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The Influence of Street Microenvironment on the Walking Activities of Older Adults: A Longitudinal Study Based on the Structural Equation Model and Manipulated Photos

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Abstract: There is growing evidence of an association between the built environment and walking activity, but knowledge of street microenvironmental factors and older adults' walking is limited and inconsistent. We used a socio-ecological model as the theoretical framework for this study, aiming to investigate longitudinally the important influences of the street microenvironment on older people's walking by manipulated street photographs and whether there are different groups of older people with different environmental preferences, and to determine the influence of environmental factors in the socio-ecological model. The clustering analysis method was used to divide the samples into four groups, and those four subgroups were put in a comparative analysis regarding their street environments by methods of semantic differential (SD). The preferences of various subgroups were checked by the variance analysis and post hoc tests, and the structural equation model (SEM) was applied to discuss the relations of correlation and influence among each factor. The results showed that "parking on the sidewalk" was rated the lowest in the pre-intervention photos, and "shaded" and "hedge" were rated the highest in the post-intervention photos, and the environmental requirements were different for the older, poorer and higher income and education subgroups. There was a significant positive relationship between residential status and architectural interventions as well as self-efficacy and physical condition. These findings suggest that when developing environmental interventions to promote walking among older adults, priority should be given to those factors that need to be improved most. In addition, attention should be paid to the differences in walking needs among different groups of older adults, with particular attention on the impact of self-selected living environments on street-level environmental interventions.

Keywords: social ecological model; street microenvironment; environmental intervention; walking activities of older adults; structural equation model (SEM)

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1. Introduction

According to statistics newly released by the National Bureau of Statistics, the population of people over 60 years old in China has reached 264 million, which accounts for 18.7% of the total national population (DB/OL 2021). China has become a country with the largest population of older adults in the world (Gagnon et al. 2018). Increasing evidence has suggested that walking activity is the best form of exercise for older adults, as walking as an activity is healthy (De Fré et al. 2009; Manson et al. 2002), convenient and popular among older adults (Murtagh et al. 2010). In addition, it does not need special equipment or clothes and can be conducted at any time, either individually or in the company of others. Consequently, it may be easily incorporated into daily activities (Hamdorf et al. 2002; Tudor-Locke et al. 2002). Due to their socio-economic attributes and physical function characteristics, walking activities in the daily life of the elderly mainly involves transportation walking in the process of daily life, such as shopping, picking up children and social

interactions. It also involves leisure walking as well as walking dogs and other activities for exercise (Jiang et al. 2020).

The social ecological model shows that healthy behaviors of human beings are affected by factors such as personal features, interpersonal relationships, the environment and policies (Bronfenbrenner 1979; Handy et al. 2002). The complicated and dynamic correlations among individuals, society and environmental factors shape body activities and behaviors (Pan et al. 2009). For many people, green open space is a restorative environment. In a restorative environment, individuals will effectively recover their declining ability to concentrate and experience deep physical and mental healing (Kaplan 1995; Kaplan and Kaplan 1989). Chinese scholars (Zhang Junyan, Zeng Cihui, etc.) as well as others (Ulrich, Kaplan. S, Kaplan. R, Hartig, Herzog, Nasar, etc.) have long been studying restorative environments. Physical and mental health as well as social adaptation and participation of the elderly continue to deteriorate with age. This requires affection as well as proper physical and mental health through social interaction (Liu and Chen 2011; Wu and Xing 2008; Yu 2020). The availability of green space suitable for walking was found to be correlated to longer life expectancy (Takano et al. 2002). Green open space is of great significance to improve the quality of life and physical and mental health of the elderly (Bedimo-Rung et al. 2005; Francis et al. 2012; Kent and Thompson 2014; Kemperman and Timmermans 2014). Bedimo-Rung et al. (2005) proposed a green space impact analysis model for evaluating physical activity. It summarizes park environmental elements based on six dimensions: characteristics, quality, accessibility, aesthetics, safety and policy. Giles-Corti et al. (2005) studied the impact of public open space on walking behaviors by measuring public open space based on four dimensions: activities, environmental quality, facilities and safety. Francis et al. (2012) used the social ecological model to study the relationship between public space and the sense of community. Meanwhile, Lachowycz and Jones (2013) discussed the health impact mechanism of green space, revealing potential adjustment factors. Adjustment mechanisms and mediating variables between green space and health were also proposed. In general, relevant research mostly focused on green open spaces such as parks, green spaces and communities, while streets, which are the most frequently used public space by the elderly, were less considered.

More and more people have regarded the characteristics of the street building environment as a key factor to influence walking (McLeroy et al. 1988). While the street is a public space used most frequently by older adults, its comprehensive environment has a crucial influence on body activities and the psychological mood of older adults (McNeill et al. 2006; Rhodes et al. 2006). Thus, it is necessary to inspect the street space from an aging perspective and promote its walkability. Traditional "walking capability" is an assumption based on sound walking capabilities and it cannot reflect the variety of population and ages of all people (Stafford and Baldwin 2018). In fact, the influence of the built environment and social environment on the body activities of older adults are, so far, ignored by us all. However, previous inspection found an inconsistent correlation between the built environment and the body activities of older adults (Barnett et al. 2017). In addition, Van Cauwenberg et al. (2018) carried out a systematic analysis of the correlation between physical exercise and the built environment. Their results are heterogeneous (either no correlation or inverse relationship). What the article wants to express is the built environment. Built environment refers to the man-made environment provided for human activities, including large-scale urban environments (Wikipedia). The "built environment", as we define it, comprises urban design, land use and the transportation system, and encompasses patterns of human activity within the physical environment (Handy et al. 2002). The built environment normally possesses macroscopic properties, i.e., walkability, street connectivity or population density. However, detailed information at a micro level may be of importance (Brownson et al. 2009; Moudon and Lee 2003; Boarnet et al. 2006), such as the flatness of the street, the condition, flow and speed of traffic, sidewalk barriers, sanitary conditions, vegetation and benches. The alteration of the macro-built environment is normally subject to high-level government policies at huge economic costs and therefore

it is hard to change it in the existing street environment. Because the environmental factors at the micro level are mostly within the jurisdiction of local governments and easy to change (Swinburn et al. 1999), it is easier and less costly to modify microenvironmental factors than to modify macroenvironmental factors in support of the ambulatory activities of older adults.

