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Review

Environmental Factors Associated with Older Adult's Walking Behaviors: A Systematic Review of Quantitative Studies

Hae Young Yun

Asia Research Institute, National University of Singapore, Singapore 119260, Singapore; ariyhy@nus.edu.sg

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Abstract: The aim of this study is to systematically review the relationship between neighborhood environments and all types of walking behaviors among older adults. Seventy peer-reviewed journal articles which met the selection criteria were examined. Research designs were summarized by geographical location and the associations of environmental characteristics and walking were calculated. Interactions between moderators and environmental characteristics for all types of walking were also categorized. Results have shown that transport walking is the most supported by neighborhood environmental characteristics. The positively related environmental characteristics are walkability, urbanization, land use mix-diversity and accessibility, walking amenities, and bicycle lanes. Total walking was positively associated with walkability and urbanization. Recreational walking was associated with neighborhood employment/income level, nearness to public transport/bus stops, and social cohesion. The most commonly used moderators were age and gender, but inconsistent moderating effects between neighborhood environments and walking were also found. In densely populated environments such as Hong Kong, older adults walked mostly for both transport and recreation. In contrast, American older adults in low density areas walked less for transport and more for recreation. Findings support a strong relationship between neighborhood environments and older adults' walking. Future research should focus on longitudinal studies and comparison studies by geographic location.

Keywords: neighborhood environment; older adults; total walking; walking for transport; walking for recreation; moderator; systematic review

1. Introduction

Older adults aged 60 or older are a fast-growing population group in every country in the world [1] and a great deal of literature has focused on them. In particular, a growing body of literature written on the relationship between the physical activity of older adults and neighborhood environments has been recently published [2]. Walking is the most common leisure-time physical activity among older adults. Housework and gardening, which take place at home and not in the neighborhood, are ranked second and third respectively [3,4]. However, exploring the relationship between neighborhood environments and physical activity may lead to limited or misleading research findings if physical activity is not defined more specifically [5], since some physical activity reported by older adults is performed at home (e.g., housework and gardening) and thus would not necessarily be influenced by the neighborhood environment. Thus, this study aims to review the relationship specifically between neighborhood environments and walking behaviors (not more general physical activity) among older adults.

As the most common type of physical activity, walking has garnered much interest, since increased walking provides substantial health benefits both physically and mentally [6,7]. A great deal of literature shows that various health conditions such as diabetes [8], hypertension [9], and dementia [10]

have improved through regular walking or walking programs in neighborhoods. For example, Simonsick et al.'s study found that older women walking regularly, more than eight blocks per week, had fewer depressive symptoms, fatigue symptoms and cardiovascular disease, and an enhanced lung function [11].

As older adults age, their life space area shrinks, implying that most spend more time in their immediate neighborhood, with a greater dependency on neighborhood resources than younger age groups [12–14]. Among older adults, walking (a type of non-motorized transport) primarily substitutes for trips by car, especially in highly dense cities such as Singapore [15]. It is likely that compact and sustainable urban development can support neighborhood walking among older adults. Conversely, elderly walking behavior may be discouraged by environmental barriers in the neighborhood because of age-related physical limitations [16]. Barrier-free neighborhood environments enable older adults to frequently utilize non-motorized transport (i.e., walking), especially in highly compact and dense cities with a number of neighborhood-based amenities. This in turns reduces fossil fuel consumption and air pollution for sustainable environments.

An ecological model of active living [17] hypothesizes that walking as a type of physical activity is associated with neighborhood environmental characteristics. More specifically, objectively-assessed neighborhood characteristics (e.g., pedestrian/bike facilities, aesthetics, traffic safety, walkability, parking, transit) and perception of neighborhood environmental characteristics (e.g., safety, attractiveness, accessibility, convenience, comfort, perceived crime) are associated with walking behaviors. Moreover, walking behaviors are associated with intrapersonal characteristics such as demographics, and biological, psychological, and family situations.

Some of the review papers published on this topic reveal limited coverage of important findings which are necessary for a better understanding of this field of study. Van Cauwenberg et al. [18] reviewed quantitative studies about the relationship between neighborhood environments and older adults' physical activity behaviors (not only limited to walking). This study, however, did not clearly review the differences between the subjective and objective measurements of environment and did not cover developing regions such as Africa and South America. In addition to this study, three other systematic review papers were recently published examining the relationship between physical activity [2], leisure-time physical activity [19], and active travel [20] combining walking, bicycling, and physical activity outcomes among older adults. Yet, these papers missed the comparison of the relationship between all types of walking behaviors (total, transport, and recreation) and neighborhood environments. As the past reviews of neighborhood environment on walking behavior were published in 2004 and 2008 [21,22], more recent works on the neighborhood environment and walking behavior have not been considered. These two review papers also targeted the general population, not older adults. Thus, it is not easy to understand how neighborhood environmental characteristics support different types of walking behaviors among older adults at the same time. Moreover, more and more recent studies have explored the moderating effects of intrapersonal characteristics and environmental characteristics for walking behaviors, so a summary of moderating effects is essential. Up to this point, there are no papers that compare walking outcomes by geographical region or country. Thus, this study aimed (1) to compare summary findings for research design by geographical regions; (2) to identify neighborhood environmental factors related to walking behaviors illustrating the similarities and differences between objective and subjective measurements; (3) to reveal interactions of moderating and environmental factors for walking behaviors; (4) to explain how walking behavior outcomes are different by geographical region or country; and (5) to suggest future research directions, targeting quantitative studies.

2. Research Methods

This systematic literature review followed the guidelines of Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) [23]. In particular, methods (e.g., protocol and registration, eligibility criteria, search strategy) and results (e.g., study selection, study characteristics,

synthesis of results) guidelines were considered. Moreover, all papers were reviewed at least twice to obtain intra-coder (within-coder) reliability in paper selections and data coding procedures. In cases where the classification was not clear to the author, previous review papers such as Barnett et al. [2], Cerin et al. [20], Van Cauwenberg et al. [19], and Sallis et al. [24] were considered as a coding reference if the same studies were available from their studies for neighborhood environmental associations.

2.1. Selection Criteria

The criteria for this review were limited to peer-reviewed journal articles and the specific criteria were as follows:

1. If the research participants' minimum age was 60 or over or the average age of research participants was 70 or greater, the studies were included. However, there are some exceptions. If the sample size was over 1000 and the study represented a specific country with a limited number of published papers (e.g., Singapore) [25], the study was included, although the sample's minimum age was 55 years old. Kerr et al.'s study [26] was also accepted as an exception (although the age limit was 50 years old or older) since the study called participants older adults and the sample size was over 5000. The research participants within the inclusion criteria were limited to older adults living independently in their neighborhoods or retirement villages. The studies were excluded if participants were institutionalized or disabled in walking.
2. This study aimed to explore the relationship between neighborhood environments and walking behaviors of the elderly. Thus, studies including transport/utilitarian walking, recreational walking, and total walking of older adults were selected. However, if dependent variables were about (1) physical activity, not walking or (2) combined exercises, such as walking and cycling, such studies were also disqualified. Recently, a large number of studies have objectively measured physical activity. If the objectively-measured physical activity outcomes were step counts within neighborhoods utilizing Global Positioning Systems (GPS) or pedometers and the author defined the physical activity as neighborhood walking, these papers passed inclusion criteria. However, if the objectively-measured physical activity outcomes were divided into light, moderate, and vigorous physical activities, not walking, these were not included. In addition, studies which were limited to health status, Body Mass Index (BMI), and quality of life, instead of measuring walking behaviors, were ignored.
3. This study reviewed only quantitative research methods combining cross-sectional and longitudinal studies. Some intervention studies, such as physical activity, walking programs or encouragement calls, were eliminated. Hence, research with built-environment interventions, such as a temporary walking path with a controlled car access, were included. In addition, only studies adjusted by at least one socio-demographic characteristic (e.g., age, gender, education), were incorporated in this analysis. However, studies using pedestrian environmental audits were accepted as an exception without adjustment, since those are rare.

2.2. Search Strategy

English language journals between January 2000 and June 2016 were searched, using the selected keywords below, from the following databases: Psycinfo, Web of Science Core Collection, PubMed, Avery, Environment Index, Medline, Academic Search Complete, & TRID (i.e., integrated database combining Transportation Research Information Services [TRIS] Database and International Transport Research Documentation [ITRD] Database). The combined keywords using 'AND function' were as follows: Walking, walk, pedestrian, older adults, the elderly, seniors, neighborhood, built or physical environment. A total of 2338 studies were identified. Seventy peer-reviewed journal papers (one in Africa, 16 in Asia, 15 in Europe, 32 in North America, two in Oceania, and four in South America) were chosen for this study. The process of narrowing down to 70 papers is detailed in Figure 1. Figure 1 shows a cascading process of removal by this criteria: Duplicates, by title (not the intended

focus), by age (did not meet target age group), by abstract (the abstract was closely examined to check for relevance), and by quantitative orientation (to remove the qualitative studies). The last search involved a manual search (using Google Scholar and from forthcoming articles mentioned in the references of earlier published works) in order to obtain relevant studies published from January 2016 to October 2018.

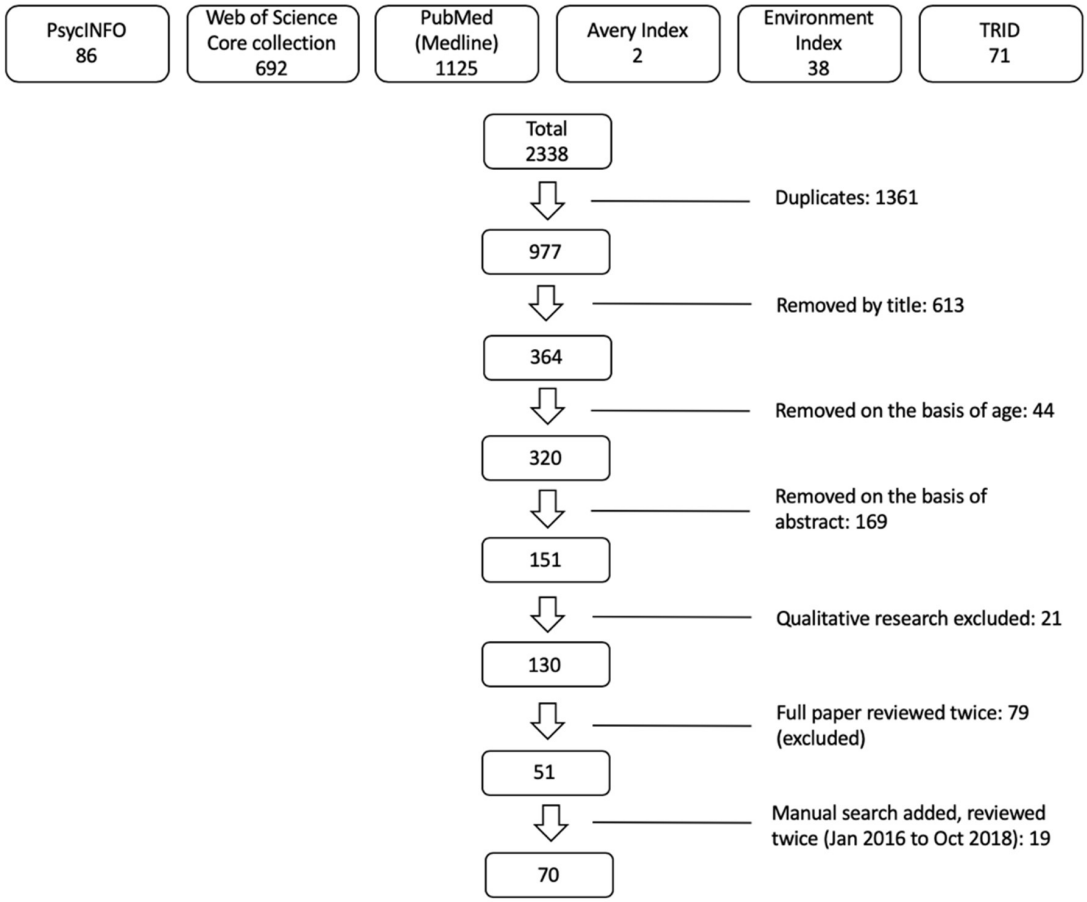

Figure 1. Flow chart of literature search strategy.

2.3. Data Classification and Analysis Strategy for Research Design

After reviewing the full papers at least twice, the following research design information was extracted from the individual manuscripts: (1) Author names and published year; (2) journal article titles; (3) countries and geographical regions; (4) research methods (e.g., longitudinal and cross-section studies); (5) geographical location settings (e.g., urban, mixed, or rural areas); (6) minimum age of sample; (7) percentage of males from sample; (8) sample size; (9) sampling method by stratification and individual; (10) project name; (11) neighborhood measurement method (e.g., objective or perceived, measurement scale names or tools used); (12) walking behavior measurement or tools utilized (e.g., objectively measured or self-reported, measurement scale name or tool used); and (13) dependent variables. All information was classified by geographical region since there were no review papers categorizing summaries by geographical regions, to the author's best knowledge.

