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Social-ecological correlates of older adults' outdoor activity patterns

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ABSTRACT

Introduction: An understanding of outdoor activity patterns of older adults may help in the development of more tailored physical activity programs for enhancing higher physical activity levels and more effective environmental interventions. This study aimed to identify patterns of outdoor activity of older adults, and to examine their relationships with physical activity levels and correlates of these patterns.

Methods: Based on data collected among 363 respondents aged 60 or older in Dalian, China, a two-step cluster analysis approach was adopted to identify outdoor activity patterns; one-way analysis of variance and chi-square tests were performed to examine differences in physical activity levels across activity patterns; and a multinomial logistic regression model was estimated to examine the socio-ecological correlates of each activity pattern.

Results: The study identified five distinct activity patterns, namely: 1) utilitarian activity pattern; 2) low frequency/short duration leisure-time physical activity pattern; 3) sedentary activity pattern; 4) long duration leisure-time physical activity pattern; and 5) high frequency leisure-time physical activity pattern. The type of activity pattern was associated with older adults' physical activity levels. Older adults' patterns of outdoor activity participation were associated with their age, gender, education level, physical ability and household type. In addition, neighborhood characteristics such as accessibility to local shops, safety from crime, social capital and social cohesion were also significantly associated with outdoor activity patterns.

Conclusions: The findings can help health professionals to develop tailored physical activity programs for older adults with certain socio-demographic characteristics and urban planners to design suitable environmental interventions supporting the habitual activity pattern of specific subgroups of older adults.

1. Introduction

Regular participation in physical activity is an important contributor to healthy aging. For example, it reduces the risk of coronary heart disease, stroke, diabetes, hypertension, depression and cognitive decline (Nelson et al., 2007; World Health Organization, 2010). Leisure-time physical activity can be a substantial source of physical activity in older adults (≥60 years), because they typically have more discretionary time to participate in leisure-time physical activity after retirement. Moreover, leisure-time physical activity is

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particularly beneficial because, apart from conferring physical health benefits (Arem et al., 2015; Sofi et al., 2008), it is more strongly related to mental health benefits and supports more social interaction than other physical activity domains (Sugiyama et al., 2008; Cerin et al., 2009). Thus, leisure-time physical activity has received considerably much attention in the literature.

Older adults can engage in weekly leisure-time physical activity in different ways. For example, one person might frequently participate in shorter durations of leisure-time physical activity, while another's leisure-time physical activity is done infrequently but for longer durations. In order to increase the long-term adherence to leisure-time physical activity, matching leisure-time physical activity prescriptions to older adults' habitual patterns is recommended, and therefore, insights into the patterns of leisure-time physical activity among older adults are needed. However, existing research has primarily focused on a summary score of leisure-time physical activity levels (e.g., Cerin et al., 2013; Huston et al., 2003; Lindström et al., 2001), ignoring the differences in patterns of leisure-time physical activity behavior of older adults.

In addition, older adults may participate in multiple domains/types of outdoor activity for different purposes in a week. For example, some older adults who have more household duties may often walk for utilitarian purposes (i.e., shopping) and as a leisure activity for fun, relaxation or exercise, while others who tend to participate in leisure-time walking for exercise may also often conduct sedentary activities such as playing cards or mahjong which is an important social activity for the older Chinese population (Li and Zhang, 2015). A systematic analysis of the diverse outdoor activities, and an identification of weekly outdoor activity participation patterns among older adults, may provide an improved understanding of the interplay among outdoor activities, in relation to older adults' overall outdoor physical activity levels. However, existing studies of leisure-time physical activity have primarily concentrated on these issues in isolation. For example, it remains unclear whether an infrequent, shorter duration of leisure-time physical activities is associated with high weekly levels of utilitarian physical activity. Further, the question of whether high levels of leisure-time physical activities and high levels of sedentary activities co-exist in a group of older adults remains unanswered.