The previous studies in this field were mostly horizontal studies and comparisons, as a longitudinal study was believed to be of high difficulty and almost impossible to be realized. The great majority of evidence in this research field comes from observational studies and causal relationships established by experimental studies, which are strongly demanded (Van Cauwenberg et al. 2011; Ferdinand et al. 2012; McCormack and Shiell 2011). However, it is very costly and time-consuming to conduct natural experiments in real environments and such experiments would cause a long-term influence. The study of influencing factors of the attraction of microenvironmental factors towards walking activities on streets could be conducted by studying the street environment photos that have been shot so as to realize a longitudinal study through a comparison between photos before and after manipulation. The street view photos before and after manipulation are combined with the semantic differential (SD) method that has been widely used to assist research associated with streetscape analysis. Matsumoto and Takai (1992) performed the investigation of personal preference on streetscape using the SD method through photographs. Several researchers have shown that the combination of the VR and SD methods was considerably effective to perform evaluations of streetscapes (Koba and Kishimoto 2009; Koizumi et al. 2009). Other researchers conducted typology method and image analysis methods, using pictures, maps and even computer graphic images (Dokyu and Yamamoto 2003; Seta et al. 2003; Yoshimura and Tsukamoto 2010). Besides, there is no need to accurately define an older adults' "local neighborhood" (Brownson et al. 2009; Spittaels et al. 2009) nor do the older adults have to recall their environmental perceptions and experiences because exposure to and assessment of the environment occurs simultaneously and consistently between participants (Carpiano 2009). It is more convenient for older adults to choose among photos with an effect of reality than to receive an investigation by words and data. A modification of the environmental attributes of one or several independent factors has the potential to encourage more older adults to walk. The measurement of several factors before and after intervention was conducted to obtain the corresponding data, and the blocks suitable for the walking of older adults created or altered by interventions were also obtained. The above blocks may not immediately lead to more walking activities of older adults but may bring other health benefits (Reiner et al. 2013; DiPietro 2001).

One paper establishing the environmental factors relating to overall physical activities and walking activities was a systematic review in which assorted analyses showed that almost half of the studies in the field were concentrated in North America, followed by Europe, with only one research paper from China focusing on the influences of the built environment on the walking activities of older adults in Hong Kong (Barnett et al. 2017). Though there have been large amounts of quantitative and qualitative studies on walking and its influence on older adults, China differs greatly from Western countries in aspects such as the social, economic, cultural and institutional environments. Early retirement age, special family structure and living habits, as well as the different perceptions deriving from a special cultural edification which further leads to different preference for the environment are some examples of how walking and its influencing mechanism of older adults in China differs greatly with Western countries. These differences lead to a large divergence between older adults living in China and those in Western countries in the mode of walking and its influencing factors (Cao 2015). Consequently, overseas study results would face a confinement in their applicability in China (Feng and Yang 2015). A recognition of those potential influencing factors will help to design more targeted intervention strategies, which may provide reference for the subsequent exploratory studies in this field.

The main purposes of this study are (1) to uncover the important influencing factors of street microenvironment modification on the walking activities of older adults; (2) analyze

the differences among the various groups of older adults with corresponding cognitive preferences, as well as among various groups of older adults; (3) conduct a study on the correlation and influencing relationship among the demographics, physical condition, self-efficacy, living environment and environmental intervention and (4) improve and optimize the quality of the street microenvironment so as to increase the walking activities of older adults. This study may provide direction for future interventions of the street environments for the local government.

2. Materials and Methods

2.1. Materials

2.1.1. Design and Participants

All participants had to be over 60 years old. Scheme experiment and questionnaire survey were carried out for ten older adults before the collection of data, according to the results of which the unclear or ambiguous statements of those questions were adjusted to corresponding words that could be more easily understood by the older adults. Some blank-filling questions were adjusted to multiple choice questions that would be more convenient for the older adults to answer. Influenced by the worldwide pandemic in 2020, the survey took the form of an online questionnaire that could be answered using public and available online tools, making the questionnaire survey non-contact, which was safe, convenient and effective. Compared with on-site questionnaires, a virtual questionnaire needs less resources and is free of the confinements of geographical location or weather. The real data were collected in August 2020. It took approximately 30 min to complete the online questionnaire survey and the participants were automatically offered the right to be informed once they had completed filling in the questionnaires.

The questionnaires were answered online, and there were 171 older adults who completed filling in this questionnaire, among whom 10 participants failed to complete their answers. A total of 165 analysis samples were finally obtained by omitting the incomplete questionnaires.

2.1.2. Structured Questionnaire

The structured questionnaire collected sociodemographic statistical information (such as gender, age, education level, employment condition, occupation before retirement, monthly income, living status, period of resident, floor of home, elevator condition, monthly ticket, driver's license, etc.), and evaluations of body functions, self-efficacy, street environmental intervention and current living environments.

In order to evaluate body functions, a body functions scale was used in the RAND SF-36 validation questionnaire (Haywood et al. 2005; Ware et al. 1994), which requested the testee to evaluate the body condition of themselves, times of daily walking, restrictions influencing their walking, usage of a walking aid and their worries about falling down (i.e., on the stairs, chairs, coarse roads or roads after rain or snow, etc.). The evaluations were categorized into five classes: extremely worried, worried, ordinary, a bit concerned, not concerned. In addition, the testee were also requested to evaluate their capabilities of handling daily living affairs (such as dressing, taking a bath, going to the toilet, walking, looking after children, doing housework and shopping, etc.). The evaluations were categorized into five classes: incapable by myself, assisted by others, uncertainty, a bit difficult, coping with all by myself.

The questions aiming at the evaluation of self-efficacy were similar to those used in previous studies (Van Dyck et al. 2009; De Bourdeaudhuij and Sallis 2002). However, the questions in this study were specialized for those walking with a destination that is within a 10-min walk. The questionnaire was conducted by inquiring the testee "which of the following you would prefer to choose when you were going to get to a destination which is within a 10-min walk?" to evaluate their preferences for the active/passive walking: "walking, bicycle, motorbikes, public transport, or private cars". The evaluation for self-efficacy contained only one item: "whether you have confidence in walking for a further

10 min to reach the destination when you are tired or confronted with bad weather?" The scope of responding options were "no confidence, I guess I can't, uncertainty, I guess I can, I'm confident to do it". The inquiry of disturbance of perception was in the form of "which reason are you incapable of bearing a further 10 minutes' walk?" The following options to respond were "lack of time, health problems, bad weather or other conditions" and were used to evaluate the main reasons for their incapability of a further walk. One evaluation of social support was conducted in the form of "what are the attitudes of your family members and friends towards your walking?" Four options to respond were "they support me by encouragement, they accompany me to do it, they arrange it for me and they complain about my walking" and were used to evaluate whether the walking of testee was supported by their family members or friends, with the responding scope of which was "never, seldom, ordinary, sometimes, often".