2.4. Coding and Association Calculation Strategy of Enviromental Characteristics

The environment characteristics were broadly divided into two parts: Perceived environments and objectively-measured environments. The perceived environmental characteristics were classified using the Neighborhood Environment Walkability Scale (NEWS) since it was the most frequently used measurement tool for the perception of neighborhood environments from the selected

studies. Supplementary classifications were added after reviewing other studies. For example, destinations, safety-related characteristics, infrastructure-related characteristics, and aesthetics were four main characteristics. Under these characteristics, sub-characteristics were added (e.g., land use mix-diversity and accessibility, perceived safety/personal safety, pedestrian/traffic safety). In order to classify objectively-measured neighborhood characteristics in a parallel way, additional main and sub-characteristics (e.g., walkability/walk score, urbanization, density, detailed destinations, neighborhood social cohesion) were also inserted in the classification table.

Individual numbers were imposed on individual studies and then the geographical region indicators (e.g., Africa: AF, Asia: A, NA: North America) were given alongside the numbers. Almost all models, adjusted by socio-demographic characteristics such as age, gender, and education, with multiple environmental variables were chosen for analysis. However, statistical models with a single environmental variable were also accepted in the association calculation if the environmental variables were objectively measured and adjusted by socio-demographic characteristics. Multiple statistical models with different subsamples in one study were considered as multiple studies for association calculation, so that separate identifications were assigned (e.g., women only [W] and men only [M] with the study number) [24]. In addition to this, a study examined various buffer levels in which the summed study is calculated as 1. For example, if there were models with four different buffers and the same sample size, the models were marked as [I], [II], [III], and [IV] to indicate different buffers and then those were considered as one study. In the association calculation, each model was multiplied by 0.25 so the summed number is 1 [2,20]. In addition, if the dependent variables were measured by different methods such as minutes of walking and frequency of walking in the same study, the findings were considered as two separate results although the sample size is the same [20].

The characteristics of neighborhood environments related to walking outcomes were categorized into 'positive' (+) and 'negative' (−) with the *p*-value at <0.05. If the p-values were between 0.05 and 0.10, the characteristics were categorized into 'uncertain' (+/−) in cases where *p*-values were illustrated in the studies chosen. If the *p*-value was over 0.10, the characteristics were categorized into unrelated (ø) [24]. The level of association for each environmental attribute was calculated when three or more comparable studies were available [24] and the summary codes are detailed in Table 1. All environmental attributes, if tested in the selected studies, were categorized into the summary table. Some attributes which fell into $p \geq 0.10$ in the multiple variable models adjusted with covariates were classified into 'unrelated' categories. It was difficult to summarize the findings by locations (e.g., urban vs. mixed/rural; North America vs. other regions) since there was an insufficient number of studies categorized by location. The author illustrated the summed association of total environments. The associations of perceived and objectively-measured environments were also calculated individually. The attributes having both positive and negative values in different studies were summed up and marked with an asterisk (*) regardless of association level. The moderation effects were excluded in the association calculation.

Table 1. Summary table explaining association and meaning of codes.

% of Research Supporting Association	Summary Code	Meaning of Code
0–33	ø	No association
34–59	?	Indeterminate or inconsistent
60–100	+	Positive association
	−	Negative association

In the case four or more studies support an association or no association, it was coded as øø, ++, or −−. The ?? code points out an attribute that has been frequently studied with a lack of consistency in the findings.

2.5. Classification of Moderators

Moderators were classified by socio-demographic characteristics, physical and psychosocial factors, and environmental factors (objectively-assessed and perceived). If the interactions between

socio-demographic/physical or psychosocial characteristics and environments were utilized, the interactions were classified under either socio-demographic or physical/psychosocial characteristics. Environmental characteristics used as moderators were categorized into either objectively-measured or perceived environmental factors.

2.6. Classification of Walking Types

Walking behaviors were categorized into three types: (1) total walking; (2) walking for transport; and (3) walking for recreation. The walking measurements were highly diverse (e.g., walking minutes per week, walking minutes per day, walking frequency per week, ratio of participants achieving 150 min or more per week, ratio of no walking, number of walking days per week, never to daily walking). Consolidating the walking outcomes, it was revealed that the most frequently measured walking behavior outcomes were walking minutes per week and ratio of certain walking minutes or above per week (i.e., % older adults walking ≥150 min/week or not walking). These three walking behavior types were categorized by geographical locations to explore whether there were geographical differences present.

3. Results

3.1. Summary of Selected Studies by Geographical Region

The summary of individual studies by geographical regions is shown in Table 2. Among the 70 selected articles, a majority of the articles were published in North America (45.7%, 32 articles), followed by Asia (22.9%, 16), Europe (21.4%, 15), South America (5.7%, 4), Oceania (2.9%, 2), and Africa (1.4%, 1). By country, the top country publishing journal papers related to environments and older adults' walking behaviors was the United States (38.6%, 27 papers), followed by Hong Kong (11.4%, 8), Belgium (8.6%, 6), Canada (7.1%, 5), and the United Kingdom (5.7%, 4). Although the majority of journal papers were published in the US, it is noteworthy to mention that recently published papers came from other countries such as Nigeria, in Africa [27]; Korea [28], Singapore [25,29], and Taiwan [30] in Asia; Portugal [31] and Spain [32] in Europe; and Brazil [33–35] and Columbia [36] in South America. Almost all studies (95.7%, 67 out of 70) were cross-sectional, only three studies (4.3%) were longitudinal, and all the longitudinal studies were conducted in the United States [37–39]. Almost half of the studies (46.5%, 33 out of 71) were completed in urban areas while only two studies (2.8%) were conducted in rural areas. The results of the Korean study were divided into two geographical locations (urban and rural areas) reporting separate findings. The rest of the studies were completed in mixed density areas or the densities were unknown [31,40,41]. To be more specific, all African and South American studies [27,33–36] were performed in urban areas but studies on other continents were conducted in mixed density settings. The two studies in rural areas were only conducted in Asia (Japan [42] and Korea [28]). Almost 90% of the studies were conducted on older adults, aged 60 or more. However, 8.5% of studies incorporated slightly younger seniors [25,26,40,43–45]. In terms of gender ratio, five studies (7%) targeted only women (Korea [28] and USA [26,40,41,46]) and two studies (2.8%) focused only on men (USA [37,38]). Most studies with a proportion of males fall into two categories: Less than 40% (one third of 70 studies) and 40% to less than 50% (almost half the studies). The sample sizes range from 85 [29] in Singapore to 48,879 [47] in Belgium; 28% of the selected studies had 400 participants or less.

Table 2. Summary of individual studies by geographical regions.

		Africa	Asia	Europe	North America	Oceania	South America	Total	
								N	%
Country	Nigeria	[27]						1	1.4
	Hong Kong, China		[48–54,74]					8	11.4
	Mainland, China		[75]					1	1.4
	Japan		[42,76,77]					3	4.3
	S. Korea		[28]					1	1.4
	Singapore		[25,29]					2	2.9
	Taiwan		[30]					1	1.4
	Belgium			[47,55–58,78]				6	8.6
	Finland			[79]				1	1.4
	UK			[70,71,80,81]				4	5.7
	Netherlands			[82,83]				2	2.9
	Portugal			[31]				1	1.4
	Spain			[32]				1	1.4
	Canada				[43,44,84–86]			5	7.1
	USA				[26,37–41,45,46,59–69,87–94]			27	38.6
	Australia					[72,73]		2	2.9
	Brazil						[33–35]	3	4.3
	Columbia						[36]	1	1.4
	Total by region	1	16	15	32	2	4	70	100.0
Research method	Cross-sectional	[27]	[25,28–30,42,48–54,74–77]	[31,32,47,55–58,70,71,78–83]	[26,40,41,43–46,59–69,84–94]	[72,73]	[33–36]	67	95.7
	Longitudinal				[37–39]			3	4.3
Density	Urban	[27]	[25,28,29,48–54,74,75]	[70,71,79,82]	[38,39,43,44,59,66–69,91,92,94]		[33–36]	33	46.5
	Mixed (urban/suburban/rural)		[30,76,77]	[32,47,55–58,78,83]	[26,37,45,46,60–65,84–90,93]	[72,73]		31	43.7
	Mixed (urban/rural)			[80,81]				2	2.8
	Rural		[28,42]					2	2.8
	Unknown			[31]	[40,41]			3	4.2
Age	50+				[26]			1	1.4
	55+		[25]		[40,43–45]			5	7.1
	60+	[27]	[28,29,74,75]		[41,66,90,91,94]		[33–36]	14	20.0
	65+		[30,42,48–54,76,77]	[31,32,47,55–58,70,71,78,80–83]	[38,39,59–65,67–69,84–89,92]	[72]		45	64.3
	70+			[79]	[46,93]			3	4.3
	Unknown				[37] (mean: 70),	[73] (mean: 76.9)		2	2.9
Gender (% of Men)	0% (Women only)		[28]		[26,40,41,46]			5	7.0
	> [65]		[25,54]	[31,79,81]	[39,45,66–69,84,85,88,90–93]	[73]	[33–36]	22	31.0
	40 ≤ X < 50		[29,42,48–53,76]	[32,47,55–58,70,71,78,80,82,83]	[59–65,86,89,94]	[72]		33	46.5
	50 ≤ X < 100	[27]	[30,74,75,77]		[61]			6	8.5
	100% (Men only)				[37,38]			2	2.8
	Unknown				[43,44,87]			3	4.2

Table 2. *Cont.*

			Africa	Asia	Europe	North America	Oceania	South America	Total	
									N	%
Sample size		<200		[29,74]	[31,70,71,80]	[46,64,69,84,85]			11	15.7
		200 to 400	[27]		[81]	[39,61,90,91,94]	[73]	[35]	9	12.9
		401 to 800		[25,28,42,48–53]	[32,55–58,79,82]	[38,62,63,65–68,93]			24	34.3
		801 to 1200		[30,54]		[45,60,87,88]			6	8.6
		>1200		[75–77]	[47,78,83]	[26,37,40,41,43,44,59,86,89,92]	[72]	[33,34,36]	21	28.6
Sampling method	Cluster (Stratified by)	Walkability & SES	[27]	[48–54]	[55–58]	[59–64]			18	25.7
		Walk Score/Walkability				[85,89]	[73]		3	4.3
		Housing density				[87]			1	1.4
		Census tract or Neighborhood		[75,77]		[39,46,66–69,92]		[35]	10	14.3
		Deprivation			[70,71]				2	2.9
		Income/SES						[33,34,36]	3	4.3
		Age, gender, and/or ethnicity		[74]	[47,56–58,78]	[65], ([59])		[35]	4 (9)	5.7 (12.9)
		Unknown		[30]			[72]		2	2.9
		None (Convenient/Purposive)		[25,28,29,42,76]	[31,32,79–83]	[26,37,38,40–45,84,86,88,90–94]			27	38.6
	Individual	Random		[25,30,42,48–53,75–77]	[32,47,55–58,78,79,82,83]	[39,41,43–45,59,61,63,64,66–69, 84–86,88,89,93,94]	[72,73]	[35,36]	46	65.7
		Systematic				[46]			1	1.4
		Convenience/Purposive	[27]	[28,29,54,74]	[31,70,71]	[26,37,40,60,62,87,90–92]		[33,34]	19	27.1
		Random + Convenience/Purposive			[80,81]				2	2.9
		Unknown				[38,65]			2	2.9
Project name		HKE*		[48–53]					6	8.6
		BAS			[47,78]				2	2.9
		BEPAS Seniors			[55–58]				4	5.7
		GBE			[80,81]				2	2.9
		BE *			[70,71]				2	2.9
		WTTBEEMS				[84,85]			2	2.9
		MHTS 2008				[43,44]			2	2.0
		SNQLS				[60–63,65]			5	7.1
		SHAPE				[39,66–69]			5	7.1
		ME *				[90,91]			2	2.9
		2004, 2008 NHS				[40,41]			2	2..9
		EpiFloripa Elderly						[33,34]	2	2.9
		Projects with only one publication		[54,75,76]	[31,32,79,82,83]	[26,38,45,59,64,86–89,92,93]	[72]		20	28.6
		Unknown	[27]	[25,28–30,42,74,77]		[37,46,94]	[73]	[35,36]	14	20.0

Table 2. *Cont.*

			Africa	Asia	Europe	North America	Oceania	South America	Total	
									N	%
Neighborhood measurement										
Objective		EAST-HK		[49,50,52]					3	4.3
		SPACES & NBOT				[64]			1	1.4
		SWEAT				[69]			1	1.4
	GIS	400–500 m		[25]		[46,60,65,87]		[36]	6	8.6
		500 m < X ≤ 1000 m		[76]		[59,62,63,67,68,88,89]	[72]		9	12.9
		>1000 m			[82]	[26,40]			3	4.3
		Administrative boundary		[75]	[32,55–58,70]	[37,38,43,44,66,67,69,92,93]		[34]	17	24.3
		Walk Score				[84–86]			3	4.3
		Unknown			[47,78]				2	2.9
		Total by region							45	64.3
Perceived		ALPHA			[31]				1	1.4
		NEWS	[27]	[25,28,48,51,54,74]	[58,71]	[41,60,61,63,85,87,90,91,94]	[73]	[33,35]	21	30.0
		IPAQ-E		[30,42,77]					3	4.3
		SNE			[80]				1	1.4
		NOS			[81]				1	1.4
		NES				[66]			1	1.4
		Unknown/self-administered		[29,53]	[47,78,79]	[37,39,45,67,69,87]			11	15.7
		Total by region							39	54.3
Walking behavior measurement										
Objective		GPS			[70,71]				2	2.9
		Accelerometer			[31]				1	1.4
Self-reported		IPAQ	[27]	[30,48–51,54]	[55–58,80,81]	[88]		[33–36]	18	25.7
		NWQ-CS		[52,53]					2	2.9
		HTS		[75]	[83]	[43,44,84]			5	7.1
		PASE		[42,74]	[32]	[59]			4	5.7
		CHAMPS				[41,60–65,85]	[73]		9	12.9
		NPAQ				[90,91]			2	2.9
		AAS					[72]		1	1.4
		NPAQ & AAS		[28]					1	1.4
		LAPAQ			[82]				1	1.4
		YPAS				[38,39,66,68,69]			5	7.1
		HIS				[92]			1	1.4
		SPPARCS				[87]			1	1.4
		Unknown/self-administered		[25,29,76,77]	[47,78,79]	[26,37,40,45,46,67,86,89,93,94]			17	24.3

