounts of physical activity to allow for health maintenance and disability prevention such that insufficient physical activity is now recognized as the fourth leading cause of death worldwide (World Health Organization, 2009). In keeping with ecological approaches to health promotion (Richard, Gauvin, & Raine, 2011; Sallis et al., 2006, 2009), a growing body of research has focused on identifying environmental and policy determinants of involvement in physical activity that go above and beyond individual determinants (Owen et al., 2004; King, Sarariano, Marti, & Zhu, 2008). Cross-sectional research (Owen et al., 2007; French, Story, & Jeffery, 2001; Gauvin et al., 2005, 2008; Humpel, Marshall, Leslie, 2004; Humpel, Owen, & Leslie, 2002; Lee et al., 2009; McKinnon et al., 2009; Yeh & Katz, 2006) shows that mixed land use (i.e., side-by-side presence of residential and commercial spaces) and availability of services and amenities are associated with more frequent and lengthier durations of walking among adults of all ages. Self-report data also link safety and aesthetics to regular involvement in recreational walking (e.g., De Bourdeaudhuij, Sallis, & Saelens, 2003; Ewing, 2005, Ewing et al., 2006; Giles-Corti et al., 2003, Giles-Corti, Timperio, Bull, & Pikora, 2005; Raine, 2004; Van Lenthe, Brug, Mackenbach, 2005).

Although this literature is growing in quantity, there is consensus that additional and improved data that are couched within sound conceptual frameworks are required

Received December 24, 2010; Accepted October 18, 2011
Decision Editor: Merril Silverstein, PhD

(Cunningham & Michael, 2004). Towards this end, the model of neighborhood effects on aging of Glass and Balfour (2003) provides an appropriate conceptual underpinning. Drawing heavily from Lawton's (1973, 1980) ecological model of aging, their model posits that the degree of person–environment fit determines the degree of adaptation and subsequent health. However, extending Lawton's proposition and integrating the notions of positive and negative effects, Glass and Balfour hypothesize that neighborhood environments can lead to either deleterious or salutogenic effects on health. On the one hand, the neighborhood can impose demands or barriers on the individual. In such cases, person–environment fit tips in favor of creating an environmental press. On the other hand, neighborhood environments can facilitate adaptation by supporting and reinforcing individual competencies. In such cases, the person–environment fit tips in favor of creating an environmental buoy. Socioenvironmental conditions, social integration, physical aspects of places, and services/resources can create environmental presses or buoys, which in turn interact with personal competencies to produce differential person–environment fit. In keeping with the notion of environmental buoys and pressors proposed by Glass and Balfour (2003), an environment rich in services and amenities may serve to potentiate walking and other forms of active transportation among seniors, whereas an environment poor in such services may become unwieldy for seniors to handle and promote avoidance of walking and use of services and amenities.

From an empirical standpoint, although data are accumulating rapidly on the environmental determinants of physical activity among children and adults of working age, there are only a few studies that address the environmental determinants of physical activity among seniors (King et al., 2008). The dearth of data is even more glaring for one of the activities most engaged in by the population in general and seniors namely, walking. Some authors (Ewing 2005; Gauvin et al., 2008) have suggested and shown that the determinants of different types of walking (i.e., recreational vs. transportation) must be studied separately from leisure time physical activity, as their determinants may be unique. Given that the health and occupational status of older adults are often different from that of younger persons, environmental determinants of walking may be different among seniors in comparison to children, adolescents, and younger adults.

In addition, there have been calls to improve the quality of measurement of environmental determinants through application of geographic information systems (GIS) technology (see AJPM special issue). To date, only three studies (Frank, Schmid, Sallis, Chapman, & Saelens, 2005; Nagel, Carlson, Bosworth, & Michael, 2008; Owen et al., 2007) have replicated findings showing that greater proximity to a variety of local services and amenities is associated with more walking using GIS technology. For example, using a GIS-built environment indicator involving land-mix use, residential density, and connectivity, Frank et al. (2005) observed associations between greater land mix, density, and connectivity and higher number of minutes of physical activity per day as measured by accelerometry. In Australia, Owen et al. (2007) also showed strong associations between a GIS-derived walkability indicator based on connectedness and proximity to resources and walking for transportation. More recently and in contrast, Nagel et al. (2008) showed that transportation behavior among adults was not linked to a GIS-built environment indicator of the density of resources within a quarter mile (0.4 km) and half mile (0.8 km) radius around the home. However, among those who did walk, the duration of walking was inversely associated with the amount of automobile traffic and positively associated with the number of commercial establishments. These data suggest that more information is required on the association of environments with walking.

Finally, much of the extant research is cross-sectional, thus limiting inferences that can be made about the causal role of environmental factors in supporting more walking. To our knowledge, the one study examining environmental determinants longitudinally (Li et al., 2005) showed that neighborhoods with safe walking environments and proximity to physical activity facilities had lower rates of decline in walking among older adults.

In an effort to contribute to the literature on environmental determinants of walking among older adults, we linked longitudinal data from a cohort of seniors to data from a geographic information system called MEGAPHONE (Daniel & Kestens, 2007) with the aim of determining whether or not closer proximity to local services and amenities (i.e., potential buoy or pressor) was associated with greater frequency of walking (i.e., healthful response) over time among community-dwelling seniors over and above individual level determinants. The linkage between the NuAge cohort and the MEGAPHONE geographic information system is called VoisiNuAge—a close homonym of the French word for neighborhood.

Method

Participants

Participants were from the NuAge cohort (Gaudreau et al., 2007; Payette et al., 2010), a 5-year observational study of 1,793 men and women aged 67–84 years who reported being in good general health at inception in 2003. Participants were recruited from an age- and sex-stratified random sample drawn from the Québec Medicare database (RAMQ—Régie de l'Assurance Maladie du Québec) for the regions of Montreal, Laval, and Sherbrooke in the province of Québec, Canada. Because health care coverage is universal in Québec, all residents of the province are included in this database. Men and women who were living in the

community were included if they spoke French or English, were free of disabilities in activities of daily living, were without cognitive impairment (Modified Mini-Mental State >79), able to walk one block or to climb a one-floor flight of stairs without rest, and willing to commit to a 5-year study period (2003–2008). Those who had heart failure (≥class II), chronic obstructive pulmonary disease requiring oxygen therapy or oral steroids, inflammatory digestive diseases or cancer treated either by radiation therapy, chemotherapy or surgery in the past five years were excluded. The numbers of participants recruited in each age strata were as follows: 70 years: 337 female and 329 male; 75 years: 305 female and 289 male; 80 years: 298 female and 235 male. Computer-assisted interviews (William) were carried out by trained research dieticians and nurses following rigorous standardized procedures, and participants were tested annually on a series of nutritional, functional, medical, biological, and social measurements.