Semantic differential (SD) was applied in the comparison between the street environments before and after manipulations (Zhuang 1996). A total of 153 scenery photos of typical streets that had been selected of Dalian city were taken from the horizontal sight. After consultations with several experts in this field, we selected the sidewalk photos of one city street of a happy family community in Dalian study materials. The photos received an experimental treatment with the software AdobePhotoshop® for the environmental attributes in them (walking barrier-free, sidewalk leveling, with isolation band, sidewalk dedicated, shady, rest on the roadside, clean), so as to form a comparison of the environments in them before and after manipulations (Van Cauwenberg et al. 2012; Van Cauwenberg et al. 2014a, 2014b).The environmental factors to be manipulated were determined in the form of 20 pairs of descriptive adjective phrases of the environmental factors in photos, based on the reference of environmental attributes necessary for walking in previous studies. The evaluation results are categorized into five classes (1, 2, 3, 4, 5), of which a higher mark referred to a higher level of evaluation.

In order to make the test contents more suitable for China's national conditions, the residential environment scale was obtained by adapting the Neighborhood Environmental Walking Scale (NEWS) developed by Sallis and others, which has been widely used in studies (Sallis et al. 1997). NEWS is a questionnaire most frequently used that aims to evaluate environmental perception (Brownson et al. 2009; Spittaels et al. 2009). The reliability and validity indicators are retested in several fields (Cerin et al. 2006; Saelens et al. 2003). The environmental perception of the local streets of participants themselves were evaluated by inquiring about the conditions of their current living environment in the form of options such as "the reason for living here, the feelings of living here, security of surrounding circumstances, condition of surrounding streets".

The content of this questionnaire was specially designed for the current study and overall reliability and validity analyses were conducted. Since the standardized Cronbach's coefficient alpha was 0.948, which was over 0.9, and the result of KMO test was 0.838, which was over 0.8, this questionnaire shows a very high level of overall reliability and a good validity of the research data.

2.2. Methods

The IBM SPSS Statistics 23.0 was applied in all of the following analyses, and they were conducted in the following procedures. First of all, the sociodemographic characteristics of the samples were put into a frequency analysis which described the features of participants. Next, the K-prototype clustering methods were applied, and four subgroups were finally obtained by clustering. Each subgroup was evenly distributed in population features, which showed a comparatively good effect of clustering. The semantic differential (SD) method was applied to obtain the mean values and overall mean values of each subgroup, before and after manipulations of the street environments, for a comparative analysis. Then the analysis of variance was applied (its full name is one-way analysis of variance) to study whether, among the four subgroups, there were differences in aspects such as sociodemographic characteristics, body functions, subjective consciousness, street

environmental interventions or current living environments. As for continuous variables, MANOVA was applied to check the differences among four subgroups. We used Tukey's post-test analysis (Field 2005) in case of a homogeneous variance to explain Wilks' lambda, and to explain Tamhane in case of a heterogeneous variance. As for categorical variables, the chi-squared test was applied for the differences among four subgroups. The sample significance level was defined as alpha = 0.05. Finally, an analysis was conducted by the structural equation modeling (SEM) to determine the influence relationships among the sociodemographic characteristics, body functions, self-efficacy, street environmental interventions and current living environment. The path analysis was conducted with the development of the theoretical model so as to facilitate a clear analysis of the effects of individual indicators on the whole and the correlations among individual indicators.

3. Results

3.1. Descriptive Characteristics of the Sample

The frequency number of sociodemographic characteristics of samples were analyzed and the features of participants were described. The sociodemographic characteristics of 165 testees are shown in Table 1. In general, the proportion of female testees in the sample was 69%, which accounted for the vast majority of testees. The 60–65 age group accounted for the highest proportion, at 36% among all age brackets. The proportion of "with an education level of high middle school and vocational study" was 26%. A total of 90% of the older adults were not under employment. The proportion of "enterprise staff" accounted for 35%. Over 34% of the testees had a monthly income of over 4000 CNY, and over 50% of the testees were "living together with their spouses". Over 50% of the testees were "over 10 years". Nearly 50% of the older adults were living on "1st–3rd floor" at the time when they were surveyed. Half of the testees lived in a building with no elevators and 38% of the testees possessed a "senior metro card". In addition, the proportion of older adults taking free bus cards also accounted for 31%. The vast majority of testees had no driver's license, which accounted for 77% of the whole sample.

Table 1. Descriptive characteristics of the sample (n = 165).

Classification	Classification Level	Frequency	Percent	Mean	Std. Deviation
Gender	Male	51	31%	1.69	0.46
	Female	114	69%		
Age	60–65 years old	59	36%	2.19	1.10
	66–70 years old	44	27%		
	71–75 years old	34	21%		
	Over 76 years old	28	17%		
Educational level	Primary school and below	22	13%	3.06	1.33
	Junior middle school	40	24%		
	High middle school and vocational study	43	26%		
	Junior college	26	16%		
	Bachelor's degree and above	34	21%		
Employment condition	Employed	16	10%	1.9	0.30
	Not employed	149	90%		
Occupation before retirement	Civil servants and managers	20	12%	3.07	1.45
	Employees of public institutions	42	26%		
	Enterprise staff	57	35%		
	Self-employed	14	9%		
	Farmer	16	10%		
	Others	16	10%		

Table 1. *Cont.*

Classification	Classification Level	Frequency	Percent	Mean	Std. Deviation
Monthly income	Less than 1000 CNY	14	9%	3.66	1.25
	1000~2000 CNY	12	7%		
	2000~3000 CNY	46	28%		
	3000~4000 CNY	37	22%		
	Over 4000 CNY	56	34%		
Living status	Living alone	30	18%	2.25	0.92
	Living together with their spouses	86	52%		
	Living together with their children	29	18%		
	Three generations under one roof	18	11%		
	Others	2	1%		
Period of residence	Less than 1 year	1	1%	4.03	1.16
	1–3 years	27	16%		
	4–5 years	20	12%		
	6–10 years	35	21%		
	Over 10 years	82	50%		
Floor of home	1st~3rd floors	81	49%	1.97	1.14
	4th~5th floors	32	19%		
	6th~10th floors	32	19%		
	11th~20th floors	16	10%		
	More than 20 floors	4	2%		
Elevator condition	Yes	84	51%	1.49	0.50
	No	81	49%		
Monthly ticket	No	24	15%	3.3	1.32
	Ordinary monthly ticket	11	7%		
	Free bus cards	51	31%		
	Senior metro card	63	38%		
	Traffic allowance	3	2%		
	Others	13	8%		
Driver's license	Yes	38	23%	1.72	0.59
	No	127	77%		