Table 2. *Cont.*

			Africa	Asia	Europe	North America	Oceania	South America	Total	
									N	%
Dependent variables	TW	Continuous (min/hour)		[29,52,75,76]	[83]	[26,38,45,90–92]			11	15.7
		Continuous (frequency)		[75]		[43,46]			3	4.3
		Continuous (distance)				[37,43]			2	2.9
		Categorical (type of travel)				[44]			1	1.4
		Categorical (ordinal/level)		[42,74]	[70,71]	[62,69]		[36]	6	8.6
		Categorical (No walking vs. walking)				[43]	[72]		2	2.9
		Categorical (150 m+)		[28,77]	[80,86]	[37,40,86,87,94]	[72]	[35]	11	15.7
		Categorical (3+ or 5+ days walking)				[59,93], (5+ days), [94] (3+ days)			3	4.3
		Total Studies for Total Walking							39	55.7
	TRW	Continuous (min/hour)	[27]	[50,51,54]	[32,55,56,58,79,82]	[63,65,85,92]			14	20.0
		Continuous (frequency)		[53,54]		[84,85]			4	5.7
		Continuous (distance)			[79]				1	1.4
		Categorical (ordinal/level)		[25]	[79]	[46,61,64]		[33]	6	8.6
		Categorical (No walking vs. walking)				[41,60,85,89,93]		[34]	6	8.6
		Categorical (60 m+)		[77],	[81]		[73]		3	4.3
		Categorical (150 m+)		[30]		[41]			2	2.9
		Categorical (5+ days walking)			[47,78]				2	2.9
		Total Studies for Transport Walking							38	54.3

Table 2. *Cont.*

		Africa	Asia	Europe	North America	Oceania	South America	Total	
								N	%
RW	Continuous (min/hour)	[27]	[48,49,51,52,54]	[55,57,58]	[63,68,92]			12	17.1
	Continuous (frequency)		[54]		[46]			2	2.9
	Categorical (ordinal/level)				[39,61,62,66,67]		[33]	6	8.6
	Categorical (No walking vs. walking)				[41,60,88,93]		[34]	5	7.1
	Categorical (30 m+)		[77]					1	1.4
	Categorical (60 m+)			[81]				1	1.4
	Categorical (150 m+)		[30]		[41]	[73]		3	4.3
	Categorical (10,000+ steps)			[31]				1	1.4
	Total Studies for Recreational Walking							31	44.3

1. Project name: HKE: Hong Kong Elderly, BAS: Belgian Aging Studies, BEPAS Seniors: Belgian Environmental Physical Activity Study in Seniors, GBE: Great Britain Elderly, BE: Birmingham Elderly, WTTBEEMS: The Walk the Talk: Transforming the Built Environment to Enhance Mobility in Seniors, MHTS 2008: Montreal Household Travel Survey 2008, SNQLS: Senior Neighborhood Quality of Life Study, SHAPE: Senior Health and Physical Exercise, ME: Michigan Elderly, 2004, 2008 NHS: 2004, 2008 Nurses' Health Study, EpiFloripa Elderly: Health Status of the Elderly Population in Florianópolis: Population-Based Study, * : Named by the author, Project names with only one publication: (1) ALECS: Active Lifestyle and the Environment in Chinese Seniors, ZHTZ: Zhongshan Household Travel Survey, AGES: Aichi Gerontological Evaluation Study in Asia; (2) SCAMOB: Screening and Counseling for Physical Activity and Mobility (SCAMOB) project, ELANE study: Elderly And their Neighborhood study, MRN: Mobility Research Netherlands, PNWRP: Portuguese National Walking and Running Program, EMEF travel survey: Enquesta de Mobilitat en dia Feiner travel survey in Europe; (3) CCHS-HA survey: Canadian Community Health Survey Healthy-Aging 2008–2009 Cycle, ACT study: Adult Changes in Thought study, NPAEM: Neighborhoods and Physical Activity in Elderly Men, SMARTRAQ (Atlanta region) study: Strategies for Metropolitan Atlanta's Regional Transportation and Air Quality study, CNDS: Chicago Neighborhood and Disability Study, SDWHI: San Diego Women's Health Initiative Cohort, 2003 CHIS: 2003 California Health Interview Survey, HAN Walking Study: Healthy Aging Research Network Walking Study, NASH: Neighborhoods and Senior Health, MOBILIZE Boston Study, NE-WAS: Neighborhood Environment-Wide Association Study in North America; and (4) HWSS: Health and Wellbeing Surveillance System in Oceania. 2. Neighborhood measurement tool name: EAST-HK: Environment in Asia Scan Tool-Hong Kong, SPACES: Pedestrian and Cycling Environment Scan, NBOT: Neighborhood Brief Observation Tool, and SWEAT: Senior Walking Environmental Audit Tool. 3. Environment assessment tool name: ALPHA: Assessing Levels of Physical Activity and fitness at population level, NEWS: Neighborhood Environment Walkability Scale, IPAQ-E: International Physical Activity Questionnaire-Environment, SNE: Supportive Neighborhood Environment, NOS: Neighborhood Open Space, NES: Neighborhood Environment Scale. 4. Physical activity assessment tool name: IPAQ: International Physical Activity Questionnaire, NWQ-CS: Neighborhood Walking Questionnaire for Chinese Seniors (adapted from NPAQ: Neighborhood Physical Activity Questionnaire), HTS: Household Travel Survey, PASE: Physical Activity Scale for the Elderly, CHAMPS: Community Healthy Activities Model Program for Seniors, NPAQ: National Physical Activity Questionnaire, AAS: Active Australia Survey, LAPAQ: Longitudinal Aging Study Amsterdam (LASA) Physical Activity Questionnaire, YAPS: Yale Physical Activity Survey, HIS: Health Interview Survey, SPPARCS: Study of Physical Performance and Age-Related Changes in Sonomans. 5. TW: Total Walking, TRW: Walking for Transport, RW: Walking for Recreation.

Neighborhood selection was conducted using a variety of methods. The most common method was to stratify the neighborhood by walkability and socio-economic status (SES; 25.7%, 18 studies). The other common method was to use the census tract (14.3%, 10 studies). Among the 70 studies, 27 studies (38.6%) did not use stratified sampling methods. Stratification by walkability and SES were used in Africa [27], Asia [48–54], Europe [55–58], and North America [59–64]. In the individual selection for sampling procedures, two-thirds of the studies randomly selected participants. The other common method was convenience/purposive sampling (27.1%). More than half of the studies were on identified projects with multiple publications performed in four continents, Asia (Hong Kong [48–53]), Europe (Belgium [55–58]), North America (USA [39,60–63,65–69]), and South America (Brazil [33,34]). Nineteen identified projects (27.1%; three studies in Asia, five studies in Europe, and eleven studies in North America) were associated with only one publication. Neighborhood environments are measured in two ways: objective indicators (39 out of 70) and perception (45 out of 70). Thirteen studies (18.6%) measured neighborhood environments both ways in three continents (i.e., Asia, Europe, and North America). In the objective measurement, Geographic Information Systems (50.0%; GIS) were the most frequently harnessed method, followed by Walk Score and EAST-HK (4.3%) respectively. The neighborhood boundaries assessed by GIS were network buffer, radius buffer, or administrative district. Those methods were utilized in all continents excluding Africa (which only measured participants' perceptions) [27]. NEWS (30.0%) was used to measure neighborhood perceptions across all the continents. Self-administered/unknown questionnaires (15.7%) were frequently used as well. The most frequent measurement tool of walking behavior was the International Physical Activity Questionnaire (IPAQ; 25.7%), mainly used in Asia, Europe, and South America. Community Healthy Activities Model Program for Seniors (CHAMPS; 12.9%) and Yale Physical Activity Survey (YPAS; 7.1%) followed, primarily utilized in North America. Only three projects (4.3%) objectively measured walking behaviors by GPS [70,71] or accelerometer [31] in Europe. The most frequent measurement of walking behaviors across all walking types was walking minutes/hours. Eleven studies (out of 39) in total walking, 14 studies (out of 38) in transport walking, and 12 studies (out of 31) in recreational walking measured walking minutes. This dependent variable measurement method was used in research in four continents (i.e., Africa, Asia, Europe, and North America). Oceanian and South American studies mainly assessed walking behaviors with categorical variables (e.g., no walking vs. walking, less than 60 min walking vs. 60+ minutes walking, and less than 150 min walking vs. 150+ min walking) [33–36,72,73].

3.2. *Summary of Association Between Neighborhood Environmental Characteristics and Walking Types*

Overall, the environmental characteristics with strong association to older adults' walking behaviors are as follows: Walkability, urbanization, employment/income, land use mix-diversity, land use mix-accessibility, residential entrance accessibility, indoor places for walking, distance to Central Business District (CBD; -), presence of walking amenities (e.g., benches), bicycle lanes, and neighborhood social cohesion. However, the associations differ by walking types (total, transport, and recreation) (Table 3).

Table 3. Summary of association between environmental characteristics and walking types.

ENVIRONMENTAL CHARACTERISTICS	TOTAL						TRANSPORT						RECREATION					
	Perception		Objective		Total		Perception		Objective		Total		Perception		Objective		Total	
	Assoc.	% of Stud.	Assoc.	% of Stud.	Assoc.	% of Stud.	Assoc.	% of Stud.	Assoc.	% of Stud.	Assoc.	% of Stud.	Assoc.	% of Stud.	Assoc.	% of Stud.	Assoc.	% of Stud.
Walkability	**++**	**71**	**+**	**84**	**++**	**74**	ø	0	**++**	**73**	**++**	**68**	ø	0	??	48	??	43
Urbanization	-	-	**++**	**100**	**++**	**100**	-	-	**++**	**100**	**++**	**100**	-	-	-	-	-	-
Density																		
Population/Housing	øø	11	??	50 *	øø	31 *	øø	24	??	45	øø	29	øø	0	øø	33	øø	10
Employment/Income	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**+**	**83**	**+**	**83**
Intersection density	ø	0	??	46 *	??	35 *	øø	31	??	38	øø	32	øø	7	øø	23	øø	17
Destinations																		
Land use mix (diversity)	**+**	**100**	øø	31 *	??	39 *	**++**	**60**	?	57	**++**	**60**	øø	25 *	??	40 *	øø	29 *
Land use mix (accessibility)	??	50	??	40	??	44	**++**	**64**	?	50	**++**	**64**	øø	29	**+**	**100**	øø	33
Residential entrance accessibility	-	-	-	-	-	-	**++**	**71**	-	-	**++**	**71**	øø	0	-	-	øø	0
Eating & Retail	??	35 *	øø	0	øø	25 *	-	-	??	50	??	50	-	-	-	-	-	-
Social gathering places	ø	21	øø	5	øø	11	ø	0	øø	31	øø	25	ø	0	ø	0	øø	0
Other destinations	?	38	??	33	??	34	-	-	øø	31	øø	31	-	-	-	-	-	-
Overall recreational spaces	øø	27 *	?	33	øø	29	øø	33	ø	25	øø	31	øø	32	øø	25	øø	30
Recreational facility	ø	17	**+**	**78**	??	47	??	36	øø	30	øø	33	ø	0	ø	0	øø	0
Green space	øø	20	??	56	??	43	øø	25	?	50	øø	33	ø	0	øø	25	øø	11
Indoor places for walking	-	-	-	-	-	-	-	-	-	-	-	-	**++**	**63**	?	50	**++**	**60**
Public transport/Bus stop	øø	8	??	50	øø	27	øø	31 *	??	38	øø	32 *	øø	10	ø	8	øø	10
Distance to CBD/Business	-	-	**-**	**67**	**-**	**67**	-	-	-	-	-	-	-	-	-	-	-	-
Safety-related																		
Safety from crime/Personal safety	øø	19	**+**	**100**	øø	24	øø	15 *	-	-	øø	15 *	øø	6 *	ø	25	øø	9 *
Streetlights/No stray animals	øø	0	**+**	**75**	øø	15	ø	25	ø	33	øø	30	ø	0	ø	0	øø	0
Disorder	ø	14	**?**	**50**	øø	30	øø	10	**+**	**80 ***	øø	26 *	øø	0	ø	0	øø	28
Seeing people being active/Presence of people	??	50	-	-	??	50	??	36	-	-	??	36	??	50	-	-	øø	50
Traffic safety/Pedestrian safety	??	18	-	-	??	18	øø	29 *	ø	0	øø	26 *	øø	12	-	-	øø	12
Traffic hazard	-	-	-	-	-	-	øø	0	-	-	øø	0	øø	0	-	-	øø	0
Traffic speed/volume	-	-	-	-	-	-	ø	17	-	-	ø	17	øø	0 *	ø	14 *	øø	23 *
Traffic safety devices	-	-	-	-	-	-	øø	8	**++**	**75**	øø	18	øø	0	-	-	øø	0
Bridge/overpass	-	-	-	-	-	-	-	-	-	-	-	-	??	50	-	-	??	50
Infrastructure-related																		
Overall infrastructure	-	-	-	-	-	-	??	39	?	50	??	39	øø	19	-	-	øø	19
Presence and quality of sidewalk	øø	5	**++**	**60**	øø	23	**++**	**67 ***	øø	25	??	54 *	øø	30	øø	0	øø	17
Amenities	-	-	-	-	-	-	**++**	**73**	ø	0	**++**	**62**	øø	20	?	50	øø	25
Physical barriers	øø	0	øø	10 *	øø	20 *	øø	32 *	ø	0	øø	27 *	øø	0	ø	0	øø	29
Bicycle lanes	øø	13	-	-	øø	13	**+**	**67**	-	-	**+**	**67**	ø	17	-	-	ø	17
Aesthetics																		
Aesthetics	??	55	ø	0	??	50	øø	22	ø	25	øø	22	??	50	?	42	??	49
Air quality/Quietness	ø	17	ø	0	øø	13	ø	0	-	-	ø	0	ø	0	**+**	**75**	??	50
Social environment																		
Neighborhood social cohesion	øø	21	-	-	øø	21	øø	15 *	-	-	øø	15 *	**++**	**63**	-	-	**++**	**63**

*: Environmental characteristics with both positive and negative associations. / Please refer to Table 1 for association codes.