Participants for the VoisiNuAge investigation were those who resided in the Montreal metropolitan area (n = 848). For the current investigation, we further limited the sample to those who were still in the cohort at Year 3 of the follow-up (n = 681) and thus excluded dropouts (n = 68), persons who moved between measurement times (n = 88), and deaths (n = 11). A subsample of 521 of these 681 participants (76.5%) providing complete data on all variables of interest in this study was included. Participants signed an informed consent form, which had been approved by the Ethics committees of the University Institutes of Geriatrics of the Université de Montréal (Institut Universitaire de Gériatrie de Montréal) and of the Université de Sherbrooke (Institut Universitaire de Gériatrie de Sherbrooke).

Measures

Frequency of walking.—Members of the NuAge cohort completed the Physical Activity Scale for Seniors (PASE; Washburn, Smith, Jette, & Janney, 1993) at each measurement period. The PASE is a brief questionnaire that requires participants to estimate the frequency and duration of a variety of physical activities and has been shown to have good reliability and validity among seniors (Schuit et al., 1997; Washburn et al., 1993). Because of our interest in walking in this study, we singled out the question relating to the frequency of walking which read as follows: "Over the past 7 days, how often did you walk outside your home for any reason: for example, for fun or exercise, walking to work, walking the dog, etc.?" Response options were never (0 days), seldom (1–2 days), sometimes (3–4 days), or often (5–7 days). Although there were data pertaining to duration of walking, we elected to focus on the frequency of episodes rather than a combined indicator of frequency and duration because there is concern in the literature about the validity of duration data and because the response options for the duration data were very broad (i.e., smallest duration category was 1 hr). Although there are no validity data on this specific question of the PASE, it is worth mentioning that it does have face validity as it shares substantial resemblance with another frequently used and validated question from the International Physical Activity Questionnaire (Craig et al., 2003) which reads as follows: "Think about the time you spent walking in the last 7 days. This includes at work and at home, walking to travel from place to place, and any other walking that you might do solely for recreation, sport, exercise, or leisure. During the last 7 days, on how many days did you walk for at least 10 minutes at a time?" In addition, we found that the body mass index of persons who self-reported walking often was significantly lower than that of people reporting walking never (27.3 ± 3.8 vs. 29.3 ± 5.5, $p < .001$) and that overall PASE scores were higher among persons reporting walking often in comparison to persons reporting never walking (103.8 ± 47.3 vs. 81.8 ± 42.1, $p < .002$). We also observed that use of public transportation at least once per week in the previous year predicted reporting walking both often (odds ratio [OR] = 5.34; 95% confidence interval [CI]: 2.70, 10.53) and sometimes (OR = 3.03; 95% CI: 1.41, 6.50). These associations suggest good concurrent validity.

Proximity of local services and amenities with the home.—Information regarding the proximity of local services and amenities within the vicinity of the participants' homes was extracted from the MEGAPHONE geographic information system (Daniel & Kestens, 2007). Services and amenities compiled in MEGAPHONE were obtained from a private business and service registry (Tamec. Inc.) containing some 120,000 records for the greater Montreal Area and further geocoded at the address and six-digit Canadian postal code levels. Records were categorized both with Standard Industrial Classification (SIC) Codes and further product names corresponding to the classification of the yellow pages directory. Using product names and SIC codes, we identified and extracted 16 different resources deemed as relevant for supporting walking among older adults: banks, libraries, bookstores, theaters/movie theaters, places of worship, cultural community centers for seniors, physical activity places with and without instruction, pharmacies, grocery chains, shopping centers, corner stores, specialty food stores, cafes/bistros, restaurants, fast-food restaurants, and parks. After having computed the shortest road network distance from each participant's residence to each of the targeted resources, we performed a principal component analysis on the log-transformed distance data limiting the factors to one (the scree plot suggested the existence of one main factor that explained 38.3% of the variance). We computed factor scores, which were then recategorized into quartiles. Table 1 shows average distances to each of the services and amenities for each quartile of the factorial score along with component loadings on the single

Table 1. Average Distance (m) Between the Home and Each of 16 Local Services and Amenities as a Function of Quartile of Factor Scores for 521 Participants in the VoisiNuAge Study and Component Loadings From a Single-Factor Principal Components Analysis

	First quartile	Second quartile	Third quartile	Fourth quartile	
	Closest	Close	Far	Furthest	
	Mean (*SD*)	Mean (*SD*)	Mean (*SD*)	Mean (*SD*)	Component loadings
Bank	303.7 (135.3)	402.0 (163.0)	652.4 (212.6)	1036.9 (516.1)	0.613
Bookstore	701.9 (497.9)	1056.2 (633.3)	1407.3 (637.0)	2787.2 (2115.1)	0.728
Café/bistro	409.8 (367.4)	809.4 (541.2)	1243.1 (750.2)	1748.6 (854.6)	0.752
Place of worship	248.7 (151.8)	408.0 (268.1)	633.7 (351.2)	1014.6 (626.8)	0.608
Cinema/theater	1349.6 (928.3)	2241.71375.9)	2918.7 (1761.1)	5004.4 (2706.6)	0.614
Cultural community center	703.0 (540.9)	786.4 (622.0)	1011.7 (600.7)	2085.8 (2308.9)	0.310
Convenience store	189.8 (124.5)	335.5 (226.1)	483.6 (276.1)	801.7 (431.2)	0.506
Fast food restaurant	405.3 (287.5)	659.9 (351.6)	815.2 (339.3)	1255.5 (626.8)	0.705
F&V shop, bakery, butcher	243.2 (134.6)	493.5 (266.4)	726.3 (317.6)	1172.0 (662.7)	0.738
Grocery chain	302.6 (212.0)	557.7 (281.1)	732.1 (289.8)	1259.6 (621.7)	0.725
Library	842.4 (568.7)	1411.4 (991.3)	1642.6 (1056.2)	2134.6 (1067.1)	0.494
Physical activity with instruction	755.5 (485.5)	930.1 (426.2)	1296.5 (640.7)	1485.1 (739.3)	0.588
Physical activity no instruction	709.9 (499.1)	908.8 (488.7)	1079.5 (553.2)	1258.4 (507.7)	0.482
Pharmacy	307.9 (168.0)	494.6 (291.6)	669.9 (236.8)	1247.1 (696.3)	0.640
Restaurant	151.8 (119.5)	322.6 (195.9)	510.9 (204.2)	873.6 (458.6)	0.796
Shopping center	2653.2 (1146.8)	2435.1 (1278.3)	3023.7 (1874.4)	4853.6 (3131.6)	0.346

