Associations among perceived walkability of neighborhood environment, walking time, and functional mobility by older adults: An exploratory investigation

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Running Head: Perception of walkability, walking time, and functional mobility

Abstract

This study explored the associations between the perceived walkability of neighborhood environment, walking time, and functional mobility by community-dwelling older adults in Hong Kong SAR, China. Seventy community-dwelling older adults (Mean age = 78.00 ± 7.40 years) participated in this study. Their perceived walkability of neighborhood environment was evaluated by the Chinese abbreviated version of Neighborhood Environment Walkability Survey (NEWS-A) and their walking time within a week was self-reported. The 10-Meter Walk Test and Tinetti Performance-Oriented Mobility Assessment (POMA) were used to assess the functional mobility of the participants, regarding their gait speed, balance, and gait performance, respectively. Results suggest that the perceived walkability of neighborhood environment (Aesthetics subscale) positively associated with the gait speed (r_s = .35, p = .003), scores of the POMA-Balance (r_s = .389, p = .001) and POMA-Gait (r_s = .343, p = .004). This exploratory analysis augmented our contemporary understanding that older adults who could walk faster and with better balance and gait performance are associated with more positive perceived walkability of their neighborhood environment. It provides useful insight that could inform future high-impact investigations.

Keywords: Older adults; Perceived walkability; Neighborhood environment; Balance; Gait

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1. Introduction

The population of older adults increases drastically in many urban cities. Consequently, many studies have focused on investigating the associations among the neighborhood environment, active lifestyle, and health in the older population. Researchers have also prioritized their investigations in various high impact issues. For example, many of them have been focusing on how different environmental attributes could affect walking and behaviors of physical activities (Barnett, Cerin, Zhang, Sit, Johnston, Cheung, & Lee, 2016; Owen, Humpel, Leslie, Bauman, & Sallis, 2004; Saelens & Handy, 2008; Satariano, Kurtovich, Kealey, Hubbard, Bayles, & Prohaska, 2010; van Cauwenberg, De Bourdeaudhuij, De Meester, van Dyck, Salmon, Clarys, & Deforche, 2011; Witten, Blakely, Bagheri, Badland, Ivory, Pearce, & Schofield, 2012; Yu, Cheung, Lau, & Woo, 2017). Indeed, benefits of walking and participating in physical activity to older adults, such as decreasing mortality and preventing cancers, stroke, high blood pressure, and fall incidents have been well-evidenced (Vogel, Brechat, Leprêtre, Kaltenbach, Berthel, & Lonsdorfer, 2009).

Older adults are usually spending more time in their residential neighborhood environment than young adults. Thus, the influence of neighborhood environment on the older population is worth to be investigated

(Gallagher, Gretebeck, Robinson, Torres, Murphy, & Martyn, 2010). The environmental hazard could account for more than twenty-five percent of older adults' falls (Rao, 2005; Rubenstein & Josephson, 2002). Conversely, a neighborhood design with preferable walkability could promote walking (Kelsey, Procter-Gray, Hannan, & Li, 2012; Michael, Green, & Farquhar, 2006). Subsequently, it could help prevent falls and improve the residents' physical and mental health effectively (Kerr, Rosenberg, & Frank, 2012; Yen, Michael, & Perdue, 2009). As a result, this has informed many researchers to further investigate the age-friendly built environment for residents in many aging cities.

Previous researchers have reviewed the associations among the perceived walkability of the environment, objectively-assessed walkability of the environment, and walking time by older adults (Cerin, Nathan, van Cauwenberg, Barnett, & Barnett, 2017). The objectively assessed walkability of the environment has been usually assessed by the Geographic Information System (GIS) and the available publicity data. Some research teams also conducted a specific field audit to identify the specific attributes in the built environment (Ball, Bauman, Leslie, & Owen, 2001). On the other hand, the perceived walkability of the environment was usually evaluated by questionnaires or interviews on different domains (e.g., density, connectivity, aesthetics, and the availability of the walking facilities). This methodology has been widely adopted in studying environment and health, and geography (Cerin et al., 2017; Duncan, Spence, & Mummery, 2005; Renalds, Smith, & Hale, 2010;