Older adults' outdoor activity behavior can potentially be explained by social and ecological factors that may operate at multiple levels (Sallis and Owen, 2002). Existing research on older adults' overall leisure-time physical activity levels (e.g., Gao et al., 2015; Wilcox et al., 2000) has emphasized this social-ecological approach to understand whether differences in older adults' overall leisure-time physical activity levels can be attributed to differences in socio-demographic and neighborhood characteristics. Van Cauwenberg et al. (2018) systematically reviewed the research into the relationships between environmental attributes and leisure-time physical activity of older adults. They found that access to parks/open space, and aesthetically pleasing scenery were significantly associated with leisure time walking/physical activity of older adults. Socio-demographic characteristics such as gender, age, education, income and household structure have also been demonstrated associations with older adults' physical activity (Booth et al., 1997; Menai et al., 2015; Milanovic et al., 2013; Satariano et al., 2010; Weiss et al., 2007). Despite the considerable amount of research on older adults' physical activity levels, relatively few studies have examined the effects of socio-demographic and neighborhood characteristics on older adults' physical activity patterns. Some examples include Arnardottir et al. (2013), Mooney et al. (2015), and Steeves et al. (2019). Specifically, Arnardottir et al. (2013) examined gender differences in daily physical activity patterns of older adults in terms of the amount of activity during a 4-h period. They found that men were physically more active than women between 4 a.m.-8 a.m. and 8 a.m.-noon. Mooney et al. (2015) investigated patterns of types of physical activity among older adults and correlates of these patterns. They found that individual and neighborhood characteristics were associated with distinct physical activity patterns. Steeves et al. (2019) examined the differences in physical activity patterns of older adults in terms of the activity counts/minute and timing of activity within different physical functioning groups. They found that during the most active hour of the day (11:00 a.m.), the oldest, lowest physical functioning group was less active than the youngest, highest physical functioning group. However, the focus of these studies is not specifically on older adults' patterns of weekly outdoor activities which are considered to have a greater effect on physical and mental health than indoor physical activities (Thompson Coon et al., 2011).

Apart from the above methodological and substantive knowledge gaps, another limitation is that most studies were conducted in Western countries such as United States, Europe and Australia and studies in Asia countries, such as China, are scant. Different regions or countries tend to have different cultures and people from different cultural backgrounds tend to have different preferences for outdoor leisure activities. For instance, traditional Chinese leisure culture has heavily affected the attitudes and behaviors of the leisure activity of Chinese people (Feng, 2017). They have a higher preference for participation in playing mahjong/chess, Tai Chi, Qigong or line dancing, while Whites in the US are more likely to participate in physical exercise such as running, jogging or walking (Sasidharan et al., 2005; Liu et al., 2008). These differences in preferences toward leisure activities may in turn cause different demands for environmental supportiveness. Thus, findings on the relationships between neighborhood characteristics and physical activity in older adults based on data from Western countries may not be applicable to Asian countries such as China. Given these limitations, the purpose of this study is threefold: (a) to determine whether distinct patterns exist among Chinese older adults in their weekly outdoor activity participation, and (b) to explore how these patterns of outdoor activity participation are associated with older adults' overall outdoor physical activity levels, and (c) to examine associations of these patterns of outdoor activity participation with socio-demographic and neighborhood characteristics.

2. Methods

2.1. Study setting

We chose the Dalian urban area as our study area to examine the outdoor activity behaviors of older adults in the Chinese context. Located in one of the three largest coastal urban agglomerations with the most competitive economies in China, Dalian is a high-density, mixed-use city with a built-up area of 396 km^2 and a population of 3.05 million (Dalian Municipal Bureau of Statistics,

2016), which is different from many low-density cities in Western countries. The area of park green space and neighborhood green space were 30.4 km^2 and 20.4 km^2 respectively (Yang et al., 2017). In the three agglomerations, there are many cities with similar urbanization levels and urban (neighborhood) characteristics to Dalian (National Bureau of Statistics of China, 2010). Thus the research findings in Dalian might be typical and informative of the type of cities.

2.2. Participants and procedures

The data used for this study were collected in diverse neighborhoods in Dalian, China. The neighborhoods were purposively selected from three location categories, namely, the inner city, the fringe of the city and the area between the inner city and the fringe, in order to have substantial variation with respect to neighborhood environmental characteristics. Then, in each area, residents aged 60 or older were approached personally. Considering the fact that different older people may have different preferences for outdoor activity locations and the inclusion of such diverse older people is important to capture a representative sample, participants were recruited from different outdoor locations such as yards, streets, local squares, parks, etc. Those who are eligible and agreed to participate were asked to answer a series of questions about their weekly routine outdoor activity behavior, socio-demographic characteristics and perceptions of neighborhood environments.

Between August and September 2017, a total of 391 surveys were completed, out of which 28 were eliminated due to missing information, inaccurate records or implausible responses, etc. The final sample for analysis includes 363 individuals.