factor from the principal components analysis. The average distance to the 16 services and amenities across quartiles were 648.4, 887.6, 1184.3, and 1899.3 m, respectively. Component loadings were largest for food establishments and smallest for shopping malls, cultural community centers, and fitness centers without instructional programs.

Health and sociodemographic characteristics.—Questions from the SF-36 Physical Component Score and Social Functioning subscales (Ware & Sherbourne, 1992), the Geriatric Depression Scale (Yesavage et al., 1983), and the System for Measuring Functional Autonomy Scale (SMAF; Hébert, Carrier, & Bilodeau, 1988) were compiled. Sociodemographic characteristics were assessed by a series of questions related to age, sex, education (recoded 11 years or less; between 12 and 13; 14 years or more), marital status (recoded married/living common-law, single, single/separated, widowed), country of birth (Canada/elsewhere), and annual family income (recoded as below/above the low-income cutoff of Statistics Canada).

Perceptions of the neighborhood environment.—A series of questions addressing perceptions of the neighborhood was added to the measurement protocol late in Year 3. A subsample of 476 participants completed the questionnaire at the end of the third measurement period, whereas another subsample (n = 111) completed the questionnaire at the beginning of the fourth measurement period. Given the fact that the environments were unlikely to change over such a short period and that these perceptions were measured at only one time, these data were considered as individual-level variables rather than time-changing covariates for purposes of analyses. The following measures were included: *Perceived Housing and Social Environment*. Questions relating to years of tenure in the current dwelling were recoded as less than five years, 5–19 years, 20 or more years and for years in the neighborhood were recoded less than ten years, 10–29 years, 30 or more years. Items pertaining to the social environment in the neighborhood addressed the number of children living in the neighborhood (0, 1, 2 or more), sense of belongingness to the neighborhood (i.e., very strong, somewhat strong, somewhat/very weak), and proximity to social network (i.e., living alone without friend/relative in the neighborhood; living with at least one other person or having friends/relatives in neighborhood; living with at least one other person and having friends/relatives in neighborhood). Extent of social support was assessed by summing the dichotomized values of responses to four items: the availability of help in case of illness, disability, or problem, of someone who could take care of the respondent as long as necessary, of someone who could take care of the respondent for a short period of time, and of someone who could take care of the respondent from time to time. *Perceived quality of walking environment and transportation services*. Perceptions of the user-friendliness of the walking environment were assessed with the following questions: "how easy or difficult is it to get around on foot in the neighborhood" (i.e., very easy, somewhat easy, somewhat/very difficult), in your opinion how many minutes does it take to get to the nearest subway station or a bus stop (i.e., within a 5-minute walk, more than a 5-minute walk), "do you have access to a motor vehicle in your household" (i.e., yes vs. no), and do you have a valid driver's license. *Perceived Access to Overall Neighborhood Services and Amenities*. We assessed perceived accessibility to key resources for older adults using a four-item scale involving the ease/difficulty of accessing resources in the neighborhood: (a) good quality affordable food, (b) a good

range of businesses and services (pharmacy, etc.), (c) leisure activities of interest, and (d) facilities to engage in preferred physical activities or sports (reliability coefficient: 0.63). Response scale format ranged from very/somewhat easy to somewhat/very difficult. Individual items were summed up, and overall scores were divided in tertiles. We also asked respondents to estimate the perceived walking distance (in min) between the respondent's residence and the nearest of a series of services and amenities including: grocery/food store, convenience/corner store, bank, pharmacy, community/leisure center, sports centers, restaurant/bistro/café, library/cultural center, store/shopping center, church/place of worship, CLSC/medical clinic, and park. The scale had an internal consistency reliability coefficient of .82. Individual estimates were summed, and resulting overall scores were recategorized into quintiles of the proportion of resources available within a 5-min walk of the home.

Further information on the validity and reliability of these measures is available elsewhere (Richard et al., 2009).

Analysis

We performed descriptive and inferential analyses. First, variable distributions were examined and then descriptive analyses were conducted to characterize respondents in terms of frequency of walking at different points in time, availability of local services and amenities, and control variables. Also, because both the exposure and outcome variables were likely to include a spatial component, we examined spatial autocorrelations in these variables prior to analysis. Because our main interest was in examining changes over time in the frequency of walking, we modeled reported frequency of walking as an ordinal outcome (i.e., walking often, sometimes, seldom, vs. never) using growth curves (Raudenbush & Bryk, 2002). More specifically, we conceptualized the repeated measures of walking frequency as nested within persons and created two dummy variables contrasting reports occurring at the second measurement period (T2) to those recorded at inception into the cohort (T1), and reports occurring at the third measurement period (T3) to those recorded at inception into the cohort (T1), respectively. Then, we began the model building exercise using successive steps. First, we estimated the bivariate association between quartiles of availability of the 16 services and amenities and frequency of walking at T1 (i.e., the intercept), whereas modeling reported frequency of walking at T2 and T3 (i.e., slopes representing the positive or negative growth of frequency of walking over time). This allowed us to estimate the cross-sectional association of proximity with frequency of walking at T1 while still modeling change in walking pattern over time. Next, we entered the quartiles of availability of services and amenities as moderators of the time slopes. This allowed us to examine if the changes in walking frequency over time were differentially associated with proximity to services and amenities. Then, we successively added blocks of control variables to examine the extent to which any associations with environmental factors were attenuated by addition of individual-level variables. We entered blocks of variables as follows: (a) age, sex, sociodemographic, and health characteristics; (b) perceived housing and social environment; (c) perceived services and walking environment as well as availability of a driver's permit and an automobile; and (d) perceived neighborhood amenities and resources. Finally, we produced empirical Bayes residuals of the final model and estimated spatial autocorrelation in residuals to examine whether or not modeling had accounted for all spatial clustering.