3.2. Semantic Differential (SD)

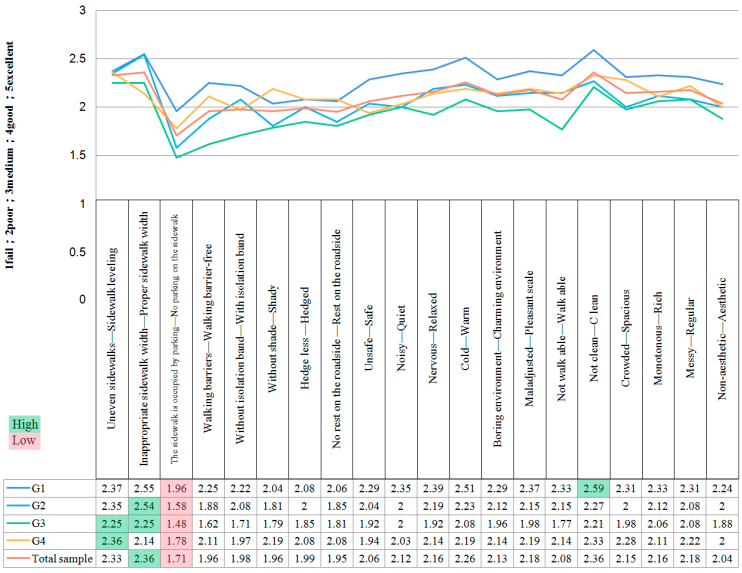
The sample was categorized by clustering analysis. Cluster analysis selected sociodemographic statistical information variables in the questionnaire. The K-prototype clustering analysis was applied since the nominal data contained in the whole data. A cluster analysis of 20 iterations was performed on the sample to identify subgroups of people with different environmental preferences for walking. Based on the increase in model fitting and the number of participants in each subgroup, four subgroups were finally selected. It is shown in Table 2 that the numbers of these four groups were 51, 26, 52 and 36. The proportion of each group was, separately, 31%, 16%, 31% and 22%. On the whole, the distribution of the crowd in the above category is uniform, indicating that the clustering effect is good from a whole perspective.

Table 2. Number of cases in each cluster.

Cluster	1	51.000	31%
	2	26.000	16%
	3	52.000	31%
	4	36.000	22%
Valid		165.000	
Missing		0.000	

The semantic differential (SD) was applied to compare and analyze the major factors of each subgroup that have influence on the ambulatory activities of older adults before and after environmental manipulations of the photos. The street environment was studied from a perspective of psychological perception, wherein the process included the select 20 pairs of adjective phrases being evaluated by setting five evaluation scales. The corresponding mark of each evaluation scale was 1, 2, 3, 4 and 5, while a higher mark referred to a higher level of evaluation. Figures 1 and 2 are, respectively, the mean values and overall mean values of the sample before and after the environmental interventions.

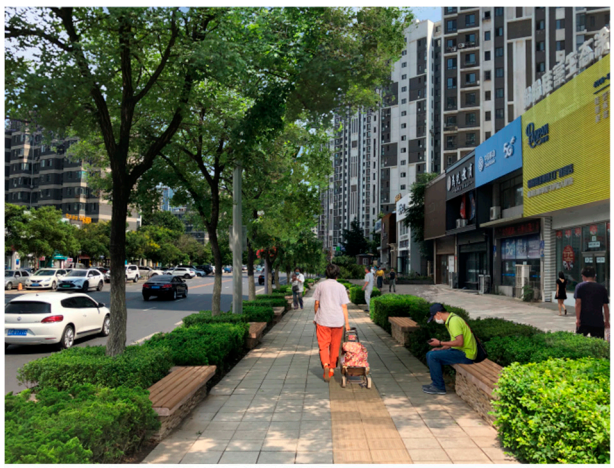
(**a**)



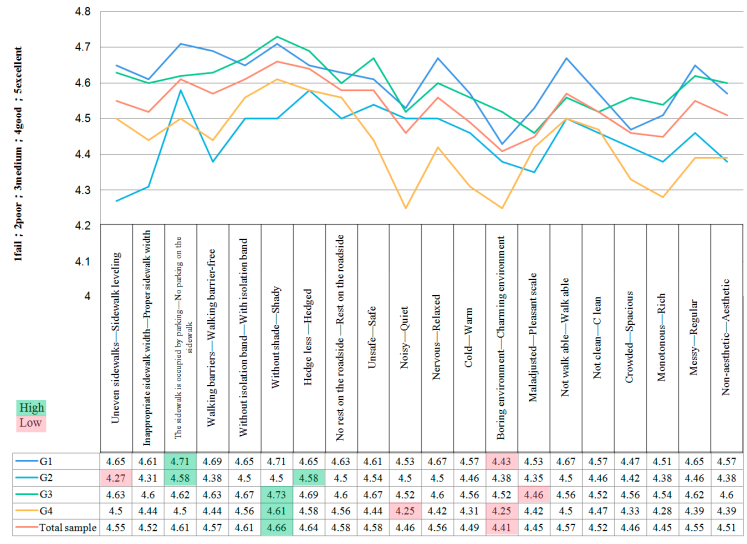
G1	2.37	2.55	1.96	2.25	2.22	2.04	2.08	2.06	2.29	2.35	2.39	2.51	2.29	2.37	2.33	2.59	2.31	2.33	2.31	2.24
G2	2.35	2.54	1.58	1.88	2.08	1.81	2	1.85	2.04	2	2.19	2.23	2.12	2.15	2.15	2.27	2	2.12	2.08	2
G3	2.25	2.25	1.48	1.62	1.71	1.79	1.85	1.81	1.92	2	1.92	2.08	1.96	1.98	1.77	2.21	1.98	2.06	2.08	1.88
G4	2.36	2.14	1.78	2.11	1.97	2.19	2.08	2.08	1.94	2.03	2.14	2.19	2.14	2.19	2.14	2.33	2.28	2.11	2.22	2
Total sample	2.33	2.36	1.71	1.96	1.98	1.96	1.99	1.95	2.06	2.12	2.16	2.26	2.13	2.18	2.08	2.36	2.15	2.16	2.18	2.04

(**b**)

Figure 1. (**a**) Street environment before intervention (original photo); (**b**) SD analysis method—4 subgroups and total sample street environment pre-intervention evaluation scale.



(**a**)



G1	4.65	4.61	4.71	4.69	4.65	4.71	4.65	4.63	4.61	4.53	4.67	4.57	4.43	4.53	4.67	4.57	4.47	4.51	4.65	4.57
G2	4.27	4.31	4.58	4.38	4.5	4.5	4.58	4.5	4.54	4.5	4.5	4.46	4.38	4.35	4.5	4.46	4.42	4.38	4.46	4.38
G3	4.63	4.6	4.62	4.63	4.67	4.73	4.69	4.6	4.67	4.52	4.6	4.56	4.52	4.46	4.56	4.52	4.56	4.54	4.62	4.6
G4	4.5	4.44	4.5	4.44	4.56	4.61	4.58	4.56	4.44	4.25	4.42	4.31	4.25	4.42	4.5	4.47	4.33	4.28	4.39	4.39
Total sample	4.55	4.52	4.61	4.57	4.61	4.66	4.64	4.58	4.58	4.46	4.56	4.49	4.41	4.45	4.57	4.52	4.46	4.45	4.55	4.51

(**b**)

Figure 2. (**a**) Street environment after intervention (manipulated photos); (**b**) SD analysis method—4 subgroups and total sample street environment post-intervention evaluation scale.