2.3. Instruments

To measure routine outdoor activity behavior, an interviewer-administered questionnaire involving 7-day recall was used. Fig. 1 displays in more detail how respondents' weekly activity-travel information was collected. Firstly, respondents were asked to think of their typical week as a continuous series of scenes or episodes in a film and select all the habitual outdoor activities that are conducted in a typical week. As habitual activities are routinely conducted with some degree of regularity, the recall data will not be severely biased. Secondly, they were promoted to provide detailed information on each activity episode: start time, origin, destination, travel mode, route names or bus number if travelling by bus, trip duration, and activity duration. Then, respondents were asked to indicate whether they always go back home after the activity. If yes, they need to provide the trip information: time, origin, destination, travel mode, route names or bus number if travelling by bus, trip duration; if no, provide the same relevant information on the subsequent activity they performed as the first activity episode and then provide the trip-back-home information until there is no additional activity during a single tour. Thirdly, the frequency of each home-based tour and the day(s) of the week when it is conducted were solicited. Considering the situation that respondents sometimes may conduct the same activity at a different destination or start at a different time, etc., the detailed activity-travel information on the same activity type under another spatial-temporal context is also needed to be specified.

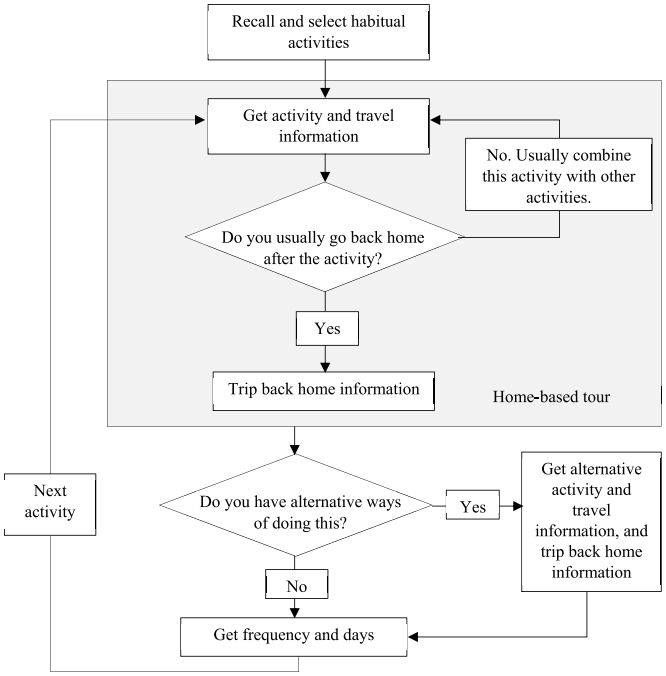

Fig. 1. Flowchart for collecting weekly outdoor activity-travel information.

Data on gender, age, education level, income level, household composition and physical ability were obtained using a socio-demographic questionnaire. To measure participants' physical limitations, they were asked to respond (not at all; a little; a moderate amount; very much; an extreme amount) to the following question: "To what extent has your physical capability hindered you from engaging in routine outdoor activities". A following questionnaire was used to ask participants to evaluate their local area by responding to questions concerning various environmental characteristics. The subscales employed in this study include the following: accessibility to local shops, footpath conditions, neighborhood aesthetics, traffic safety, crime safety, social capital and social cohesion. To measure accessibility to local shops, respondents were asked to report their perceived distance to their most known or frequently visited shopping place using the duration in minutes. Regarding footpath conditions, neighborhood aesthetics, traffic safety and crime safety, respondents were asked to indicate their degree of satisfaction with each one on a five point Likert scale. To measure social capital and social cohesion, the following questions were used: a) How many people in your neighborhood do you know well enough to talk with (five categories from very few to quite a lot); b) How do you rate the social relations with your neighbors (five categories from very poor to very good). In addition, distance to the nearest park was objectively measured using ArcGIS combined with Baidu Map, using network distances.

2.4. Data analysis

A cluster analysis approach was used to identify patterns of weekly outdoor activity behavior that may influence older adults' overall outdoor physical activity levels. Cluster analysis focuses primarily on the process of categorization (Norusis, 2010). By grouping older adults who have similar leisure-time physical activity participation patterns in terms of frequency and average episode duration and who participate in similar weekly amounts of utilitarian physical activity and sedentary activity, patterns of weekly outdoor activity participation can be identified.