Results

Table 1 shows descriptive information for the main exposure variable. As can be seen, the quartiles of proximity to services nicely capture differing distances to the variety of services and amenities under scrutiny with persons residing in the first quartile of proximity being at about 650 m on average from these services and those residing in the fourth quartile being on average about four times that distance (about 1.9 km) away on average from the set of services.

VoisiNuAge participants dropping out (n = 68), migrating to another dwelling (n = 88), or dying (n = 11) did not differ from other VoisiNuAge participants (n = 681) in terms of education, likelihood of owning their residence, number of children living in the neighborhood, social functioning, and likelihood of reporting walking often at baseline. Those dying showed a nonsignificant tendency to be older ($p < .07$), have lower physical component scores ($p < .10$), higher depression scores ($p < .10$), and poorer functional status ($p < .104$). Those dying were also more likely to be born outside Canada ($p < .05$) or report low income ($p < .005$). Those moving were more likely to be widowed at baseline ($p < .04$), to report low income ($p < .005$), and to be born outside Canada ($p < .002$). Those born outside Canada were less likely to dropout ($p < .002$). Among the remaining participants (n = 681), those with incomplete data (160) were more likely to be born outside Canada and less likely to have a university degree ($p < .01$) in comparison to participants with complete data (n = 521) but did not differ on other variables. Examination of a map (not shown to preserve participant anonymity) showed that participants resided throughout the Island of Montreal and its North Shore suburb of Laval indicating that there was a broad diversity of urban and suburban neighborhoods wherein participants resided. As shown in Table 2, the final subsample showed substantial variability across all indicators of health and sociodemographic characteristics, despite the fact that the NuAge cohort is known to represent a generally more educated, less culturally diverse, and wealthier group of people in comparison to the older adults of the province of Quebec from which it was drawn. With respect to the outcome variables, descriptive data show that between one third and just

Table 2. Characteristics of 521 Participants in the VoisiNuAge Study Who Provided Longitudinal Data on Walking

Characteristic	*n* (%)	Mean	*SD*
Outcome variables			
T1 frequency of walking			
Never (0 days)	83 (15.9)		
Seldom (1–2 days)	88 (16.9)		
Sometimes (3–4 days)	104 (20.0)		
Often (5–7 days)	246 (47.2)		
T2 frequency of walking			
Never (0 days)	122 (23.4)		
Seldom (1–2 days)	111 (21.3)		
Sometimes (3–4 days)	97 (18.6)		
Often (5–7 days)	191 (36.7)		
T3 frequency of walking			
Never (0 days)	101 (19.4)		
Seldom (1–2 days)	92 (17.7)		
Sometimes (3–4 days)	100 (19.2)		
Often (5–7 days)	228 (43.8)		
Main exposure (GIS-derived proximity to 16 services and amenities from the home)			
Accessibility to 16 services and amenites			
First quartile (closest)	131 (25.1)		
Second quartile (close)	132 (25.3)		
Third quartile (far)	131 (25.1)		
Fourth quartile (Furthest)	127 (24.4)		
Sociodemographic and health characteristics			
Age		74.7	4.1
Sex			
Male	243 (46.6)		
Female	278 (53.4)		
Country of birth			
Canada	420 (80.6)		
Elsewhere	101 (19.4)		
Marital status			
Single	61 (11.7)		
Widowed	139 (26.7)		
Divorced/separated	41 (7.9)		
Married/common law	280 (53.7)		
Education			
2–11 years	211 (40.5)		
12–13 years	87 (16.7)		
14 years or more	223 (42.8)		
Family income			
<Low-income cutoff	53 (10.2)		
>Low-income cutoff	468 (89.8)		
Housing ownership			
Owner	327 (62.8)		
Tenant	194 (37.2)		
SF-36 physical component		49.1	8.6
SF-36 social functioning		89.4	17.2
Geriatric Depression Scale		4.8	4.4
Functional status (SMAF)		6.2	4.3
Housing and social environment			
Children living nearby			
None	185 (35.5)		
1	138 (26.5)		
2 or more	198 (38.0)		
Social support			
Maximum score	345 (66.2)		
Less than maximum score	176 (33.8)		
Number of years of tenure in dwelling			
Less than five years	37 (7.1)		
5–19 years	193 (37.0)		
20 years or more	291 (55.9)		
Number of years of tenure in neighborhood			
Less than ten years	78 (15.0)		
10–29 years	170 (32.6)		
30 years or more	273 (52.4)		
Sense of belongingness to the neighborhood			
Very strong	185 (35.5)		
Somewhat strong	220 (42.2)		
Very/somewhat weak	116 (22.3)		
Proximity to social network			
Live alone without friend/relative in neighborhood	41 (7.9)		
Live with at least one other person or have friends/relatives in neighborhood	249 (47.8)		
Live with at least one other person and have friends/relatives in neighborhood	231 (44.3)		
Transportation services and walking environment			
Availability of bus stop or subway station within 5-min walk			
Yes	289 (55.5)		
No	232 (44.5)		
User-friendliness of the walking environment			
Very easy	426 (81.8)		
Somewhat easy	74 (14.2)		
Very/somewhat difficult	21 (4.0)		
Availability of a motor vehicle in the household			
Yes	420 (80.6)		
No	101 (19.4)		
Having a valid driver's license			
Yes	393 (75.4)		
No	128 (24.6)		
Perceived neighborhood amenities and services			
Perceived accessibility to key resources for older adults			
First tertile (lower)	177 (34.0)		
Second tertile (average)	151 (29.0)		
Third tertile (higher)	193 (37.0)		
Proportion of services and amenities perceived to be located within a 5-min walk			
First quintile (fewest)	76 (14.6)		
Second quintile (few)	140 (26.9)		
Third quintile (average)	78 (15.0)		
Fourth quintile (many)	128 (24.6)		
Fifth quintile (most)	99 (19.0)		

Note. SMAF = System for Measuring Functional Autonomy.

over 40% of the sample report walking often (5–7 days) outside the home in the past seven days across the three measurement periods, whereas between one fifth and one fourth of the sample report never walking outside the home across the 3-year period. Moran's I for proximity to services and walking at T1 were 1.28 ($z = 11.50$, $p < .0001$) and 0.28

($z = 2.54$, $p < .01$) suggesting large and small spatial autocorrelations, respectively.