It can be learned from the tables that before the street environmental interventions, "the sidewalk is occupied by parking" received the lowest level of evaluation in each subgroup. Meanwhile, the highest evaluations of each subgroup were "clean" for group

one, "proper sidewalk width" for group two, "proper sidewalk width" and "flat and neat sidewalk" for group three and "flat and neat sidewalk" for group four.

After the street environmental interventions, the highest evaluations for each subgroup were "shady" and "no parking on sidewalk" for group one, "no parking on sidewalk" and "hedged" for group two and "shady" for group three and group four. Meanwhile, the lowest evaluations for each subgroup were "charming environment" for group one, "flat and neat sidewalk" for group two, "pleasant scale" for group three and "quiet" and "fascinating environment" for group four.

In general, before the environmental manipulations, "sidewalk is occupied by parking" became the crucial problem, while "shady" and "hedged" obtained the highest level of evaluation after the environmental manipulations, with attention also on the sidewalk free of parking.

3.3. Analysis of Variance and Back Testing

Analysis of variance was applied to test the subgroups with preferences for walking environment and to analyze the differences among them. Table 3 shows that the four subgroups had significantly different preferences for the 23 items ($p < 0.05$), meaning a significant difference in preferences for 23 items for various subgroup samples.

Table 3. Differences in sociodemographic characteristics, body functions, self-efficacy, current living environment and street environmental interventions between the subgroups.

	Cluster Number (Mean ± Std. Deviation)				F	*p*	Multiple Comparisons
	1.0 (*n* = 51)	2.0 (*n* = 26)	3.0 (*n* = 52)	4.0 (*n* = 36)			
Age	2.16 ± 0.99	3.12 ± 1.14	1.96 ± 1.03	1.89 ± 1.01	8.887	0.000 **	2.0 > 1.0; 2.0 > 3.0; 2.0 > 4.0
Education level	2.22 ± 0.76	1.58 ± 0.76	3.77 ± 0.94	4.31 ± 0.86	82.756	0.000 **	1.0 > 2.0; 3.0 > 1.0; 4.0 > 1.0; 3.0 > 2.0; 4.0 > 2.0; 4.0 > 3.0
Occupation before retirement	3.00 ± 0.57	5.12 ± 0.82	1.79 ± 0.72	3.56 ± 1.52	77.663	0.000 **	2.0 > 1.0; 1.0 > 3.0; 4.0 > 1.0; 2.0 > 3.0; 2.0 > 4.0; 4.0 > 3.0
Monthly income	3.39 ± 0.72	1.62 ± 0.80	4.58 ± 0.67	4.19 ± 0.86	98.493	0.000 **	1.0 > 2.0; 3.0 > 1.0; 4.0 > 1.0; 3.0 > 2.0; 4.0 > 2.0; 3.0 > 4.0
Floor of home	1.76 ± 0.93	1.38 ± 0.70	1.62 ± 0.82	3.19 ± 1.21	27.188	0.000 **	4.0 > 1.0; 4.0 > 2.0; 4.0 > 3.0
Elevator condition	1.63 ± 0.49	1.92 ± 0.27	1.40 ± 0.50	1.11 ± 0.32	20.490	0.000 **	2.0 > 1.0; 1.0 > 3.0; 1.0 > 4.0; 2.0 > 3.0; 2.0 > 4.0; 3.0 > 4.0
Monthly ticket	3.92 ± 0.80	2.15 ± 1.41	3.08 ± 1.17	3.56 ± 1.46	13.984	0.000 **	1.0 > 2.0; 1.0 > 3.0; 3.0 > 2.0; 4.0 > 2.0
Driver's license	1.88 ± 0.33	2.00 ± 0.00	1.81 ± 0.40	1.39 ± 0.49	17.921	0.000 **	1.0 > 4.0; 2.0 > 3.0; 2.0 > 4.0; 3.0 > 4.0
Your body condition	2.45 ± 0.86	2.38 ± 0.75	2.10 ± 0.87	1.97 ± 0.77	3.129	0.027 *	1.0 > 3.0; 1.0 > 4.0
Your worries about falling down (coarse roads)	2.51 ± 1.21	2.42 ± 1.06	2.79 ± 1.33	3.33 ± 1.41	3.694	0.013 *	4.0 > 1.0; 4.0 > 2.0
Your capabilities for handling daily living affairs (shopping)	4.45 ± 1.06	4.04 ± 1.37	4.75 ± 0.84	4.67 ± 0.96	3.066	0.030 *	3.0 > 2.0; 4.0 > 2.0
Your capabilities for handling daily living affairs (seek medical advice)	4.06 ± 1.24	3.62 ± 1.50	4.52 ± 1.08	4.33 ± 1.22	3.484	0.017 *	3.0 > 2.0; 4.0 > 2.0
Your capabilities for handling daily living affairs (take a public vehicle)	4.37 ± 1.17	3.85 ± 1.49	4.71 ± 0.91	4.56 ± 1.05	3.592	0.015 *	3.0 > 2.0; 4.0 > 2.0

Table 3. *Cont.*

	Cluster Number (Mean ± Std. Deviation)				F	p	Multiple Comparisons
	1.0 (n = 51)	2.0 (n = 26)	3.0 (n = 52)	4.0 (n = 36)			
For what reason are you incapable of bearing a further 10-min walk? (lack of time)	0.06 ± 0.24	0.12 ± 0.33	0.23 ± 0.43	0.36 ± 0.49	5.042	0.002 **	4.0 > 3.0; 4.0 > 2.0 > 1.0
For what reason are you incapable of bearing a further 10-min walk? (others)	0.04 ± 0.20	0.15 ± 0.37	0.12 ± 0.32	0.25 ± 0.44	2.978	0.033 *	4.0 > 3.0; 4.0 > 2.0 > 1.0
The reason for living here (close to my family or friends)	3.69 ± 1.09	3.58 ± 0.99	4.19 ± 1.12	3.78 ± 1.10	2.713	0.047 *	3.0 > 1.0; 3.0 > 2.0
The reason for living here (to take care of the grandchildren in school)	3.51 ± 1.25	2.81 ± 1.55	3.77 ± 1.38	3.56 ± 1.46	2.819	0.041 *	1.0 > 2.0; 3.0 > 2.0; 4.0 > 2.0
The feelings of living here (the building is beautiful)	3.41 ± 0.92	3.15 ± 0.88	3.56 ± 1.00	3.94 ± 0.79	4.236	0.007 **	4.0 > 1.0; 4.0 > 2.0
The feelings of living here (clean environment)	3.57 ± 1.01	3.27 ± 0.92	3.65 ± 0.97	3.97 ± 0.84	2.905	0.037 *	4.0 > 2.0
Condition of surrounding streets (the streets are easily accessible)	3.76 ± 0.93	3.15 ± 0.97	3.85 ± 1.07	3.94 ± 0.98	3.724	0.013 *	1.0 > 2.0; 3.0 > 2.0; 4.0 > 2.0
Condition of surrounding streets (crossing the street requires an overpass or underpass)	3.31 ± 1.01	2.92 ± 1.06	3.38 ± 1.07	3.75 ± 1.02	3.260	0.023 *	4.0 > 2.0
Condition of surrounding streets (traffic lights)	3.69 ± 1.05	2.88 ± 1.18	3.94 ± 1.00	3.78 ± 1.12	5.902	0.001 **	1.0 > 2.0; 3.0 > 2.0; 4.0 > 2.0
Photo before street environment intervention (walking barriers)	2.25 ± 1.28	1.88 ± 0.95	1.62 ± 1.05	2.11 ± 1.01	3.167	0.026 *	1.0 > 4.0; 4.0 > 2.0