3.2.1. Neighborhood Environmental Characteristics' Association with Total Walking

In regard to the relationship between neighborhood environmental characteristics and total walking, three neighborhood characteristics had strong associations among 25 characteristics (i.e., positive association in 74% of studies for walkability and 100% of studies for urbanization, and negative association in 67% of studies for distance to CBD) (Table 3). The detailed summary is in Table A1. Findings from seven environmental characteristics' associations with total walking were inconsistent or indeterminate (intersection density, land use mix-diversity, land use mix-accessibility, presence/accessibility of recreational facility, presence/accessibility of green spaces or parks, seeing people being active or presence of people on the street, and aesthetics or natural sights). Fifteen out of 25 neighborhood environmental characteristics were not related to older adults' walking. In comparing the perceived and objectively-assessed neighborhood environmental characteristics, objectively-measured neighborhood characteristics (recreational facility, safety from crime or personal safety, streetlights or no stray animals, and presence and quality of sidewalk) had a positive association with older adult's total walking. However, the perceived characteristics did not have a strong association with older adult's walking behavior. Perception of the diversity of mixed land use [87] had a strong association with older adult's total walking but an objective measure of the diversity of mixed land use did not. The associations with objectively measured urbanization (+) and distance to CBD (−) were related to total walking of older adults but the perceptions of those were not measured in any studies.

3.2.2. Neighborhood Environmental Characteristics' Association with Walking for Transport

Neighborhood environmental characteristics demonstrated the strongest association with transport walking among all types of walking (The detailed summary is in Table A2). Six neighborhood environmental characteristics out of 30 had strong associations (68% of studies for walkability, 100% of research measuring urbanization, 60% and 64% of studies which measured mixed land use-diversity and accessibility respectively, 71% of studies measuring residential entrance accessibility, and 62% of studies which measured presence of amenities). The association of four environmental characteristics was indeterminate or inconsistent (presence/accessibility of eating places or retail stores, seeing people active and presence of people on the street, overall infrastructure, and presence/quality of sidewalk). No evidence was found from the 20 environmental characteristics remaining.

In some cases, positive associations from the perceived neighborhood environments were clear (land use mix-diversity (60% of studies) and land use mix-accessibility (64%), residential entrance accessibility (71%), walking amenities such as benches (73%), and bicycle lanes (67%)). In other cases, objectively-assessed environmental characteristics (with the same neighborhood characteristics) were either unrelated to walking for transport or not available. Objectively-measured walkability (73%), urbanization (100%), and traffic safety devices (75%) were positively associated with older adult's transport walking but no perceptions were measured on these characteristics. The evidence from objectively-assessed social and/or physical disorder (80%) through pedestrian environmental audit tools and perceived presence/quality of sidewalks (67%) had both negative and positive associations for transport walking.

3.2.3. Neighborhood Environmental Characteristics' Association with Walking for Recreation

Significantly positive associations between neighborhood environmental characteristics and the recreational walking of older adults was found with employment/low-income ratio in the neighborhood (83% of studies), indoor walking places (60%), and perception of social cohesion (63%) out of 30 neighborhood characteristics (The detailed summary is in Table A3). Findings from walkability, aesthetics/greenery, and perception of air quality/quietness were not consistent. No association was found with the remaining 24 neighborhood characteristics.

When compared to objectively measured neighborhood environmental characteristics, the perception of indoor places for walking (63%) and neighborhood social cohesion (63%)

had strong associations with older adults' walking behaviors, but the evidence from these objectively-assessed environments was not consistent or there were no objectively-assessed environments. Objectively-measured accessibility to diverse destinations (100%) [68] and air quality/quietness (75%) [49,52] had positive relationships to senior citizen's walking, but the evidence was not sufficient because of the small study numbers. Hence, the perceptions of these environmental characteristics resulted in no associations with recreational walking of older adults.

3.3. Summary of Moderation Effects for Walking

The moderation effects of socio-demographic, physical and psychosocial, and environmental factors with neighborhood environmental characteristics differ by walking types (Table 4). The interactions between moderators and environmental characteristics were tested only once in 20 of the studies. However, some moderators (e.g., gender, age, self-efficacy, psychological barriers, social support, and area deprivation) were repeatedly tested in different studies. Gender was the most frequently studied moderator interacting with perceived [27,47,53] and objectively-assessed environmental characteristics [72] (4 out of 20 studies), followed by age [47,48,53] (3 out of 20).

Table 4. Interactions between moderators and neighborhood environmental characteristics.

		TOTAL			TRANSPORT			RECREATION		
	PERCEIVED ENVIRONMENT	**+**	**-**	**ø**	**+**	**-**	**ø**	**+**	**-**	**ø**
SOCIO-DEMOGRAPHIC										
Gender (men)	Land use mix-accessibility									[27] AF
	Walking infrastructure and personal safety				[27] AF			[27] AF		
	Traffic safety					[47] E		[27] AF		
	Presence of street lighting						[47] E			
	Perceived sitting facilities (benches)				[53] A(I)					
	Crime						[53] A(II)			
Gender (women)	Land use mix-accessibility							[27] AF		
	Walking infrastructure and personal safety						[27] AF			[27] AF
	Traffic safety					[47] E			[27] AF	
	Presence of street lighting				[47] E					
	Perceived sitting facilities (benches)				[53] A(I)					
	Crime				[53] A(II)					
Age (<75)	Land use mix-diversity						[53] A(I, II)			
	Perceived sitting facilities (benches)						[47] E, [53] A(I, II),			[48] A
	Presence of public toilets					[47] E				
	Presence of crossings						[47] E			
	Presence of street lighting				[47] E					
	Physical barriers									[48] A
	Indoor places for walking									[48] A
	Traffic speed									[48] A
Age (≥75)	Land use mix-diversity				[53] A(I, II)					
	Perceived sitting facilities (benches)				[53] A(II)		[47] E, [53] A(I),	[48] A		
	Presence of public toilets					[47] E				
	Presence of crossings						[47] E			
	Presence of street lighting				[47] E					
	Physical barriers								[48] A	
	Indoor places for walking							[48] A		
	Traffic speed								[48] A	
Education (No formal education)	Physical barriers								[48] A	
	Infrastructure for walking							[48] A		
	Indoor places for walking							[48] A		
	Fence separating sidewalks from traffic							[48] A		

Table 4. *Cont.*

		TOTAL			TRANSPORT			RECREATION		
	PERCEIVED ENVIRONMENT	**+**	**-**	**ø**	**+**	**-**	**ø**	**+**	**-**	**ø**
Education (Primary)	Physical barriers									[48] A
	Infrastructure for walking							[48] A		
	Indoor places for walking							[48] A		
	Fence separating sidewalks from traffic									[48] A
Education (Secondary and over)	Physical barriers									[48] A
	Infrastructure for walking									[48] A
	Indoor places for walking									[48] A
	Fence separating sidewalks from traffic									[48] A
Household size (Living alone)	No traffic barriers									[79] E
	No terrain barriers									[79] E
	Long distance to services (destinations)							[79] E		
	Entrance barriers									[79] E
Household size (Living with others)	No traffic barriers							[79] E		
	No terrain barriers							[79] E		
	Long distance to destinations							[79] E		
	Entrance barriers									[79] E
Age (<75) * Male	Absence of decay					[47] E				
	Absence of noise					[47] E				
Age (<75) * Female	Absence of decay					[47] E				
	Absence of noise					[47] E				
Age (≥75) * Male	Absence of decay					[47] E				
	Absence of noise					[47] E				
Age (≥75) * Female	Absence of decay						[47] E			
	Absence of noise					[47] E				
PHYSICAL or PSYCHOSOCIAL FACTORS										
Physical functioning	Safety from crime						[58] E			
Self-efficacy	Aesthetics				[65] NA *					[65] NA
	Walking facilities						[65] NA		[65] NA	
Psychological barriers	Aesthetics				[65] NA *					[65] NA
	Walking facilities						[65] NA			[65] NA
Social support	Aesthetics					[65] NA *			[65] NA *	
	Walking facilities						[65] NA			[65] NA

Table 4. *Cont.*

		TOTAL			TRANSPORT			RECREATION		
	PERCEIVED ENVIRONMENT	**+**	**-**	**ø**	**+**	**-**	**ø**	**+**	**-**	**ø**
ENVIRONMENT										
PERCEIVED										
Environmental index	Short distance to destinations						[78] E			
	Medium distance to destinations				[78] E					
Perceived Environmental index[2]	Short distance to destinations						[78] E			
	Medium distance to destinations					[78] E				
Objective										
Population density	Perceived land use mix			[41] NA, [41] NA						
Intersection density				[41] NA, [41] NA						
Stores and services density				[41] NA, [41] NA						
Area deprivation	Perceived safety	[71] E								
	Perceived quietness	[71] E								
	Perceived aesthetics	[71] E								
	Land use mix		[70] E							
	Social gathering destinations		[70] E							
	OBJECTIVELY-ASSESSED ENVIRONMENT									
SOCIO-DEMOGRAPHIC										
Gender (men)	Destinations within 400 m and 800 m buffer			[72] O						
Gender (women)				[72] O						
Household income (Individual)	Continuous Walk Score			[86] NA						
	Categorical Walk Score			[86] NA						
Age (<75) * Rural	Number of shops				[47] E					
	Public transportation subscriptions						[47] E			
Age (≥75) * Rural	Number of shops						[47] E			
	Public transportation subscriptions						[47] E			
Age (<75) * Semi-urban	Number of shops				[47] E					
	Public transportation subscriptions						[47] E			
Age (≥75) * Semi-urban	Number of shops				[47] E					
	Public transportation subscriptions						[47] E			
Age (<75) * Urban	Number of shops				[47] E					
	Public transportation subscriptions				[47] E					
Age (≥75) * Urban	Number of shops				[47] E					
	Public transportation subscriptions				[47] E					

Table 4. *Cont.*

		TOTAL			TRANSPORT			RECREATION		
PERCEIVED ENVIRONMENT		**+**	**-**	**ø**	**+**	**-**	**ø**	**+**	**-**	**ø**
PHYSICAL or PSYCHOSOCIAL FACTORS										
Poor lower-body functioning	Median block length			[87] NA						
Excellent lower-body functioning			[87] NA							
Level of frailty	Neighborhood characteristics						[82] E			
Self-efficacy	Walkability				[65] NA		[56] E	[56] E		[65] NA
	Parks and recreation									[65] NA
Psychological barriers	Walkability					[65] NA	[56] E			[65] NA
	Parks and recreation				[65] NA *					[65] NA
Social support	Walkability				[57] E, [65] NA					[65] NA
	Parks and recreation								[65] NA *	
Social norm	Walkability						[56] E			
Perceived benefits							[56] E			
Talking to neighbors							[57] E			[58] E
Social interactions among neighbors							[57] E			[58] E
Social diversity					[57] E					[58] E
ENVIRONMENT										
OBJECTIVELY-ASSESSED										
Neighborhood income (SES)	1/8 mile to park	[38] NA								
	1/2 mile to trail	[38] NA								
	Walkability						[55] E			[55] E
Rural	Presence of crossings					[47] E				
Semi-urban					[47] E					
Urban							[47] E			

Table 4. *Cont.*

		TOTAL			TRANSPORT			RECREATION		
	PERCEIVED ENVIRONMENT	**+**	**-**	**ø**	**+**	**-**	**ø**	**+**	**-**	**ø**
Land use mix-Accessibility: Non-food retail and services	1SD above average path obstructions No sloping streets				[50] A(II) [50] A(II)					
Land use mix-Accessibility: Food and grocery stores	1SD below average path obstructions No sloping streets				[50] A(II) [50] A(II)					
Land use mix-Diversity: Recreation	No signs of crime/disorder No stray animals				[50] A(II) [50] A(II)					
Land use mix-Diversity: Entertainment	No signs of crime/disorder				[50] A(II)					
Public transit point	No stray animals				[50] A(I)					
PERCEIVED										
Perceived land use mix	Objective population density Objective intersection density Objective stores and services density							[41] NA, [41] NA [41] NA, [41] NA [41] NA, [41] NA		
Proximity to recreational facilities	Recreational area of green and open spaces									[67] NA
Safety for walking	Number of street intersections							[67] NA		

Note: * $p < 0.1$.