Wood, 1970). However, previous researches suggested inconsistent evidence on the association between the environment and population health (Cerin et al., 2017; Cunningham & Michael, 2004; van Cauwenberg et al., 2011). Hovell, Sallis, Hofstetter, Spry, Faucher, and Caspersen (1989) proposed the association between the neighborhood environment and the walking for exercise. Researchers examined the association among different environmental attributes, such as street connectivity, aesthetics, land-use mix, access to services, safety, walking for transportation, and leisure purpose, in the succeeding thirty years. Van Cauwenberg et al. (2011), for example, conducted a review and stated that most of the reported environmental characteristics were not significantly associated with physical activity or walking. They believed that the result was affected by the studies' potential methodological problems that they had reviewed. Afterward, Cerin et al. (2017) reported different viewpoints in their meta-analysis. They found a strong link between the physical environment and the older adult's active lifestyle and different moderators, such as age, sex, living arrangement, individual psychological factors, and personal capability.

Although increasing numbers of studies, which investigated the association between the environment and older adults' health behavior, have taken different moderators into account, only a limited number of studies have explicitly examined the relationship between the environment and functional mobility of older adults. The older adults' ability in functional mobility could indeed reflect their walking difficulty in the community.

Therefore, it could affect their perception of the motivators and barriers to walking in their neighborhood environment. To the best of our knowledge, only two research teams have explicitly examined the relationship between perceived walkability of the neighborhood environment and different functional mobility tests, such as the gait speed test, Berg Balance Scale, and Short Performance Physical Battery test (Shumway-Cook, Patla, Stewart, Ferrucci, Ciol & Guralnik, 2002; van Holle et al., 2016). Results from Shumway-Cook et al. (2002) suggested that those older adults who performed worse in the balance tests would prefer to choose a less complicated route for their outdoor walking, for example, the route with fewer stairs and obstacles. The finding implies that older adults with different functional abilities might perceive the neighborhood environment differently.

Additionally, van Holle et al. (2016) found that the neighborhood environment could mediate the association between physical functioning and the amount of physical activity. These studies supported the ecological model of active living, in which the model proposed that different levels of ecological factors, from the social, environment, to individual level, could affect behaviors, such as walking (Sallis et al., 2006; Sallis, Owen, & Fisher, 2008). Although previous research suggested that older adults' functional mobility could affect the association between the neighborhood environment and physical activity behavior, none of them examined the association between the functional mobility of the older adults and the perceived walkability of the

neighborhood environment in an ultra-dense city.

Hong Kong is one of the densest and most walkable Asian cities (Adams et al., 2014). Different from the Western cities where most of the previously mentioned researches were conducted, Asian cities have a significantly different neighborhood design and pattern, the urbanization process, social culture, and characteristics of the older population (Garin et al., 2014; Parai & Dutt, 1994). In Hong Kong, some researchers have examined the association between the environment and older adults' walking (Cerin, Johnston et al., 2013; Yu et al., 2017). They suggested that the amount of walking could be positively associated with perceived walkability among older adults in Hong Kong. To be specific, walking for transport was significantly associated with land use's heterogeneity, access to services, human and motorized traffic, crime, and ease of access to the residential entrance (Cerin, Johnston et al., 2013). Walking for recreation was also significantly associated with access to services, physical barriers to walking, street connectivity, human and motorized traffic, indoor places for walking, aesthetics, and bridge/overpass connecting to services (Cerin, Johnston et al., 2013). The association of the overall walking with the neighborhood and perceived walkability, which took land use mix-access, street connectivity, infrastructure, and safety for walking, aesthetics, traffic safety, and safety from crime attributes into account, was also reported (Yu et al., 2017). Although the association of walking time and the perceived environment was examined, none of them took the functional mobility of an individual into

specific consideration.