* $p < 0.05$; ** $p < 0.01$.

It can be learned from the Tables that the 51 participants in group one (31%) had inferior health conditions compared to other groups, with a higher level of satisfaction than other groups before the environmental manipulations of photos.

The 26 participants of group two (16%) were of older ages and weaker health condition. They had a comparatively high level of worry about the coarse road surface and had inferior capabilities for aspects such as shopping, seeking medical advice and taking buses. Thus, compared with other groups, they were less frequently engaged in looking after grandchildren, were of the lowest education level, had the lowest monthly income, lived on comparatively low floors, universally had no elevators and the surrounding streets of their home were comparatively not well connected. The participants of this group put no emphasis on the beauty of buildings and the cleanliness of the environment compared with other groups.

The 52 participants of group three (31%) had the highest monthly income and superior capabilities for aspects such as shopping, seeking medical advice and taking buses, and their residential sites were closer to their family members and friends, which was for the purpose of more chances to look after their grandchildren who were of school age. They showed a lower level of satisfaction before the environmental manipulations of photos.

The 36 participants of group four (22%) were of the youngest mean age among all subgroups and had the highest education level as well as the best health condition. They had no worry for coarse road surfaces and lived on a comparatively higher floor than other groups, with the highest proportion of available elevators. Some of them had driver's licenses. They held more appreciation for beautiful housing and a clean and tidy environment. It was more common for the participants of group four to go by an overpass or through an underpass when crossing the street.

3.4. Structural Equation Model

A structural equation model was built to determine the influencing correlation among sociodemographic characteristics, body functions, self-efficacy, street environmental interventions and current living environment. The analytical statistics of the structural equation model (SEM) were established by spss23 AMOS, and information criteria such as GFI, RMSEA, RMR, CFI and NFI were applied for the evaluation of this model. The fitting

indexes of this model were as follows: GFI = 1 (>0.9), RMSEA = 0.00 (<0.6), RMR = 0.002 (<0.05), CFI = 1.00 (>0.9), NFI = 1.00 (>0.9), which satisfied the information criteria.

It can be learned from Figure 3 that the value of standardized path coefficient in the valuation of influence of current living environments on the architectural intervention was 0.366 > 0, and this path represented a 0.01 level of significance (z = 4.895, p = 0.000 < 0.01), which suggested a significant positive influence of the current living environments on the architectural interventions.

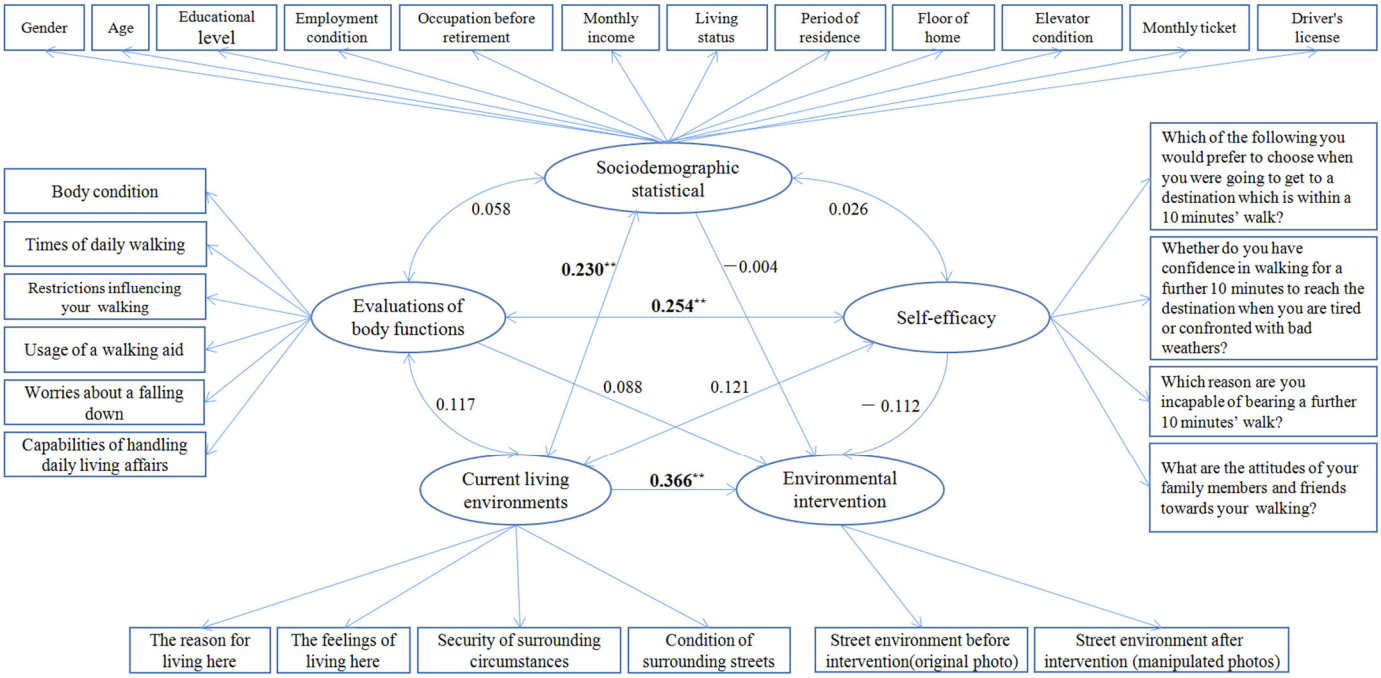


Figure 3. Structural equation modeling (SEM) was established to analyze the data to determine the relationship between sociodemographic characteristics, body functions, self-efficacy, current living environment and street environmental interventions. The numbers in the figure are standardized path coefficients, and ** indicates significance (** p < 0.01).