3.3.1. Moderators for Total Walking

Only six studies out of 20 tested interactions between moderators and environmental characteristics for total walking of the elderly. Objectively-assessed area deprivation was the only moderator for perceived environments (i.e., safety, quietness, and aesthetics) [71] for total walking of seniors and these had significantly positive associations. Interactions between area deprivation and perceived environments (i.e., land use mix and social gathering destinations) for total walking [70] were negatively associated, with statistical significance. Gender, household income, physical functioning, and objectively-measured neighborhood SES moderated objectively-measured neighborhood environments. Among them, there were no moderation effects by (1) gender [72] and destinations with 400 m and 800 m buffers, and (2) household income [86] and Walk Score (objectively-measured environmental characteristics) for total walking, but median block length moderated by excellent (not poor) lower-body functioning [87] was negatively associated. Interaction between neighborhood SES and close distance to park and trail (objectively assessed) [38] were positively associated with total walking and statistically significant.

3.3.2. Moderators for Transport Walking

Interactions between moderators and neighborhood environments were the most frequently tested for transport walking (11 out of 20 studies) among the three types of walking behaviors. Two studies tested interactions between moderators and both objectively-measured and perceived environmental characteristics [47,65] but the other studies only tested either objectively-measured or perceived environments. Among 90 moderation effects, 40 interactions were positive and 15 interactions were negative with statistical significance. For example, walking infrastructure and personal safety in males not females, perceived presence of sitting facilities for both males and females, presence of street lighting and perceived crime safety in females not males were significantly associated with transport walking [27]. Traffic safety was negatively associated with transport walking in both males and females [47]. Land use mix-diversity (+) and presence of sitting facilities (+) were associated with older seniors (≥75). Presence of public toilets (−) and presence of street lighting (+) were associated with both age groups. Age and gender interactions with neighborhood environments (e.g., absence of decay and absence of noise) were predictors of strongly negative associations with seven out of eight moderators. Age and density (rural, semi-urban, urban) moderators with objectively-measured number of shops and public transport subscriptions yielded strongly positive relations, with five out of ten environmental characteristic combinations, in a Flemish study [47]. Among physical and psychosocial factors, the interactions of perceived aesthetics with self-efficacy (+), psychological barriers (+), and social support had moderate associations as $p < 0.1$ [65]. The interactions of objectively-assessed walkability with self-efficacy (+), psychological barriers (−), and social support (+) had strong associations in Belgian and American studies [57,65].

3.3.3. Moderators for Recreational Walking

Fourteen moderators' interactions with neighborhood environmental characteristics were tested for recreational walking in 11 studies (out of 20). Among these, only one study examined interactions of moderators with both perception and objectively-assessed neighborhood factors [65]. Out of 59 interactions between moderators and neighborhood environmental factors for recreational walking, 22 moderators had positive associations and seven had negative associations. To be more specific, gender was examined as a moderator for recreational walking interacting with perceived environmental characteristics and there were sufficient moderation effects from walking infrastructure and personal safety (+) and traffic safety (+) in males, and land use mix-accessibility (+) and traffic safety (−) in females [27]. Age and education were tested as moderators interacting with perceived environmental characteristics in one Hong Kong study [48]. There were no moderating effects of environmental characteristics for younger older adults, but presence of sitting places (+), physical barriers (−), and

indoor places for walking (+) were statistically significant for older senior citizens [48]. Excluding interactions between (1) self-efficacy and parks and recreation (+) and (2) social support and parks and recreation (−), no moderators were significantly related to recreational walking. Almost all interactions tested with both perceived and objectively-measured environments showed statistically significant associations [41,67].

3.4. Summary of Walking Behaviors by Geographical Region

The walking behaviors, which were measured as dependent variables, are diverse. Some studies only measured walking for transport and/or recreation while others accounted for all types of walking (Table 5). Nevertheless, the most frequently measured dependent variables were (1) minutes of walking per week, (2) walking more than 150 min per week, and (3) no walking or less than 10 min of walking per week. Average walking minutes of seniors per week were assessed from all continents excluding Oceania. Needless to say, total walking minutes were higher than either walking for transport or recreation but distinctions between all three types of walking minutes per week were only made in Great Britain [80,81] and Chicago, USA [92]. Average walking minutes for transport were found to be higher than average walking minutes for recreation in Nigeria, Africa [27]; Hong Kong, China [48–54]; and Florianopolis, South Brazil [33,34]. However, the average minutes of transport remained similar to the walking minutes of recreation in Gent, Belgium [55–58] and Great Britain [80,81] respectively. In the US studies, average walking minutes per week for recreation were higher than the walking minutes for transport in (1) Maryland-Washington, DC region and Seattle-King County [62,63,65], and (2) Massachusetts, Pennsylvania, and California [41] but not for the study in Chicago [92]. Comparatively, a larger proportion of older adults from Asia (Japan [77] and Taiwan [30]) as well as South America (South Brazil [33,34]) walked more than 150 min per week for transport rather than recreation. More than 50% of the seniors in Japan [42,77] (Asia), Canada [86] (North America), Brazil [35], and Columbia [36] (South America) walked more than 150 min per week. Meanwhile, 23 to 38% of American [40,87,94] or Australian [72] older adults walked more than 150 min per week but no proportional information for European older adults was investigated. The ratio of Hong Kong older adults who do not walk is surely lower than other areas (3.3% [52] versus 23% [85] or 37.9% [33,34] in transport walking; 22 to 23% [49,52] versus 65.1% [33,34] in recreational walking; and 4.75% [52] versus 15% [26,94] in total walking).

Table 5. Summary of walking which is most frequently measured, by location.

GEOGRAPHICAL LOCATION			WALKING TYPES		
			TOTAL	**TRANSPORT**	**RECREATION**
			Average min/week [Number of Study]	***Average min/week [Number of Study]***	***Average min/week [Number of Study]***
Africa		Nigeria		* 138 [27]	* 73.5 [27]
Asia		Hong Kong, China	* 498 [48–53]	* 254 [48–53], * 169 [54]	* 244 [48–53], * 137 [54]
		Sungnam city & Chungnam province, Korea	Urban: * 164.8 [28] Rural: 117.8 [28]	-	-
Europe		Gent, Belgium		86 [55–58]	83 [55–58]
		Great Britain	270 [80,81] Men: 276 Women: 270	117.6 [80,81] Men: 115.8 Women: 119.4	123 [80,81] Men: 145.8 Women: 109.2
		Spijkenisse, Netherlands	-	* 194.95 [82]	-
North America		Metro Vancouver, Canada	-	222 [85] Men: 246 Women: 204	-
	USA	Baltimore, Maryland-Washington, DC region & Seattle-King County	-	36 [62], 41.4 [63], 41 [65]	204 [62], 100.6 [63], 99.5 [65]
		Portland			* 130.98 [68]
		Chicago	* 140.5 [92]	* 79.5 [92]	* 62.5 [92]
		Massachusetts, Pennsylvania, and California	-	53.9 [41]	135.9 [41]
Oceania			-	-	-
South America		Florianopolis, Santa Catarina, South Brazil	-	* 114.5 [33,34,36]	* 77.7 [33,34,36]
			≥ 150 min/week [Number of Study]	***≥150 min/week [Number of Study]***	***≥150 min/week [Number of Study]***
Africa			-	-	-

Table 5. *Cont.*

GEOGRAPHICAL LOCATION			WALKING TYPES		
			TOTAL	TRANSPORT	RECREATION
			Average min/week [Number of Study]	*Average min/week [Number of Study]*	*Average min/week [Number of Study]*
Asia		Bunkyo ward, Fuchu, & Oyama, Japan	54.2% [77] M: 54.5% W: 53.9%	50.6% (≥ 60 m/w) [77] M: 42.5% (≥ 60 m/w) W: 59.0% (≥ 60 m/w)	52.0% (≥ 30 m/w) [77] M: 56.9% (≥ 30 m/w) W: 47.0% (≥ 30 m/w)
		Kasama, Ibaraki Prefecture, Japan	52.7% [42]	-	-
		Seongnam & Chungnam, S. Korea	Urban: * 42.6% [28] Rural: 29.0% [28]	-	-
		Unknown, Taiwan	-	21.2% [30]	72.2% [30]
Europe			-	-	-
North America		Metropolitan British Columbia, Canada	61.3% [86]	-	-
	USA	Alameda County, CA, Cook County IL, Wake and Durham Counties, NC	37.8% [87]	-	-
		Temple, Killeen, Bryan, and College Station, TX	* 27.86% [94]	-	-
		Massachusetts, Pennsylvania, and California, USA	22.9% [40]	50% [41]	56% [41]
Oceania		Perth metropolitan region, Australia	30.8% [72]	-	31.3% [73]
South America		Florianopolis, Santa Catarina, South Brazil	-	26.5% [33,34]	19.6% [33,34]
		Ermelino Matarazzo district, São Paulo, Brazil	Men: 56.9% [35] Women: 34.1% [35]	-	-
		Bogotá, Columbia	62.4% [36]	-	-
			% of NO walking/week [Number of Study]	*% of NO walking/week [Number of Study]*	*% of NO walking/week [Number of Study]*
Asia		Hong Kong, China	4.75% [52]	3.3% [52]	22.1% [49], 23.2% [52]
North America		Metro Vancouver, Canada	-	23% [85]	-
	USA	San Diego County, CA	15% [26]	-	-
		Temple, Killeen, Bryan, and College Station, TX	14.61% [94]	-	-
South America		Florianopolis, Santa Catarina, South Brazil	-	37.9% [33,34]	65.1% [33,34]

Note *: urban area.

4. Discussion

In the last two decades, the association between walking behaviors and neighborhood environments has been noted in the fields of public health, urban planning and design, and transportation aiming for sustainable health status and neighborhood development. This study targeted a systematic literature review of studies on the relationship between all types of older adult's walking (total, transport, and recreation) and neighborhood environments. Although three recent systematic review papers about physical activity [2], active travel [20], and leisure-time physical activity [19] explored the association between neighborhood environments and older adults' walking behaviors, 34 of the studies reviewed here are missing from those papers. Moreover, there has been no systematic review paper comparing summaries of research designs and walking outcomes by location.

This research results found a strong relationship between the walking behaviors of older adults and neighborhood environment characteristics, illustrating how sustainable and walkable neighborhood developments should be. Nevertheless, some evidence is still too weak to generalize the significance of environmental characteristics, since the associations differ by walking types, demonstrating inconsistency from the previous findings of Barnett et al. [2], Cerin et al. [20], and Van Cauwenberg et al. [19]. This gap may be caused by a different scoring system since they used weights by sample size and ratio of gender for meta-analysis illustrating *p*-values. Additional studies incorporated in this review may fill in the gaps in these reviews. It has been found that there are no environmental characteristics associated with walking consistently, regardless of walking types, among senior citizens. Thus, this finding is not congruent with the previous findings that walkability was a strong environmental factor inducing all types of walking [2,19,20]. In this review, walkability, as well as urbanization, are strong evidence supporting total and transport walking and these findings were consistent with previous reviews [2,20]. This study also found that land use mix-accessibility and diversity strongly supported only older adult's transport walking, congruent with the findings from Cerin et al.'s review [20]. These factors are indeterminant for total and recreational walking, which is inconsistent with Barnett et al. [2] and Van Cauwenberg et al.'s reviews [19]. The positive or negative evidence for some environmental characteristics (e.g., indoor walking places, easily accessible residential entrance, distance to CBD) in this study are not congruent with other reviews.

This study found that compared to other types of walking, neighborhood environmental factors are more critical predictors of walking for transport among the elderly, which is consistent with Saelens et al.'s findings for all populations [22]. Nevertheless, geographical and environmental (objectively-measured versus perceived) differences for transport walking need to be considered. To be more specific, walkability and urbanization were mainly objectively-assessed environmental factors and these showed strong evidence supporting older adults' walking for transport. However, this evidence has a weakness in that these were only measured in Europe [32,55,56,58,78] and North America [46,60,65,84,85,89]. On the other hand, walkability was found to have no association to older adult's transport walking in highly-dense Singapore [25]. This may be due to how perceived and objectively assessed walkability is different in densely-populated Asian cities. Diversity of land use and easily accessible destinations were also measured by perceptions. These perceptions worked as strong evidence of older adult's walking for transport and were measured in diverse geographical locations such as Africa [27], Asia [25,51,53,54,77], Europe [47,78], North America [41,60,61], and Oceania [73]. Interestingly, for Singapore, the perception on diversity of land use was assessed in both objective and perceived environments; the perception of land use mix-diversity was a predictor of Singaporean older adults' walking but the objectively-measured one was not [25]. Perceptions of the environmental characteristics may reflect diverse lifestyles of older adults rather than objectively measured diversity of land use. According to Etman et al.'s study [82], accessibility within an 800 m network buffer was associated with transport walking, but the destinations beyond the network buffers were not associated with older adults' walking in Europe. Nevertheless, a Singapore case study reported eating places that were too close to home as evaluated by seniors' perceptions were negatively associated with their total walking duration [29]. With Singapore's unique urban design, retail shops and food centers are often

located within a surrounding radius of most public housing properties. These results may provide urban planners/designers and policy makers insight into how these destinations or land use mixes can improve older adults' health and be environmentally sustainable. However, the evidence still does not have enough geographical variation to generalize.