Therefore, this study attempted to fill the research gap by exploring the associations among the perceived walkability of neighborhood environment (i.e., 1. Aesthetics; 2. Infrastructure and safety for walking), walking time, and functional mobility by community-dwelling older adults in Hong Kong SAR, China. Two assessed aspects of perceived walkability of neighborhood environment were chosen (i.e., 1. Aesthetics; 2. Infrastructure and safety for walking) in this exploratory study because it is mostly believed that the functional mobility could be predominately affected by the image of the neighborhood environment in these two aspects. It was hypothesized that older adults who have better functional mobility could have a more positive perceived walkability of neighborhood environment as they should have fewer walking difficulties (hypothesis 1). It was also hypothesized that functional mobility would moderate the association between the perceived walkability of neighborhood environment and the total walking time (hypothesis 2).

2. Methods

2.1. Participants

Eligible participants were older adults aged 65 or above living in the Hong Kong SAR, China, and were capable of walking independently. They communicated clearly and cognitively healthy, with a score of 24 or

above in the Cantonese version of Mini-Mental State Examination (MMSE-C; Chiu, Lee, Chung, & Kwong, 1994).

Seventy-six older adults were recruited from an older adult community center in Hong Kong, and six of them were excluded due to the MMSE-C score < 24. All older adults were recruited from an older adult community center, which is located on the Hill Road of the Western District at Hong Kong Island, Hong Kong SAR, China. The Walk Score of the community center is 97 and it was retrieved from Walk Score™ website (www.walkscore.com). The score represents the overall high walkability of its surrounding neighborhood environment. Previous researches showed that the Walk Score was positively correlated with the objective measures of neighborhood walkability by the GIS, such as the intersection density, street density total population and access to public transit provisions (Carr, Dunsiger, & Marcus, 2010; Carr, Dunsiger & Marcus, 2011).

2.2. Procedures

The research protocol was approved by the Institutional Review Board of the University of Hong Kong / Hospital Authority Hong Kong West Cluster (HKU/HA HKW IRB; UW 16-514), and written consents were received prior to any experimental procedures.

2.3. Measures

Socio-demographics. The demographic information, including age, sex, usual walking aid (responses were dichotomized into 'with aid' or 'without aid'), exercise habit (responses were dichotomized into 'doing exercise regularly' or 'not doing exercise regularly'), the self-reported health status and the history of falling (responses were dichotomized into 'yes' or 'no'). They also rated their perceived health status on a six-point Likert Scale.

The walking time. All participants were required to recall their duration of walking (walking time) in minute(s), within the past seven days regardless of their walking purposes.

Self-reported perceived walkability. All participants were invited to answer all questions, extracted from the “Aesthetics”, and the “Infrastructure and Safety for Walking subscales” of the Chinese abbreviated version of the Neighborhood Environment Walkability Survey (NEWS-A). These two subscales were chosen because the aesthetics attribute of the environment could directly associate with the interest of walking. The infrastructure and safety for walking could associate with the availability of the pedestrian-friendly environment. Questions are about the responders' perception of the attractiveness of the surrounding neighborhood environment. The perception of aesthetics was measured by asking questions on the perception of the sufficiency of trees along the streets, the interesting things, the natural sights, and attractive buildings in the neighborhood. On the other hand, some questions are related to the availability and condition of the neighborhood environment's walking infrastructure. For example, they were asked about whether they agree

with "There are sidewalks on most of the streets in my neighborhood" or "My neighborhood is well lit at night." All participants were asked to consider to the level using a four-point Likert Scale ranging from 'Strongly disagree', 'Somewhat disagree', 'Somewhat agree' to 'Strongly agree'. The NEWS-A has been proved as a valid and reliable questionnaire in measuring the perceived walkability of neighborhood environment in Hong Kong's older adults (Cerin, Macfarlane, Ko, & Chan, 2007; Cerin et al., 2010).