As for the covariance correlation (correlativity) between self-efficacy and body condition, the standardized path coefficient was 0.254 > 0, and this path presented a 0.01 level of significance (z = 3.158, p = 0.002 < 0.01), which suggested there was a significant positive covariance correlation between self-efficacy and body condition.

As for the covariance correlation (correlativity) between the sociodemographic characteristics and current living environments, the standardized path coefficient was 0.230 > 0, and this path presented a 0.01 level of significance (z = 2.879, p = 0.004 < 0.01), which suggested there was a significant positive covariance correlation between the sociodemographic characteristics and current living environments.

There was a negative influencing relationship between self-efficacy and environmental intervention, and a positive influencing relationship between the body condition and environmental intervention. This study shows no significant influencing correlation between the sociodemographic characteristics and the body condition as well as environmental interventions.

4. Discussion

4.1. The First Aim

The current study aims to explore the street microenvironmental factors of cities by evaluating the changes of attraction of street scene photos for older adults, before and after manipulations, to find out the influencing factors.

The qualitative and quantitative results concluded by us show that "sidewalk is occupied by parking" received the lowest level of evaluation among all samples before

the environmental manipulations of street photos, and it had the largest influence on the ambulatory activities of older adults. After environmental manipulations of street photos, "shady" and "hedged" received the highest level of evaluation, and there was also attention to the "sidewalk is free of parking".

These findings coincide with the key factors concluded in previous investigations of the quality of sidewalks, which has influence on the ambulatory activities of older adults (Van Cauwenberg et al. 2012; Strath et al. 2007; Gallagher et al. 2010; Mahmood et al. 2012). Quantitative studies in the past mainly concentrated on the availability of sidewalks or overall measures as improvements of basic facilities and safety for ambulatory activities, including items such as the "existence of sidewalk", "maintenance of sidewalk", "separation from the motorized traffic" and "existence of street lighting" (Cerin et al. 2009).

Although sidewalks have been set on most pedestrian streets, almost all the participants complained about the quality of sidewalks. This study suggests that we should not just pay attention to the existence of sidewalks but also pay attention to their quality. For example, when a barrier for walking is formed by the parking of a motor vehicle or the available sidewalk is of poor quality, older adults would pay little regard to the existence of hedges when they are making decisions as to whether to go out for ambulatory activities or not. However, in the case of a street with comparatively high-quality sidewalks, the existence of hedges may further increase the walking attraction of the street to the older adults. The interactions among those environmental factors were described in the *Hierarchy of Walking Needs*, written by Alfonzo (Alfonzo 2005).

Increasingly prominent phenomena of the occupation of sidewalks by the parking of cars and bicycles has emerged in recent years, with the rapid increase in the number of private cars in China. Though the parking of vehicles is not regarded as a barrier for physical exercises, the correlation between it and the ambulatory activities has come to a crucial point. In the case of sidewalk occupation, where the width of the unoccupied part is still available for the crossing of pedestrians, the space for pedestrians would be reduced and the ambulatory activities of pedestrians would be restricted with lower walking speed and less comfort. In the case of a complete occupation of a sidewalk, pedestrians would take advantage of the closely adjacent car lane to bypass the occupied part of sidewalk, in which process the running vehicles would threaten the safety of pedestrians and the travel safety of pedestrians would be under no guarantees (Feng and Zhang 2006).

Since older adults have comparatively weak vision, hearing and capability for moving, the case above would bring much risk to their safety and have the largest influence on the ambulatory activities of older adults. As for older adults, good outdoor environments would promote their outdoor exercises, increase their opportunities for a touch with nature, improve the frequency of their social communications and allow them to keep a healthy body (Sugiyama and Thompson 2007). Compared with factors such as roadside seats and flat and neat roads, older adults welcome shady spaces with plants.

"Sidewalk is occupied by parking" and "shady" street that is "hedged" are environmental factors at the micro level, which are feasible environmental modifications with comparatively low costs and almost are within the jurisdiction of local governments, and thus they are more apt to be altered (Swinburn et al. 1999). When some intervention factors of micro-built environments are the most significant factors to determine the ambulatory activities of older adults, it is most likely to improve the level of ambulatory activities of older adults by intervention. The environmental intervention policies should not be made in a blind way but should find the factors in the most urgent need for optimization and to make the best decisions with limited resources so as to further realize the largest intervention effects.

4.2. The Second Aim

The second purpose of our study is to check whether subgroups exist with different preferences for environment and whether the environmental perceptions of those sub-

groups can be characterized by their social population, physical functions, self-efficacy and residential status.

Four subgroups were obtained after our analysis, and the levels of satisfaction of testees after environmental modifications were generally higher than those before environmental modifications.

The participants of group one expressed a comparatively higher level of satisfaction with the environments before intervention than the other groups, which suggested that some older adults with comparatively weak body conditions had either limited times of ambulatory activities or limited walking capabilities. They may seldom go out and they have no strong demands for environments, so the environmental interventions would have little influence on the ambulatory activities of this group of older adults.

The participants of group two were of elder average age and weaker health condition. They had a comparatively high level of worry about coarse road surfaces and had inferior capabilities for aspects such as shopping, seeking medical advice and taking buses. Compared with other groups, they were less frequently engaged in looking after their grandchildren, were of the lowest education level, had the lowest monthly income and the overall surrounding conditions of their home was comparatively bad. The participants of this group had no time to be concerned about the aesthetic factors of surrounding environments. The worries of participants of the second subgroup about coarse road surfaces can be explained by their limited body functions and their fears of falling down. This finding provides some support for the higher sensitivity of persons with limited body functions towards environmental factors (Alfonzo 2005). Based on that logic, older adults with limited body functions and fear of falling down would also pay more attention to the flatness of sidewalks. This coincides with the "hierarchy of walking needs" proposed by Alfonzo, wherein the "feasibility" as a lower level of demand for streets must be first satisfied before the "comfort level" as a higher level of demand can be pursued (Alfonzo 2005).

The findings of the first and second groups coincide with those of previous relevant studies. Compared with those older adults with a comparatively lower level of limitation on their capabilities, there exists a stronger correlation between environments and ambulatory activities for the older adults with a more severe level of limitation on their capabilities (Lang and Wahl 2003). The unique environmental factors which attract people with the least ambulatory activities (compared with the ordinary walking persons) are of extreme importance to the design of the street environment for the information they provide. Those designs may encourage the least active people to take more ambulatory activities.

The participants of group three had a higher monthly income and superior capabilities for aspects such as shopping, seeking medical advice and taking buses, and their residential sites were apt to be closer to their family members and friends for the purpose of more chances to look after their grandchildren who were of school age. They were more concerned about the surrounding environments for their needs of frequent outings. Consequently, they showed a lower level of satisfaction than the other groups before the environmental manipulations of photos.