In the previous research for moderating effects, the majority of moderating effects tested were not significant or there was a dearth of evidence [18–20]. The most frequently examined moderating effects for socio-demographic characteristics such as gender and age showed inconsistent findings. These inconsistencies may be associated with environmental differences (city or country-specific characteristics) or cultural differences. For example, the presence of sitting facilities encourages transport walking for older seniors in Hong Kong [53], but did not encourage older seniors' walking for transport in Belgium [47]. Cycling behaviors as a mode of transport for Belgian older adults may influence this result, or there may be enough benches in Belgium so that seniors do not recognize sitting places as significant for walkability. The moderating effects between psychosocial factors (i.e., self-efficacy (+), psychological barriers (−), social support (+), social diversity (+)) and objectively-measured walkability may be significant to promote older adults' walking [57,65], especially as transport rather than recreation. Since walkability was a significant predictor of transport walking rather than recreation walking, the moderators of psychosocial factors with walkability are more easily explained, but the evidence is still weak. The interaction of these psychosocial factors with perceived neighborhood environments (i.e., aesthetics and walking facilities) are associated with older adult's transport walking, but the evidence is not strong. Moderating factors between perceived and objectively-assessed environments tend to relate to walking of older adults [41,50,67]. This evidence can offer insights for urban planners/designers or policy makers on how sustainable neighborhood environments can encourage walking behaviors.

As of the writing of this chapter, no review papers have been published comparing the results of all types of walking outcomes of older adults. As expected, the average minutes of total walking as measured in the research is longer than that for walking for transport or recreation. In a simple comparison of walking minutes, the author can estimate how density/walkability as well as land use mix-diversity and accessibility are associated with walking behaviors, although a statistical mean comparison is not available. In the car-oriented United States neighborhood environments with low density and low diversity of land use, the elderly walked less for transport. Rather, they walked more for recreation, excluding the Chicago study [92], but the total minutes of recreation walking were much less than that of older adults residing in highly-dense areas such as Hong Kong. In the highly-dense Hong Kong studies, older adults walked the most for both recreation and transport compared to other countries. It can be interpreted that older adults walk considerably more for recreational purposes (as exercise) once walking becomes habitual as a means of transportation. However, this interpretation requires more evidence since the study results in Hong Kong come from two projects (unnamed [53] and Hong Kong Elderly [48–53]).

5. Study Limitations, Future Research Implications, and Conclusions

The author reviewed papers at least twice for reliable classifications and coding procedures to maximize intra-coder (within-coder) reliability. Although intra-coder reliability is generally higher than inter-coder reliability, it is possible that some notable inconsistencies could have been generated [95]. Thus, the author acknowledges that since a single author reviewed and coded all papers without obtaining inter-coder reliability from two or more raters, this remains a limitation. In regard to research methods, longitudinal studies on such analyses remain limited although a great deal of research on neighborhood environments and walking behaviors of older adults has flourished in recent years. Only three longitudinal studies were analyzed among the 70 peer-reviewed papers in this study. Thus, more longitudinal studies are required to obtain a greater depth of knowledge on the health outcomes in relation to built environments (e.g., whether walking behaviors of older adults result in poorer physical functioning or contribute to maintaining or increasing health status). In this review, personal

characteristics of older adults may be strongly associated with older adults' walking behaviors, but seniors' preferences or self-selection of walkable neighborhoods are not explored. Moreover, the physical or psychosocial aspects of older adults and the motivations behind their walking behaviors can be explored in greater detail. Walking for transport may be encouraged by these psychosocial aspects, and the moderating effects between psychosocial factors and walkability may support this argument [57,65]. Although the findings from different locations may differ, there are currently no comparative studies that analyze walking behaviors by geographical location or city boundaries. Hence, a comparative study looking at the same environmental characteristics and walking behaviors, internationally or across continents, could open up new scholarship and further in-depth findings.

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Conflicts of Interest: The author declares no conflict of interest.

Appendix A

Table A1. The relationship between total walking and neighborhood environment characteristics.

Total Walking										
Environmental Factors	**Perceived Environment**				**Objectively-Measured Environment**				**Summary (Total)**	
	Reference No.	**Related (+/-)**	**Uncertain (U)**	**Unrelated (ø)**	**Reference No.**	**Related (+/-)**	**Uncertain (U)**	**Unrelated (ø)**	**Association**	**% Studies**
Walkability	* [74] A, [80] E, [90] NA(NML), [91] NA(M)	+		[90] NA(ML), [91] NA(W)	[26] NA([800 NB, 4800 NB]-W), [86] NA(I, II),	+		[26] NA([1600NB]-W)	++	74
		–				–				
Urbanization		+			[37] NA(I, II), [46] NA, [83] E(YG, OG), [93] NA(I, II, III)	+			++	100
		–				–				
Density										
Population/Housing	[91] NA(M)	+		[42] A(I, II), [77] A, [77] A(M, W), [90] NA(ML, NML), [91] NA(W), [87] NA	* [43] NA(I), [40] NA, [62] NA([1200NB]-W), * [75] A(D1[I], D2[I]),	+		* [43] NA(II), * [44] NA, * [71] E, [87] NA, [76] A(250RD [I, II], 500RD [I, II], 1000RD [I, II]),	øø	31
		–			* [75] A(D1[II], D2[II])	-				
Intersection density		+		[35] SA(M, W), [87] NA,	[62] NA([1200NB]-W)	+		[36] SA(D2[500RD]), * [43] NA(I, II), * [44] NA, * [44] NA, [87] NA, [76] A(250RD [I, II], 500RD [I], 1000RD [I, II]),	??	35
		–			[36] SA(D1[500RD]), [40] NA, * [71] E, [76] A(500RD [II])	–				
Destinations										
Land use mix (diversity)	[87] NA	+			* [43] NA(I), [62] NA([1200NB]-W)	+		[36] SA(D1[500RD], D2 [500RD]), * [43] NA(II), * [44] NA, * [71] E, * [75] A(D1 [I], D2 [I]),	??	39
		–			* [75] A(D1[II], D2[II])	–				
Land use mix (accessibility)	[90] NA(ML), [91] NA(W), [87] NA	+		* [29] A, [90] NA(NML), [91] NA(M)	[40] NA, * [44] NA, * [75] A(D1[II], D2[II]),	+		* [71] E, [72] O (D1 [400NB (I, II), 800 NB (I, II)], D2 [400NB (I, II), 800 NB (I, II)]), * [75] A(D1 [I], D2 [I]), [76] A(250RD [I, II], 500RD [I, II], 1000RD [I]),	??	44
		–			[76] A(1000RD [II])	–				

Table A1. *Cont.*

Total Walking										
Environmental Factors	**Perceived Environment**				**Objectively-Measured Environment**				**Summary (Total)**	
	Reference No.	**Related (+/-)**	**Uncertain (U)**	**Unrelated (ø)**	**Reference No.**	**Related (+/-)**	**Uncertain (U)**	**Unrelated (ø)**	**Association**	**% Studies**
Eating & Retail	* [29] A, [77] A(W),	+	[77] A	[28] A(* W-U, R), [35] SA(M, W), [35] SA(M, W), [35] SA(M, W), [35] SA(M, W), [42] A(I, II), [77] A(M),		+		* [44] NA, * [71] E, * [71] E, [72]O (D1 [400 NB (I, II), 800 NB (I, II)], D2 [400 NB (I, II), 800 NB (I, II)]), [72] O (D1 [400NB (I, II), 800 NB (I, II)], D2[400 NB (I, II), 800 NB (I, II)])	øø	25
	* [29] A	–				-				
Social gathering places	* [29] A, [35] SA(W)	+		* [29] A, [35] SA(M), [35] SA(M, W), [35] SA(M, W), [35] SA(M, W), [35] SA(M, W), [35] SA(M, W), [35] SA(M, W)	[72] O (D1 [800NB(I)])	+		* [44] NA, * [71] E, [93] NA, [72] O (D1 [400 NB (I, II), 800 NB (I, II)], D2 [400 NB (I, II), 800 NB (II)])	øø	11
		–				–				
Other destinations	[35] SA(W)	+	[35] SA(W), [69] NA,	[35] SA(M), [35] SA(M),	[62] NA([1200NB]-W), [72] O (D2 [400NB(I, II)], 800NB (I, II)]), [72] O (D1 [400NB (I, II), 800NB (I)]), [93] NA,	+	[72]O (D1[800NB(II)])	* [44] NA, * [44] NA, [69] NA, [72] O (D2 [400 NB (I, II), 800 NB (I, II)]), [72] O (D1 [400 NB (I, II), 800 NB (I, II)], D2 [400 NB (I, II), 800 NB (I, II)]), [72] O (D1 [400NB (I, II), 800 NB (I, II)]), [76] A(250RD [I, II], 500RD [I, II], 1000RD [I, II]), [93] NA, [93] NA,	øø	34
		–				–				
Overall recreational spaces	[45] NA(C[II], K[II]), [77] A,	+	[77] A(W)	* [29] A, [42] A(I, II), [45] NA(AS[I, II], C[I], F[I, II], J[I], K[I], V[I, II]), [77] A(M),	[83] E(OG),	+		[76] A(250RD [I, II], 500RD [I, II], 1000 RD [I, II]), [83] E(YG)	øø	29
	[45] NA(J[II])	–				–				
Recreational facility	[35] SA(M), [35] SA(M),	+		* [29] A, [35] SA(M, W), [35] SA(M, W), [35] SA(W), [35] SA(W)	[26] NA([1600NB]-W), [62] NA([1200NB]-W), * [71] E,	+		[26] NA([800NB, 4800NB]-W)	??	47
		–				–				
Green space	[28] A(W-R),	+		* [28] A(W-U), [35] SA(M, W), [35] SA(M, W), [35] SA(M, W), [69] NA, [69] NA,	[26] NA([800NB, 1600NB, 4800NB]-W), [36] SA(D1 [500RD]), * [71] E, * [75] A(D1 [I, II], D2 [I, II])	+	[36] SA(D2 [500RD]), [38] NA(M) [a], [38] NA(M) [a],	[26] NA([800NB, 1600NB, 4800NB]-W), [36] SA(D1[500RD], D2[500RD]), [69] NA, [93] NA,	??	43
		–				–				
Public transport/Bus stop		+		[35] SA(M, W), [35] SA(M, W), [42] A(I), [77] A, [77] A(M, W),	* [75] A(D1 [I, II], D2 [I, II]), [93] NA	+		[36] SA(D1 [500RD], D2 [500RD]), [93] NA,	øø	27
	[42] A(II)	–				–				

Table A1. *Cont.*

Environmental Factors	Total Walking									
	Perceived Environment				Objectively-Measured Environment				Summary (Total)	
	Reference No.	Related (+/-)	Uncertain (U)	Unrelated (ø)	Reference No.	Related (+/-)	Uncertain (U)	Unrelated (ø)	Association	% Studies
Distance to CBD/Business		+				+		[87] NA	–	67
		–			* [43] NA(I), * [43] NA(II), * [44] NA	–				
Safety-related										
Safety from crime/Personal safety	* [28] A(W-U), [45] NA(F[II]), * [70] E, [94] NA(D2)	+		[28] A(W-R), * [29] A, * [29] A, [35] SA(M, W), [35] SA(M, W), [42] A(I, II), [45] NA(AS[I, II], C [I, II], F[I], K[I, II], V[I, II]), [87] NA, [77] A, [77] A(M, W), [94] NA(D1),	* [52] A(I, II),	+			øø	24
		–				–				
Street lights/No stray animals		+		[28] A(* W-U, R), [35] SA(M, W),	* [52] A(I), * [52] A(I, II),	+		* [52] A(II)	øø	15
		–				–				
Disorder		+		[35] SA(M, W), [69] NA, [92] NA(IN),		+		[69] NA	øø	30
	[92] NA(N)	–			[59] NA	–				
Seeing people being active/Presence of people	[77] A, [77] A(M)	+		[42] A(I, II), [77] A(W)		+			??	50
		–				–				
Traffic safety/Pedestrian safety	[36] SA(D1), [42] A(I)	+	[35] SA(W), [35] SA(W), [36] SA(D2)	[28] A(* W-U, R), * [29] A, [35] SA(M), [35] SA(M), [42] A(II), * [70] E, [87] NA, [77] A, [77] A(M, W), [94] NA(D1, D2),		+			øø	18
		–				–				
Infrastructure-related										
Presence and quality of sidewalks		+	[77] A	* [29] A, [35] SA(M, W), [36] SA(D1, D2), [42] A(I, II), * [70] E, [77] A(M, W),	* [52] A(II), * [75] A(D1 [I, II], D2 [I, II]), * [43] NA(I),	+		* [52] A(I), * [43] NA(II), * [44] NA	øø	23
		–				–				
Physical barriers		+		* [29] A, * [29] A, [35] SA(M, W), [42] A(I, II), [69] NA,	[76] A(250RD [I], 500RD [I], 1000RD [I])	+		[36] SA(D2[500RD]), * [52] A(I), [69] NA, [76] A(250RD [II], 500RD [II], 1000RD [II])	øø	20
		–			[36] SA(D1 [500RD]), * [52] A(II),	–				

Table A1. *Cont.*

Environmental Factors	Total Walking									
	Perceived Environment				Objectively-Measured Environment				Summary (Total)	
	Reference No.	Related (+/-)	Uncertain (U)	Unrelated (ø)	Reference No.	Related (+/-)	Uncertain (U)	Unrelated (ø)	Association	% Studies
Bicycle lanes		+	[77] A	[42] A(I, II), [77] A(M, W),		+			øø	13
		–				–				
Aesthetics										
Aesthetics	[28] A(W-R), [42] A(I, II), * [70] E, [77] A, [77] A(M, W),	+		* [28] A(W-U), * [29] A, [35] SA(M, W), [87] NA,		+		* [52] A(I, II)	??	50
		–				–				
Air quality/Quietness	* [70] E	+		[35] SA(M, W), [35] SA(M, W), [35] SA(M, W), * [70] E		+		* [52] A(I, II)	øø	13
		–				–				
Social environment										
Neighborhood social cohesion	[45] NA(AS[II], C[II]), [92] NA(IN)	+		[45] NA(AS[I], C[I], F[I, II], J[I, II], K[I, II], V[I, II]), [92] NA(N),		+			øø	21
		–				–				

AF: Africa/A: Asia/E: Europe/NA: North America/SA: South America/O: Oceania. YG: Younger group/OG: Older group. M: Men/W: Women. AN: Asian/C: Chinese/F: Filipino/J: Japanese/K: Korean/V: Vietnamese. U: Urban/R: Rural. N: Neighborhood/VLG: Village. IN: Individual. wN: within Neighborhood/bN: beyond Neighborhood. DP: Destination Prevalence/DD: Destination Diversity. ML: Mobility Limitation/NML: No Mobility Limitation. DR: Driving/NDR: Nondriving. YE: The young elderly/OE: The old elderly. D1 & D2: Separate model with different dependent variables. CA: Changed address in past 2 years/SA2: Same address more than 2 years/RC: Rate of change (less walking compared to baseline). L: Low/Md: Medium/H: High. [a]: Not adjusted. Model: I, II, III, IV. Network Buffer: 400NB, 800NB, 1200NB, 1600NB, & 4800NB/Radial Distance Buffer: 250RD, 500RD, 1000RD. CBD: Central Business District. *: Research in urban area.