In order to perform the analysis seeking to categorize the sample based on similar attributes, the specific outdoor activities that respondents reported were grouped into a total of 3 categories (Table 1).

Based on these considerations, the frequency of weekly leisure-time physical activity, the average episode duration of leisure-time physical activity, the weekly total amounts of utilitarian activity and sedentary activity related to 363 respondents were included in the cluster analysis. The weekly total amounts of utilitarian activity and sedentary activity were calculated by summing the durations of each type-specific activity episode. The average episode duration of leisure-time physical activity was obtained as the ratio of the weekly total amount of leisure-time physical activity to its frequency. Cluster analysis was then conducted using the two-step procedure in SPSS (SPSS Statistics v.23). The clustering algorithm is based on the log-likelihood distance (Gerhard et al., 1995). Although variables in the cluster analysis were measured on different scales, the algorithm will automatically standardize all these variables. The goodness-of-fit of the cluster solutions was measured using the silhouette measure of cohesion and separation, which is based on the average distances between -1 and +1 (Rousseeuw, 1987).

Following the cluster analysis, additional analyses were performed to examine the characteristics of the identified clusters. First, one-way analysis of variance and chi-square tests were conducted to explore differences in two measures of weekly outdoor physical activity levels across the identified groups. The weekly total outdoor physical activity levels were calculated by summing the levels of each physical activity episode which was calculated by multiplying intensity and duration. The intensity of all physical activities was not collected during the survey. Instead, each type-specific physical activity was assigned a MET value indicating its intensity, according to the 2011 compendium of physical activities (Ainsworth et al., 2011). Post-hoc tests were conducted to identify which particular differences between pairs of clusters are significant in terms of the mean of the weekly total outdoor physical activity levels. Second, a multinomial logistic regression model was estimated to examine the social-ecological correlates of each outdoor activity participation pattern (represented by each cluster).

3. Results

3.1. Sample characteristics

The basic sample characteristics are shown in Table 2. The results indicated that slightly more females than males participated in the study. They were almost equally distributed over the age categories from 60 to 80+ years of age. According to the most recent census (Droomers et al., 2001), the Dalian female older population was 50.3% and the age group 60–64 made up 34.4% of the older population of Dalian with 48.0% and 17.6% in the age group 65–79 and 80+ respectively. Thus, the sample is reasonably representative of the Dalian older population in terms of gender and age. About one third of the respondents had primary education or

Table 1
Older adults' weekly outdoor activity types.

Activity type	Description
Leisure-time physical activity	Leisure walking, Walking the dog, Dancing, Tai Chi, Qi Gong, Jogging, Playing balls, Using outdoor fitness equipment for stretching or physical exercise.
Utilitarian physical activity	Bringing grandchildren to school, Picking up grandchildren from school, Daily shopping, and Non-daily shopping.
Sedentary activity	Sitting and viewing or chatting, Playing cards/mahjong/chess, Staying in open spaces while watching grandchildren.

Table 2
Sample characteristics (N = 363).

Variable	Levels	N	%
Socio-demographics			
Gender	Male	173	47.7
	Female	190	52.3
Age	60–64 years	80	22.0
	65–69 years	73	20.1
	70–74 years	76	21.0
	75–79 years	60	16.5
	80+ years	74	20.4
Education level	Primary school or lower	119	32.8
	Middle school	106	29.2
	High school	72	19.8
	College/university	66	18.2
Income level	0 ≤ 2000 Chinese Yuan	88	24.2
	2001 ≤ 3000 Chinese Yuan	111	30.6
	3001 ≤ 4000 Chinese Yuan	62	17.1
	4000+ Chinese Yuan	102	27.1
Physical limitations	Yes	149	41.0
	No	214	59.0
Household type	With grandchildren ≤12 years	71	19.6
	No grandchildren ≤12 years	292	80.4
Environmental characteristics			
Accessibility to local shops	0–5 min	134	36.9
	6–10 min	133	36.6
	11–15 min	41	11.3
	Over 15 min	55	15.2
Distance to the nearest park	0–800 m	90	24.8
	800–1200 m	87	24.0
	1200–1600 m	77	21.2
	Over 1600 m	109	30.0
Footpath conditions	Not satisfied	55	15.1
	Satisfied	107	29.5
	Very satisfied	201	55.4
Neighborhood aesthetics	Not satisfied	191	52.6
	Satisfied	103	28.4
	Very satisfied	69	19.0
Traffic safety	Not satisfied	190	52.3
	Satisfied	123	33.9
	Very satisfied	50	13.8
Crime safety	Not satisfied	106	29.2
	Satisfied	181	49.9
	Very satisfied	76	20.9
Social capital	Some	214	59.0
	A lot	67	18.4
	Quite a lot	82	22.6
Social cohesion	Less good	95	26.2
	Good	130	35.8
	Very good	138	38.0