Families comprised of three generations are still common in China, and many older adults in China choose to live together with their adult children (Feng et al. 2013). They share a lot of family responsibilities, such as going out to buy food and picking up and sending their grandchildren from or to schools, as well as taking care of their grandchildren when the children are playing around their communities. That suggests the family structure would influence the walking of older adults (Kanaroglou et al. 2006), since the family responsibilities require more walking of them and "bind" them up, to a certain degree. Besides the influences of personal characteristics and family structure on the frequency of walking of older adults, individual social economic attributes also have significant influences on their walking (Hjorthol et al. 2010). The existing studies have shown that the increase in family income will cause more shopping and entertainment trips (Páez et al. 2007) so as to promote the overall times of trips. The results of this study support that demonstration.

The participants of group four were of the youngest mean age among all subgroups and with the highest education level as well as the best health conditions. They had no worry for coarse road surfaces and lived on a comparatively higher floor than those of the other groups, and they lived with the highest proportion of available elevators. It was more common for them to go by an overpass or through an underpass when crossing a street. They held more appreciation for beautiful housing and a clean and tidy environment. The reason why the older adults of younger ages walked more than those of elder ages is that they enjoyed better body conditions (Hjorthol et al. 2010).

The analysis of the third and fourth group show that among individual attributes, the personal monthly income and education level have significant influences on ambulatory activities. The older adults with a higher income and a higher level of education took more ambulatory activities, paid more attention to their surrounding environments and had a higher level of requirement for the environments (Canizares and Badley 2018; Alemu et al. 2016), which coincides with the findings of Schwanen. The higher level of education an older adult has received, the more profound awareness of environmental protection and a stronger willing for green travels they may have (Schwanen et al. 2001).

Through the comparison of sociodemographic characteristics, body functions, subjective consciousness, street environmental interventions or current living environments among the four subgroups, it is confirmed that there are significant differences between the subgroups. The results show that different elderly groups have different walking needs in different street microenvironments. The intervention measures for the street microenvironment should be targeted and priority should be given to the environmental factors that most need to be improved. There is no cookie-cutter solution for environmental intervention measures.

4.3. The Third Aim

The third purpose of our study is to establish the analytical data of the structural equation model (SEM), so as to determine the influencing correlations among social factors, physical and psychological conditions, environmental factors and ambulatory activities.

The result shows that there is a significant positive influencing correlation between the current living environments and architectural intervention. The environments that older adults preferred may also be affected by the environmental characteristics of the street they live on. The older adults living by streets with heavy traffic would pay more attention to the beauty of buildings and the clean and tidy environments. Those older adults with comparatively bad living conditions and surrounding environments would neglect the aesthetic factors in the environments. It has been found that the built environment and self-selection would both affect the changes of walking for older adults, while the self-selection of residents may generally weaken the influence of the built environment on the walking (Cao et al. 2009).

Another result shows that there is a significant positive correlation between self-efficacy and body condition. Self-efficacy is the most influential factor directly affecting physical activities, which coincides with the previous studies. In addition, the built environment, psychological and social factors have direct or indirect influences on the physical activities (McNeill et al. 2006; Rhodes et al. 2006; Rutt and Coleman 2005; Maddison et al. 2009). Self-efficacy, as a kind of psychological factor, plays an important role in the mediating effect. As for older adults willing to take active walks, it would help them to take further walks by improving their body conditions or their neighboring social environments. As for those older adults with comparatively poor psychological conditions (i.e., passive attitude for walking, poor self-efficacy of walking) or seldom ambulatory activities, further studies should be carried out to study which environmental intervention measures should be taken to promote ambulatory activities for the least active group of older adults (Prins et al. 2014). Our results show a good design of street architectural microenvironments may lead to positive changes of the subjective concept, which may be an important early stage for

behavior alterations. Additionally, a good design can stimulate older adults to frequently exercise outdoors.

Ecological views reveal that the physical activities are subject to the influences of interactions among demographic and psychological, social and environmental factors (Sallis and Owen 2002). Those factors have potential adjustments for the ambulatory activities of older adults. The built environmental factors of streets may be of special importance to older adults, for it is more possible for older adults who are of low mobility to rely on the very surrounding environments they are living in. It has also been found that the current living environment has the most significant influence among all other influencing factors on the environmental factors and plays an important role.

5. Advantage

It is universally acknowledged that built environments may contribute to physical exercise. However, there is a lack of longitudinal studies on the influences of the built environment, before and after alterations, on the ambulatory activities of older adults. A key advantage of this study is that the manipulated photos can enable us to test the influence of processing of the microenvironmental attributes on the attraction of streets to walking under perfectly controlled conditions. This study is free of the possible limitations of geographical location and weather and has straightforward results, which reduces the difficulty in making decisions. Another advantage of this study is to realize the determination of subgroups which separately prefer various environments for their walking activities.

6. Limitations

Since this study was conducted in an internet environment, we were unable to select the most typical samples among the internet crowd and whether to participate in this study or not was absolutely determined at the participants' own will (Eysenbach and Wyatt 2002). In addition, the internet participants tend to be of a younger age with a higher income and have more frequent visits to the internet (Shibata et al. 2009; Rhodes et al. 2003). As a result, there is a lack of universality in the selection of testees.

The samples were selected in cities, and rural areas were not taken into consideration, hence there is a lack of universality in the study sites. According to the statistics of the most recent population census of China, the population over 60 years old in rural areas accounts for up to 23.81% of people, which is higher than those in cities and towns by 7.99% (Rhodes et al. 2003). Future studies should pay more attention to the influence of environmental factors on ambulatory activities of older adults in rural areas.

The restrictions of the street scene photos lie in the fact that the speed of traffic cannot be accurately described in the photos and the noise and exhaust fumes produced by heavy traffic and running cars cannot be captured by photos. In this stage, it is still unclear whether it may lead to more ambulatory activities of older adults by a modification of streets to the ones with better environmental attributes (such as no parking on the sidewalk and increased shady areas). Therefore, our studies should be explained and used accordingly. The current study should not be deemed as the terminal of this field, and future studies would aim at testing the influence of real environmental alterations on the real ambulatory activities of older adults. Our study results provide valuable information as references for future studies.

7. Conclusions

To sum up, our study found that the modification of street microenvironments should give priority to no parking on sidewalks and the improvements of shady areas and hedges beside the street, so as to increase the ambulatory activities of older adults. This provides a clearer intervention policy for local governments. Our study results also show that among the subgroups with different environmental preferences, the older adults with elder ages, weaker body conditions and poor living environment have no high level of demand for environments, while those older adults with a higher level of income, a higher education

level and good living environment pay more attention to their surrounding environments, with more concerns for the aesthetic factors in their surrounding environments. Besides, special attention should be paid on the influence of self-selected living environments on street environmental preferences. A larger sample will be needed for future studies so as to observe and confirm the influence of alterations of street environmental factors on the attraction to the ambulatory activities of older adults by natural experiments.

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