Table A2. The relationship between transport walking and neighborhood environment characteristics.

Walking for Transport										
Environmental Factors	**Perceived Environment**				**Objectively-Measured Environment**				**Summary (Total)**	
	Reference No.	**Related (+/−)**	**Uncertain (U)**	**Unrelated (ø)**	**Reference No.**	**Related (+/−)**	**Uncertain (U)**	**Unrelated (ø)**	**Association**	**% Studies**
Walkability		+		[78] E, [78] E	[32] E(high), [55] E, [58] E, [60] NA(DR, NDR), [65] NA(500RD), [84] NA(D1, D2), [85] NA(D1), [89] NA	+		* [25] A, [32] E(low), [85] NA(D2, D3)	++	68
		−				−				
Urbanization		+			[46] NA, [56] E, [58] E, [78] E,	+			++	100
		−				−				
Density										
Population /Housing	* [25] A, [60] NA(DR, NDR), [61] NA(YE)	+		* [27] AF, [30] A, * [51] A, * [53] A(wN-D1, D2, bN-D1, D2), * [54] A(D1, D2), [61] NA(OE), [77] A, [77] A-(M, W)	[30] A, * [34] SA, [47] E, [47] E	+		[41] NA(W-1200RB-D1, D2), [47] E, [63] NA	øø	29
		−				−				
Intersection density	[41] NA(W-D1, D2), * [54] A(D1), [58] E, [60] NA(DR),	+	* [25] A	* [27] AF, [30] A, * [51] A, * [53] A(wN-D1, D2, bN-D1, D2), * [54] A(D2), [60] NA(NDR), [61] NA(YE, OE), [73] O (VLG)	* [34] SA, [63] NA	+		* [34] SA, [41] NA(W-1200RB-D1, D2),	øø	32
		−				−				
Destinations										
Land use mix (diversity)	* [25] A, * [27] AF, [41] NA(W-D1, D2), * [51] A, * [53] A(wN-D1, D2), [60] NA(DR, NDR), [61] NA(YE, OE), [73]O (N)	+		[47] E, * [53] A(bN-D1, D2), * [54] A(D1, D2), [58] E, [73] O (VLG)	* [25] A, [41] NA(W-1200RB-D2), [63] NA,	+		[41] NA(W-1200RB-D1), [64] NA,	++	60
		−				−				

Table A2. *Cont.*

Walking for Transport										
Environmental Factors	**Perceived Environment**				**Objectively-Measured Environment**				**Summary (Total)**	
	Reference No.	**Related (+/−)**	**Uncertain (U)**	**Unrelated (ø)**	**Reference No.**	**Related (+/−)**	**Uncertain (U)**	**Unrelated (ø)**	**Association**	**% Studies**
Land use mix (accessibility)	[47] E, * [51] A, * [53] A(wN-D1, D2, bN-D1), * [54] A(D1, D2), [60] NA(DR, NDR), [61] NA(YE, OE), [77] A-W, [78] E,	+	[77] A	* [25] A, * [27] AF, [30] A, * [53] A(bN-D2), [58] E, [73] O (N), [77] A-M	* [82] E(400NB, 800NB)	+		* [82] E(1200NB, 1600NB)	++	64
		−				−				
Residential entrance accessibility	* [51] A, * [53] A(wN-D1, D2, bN-D1, D2)	+		* [54] A(D1, D2)		+			++	71
		−				−				
Eating & Retail		+			* [50] A(wN-DP, wN-DP, wN-DP), [64] NA, [93] NA	+		* [50] A(wN-DD, wN-DD, wN-DD), * [50] A(bN-DP, bN-DP, bN-DP, bN-DD, bN-DD, bN-DD), [63] NA	??	50
		−				−				
Social gathering places		+		[73] O (VLG)	* [50] A(wN-DD), [93] NA	+		* [50] A(wN-DP, wN-DP, wN-DD), * [50] A(bN-DP, bN-DP, bN-DD, bN-DD)	øø	25
		−				−				
Other destinations		+			* [50] A(wN-DD), [93] NA, [93] NA, [93] NA, [93] NA	+		* [50] A(wN-DP, wN-DP, wN-DD), * [50] A(bN-DP, bN-DP, bN-DD, bN-DD), [64] NA	øø	31
		−				−				
Overall recreational spaces	[77] A, [77] A-W,	+		[30] A, * [54] A(D1, D2), [77] A-M,	[60] NA(DR),	+	[60] NA(DR)	* [34] SA, [60] NA(NDR, NDR)	øø	31
		−				−				
Recreational facility	* [33] SA(II), [61] NA(YE, OE)	+		* [33] SA(I), * [51] A, * [54] A(D1, D2), [58] E,	* [50] A(wN-DD, bN-DD), [63] NA	+		* [50] A(wN-DP, bN-DP), [63] NA, [64] NA, [64] NA, [65] NA(500RD),	øø	33
		−				−				

Table A2. *Cont.*

Walking for Transport										
Environmental Factors	**Perceived Environment**				**Objectively-Measured Environment**				**Summary (Total)**	
	Reference No.	**Related (+/−)**	**Uncertain (U)**	**Unrelated (ø)**	**Reference No.**	**Related (+/−)**	**Uncertain (U)**	**Unrelated (ø)**	**Association**	**% Studies**
Green space	[61] NA(OE),	+		* [33] SA(I, II), * [33] SA(I, II), [61] NA(YE), [81] E,	[93] NA	+		[63] NA, [63] NA	øø	33
		−				−				
Public transport/Bus stop	[47] E, * [53] A(bN-D1),	+		[30] A, * [53] A(wN-D1, D2, bN-D2), * [54] A(D1, D2), [77] A, [77] A-(M, W),	* [50] A(bN-DP), [93] NA, [93] NA	+		[47] E, * [50] A(wN-DP, wN-DD, bN-DD),	øø	32
	[60] NA(DR, NDR)	−				−				
Safety-related										
Safety from crime/Personal safety	* [33] NA(I), [47] E	+		* [25] A, * [27] AF, [30] A, * [33] SA(II), * [33] SA(I, II), [41] NA(W-D1, D2), * [53] A(wN-D1, D2, bN-D1, D2), * [54] A(D1, D2), [60] NA(DR, NDR), [61] NA(YE, OE), [63] NA, [73] O(VLG, N), [77] A, [77] A-W, [81] E, [85] NA(D1, D2, D3),		+			øø	15
	* [51] A, [58] E, [77] A(M),	−				−				
Street lights/No stray animals	* [33] SA(II)	+		* [33] SA(I), [47] E	* [50] A(wN), * [50] A(wN)	+		* [34] SA, * [50] A(bN), * [50] A(bN)	øø	30
		−				−				
Disorder		+		* [33] SA(II), * [51] A, * [54] A(D1, D2), [73] O(N), [81] E, [85] NA(D1, D2, D3), * [92] NA(IN),	* [50] A(wN, bN),	+		[64] NA, [64] NA, [64] NA	øø	26
	* [33] SA(I), * [92] NA(N)	−			[64] NA, [64] NA(graffiti)	−				
Seeing people being active/presence of people	* [54] A(D1, D2), [77] A, [77] A-W	+		[30] A, * [51] A, * [53] A(wN-D1, D2, bN-D1, D2), [77] A-M		+			??	36
		−				−				
Traffic safety/Pedestrian safety	* [27] AF, [60] NA(DR, NDR),	+		* [25] A, [41] NA(W-D1, D2), [47] E, [60] NA(DR, NDR), [61] NA(YE, OE), [63] NA, [63] NA, [73] O (VLG, N), [77] A, [77] A(W),		+		* [50] A(wN, bN)	øø	26
	[30] A, [77] A(M),	−				−				
Traffic hazards		+		* [33] SA(I, II), * [53] A(wN-D1, D2, bN-D1, D2), * [54] A(D1, D2), [85] NA(D1, D2, D3),		+			øø	0
		−				−				
Traffic speed/volume	* [51] A	+		* [51] A, * [54] A(D1, D2), [58] E		+			ø	17
		−				−				

Table A2. *Cont.*

Walking for Transport										
Environmental Factors	**Perceived Environment**				**Objectively-Measured Environment**				**Summary (Total)**	
	Reference No.	**Related (+/−)**	**Uncertain (U)**	**Unrelated (ø)**	**Reference No.**	**Related (+/−)**	**Uncertain (U)**	**Unrelated (ø)**	**Association**	**% Studies**
Traffic safety devices	* [33] SA(I)	+		* [33] SA(II), [47] E, * [51] A, * [51] A, * [54] A(D1, D2), [73] O (N),	[64] NA, [64] NA, [64] NA	+		[64] NA	øø	18
		−				−				
Infrastructure-related										
Overall infrastructure	* [53] A(wN-D1, bN-D1), * [54] A(D1), [60] NA(DR, NDR), [61] NA(YE), [63] NA,	+		* [25] A, * [27] AF, [41] NA(W-D1, D2), * [51] A, * [53] A(wN-D2, bN-D2), * [54] A(D2), [58] E, [65] NA, [61] NA(OE), [73] O(VLG, N)	* [82] E(400NB)	+	* [82] E(800NB, 1200NB)	* [82] E(1600NB)	??	39
		−				−				
Presence and quality of sidewalk	[30] A, * [33] NA(I, II), [81] E, [60] NA(DR, NDR)	+		[77] A, [77] A-(M, W),	* [34] SA, * [34] SA, * [34] SA	+		* [50] A(wN, bN), [64] NA, [64] NA, [64] NA	??	54
	[47] E	−				−				
Amenities	* [51] A, * [53] A(wN-D1, D2, bN-D1, D2), [60] NA(DR, NDR), [81] E,	+		[47] E, * [54] A(D1, D2)		+		* [50] A(wN, bN)	++	62
		−				−				
Physical barriers	* [53] A(wN-D1)	+		* [33] SA(I, II), * [33] SA(I, II), [47] E, * [51] A, * [53] A(wN-D2, bN-D1, D2), [58] E, [73] O(N),		+		* [50] A(wN, bN)	øø	27
	* [54] A(D1, D2), [73] O(VLG)	−				−				
Bicycle lanes	[77] A, [77] A(M)	+		[77] A(W)		+			+	67
		−				−				
Aesthetics										
Aesthetics	* [25] A, [60] NA(DR, NDR), [77] A, [77] A(M),	+		* [27] AF, [30] A, [41] NA(W-D1, D2), [47] E, * [51] A, * [54] A(D1, D2), [58] E, [61] NA(YE, OE), [63] NA, [65] NA, [73] O(VLG, N), [77] A(W), [85] NA(D1, D2, D3),	* [82] E(800NB, 1200NB)	+		* [82] E(400NB, 1600NB), [64] NA	øø	22
		−				−				

Table A2. *Cont.*

Walking for Transport										
Environmental Factors	**Perceived Environment**				**Objectively-Measured Environment**				**Summary (Total)**	
	Reference No.	**Related (+/−)**	**Uncertain (U)**	**Unrelated (ø)**	**Reference No.**	**Related (+/−)**	**Uncertain (U)**	**Unrelated (ø)**	**Association**	**% Studies**
Air quality/Quietness		+		* [33] SA(I, II), * [33] SA(I, II), [47] E, [47] E,		+			øø	0
		−				−				
Social environment										
Neighborhood social cohesion	* [33] SA(II), * [92] NA(IN),	+		* [33] SA(I, II, I, II, I, II), [85] NA(D1, D2, D3), * [92] NA(N),		+			øø	15
	* [33] SA(I)	−				−				

AF: Africa/A: Asia/E: Europe/NA: North America/SA: South America/O: Oceania. YG: Younger group/OG: Older group. M: Men/W: Women. AN: Asian/C: Chinese/F: Filipino/J: Japanese/K: Korean/V: Vietnamese. U: Urban/R: Rural. N: Neighborhood/VLG: Village. IN: Individual. wN: within Neighborhood/bN: beyond Neighborhood. DP: Destination Prevalence/DD: Destination Diversity. ML: Mobility Limitation/NML: No Mobility Limitation. DR: Driving/NDR: Nondriving. YE: The young elderly/OE: The old elderly. D1 & D2: Separate model with different dependent variables. CA: Changed address in past 2 years/SA2: Same address more than 2 years/RC: Rate of change (less walking compared to baseline). L: Low/Md: Medium/H: High. [a]: Not adjusted. Model: I, II, III, IV. Network Buffer: 400NB, 800NB, 1200NB, 1600NB, & 4800NB/Radial Distance Buffer: 250RD, 500RD, 1000RD. CBD: Central Business District. *: Research in urban area.