Functional mobility tests. The 10-Meter Walk Test (Graham, Ostir, Fisher, & Ottenbacher, 2008) and the Tinetti Performance-Oriented Mobility Assessment (POMA; Tinetti, 1986) were used to evaluate the functional mobility of the older adults. POMA has been widely-used clinically and was found to be associated with risk of falling in older adults (Raîche, Hébert, Prince, & Corriveau, 2000), together with excellent inter-rater reliability (Cipriany-Dacko, Innerst, Johannsen, & Rude, 1997) and concurrent reliability (Tinetti, 1986). POMA includes both Balance (POMA-Balance) and Gait (POMA-Gait) subscales. There are nine items in the POMA-Balance. Participants were required to sit, to rise from a chair, to attempt to rise, to stand for a particular second, to stand with closed eyes, to be nudged at the standing position, to turn 360 degrees, and to sit. It utilizes a 3-point ordinal scale from 0 to 2 with a total score of 16. In the POMA-Gait, participants walked on a straight line for few times, and the experimenter evaluated the gait pattern on eight items, including the gait initiation, step length, foot clearance, step symmetry and continuity, path, trunk, and the heels. A scoring system,

with scores from 0-12, was used to score the gait performance. For the 10-Meter Walk Test, participants were invited to walk on a 6-meter indoor walking course (with 2 meter acceleration and 2 meter deceleration) at a comfortable speed for three walking trials. A trained experimenter started the timing when the toes of the foot crossed the 2-meter mark and stopped the timing when the toes of the leading foot crossed the 8 meter mark. The 10-Meter Walk Test is a valid measurement that reflects the overall health status and has been shown to have excellent test-retest reliability for measuring gait speed for older adults (Peters, Fritz, & Krotish, 2013).

2.4. Statistical analysis

All statistical analyses were performed using the SPSS statistical package (version 25). The skewness test was conducted to check the normality of data. The median and the interquartile range of the non-normally distributed variable, and the mean and standard deviation of the normally distributed data were calculated. Since our data could not fulfill the requirement of utilizing the parametric tests, Spearman's rho correlation tests were conducted in our exploratory analysis to examine the associations among the perceived walkability of neighborhood environment, walking time, and functional mobility by community-dwelling older adults.

3. Results

3.1. Descriptive analysis

The older adults were aged from 65 to 94. Twenty of them were male. Forty-three participants reported that they did not usually use walking aids when walking outdoor. Most of the participants reported that they walked 5 hours or more per week. Details of all the descriptive statistics are illustrated in **Table 1**.

Table 1 near here

3.2. Correlational analysis

Multiple Spearman's rho correlation tests were computed to establish a correlational matrix among the perceived walkability of neighborhood environment, walking time, and functional mobility by community-dwelling older adults (**Table 2**). The main results suggest that the perceived walkability of neighborhood environment (Aesthetics subscale) positively associated with the gait speed (r_s = .35, p < .01), scores of the POMA-Balance (r_s = .39, p < .01) and POMA-Gait (r_s = .34, p < .01). While there are significant and positive associations among the perceived walkability (Aesthetics subscale) and functional mobility, no statistically significant association between the perceived walkability (Infrastructure and safety for walking subscale) and functional mobility could be discovered.

The total walking time was found to be associated with functional mobility, but not the perceived walkability. Statistically significant, moderate, and positive associations were found among the total walking time and the individuals' gait performance (i.e., POMA-Gait; r_s = .41, p < .01), and gait speed (r_s = .43, p < .01).

Since the correlation between the perceived walkability of the neighborhood environment and total walking time was not statistically significant, the potential moderation effect by functional mobility between the perceived walkability of neighborhood environment and the total walking time, that we hypothesized (hypothesis 2), is not evidenced.

Table 2 near here

4. Discussion

In the present study, associations among the perceived walkability of neighborhood environment, walking time, and functional mobility by community-dwelling older adults in Hong Kong SAR, China were explored. It is one of the few studies that examined these specific associations in an ultra-dense Asian city by interview and functional mobility tests. We hypothesized that older adults who have better functional mobility could have a more positive perceived walkability of neighborhood environment as they should have fewer walking difficulties (hypothesis 1). It was also hypothesized that functional mobility would moderate the association between the perceived walkability of neighborhood environment and the total walking time (hypothesis 2).