Table 3 shows the results of growth curve analyses applied to the ordinal frequency of walking outcome. As can be seen, across the 3-year period, participants showed a lower likelihood of reporting walking often with the dip being most pronounced at T2 (OR = 0.55, 95%CI: 0.43, 0.70) and marginally less so at T3 (OR = 0.79, 95%CI: 0.62, 1.03). This pattern of change over time remained stable throughout the model building exercise. More interestingly, being in both the first (OR = 3.30. 95%CI: 1.98, 5.50) and the second quartiles (OR = 1.84, 95%CI: 1.11, 3.06) of proximity to services and amenities were associated with greater likelihood of reporting walking frequently at T1 (intercept). Subsequent examination of the moderating role of quartile of proximity to services and amenities on the change over time revealed no statistically significant association suggesting that any differences in likelihood of reporting walking frequently at T1 were carried over unchanged at T2 and T3. In other words, there was a greater likelihood of reporting walking frequently among persons living in the first and second quartiles of proximity at all times, but these likelihoods did not become greater or smaller over time. Furthermore, although addition of successive blocks of variables attenuated these associations, we observed that associations remained statistically significant, suggesting that the associations were not confounded with numerous other variables, which might be thought to be associated with the outcome variable. In this regard, in the final model, we observed that women, persons with 12 or 13 years of schooling, those who had higher scores on the Geriatric Depression Scale, those with one child residing in the neighborhood, those perceiving the user-friendliness of the walking environment to be poor, and those who had a car had a lower likelihood of reporting walking often, whereas persons with higher scores on the physical component score of the SF-36 had a higher likelihood of reporting walking often. To further illustrate the findings, Figure 1 presents the frequency of walking reported by participants living in each of the quartiles of proximity of resources (panels a through d). As can be seen, persons living in the first (closest) quartile of proximity showed a tendency to maintain and perhaps even increase the likelihood of walking often, whereas persons living in other quartiles appear to show no change or a tendency toward decreased likelihood of walking often. The spatial autocorrelation in the empirical Bayes residuals was .029 ($z = 0.27$, $p = .78$) indicating the absence of spatial autocorrelation in residuals.

Discussion

This paper examined whether or not better proximity to local services and amenities was associated with maintenance of more frequent walking over time among urban-dwelling seniors over and above individual-level characteristics. We linked data from a cohort of seniors who were followed for a 3-year period to data from a GIS system to determine the average distance from the home to 16 different services and amenities likely to be used often by seniors and then classified participants into quartiles of proximity to resources. Analyses showed that there was substantial variability in proximity to services and amenities in the cohort, despite the fact that they all lived in the same large urban area. For example, on average some people lived about 650 m away from resources, whereas others lived on average 1900 m away from these same types of resources/amenities. There was also substantial variability in the reported frequency of walking both at each time point and over time, with some participants reporting never walking outside the home, whereas others reporting this activity often. Of greater interest in relation to the objective of this paper, results of unadjusted and adjusted growth curve analyses on the ordinal walking frequency outcome showed that proximity to resources was associated with walking often. That is, findings showed that living in the first or second quartile of proximity to services and amenities was associated with a greater likelihood of walking often at T1 (inception of the cohort) and that these patterns carried throughout the second and third measurement periods without becoming more or less pronounced. These findings are consistent with existing literature (French et al., 2001; Gauvin et al., 2005, 2008; Humpel et al., 2002, 2004; Lee et al., 2009; McKinnon et al., 2009; Yeh & Katz, 2006) showing that greater density of destinations is more likely to elicit walking among neighborhood residents. However, they extend previous findings by showing that the association persists over time and that living in a well-serviced urban area is associated with maintenance of frequent walking. These findings are indeed important as remaining physically active and staying connected with the community have been shown to be determinants of successful aging, prevention of disability, and avoidance of social exclusion. The findings also provide some support for the notion that environmental buoys and pressors elicit adaptive and maladaptive health behaviors, respectively (Glass & Balfour, 2003), in that populations living in areas with more abundant resources were more likely to maintain their walking patterns, whereas those in more isolated areas were more likely to persist in not walking.

This pattern of findings certainly requires replication and extension beyond the urban context from which the data emerged. In particular, although we observed that proximity to services was associated with greater likelihood of walking often, we do not have any information on the actual frequency of utilization of specific service destinations that are located nearby. For example, seniors may elect to go to a bank that is farther away from their home because they have a long-standing business relationship with the bank manager. Or, seniors might purchase their prescriptions at a pharmacy further away because its products are more affordable

Table 3. Results of Ordinal Growth Curve Analyses Examining the Association Between Quartiles of Access to 16 Local Services and Amenities and Frequency of Involvement in Walking Across the Three First Measurement Periods Among 521 Participants of the VoisiNuAge Study