Table A3. The relationship between recreational walking and neighborhood environment characteristics.

Walking for Recreation										
Environmental Factors	**Perceived Environment**				**Objectively-Measured Environment**				**Summary (Total)**	
	Reference No.	**Related (+/−)**	**Uncertain (U)**	**Unrelated (ø)**	**Reference No.**	**Related (+/−)**	**Uncertain (U)**	**Unrelated (ø)**	**Association**	**% Studies**
Walkability		+		[58] E	[60] NA(DR), [62] NA(h), [88] NA(M-CA-100RB, 500RB, 1000RB), [88] NA(W-CA-1000RB), [88] NA(W-SA2-100RB),	+	[88] NA(W-CA-100RB, 500RB), [88] NA(W-SA2-500RB, 1000RB)	[55] E, [60] NA(NDR), [62] NA(m), [88] NA(M-SA2-100RB, 500RB, 1000RB),	??	43
		−				−				
Density										
Population/Housing		+		* [27] AF, [30] A, [31] E(M, W), * [48] A, * [51] A, * [54] A(D1[I, II], D2[I, II]), [60] NA(DR, NDR), [61] NA(YE, OE), [77] A, [77] A(M, W),	* [66] NA, * [66] NA, * [67] NA(N)	+		* [34] SA, [41] NA(W-1200RB-D1, D2) [a], [63] NA,	øø	10
		−				−				
Employment/Income		+			* [34] SA(m), * [66] NA, * [67] NA(N),	+		* [34]SA(h)	+	83
		−				−				
Intersection density	[60] NA(DR)	+		* [27] AF, [30] A, [41] NA(W-D1, D2), * [48] A, * [51] A, * [54] A(D1[I, II], D2[I, II]), [58] E, [60] NA(NDR), [61] NA(YE, OE), [73] O(D1[VLG])	* [34] SA(m), * [67] NA(N), * [68] NA(800RB[I]),	+		* [34] SA(h), [41] NA(W-1200RB-D1, D2) [a], [63] NA, * [67] NA(IN-800RB), * [68] NA(400RB[I, II, III], 800RB [II, III])	øø	17
	[73] O(D2[- VLG])	-				−				
Destinations										
Land use mix (diversity)	[30] A, [30] A, [60] NA(DR), [61] NA(YE)	+		* [27] AF, [41] NA(W-D1, D2), * [48] A, * [51] A, * [54] A(D1[I, II], D2[I, II]), [58] E, [60] NA(NDR), [61] NA(OE), [73]O(D1[VLG, N], D2[N])	* [68] NA(400RB[I, II, III], 800RB[I, II, III]),	+		* [34] SA, [41] NA(W-1200RB-D1, D2) [a], * [49] A(I, II)	øø	29
	[73] O(D2[VLG])	−			[63] NA	−				
Land use mix (accessibility)	* [27] AF, * [51] A, [60] NA(DR), [61] NA(YE),	+	[77] A, [77] A(W)	[31] E(M, W), * [48] A, * [54] A(D1[I, II], D2[I, II]), [58] E, [60] NA(NDR), [61] NA(OE), [73] O(D1[N], D2[N]), [77] A(M)	* [68] NA(400RB[I, II, III], 800RB[I, II, III]),	+			øø	33
		−				−				
Residential entrance accessibility		+		* [48] A, * [51] A, * [54] A(D1[I, II], D2[I, II]),		+			ø	0
		−				−				

Table A3. *Cont.*

Walking for Recreation										
Environmental Factors	**Perceived Environment**				**Objectively-Measured Environment**				**Summary (Total)**	
	Reference No.	**Related (+/−)**	**Uncertain (U)**	**Unrelated (ø)**	**Reference No.**	**Related (+/−)**	**Uncertain (U)**	**Unrelated (ø)**	**Association**	**% Studies**
Social gathering places		+		[73] O(D1[VLG], D2[VLG])		+		* [49] A(I, II), [93] NA	ø	0
		−				−				
Overall recreational spaces	[30] A, * [48] A, * [39] NA(RC-N), * [67] NA(IN),	+		* [39] NA(N), * [54] A(D1[I, II], D2[I, II]), [58] E, * [67] NA(IN), [77] A, [77] A(M, W),	* [66] NA	+		* [34] SA, [60] NA(DR, NDR),	øø	30
		−				−				
Recreation facility		+		* [33] SA(I, II), [61] NA(YE, OE),		+		* [49] A(I, II), * [49] A(I, II), [63] NA, [63] NA	øø	0
		−				−				
Indoor places for walking	* [48] A, * [51] A, * [54] A(D1[II]),	+		* [54] A(D1[I], D2[I, II])	* [49] A(II),	+		* [49] A(I),	++	60
		−				−				
Green space		+		[31] E(M, W), * [33] SA(I, II), * [33] SA(I, II), [61] NA(YE, OE), [81] E,	* [49] A(I), * [67] NA(N), * [68] NA(800RB[I])	+		* [49] A(I, II), * [49] A(II), [63] NA, [63] NA, * [67] NA(I-800RB), * [68] NA(800RB[I]), [93] NA	øø	11
		−				−				
Public transport/Bus stop	* [54] A(D1[II], D2[II])	+		[30] A, [31] E(M, W), * [54] A(D1[I], D2[I]), [60] NA(DR, NDR), [77] A, [77] A(M, W),	* [68] NA(800RB[I])	+		* [68] NA(400RB[I, II, III], 800RB[II, III), [93] NA	øø	10
		−				−				
Safety-related										
Perceived safety from crime/Personal safety	* [33] SA(I, II-d), * [39] NA(RC-N),	+		* [27] AF, [30] A, [31] E(M, W), * [33] SA(I, II-n), * [39] NA(N), [41] NA(W-D1, D2), * [51] A, * [54] A(D1[I, II], D2[I, II]), [58] E, [60] NA(DR, NDR), [61] NA(YE, OE), [63] NA, * [66] NA, [73] O(D1[VLG, N], D2[N]), [77] A, [77] A(M, W), [81] E	* [52] A(II)	+		* [49] A(I, II), * [52] A(I)	øø	9
	[73] O(D2[VLG])	−				−				
Street lights/No stray animals		+		* [33] SA(I, II)		+		* [34] SA, * [49] A(I, II), * [52] A(I, II), * [52] A(I, II)	øø	0
		−				−				
Disorder		+		* [48] A, * [51] A, * [54] A(D1[I, II], D2[I, II]), * [66] NA, [73] O(D2[N]), * [92] NA(N), * [92] NA(IN),		+		* [49] A(I, II)	øø	28
	[73] O(D1[N]), [81] E	−			* [49] A(I, II)	−				

Table A3. *Cont.*

Walking for Recreation										
Environmental Factors	**Perceived Environment**				**Objectively-Measured Environment**				**Summary (Total)**	
	Reference No.	**Related (+/−)**	**Uncertain (U)**	**Unrelated (ø)**	**Reference No.**	**Related (+/−)**	**Uncertain (U)**	**Unrelated (ø)**	**Association**	**% Studies**
Seeing people being active/presence of people	[30] A, * [54] A(D1[I], D2[I]), [77] A, [77] A(M)	+		* [48] A, * [51] A, * [54] A(D1[II], D2[II]), [77] A(W)		+			??	50
		−				−				
Traffic Safety/Pedestrian Safety	[31] E(W), [60] NA(DR)	+	[60] NA(NDR)	* [27] AF, [30] A, [31] E(M), [41] NA(W-D1, D2), [60] NA(DR, NDR), [61] NA(YE, OE), [63] NA, * [67] NA(IN), [73] O(D1[VLG, N], D2[VLG, N]), [77] A, [77] A(M, W)		+			øø	12
		−				−				
Traffic hazards		+		* [33] SA(I, II), * [48] A, * [54] A(D1[I, II], D2[I, II])		+			ø	0
		−				−				
Traffic speed/volume		+		* [48] A, * [51] A, * [54] A(D1[I, II], D2[I]), [58] E	* [68] NA(400RB [I, III]-H, 800RB [I, II, III]-H)	+		* [49] A(I, II), * [68] NA(400RB[II]-H, 400RB[I, II, III]-Md, 800RB[I, II, III]-Md)	øø	23
	* [51] A, * [54] A(D2[II])	−			* [68] NA(400RB[I, II, III]-L, 800RB[I, II, III]-L)	−				
Traffic safety device		+		* [33] SA(I, II), * [48] A, * [51] A, * [54] A(D1[I, II], D2[I, II]), [73] O(D1[N], D2[N])		+			øø	0
		−				−				
Bridge/Overpass	* [48] A, * [51] A	+		* [54] A(D1[I, II], D2[I, II])		+			??	50
		−				−				
Infrastructure-related										
Overall infrastructure	* [27] AF, * [48] A, [60] NA(DR)	+		[41] NA(W-D1, D2), * [51] A, * [54] A(D1[I, II], D2[I, II]), [58] E, [60] NA(NDR), [61] NA(YE, OE), [63] NA, [73] O(D1[VLG, N, N], D2[VLG, N, N]), [81] E		+			øø	19
		−				−				
Presence and quality of sidewalk	[30] A, * [33] SA(II)	+		* [33] SA(I), [77] A, [77] A(M, W)		+		* [34] SA, * [34] SA, * [49] A(I, II), * [52] A(I, II), * [68] NA(400RB[I, II, III], 800RB[I, II, III]),	øø	17
		−				−				
Amenities	* [54] A(D1[I], D2[I])	+		* [48] A, * [51] A, * [54] A(D1[II], D2[II]), [81] E	* [49] A(II),	+		* [49] A(I),	øø	25
		−				−				

Table A3. *Cont.*

Walking for Recreation										
Environmental Factors	**Perceived Environment**				**Objectively-Measured Environment**				**Summary (Total)**	
	Reference No.	**Related (+/−)**	**Uncertain (U)**	**Unrelated (ø)**	**Reference No.**	**Related (+/−)**	**Uncertain (U)**	**Unrelated (ø)**	**Association**	**% Studies**
Physical barriers		+		* [33] SA(I, II), * [33] SA(I, II), * [48] A, * [54] A(D1[I], D2[I]), [58] E, [73] O(D1[VLG], D2[VLG, N])		+		* [52] A(I, II)	øø	29
	* [51] A, * [54] A(D1[II], D2[II]), [73] O(D1[N])	−				−				
Bicycle lanes		+		[77] A, [77] A(W)		+			øø	17
		−	[77] A(M)			−				
Aesthetics										
Aesthetics	[30] A, [31] E(W), [41] NA(W-D1, D2), * [51] A, [60] NA(DR), [73] O(D1[VLG]), [77] A, [77] A(M, W), [81] E	+	[58] E	* [27] AF, [31] E(M), * [48] A, * [54] A(D1[I, II], D2[I, II]), [60] NA(NDR), [61] NA(YE, OE), [63] NA, [73] O(D1[N], D2[VLG, N])	* [49] A(I, II), * [52] A(I)	+		* [49] A(I, II), * [49] A(I, II), * [52] A(II)	??	49
		−				-				
Air quality/Quietness		+		* [33] SA(I, II, I, II),	* [49] A(I, II), * [52] A(I)	+		* [52] A(II)	??	50
		−				−				
Social environment										
Neighborhood social cohesion	* [39] NA(N), * [66] NA, * [92] NA(IN)	+		* [39] NA(RC-N), * [92] NA(N)		+			++	63
		−				−				

AF: Africa/A: Asia/E: Europe/NA: North America/SA: South America/O: Oceania. YG: Younger group/OG: Older group. M: Men/W: Women. AN: Asian/C: Chinese/F: Filipino/J: Japanese/K: Korean/V: Vietnamese. U: Urban/R: Rural. N: Neighborhood/VLG: Village. IN: Individual. wN: within Neighborhood/bN: beyond Neighborhood. DP: Destination Prevalence/DD: Destination Diversity. ML: Mobility Limitation/NML: No Mobility Limitation. DR: Driving/NDR: Nondriving. YE: The young elderly/OE: The old elderly. D1 & D2: Separate model with different dependent variables. CA: Changed address in past 2 years/SA2: Same address more than 2 years/RC: Rate of change (less walking compared to baseline). L: Low/Md: Medium/H: High. [a]: Not adjusted. Model: I, II, III, IV. Network Buffer: 400NB, 800NB, 1200NB, 1600NB, & 4800NB/Radial Distance Buffer: 250RD, 500RD, 1000RD. CBD: Central Business District. *: Research in urban area.

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