Most of the older adults reported that they walked 5 hours or more in a week. The walking time of participants in the current study is comparable with a previous Hong Kong study, in which the older adults in

Hong Kong reported on average 569 and 254 minutes per week of overall and within-neighborhood walking for transport repectively (Cerin, Lee et al., 2013). The high walking time of older adults may be contributed by the urban design which is favourable for walking. As Adams et al. (2014), Hong Kong is one of the cities with the highest walkability. Hong Kong has been stipulated a comprehensive and integrated approach to pedestrian planning for many years (Tan & Xue, 2014). In this transit-oriented cities, Hong Kong people do usually walk for their daily activity nearby and the public transport is the most popular way of travel (Siu, 2019). While the older adults spend most of their time interacting with the neighborhood by walking, the personal experience and the ability to walk may contribute to their perception of the neighborhood environment.

Results suggest that the perceived walkability of neighborhood environment (aesthetics subscale) positively associated with the gait speed, scores of POMA-Balance, and POMA-Gait. It implies that older adults, who could walk faster and with better balance and gait performance, are associated with more positive perceived walkability of their neighborhood environment. It supports our first hypothesis. However, since the correlation between the perceived walkability of the neighborhood environment and total walking time was not statistically significant, the hypothesized moderation effect by functional mobility between the perceived walkability of neighborhood environment and the total walking time (hypothesis 2) is not evidenced and the hypothesis 2 is rejected.

Our findings align with a previous study conducted in Portland (USA) in which the association between the neighborhood environment and the gait speed of older adults was demonstrated (Nagel, 2012). One of the potential explanations of this finding is that older adults with better functional mobility could enjoy the scenery more feasibly, since they should have fewer walking difficulties during outdoor ambulation (Huh et al., 2011; Volkers & Scherder, 2014). Better physical health is usually associated with better mental health and, therefore, could also contribute to a more positive perception of the surrounding environment (Chippendale & Boltz, 2014; Cooper et al., 2011). However, due to the nature of the cross-sectional studies, the causal relation cannot be concluded and the exact mechanism of this association remains unclear.

Previous research suggested that the perceived walkability of the neighborhood environment is an independent variable that could affect walking time, which contributed to the health of an individual (Kerr et al., 2012). However, the causal relationship could be in a reverse direction. For example, a study illustrated that perception of the environment could change with the improvement of physical capability after exercise interventions (Humpel, Marshall, Leslie, Bauman, & Owen, 2004). It well illustrated that the change of personal health condition might affect the perception of the environment of an individual.

It is worth noted that the perceived walkability was used frequently to evaluate the neighborhood environment when attempting to investigate the association between the environment and health behavior.

Various researchers have suggested that the rating of aesthetics attributes by an individual might not be consistent with the objectively-measured walkability (Ball, Bauman, Leslie, & Owen, 2001; Koohsari, Badland, Sugiyama, Mavoa, Christian, & Giles-Corti, 2015; Leslie et al., 2005). Older adults who are actively participating in physical activities may also have different perceptions of their surrounding environment (Parra, Gomez, Sarmiento, Buchner, Brownson, Schimd, & Lobelo, 2010). Besides, it is also worth noted that our present results suggested that the total walking time is not significantly associated with the perceived walkability of either the aesthetics subscale or infrastructure and safety for walking subscale in the NEWS-A. Cerin et al. (2013) found that the association between the perceived walkability (Aesthetics subscale) and the walking for transport was not significant, but the perceived walkability (aesthetics) was significantly associated with walking with recreation. Since our present study measured the walking time regardless of purpose, it is not surprising that no significant association between the total walking time and perceived walkability could be discovered.