	Model 1[a,b]	Model 2[b,c]	Model 3[b,d]	Model 4[b,e]	Model 5[b,f]	Model 6[b,g]
	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Examination of change over time						
Dummy variable contrasting T2–T1	0.55*** (0.43, 0.70)	0.55*** (0.43, 0.70)	0.54*** (0.42, 0.69)	0.53*** (0.42, 0.68)	0.53*** (0.42, 0.68)	0.53*** (0.42, 0.68)
Dummy variable contrasting T3–T1	0.79† (0.62, 1.03)	0.79† (0.62, 1.00)	0.77* (0.60, 0.98)	0.77* (0.60, 0.98)	0.77* (0.60, 0.98)	0.77* (0.60, 0.98)
Main exposure variable						
Accessibility to 16 services and amenities						
First quartile (closest)		3.30*** (1.98, 5.50)	2.82*** (1.61, 4.92)	2.52*** (1.42, 4.49)	2.21** (1.24, 3.93)	2.49** (1.31, 4.72)
Second quartile (close)		1.84* (1.11, 3.06)	2.01** (1.20, 3.38)	1.86* (1.09, 3.18)	1.65† (0.96, 2.82)	1.77† (1.00, 3.15)
Third quartile (far)		1.22 (0.74, 2.02)	1.21 (0.73, 2.00)	1.15 (0.69, 1.94)	1.15 (0.68, 1.92)	1.19 (0.70, 2.02)
Fourth quartile (furthest)—Ref		1.00	1.00	1.00	1.00	1.00
Sociodemographic and health characteristics						
Age (grand mean centered)			1.01 (0.96, 1.06)	1.01 (0.96, 1.06)	1.00 (0.96, 1.05)	1.00 (0.96, 1.06)
Sex						
Female			0.71† (0.47, 1.07)	0.64* (0.42, 0.98)	0.57* (0.37, 0.89)	0.56* (0.36, 0.88)
Male—Ref			1.00	1.00	1.00	1.00
Country of birth						
Elsewhere			1.57† (0.99, 2.49)	1.52† (0.95, 2.43)	1.46 (0.92, 2.33)	1.43 (0.89, 2.30)
Canada—Ref			1.00	1.00	1.00	1.00
Marital status						
Single			2.00† (1.03, 3.91)	1.63 (0.75, 3.57)	1.45 (0.66, 3.17)	1.47 (0.66, 3.26)
Widowed			1.23 (0.76, 2.00)	1.38 (0.79, 2.43)	1.26 (0.72, 2.23)	1.27 (0.72, 2.53)
Divorced/separated			1.55 (0.75, 3.23)	1.47 (0.66, 3.30)	1.32 (0.60, 3.05)	1.37 (0.60, 3.12)
Married/common law—ref			1.00	1.00	1.00	1.00
Education						
2–11 years			0.93 (0.62, 1.40)	0.98 (0.65, 1.50)	0.91 (0.60, 1.39)	0.91 (0.59, 1.40)
12–13 years			0.57* (0.34, 0.97)	0.62† (0.36, 1.06)	0.60† (0.35, 1.03)	0.59† (0.34, 1.02)
14 years or more—Ref			1.00	1.00	1.00	1.00
Family income						
<Low–income cutoff			0.70 (0.38, 1.30)	0.73 (0.39, 1.37)	0.64 (0.34, 1.21)	0.64 (0.34, 1.21)
>Low–income cutoff—Ref			1.00	1.00	1.00	1.00
Housing ownership						
Tenant			1.38 (0.91, 2.10)	1.43 (0.90, 2.28)	1.32 (0.83, 2.10)	1.34 (0.83, 2.15)
Owner—Ref			1.00	1.00	1.00	1.00
SF-36 physical component (grand mean centered)			1.04*** (1.02, 1.07)	1.05*** (1.02, 1.08)	1.05*** (1.02, 1.08)	1.05*** (1.02, 1.08)
SF-36 social functioning (grand mean centered)			0.99 (0.98, 1.01)	1.00 (0.98, 1.01)	0.99 (0.98, 1.01)	0.99 (0.98, 1.01)
Geriatric Depression Scale (grand mean centered)			0.94** (0.90, 0.99)	0.95* (0.91, 1.00)	0.96† (0.92, 1.00)	0.96† (0.91, 1.00)
Functional status (SMAF—grand mean centered)			0.97 (0.92, 1.02)	0.97 (0.93, 1.03)	0.97 (0.92, 1.02)	0.97 (0.92, 1.02)
Perceived housing and social environment						
Children living nearby						
2 or more				0.50† (0.30, 0.82)	0.51† (0.31, 0.84)	0.51 (0.31, 0.84)
1				0.65** (0.38, 1.09)	0.65** (0.39, 1.10)	0.67** (0.39, 1.14)
None—Ref				1.00	1.00	1.00
Social support						
Less than maximum score				0.84 (0.56, 1.26)	0.79 (0.52, 1.19)	0.77 (0.51, 1.18)
Maximum score—ref				1.00	1.00	1.00

(Table 3 continues)

Table 3. Results of Ordinal Growth Curve Analyses Examining the Association Between Quartiles of Access to 16 Local Services and Amenities and Frequency of Involvement in Walking Across the Three First Measurement Periods Among 521 Participants of the VoisiNuAge Study *(Continued)*

	Model 1[a,b]	Model 2[b,c]	Model 3[b,d]	Model 4[b,e]	Model 5[b,f]	Model 6[b,g]
	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Number of years of tenure in dwelling						
Less than five years				0.52 (0.25, 1.33)	0.63 (0.27, 1.46)	0.65 (0.28, 1.53)
5–19 years				1.02 (0.62, 1.62)	1.02 (0.62, 1.68)	1.04 (0.62, 1.72)
20 years or more—Ref				1.00	1.00	1.00
Number of years of tenure in neighborhood						
Less than ten years				1.06 (0.54, 2.09)	1.07 (0.55, 2.11)	1.06 (0.54, 2.10)
10–29 years				1.04 (0.66, 1.65)	1.03 (0.65, 1.64)	1.02 (0.63, 1.63)
30 years or more—Rref				1.00	1.00	1.00
Sense of belongingness to the neighborhood						
Very/somewhat weak				0.64† (0.38, 1.07)	0.71 (0.42, 1.18)	0.74 (0.44, 1.25)
Somewhat strong				1.04 (0.68, 1.58)	1.01 (0.65, 1.53)	0.99 (0.65, 1.53)
Very strong—ref				1.00	1.00	1.00
Proximity to social network						
Live along without friend/relative in neighborhood				1.20 (0.51, 2.81)	1.15 (0.49, 2.70)	1.14 (0.48, 2.73)
Live with at least one other person or have friends/relatives neighborhood				0.89 (0.57, 1.39)	0.83 (0.53, 1.31)	0.82 (0.52, 1.30)
Live with at least one other person and have friends/relatives neighborhood—Ref				1.00	1.00	1.00
Perceived transportation services and walking environment						
User-friendliness of the walking environment						
Very/somewhat difficult					0.34* (0.14, 0.86)	0.33* (0.13, 0.85)
Somewhat easy					0.71 (0.42, 1.21)	0.72 (0.41, 1.24)
Very easy—Ref					1.00	1.00
Availability of a motor vehicle in the household						
Yes					0.55† (0.27, 1.09)	0.55† (0.27, 1.11)
No—Ref					1.00	1.00
Having a valid driver's license						
Yes					0.74 (0.71, 2.56)	0.72 (0.37, 1.38)
No—Ref					1.00	1.00
Perceived neighborhood amenities and services						
Perceived accessibility to key resources for older adults						
First tertile (lower)						0.96 (0.61, 1.53)
Second tertile (average)						1.12 (0.69, 1.78)
Third tertile (higher)—Ref						1.00

(Table 3 continues)

Table 3. Results of Ordinal Growth Curve Analyses Examining the Association Between Quartiles of Access to 16 Local Services and Amenities and Frequency of Involvement in Walking Across the Three First Measurement Periods Among 521 Participants of the VoisiNuAge Study (*Continued*)

	Model 1[a,b]	Model 2[b,c]	Model 3[b,d]	Model 4[b,e]	Model 5[b,f]	Model 6[b,g]
	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Proportion of services and amenities perceived to be located within a 5-min walk						
First quintile (fewest)						1.05 (0.52, 2.13)
Second quintile (few)						1.22 (0.67, 2.23)
Third quintile (average)						0.86 (0.42, 1.64)
Fourth quintile (many)						0.88 (0.50, 1.55)
Fifth quintile (most)—ref						1.00

Notes. CI = confidence interval; OR = odds ratio; SMAF = System for Measuring Functional Autonomy.

[a]Model 1: Includes only dummy variables contrasting T2 and T3 measures of walking frequency to T1 measures thus creating growth curves.

[b]For all models, the intercept (values not shown) represented the likelihood of walking often for a person living in an area in the fourth quartile of distance to services and amenities (Q4, furthest away); ordinal models are based on a cumulative probability model and therefore include threshold estimates for membership in other categories of the outcome variable (values not shown).

[c]Model 2: Includes the time variables in Model 1 plus variables operationalizing quartiles of accessibility to 16 services and amenities.

[d]Model 3: Includes the variable in Model 2 plus two series of dummy variables accounting for reported frequency of walking 1 year and 2 years previous to the T3 measurement.

[e]Model 4: Includes variables in Model 3 plus sociodemographic and health characteristics.

[f]Model 5: Includes variables in Model 4 plus perceived housing and social environment variables.

[g]Model 6: Includes variables in Model 5 plus perceived transportation services and walking environment variables.

†$p < .10$; *$p < .05$; **$p < .01$; ***$p < .001$.

or the pharmacist provides personalized attention. Further data on the patterns of utilization of services and amenities would allow for more fine-grained analyses on how seniors navigate within their neighborhood environments.

In addition, despite controlling for health and functional status, the beneficial effects of living in an area with more proximal services and amenities remained unchanged, thereby lending credence to the robustness of the overall environmental buoying effect. However, a higher score on the physical component score of the SF-36 was associated with greater likelihood of frequent walking, whereas poor perceived user-friendliness of the neighborhood and presence of a child living in the neighborhood were linked to lower likelihood of frequent walking. We also observed that the likelihood of reporting frequent walking significantly decreased from T1 to T2 and was marginally reduced from T1 to T3. It is possible that some (but not all) respondents experienced decrements to their health and functional status, which may in turn have lead to decreased frequency of walking. We note also that in keeping with the model of neighborhood effects on aging of Glass and Balfour, it is possible that the overall buoying effect of plentiful services and the detrimental effect of a dearth of amenities may be more pronounced among persons with compromised health and functional status. A next step in this research would be to provide empirical evidence of the suggestion of Glass and Balfour that within a population, people with compromised health or functional status (including frail seniors) may benefit more from the buoying effects and suffer more from the pressor effects of their environment in comparison to more well seniors (see also Beard et al., 2009). Future investigations could thus examine how personal characteristics and perceptions moderate the main buoying or pressor effects of neighborhood environments on walking. Studies on the possible mediating role of perceptions and personal characteristics in the association between proximity to services and walking behavior are equally warranted.

Despite these interesting findings, the study has limitations. First, given that the cohort from which participants were drawn includes persons who are wealthier, healthier, less ethnically diverse, and more likely to agree to participate in a longitudinal study, results may not be generalizable to other samples including less healthy individuals and persons with more limited financial resources. As a result, the prevalence of frequent walking in the current sample is likely higher than in the general population of seniors, and the more favorable health status of cohort members may have lead to smaller declines in walking frequency over time. Replication and further follow-up are thus required. Furthermore, the outcome variable was self-reported and included a single item. Despite its face validity, the findings should be replicated with both accelerometry data and more refined self-report data, which include estimated duration and intensity of walking episodes. Moreover, the GIS-derived data with respect to environmental proximity were