The associations between the perceived walkability (infrastructure and safety for walking subscale) and total walking time or functional mobility were not significant. It echoes with the result of a previous study, suggesting that not all elements of perceived walkability are related to the older adult's walking behavior (Owen

et al., 2004). The perceived infrastructure and safety for walking did not determine the recreational walking of older adults in Hong Kong (Cerin, Johnston et al., 2013).

The study results also suggest that the functional mobility is significantly associated with the perceived walkability of the neighborhood environment. It is a reasonable illustration that may inform the difference between the objectively assessed walkability and the perceived walkability, given that all participants of our present study were living in the same neighborhood environment. Thus, the variety of perceived walkability should be based on individual factors predominately.

Some limitations are necessary to be considered when interpreting the research findings. Firstly, because of the cross-sectional nature of the study, the findings could not concrete the causal relationship among the perception of neighborhood, functional mobility, and walking time. Furthermore, the participants were recruited by convenience sampling in the community center, contributing to the selection bias. The older adults are usually being encouraged to be active by the social workers in the centers. Thus, the results of the current study could only provide the exploratory information of the association. In future studies, the sampling to recruit the representable participants could be utilized to further investigate the association.

Researchers, urban planners, and health care providers should be aware of the contribution by an individual's functional mobility of older adults when interpreting perceived walkability as a measurement of the

neighborhood environment. Personal factors could indeed primarily affect perceived walkability. More importantly, future studies should be conducted to examine different potential confounders and moderators for the association between perceived walkability and functional mobility in the older population. Functional mobility may be one of the many factors associated with the perceived walkability of neighborhood environment. Different economic or social status, which could affect the resources for preserving health and well-being and the affordability of better living conditions, may also be the confounding factors on perceived walkability and functional mobility by older adults.

Declaration of Competing Interest

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Table 1 Descriptive analysis of different variables

Variables	*N*	
Age **(***M; SD*)	70	78.00 (7.40)
Number of previous falls (*Mdn*; *IQR*)	66	1 (0-2)
MMSE-C **(***M; SD*)	70	27.56 (1.83)
NEWS-A (Aesthetics subscale; *M; SD*)	70	2.37 (0.79)
NEWS-A (Infrastructure and safety for walking subscale; *M; SD*)	70	2.93 (0.36)
POMA (Balance subscale; *Mdn*; *IQR*)	70	16 (15-16)
POMA (Gait subscale; *Mdn*; *IQR*)	70	12 (11-12)
POMA (*Mdn*; *IQR*)	70	27 (25-28)
Gait speed (meter(s)/second; *M; SD*)	70	0.91 (0.29)
Total walking time (minute(s)/week; *Mdn*; *IQR*)	61	300 (140-420)

Note: *N* = Sample size; *M* = Mean; *Mdr*= Median; *SD* = Standard deviation; *IQR* = Interquartile Range MMSE-C = Cantonese version of the Mini-Mental State Examination; NEWS-A = The Chinese abbreviated version of Neighborhood Environmental Walkability Survey; POMA = Tinetti Performance-Oriented Mobility Assessment

Table 2 Correlation matrix of the main outcome variables

Spearman's rho correlation (r_s)	**1. Walking time**	**2. POMA-Balance**	**3. POMA-Gait**	**4. Walking Speed (m/s)**	**5. Self-Reported Health Status**	**6. NEWS-A (I)**	**7. NEWS-A (A)**
1.	-	.24	.41**	.43**	.10	-.04	.22
2.		-	.44**	.43**	.14	-.02	.39**
3.			-	.59**	-.06	-.10	.34**
4.				-	.14	-.04	.33**
5.					-	-.11	-.04
6.						-	.19

Note: POMA = Tinetti Performance-Oriented Mobility Assessment; NEWS-A (I) = The Chinese abbreviated version of Neighborhood Environmental Walkability Survey (Infrastructure and safety for walking subscale); NEWS-A (A) = The Chinese abbreviated version of Neighborhood Environmental Walkability Survey (Aesthetic subscale); r_s = Spearman's rho correlation coefficient;

** $p < .01$