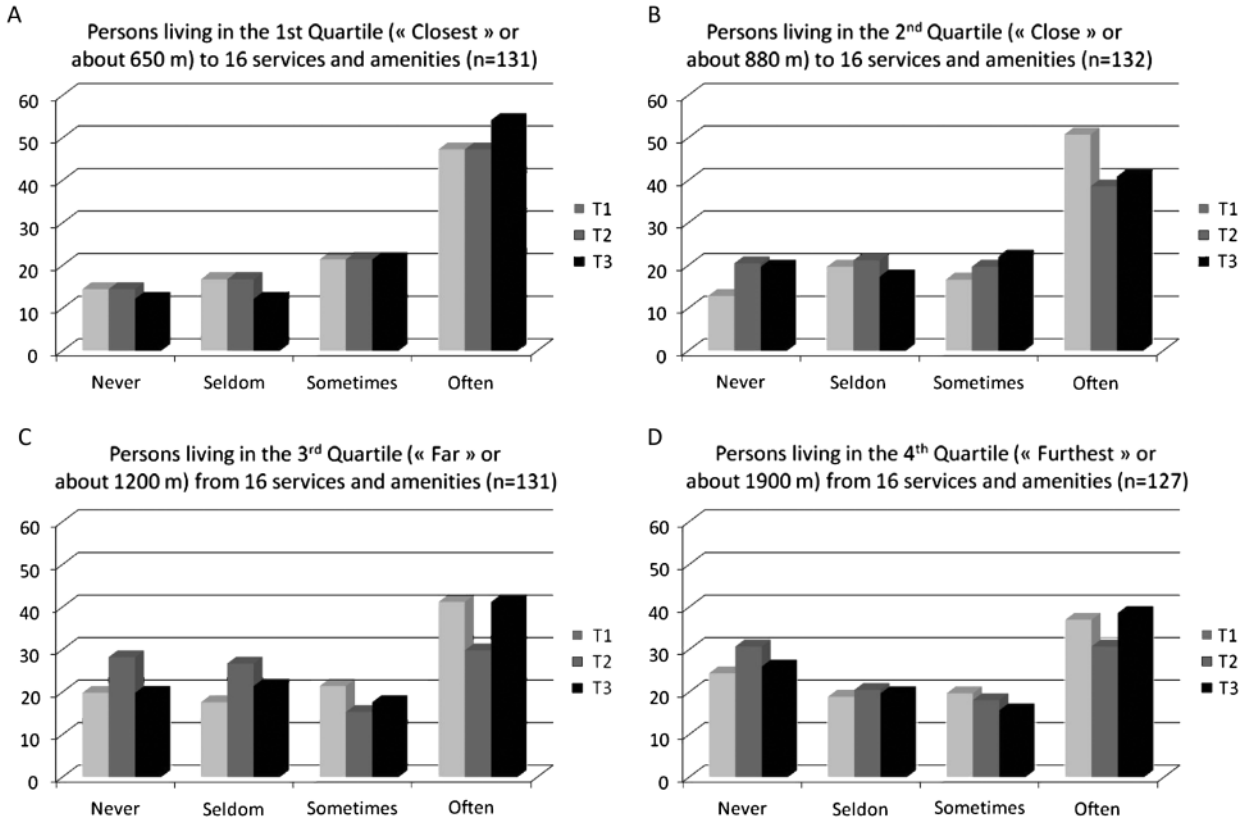

Figure 1. Proportion of VoisiNuAge participants reporting walking never, seldom, sometimes, and often as a function of quartiles of accessibility to 16 services and amenities across a 3-year period. A. Persons living in the first quartile ("closest" or about 650 m) to 16 services and amenities (n = 131). B. Persons living in the second quartile ("close" or about 880 m) to 16 services and amenities (n = 132). C. Persons living in the third quartile ("far" or about 1200 m) from 16 services and amenities (n = 131). D. Persons living in the fourth quartile ("furthest" or about 1900 m) from 16 services and amenities (n = 127).

collected in 2004, around the time of the inception of the cohort. It is possible that environments changed across the 3-year measurement period with some areas becoming gentrified and others experiencing deterioration. Some participants may thus have been misclassified in terms of proximity to services and amenities. Although future investigations should ascertain the extent to which environments change over time, there is general agreement that any changes in environments over a 3-year period should be relatively limited, suggesting that the likelihood of misclassification is small. Similarly, other important neighborhood characteristics were not assessed and controlled for in this investigation and may have influenced findings. We note that given that spatial autocorrelations initially present in the outcome variable were no longer present in the residuals of the final model, these influences may be limited. However, other factors might include local traffic patterns and volume, presence of curbs and sidewalks, and social characteristics, such as perceived safety and criminal activity. Future investigations could integrate observational data or crime data with GIS data to further examine how proximity to resources may or may not support frequent walking. Finally, although the frequency of walking data are longitudinal, it is still not possible to claim that living in a well-serviced area acts as a cause of changes in frequency of walking because people were not randomized to live in selected locations—rather they self-select into neighborhoods. This is likely to be particularly true in this sample because 84% of participants reported having lived in their neighborhood for 10 years or more and about 52% indicated living there for 30 years or more. Although it is difficult to overcome these limitations, future studies designed to examine the impact of environmental changes occurring through natural experiments (Petticrew et al., 2005; e.g., densification of services and amenities, implementation of walking trails, implementation of traffic calming measures, transforming selected street segments into pedestrian walkways, and improving public transportation services) might help advance our thinking about the causal role of environmental determinants of walking among seniors. That is, although the conduct of randomized trials in relation to environmental issues is challenging, they are possible (Macintyre, 2011). And, other alternatives to randomized trials are also increasingly being promoted (Bonell et al., 2011; Cousens et al., 2011). From a policy standpoint, it might be interesting to examine whether or not residences for well and frail seniors ought to be established in densely

serviced areas rather than in remote areas to allow greater proximity to amenities and more frequent walking behavior.

Conclusion

Preventing disability and promoting social engagement among seniors is a public health priority in many industrialized nations. Understanding how community environments are associated with being more physically active can be useful to policy makers and interventionists who jointly work toward creating, maintaining, and transforming those life settings that are most likely to promote the health of older adults. Findings from the current investigation offer additional evidence that living in areas that are plentiful in terms of amenities and resources is linked to more active lifestyles, a finding that could be translated into public policy.

Funding

This work was supported by the Canadian Institutes of Health Research (grant number MOP-173669) and the Fonds de la recherche en santé du Québec (grant number #16207 to L. R. and #20328 to Y. K.).

Acknowledgments

L. G., L. R., Y. K., and M. D. planned the study. L. G. coordinated all statistical analyses. L. G. wrote the paper. B. S., H. P., and S. M. contributed to planning the study. L. R., Y. K., B. S., and G. M. contributed to interpretation of results. All authors revised the manuscript. L. G. holds a CIHR/CRPO (Canadian Institutes of Health Research/Centre de recherche en prevention de l'obésité) Applied Public Health Chair on Neighborhoods, Lifestyle, and Healthy Body Weight.

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