lower, and 41.0% of the respondents had physical limitations. Households with no grandchildren made up 80.4% of the sample. Regarding neighborhood environmental characteristics, the results showed that the majority of the respondents (73.5%) perceived accessibility to local shops as within 10 min. About 52% and 29% were not satisfied with traffic safety and crime safety respectively. Regarding social capital, the results showed that 22.6% of the sample stated that they had quite a lot of friends or neighbors in their neighborhood whom they know well enough to talk with. Thirty-eight percent of respondents rated their social relations with neighbors as very good.

3.2. Outdoor activity patterns

The first aim of the study was to explore whether distinct patterns of outdoor activity participation exist among older adults. The two-step cluster analysis produced five clusters. The average silhouette width provides an evaluation of clustering validity, which ranges from -1, when the clustering configuration has been arbitrary, to 1, when the clustering configuration is unequivocal. The silhouette score in the present study was 0.4, suggesting a fair cluster solution. Table 3 shows total frequency (trips/week) of participation in leisure-time physical activity, average time (minutes/trip) spent on the leisure-time physical activity, total time (minutes/week) spent on utilitarian activities (active travel) and total time (minutes/week) spent on sedentary activities by older adults belonging to each cluster.

Cluster 1 showed a *utilitarian activity pattern* and represented 12.4% of the sample. The cluster was characterized by medium

Table 3
Cluster profiles.

Variable	Cluster 1 *Utilitarian activity pattern* (12.4%)	Cluster 2 *Low frequency/short duration LTPA pattern* (25.9%)	Cluster 3 *Sedentary activity pattern* (10.5%)	Cluster 4 *Long duration LTPA pattern* (24.2%)	Cluster 5 *High frequency LTPA pattern* (27.0%)	Total
	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
Frequency of LTPA (trips/week)	**8.8**(5.0)	**6.4**(5.2)	**9.3**(5.2)	**9.2**(3.6)	**19.0**(5.8)	**11.1**(7.0)
Duration of LTPA (minutes/trip)	**50.1**(29.5)	**17.0**(13.8)	**40.4**(22.0)	**70.0**(22.8)	**45.5**(13.2)	**44.1** (27.1)
Amounts of utilitarian activities (minutes/week)	**455.3**(181.9)	**87.1**(86.7)	**68.8**(81.4)	**84.5**(66.2)	**81.0**(77.8)	**128.5** (156.5)
Amounts of sedentary activities (minutes/week)	**366.9**(417.0)	**612.1**(476.4)	**2159.1**(498.6)	**653.8**(470.5)	**464.8**(377.4)	**714.0** (671.4)

Note: LTPA = leisure-time physical activity.

frequency/medium duration of leisure-time physical activity, high amounts of total utilitarian activities and low amounts of total sedentary activities. This cluster had the highest amount of time spent on utilitarian activities relative to other clusters. Cluster 2 may be labelled *low frequency/short duration leisure-time physical activity pattern* and represented 25.9% of the sample. Cluster 2 was characterized by low frequency/short duration of leisure-time physical activity, moderate amounts of total utilitarian activities and moderate amounts of total sedentary activities. This cluster participated in leisure-time physical activity least frequently and had the shortest average time spent on leisure-time physical activity in a trip relative to other clusters. Cluster 3 represented 10.5% of the sample and may be labelled *sedentary activity pattern*. The cluster was characterized by medium frequency/medium duration of leisure-time physical activity, moderate amounts of total utilitarian activities and high amounts of total sedentary activities. This cluster has the highest amount of time spent on sedentary activities. Cluster 4 represented 24.2% of the sample and may be labelled *long duration leisure-time physical activity pattern*. The cluster was characterized by medium frequency/long duration of leisure-time physical activity, moderate amounts of total utilitarian activities and moderate amounts of total sedentary activities. This cluster had the longest average time spent on leisure-time physical activity on a trip. Cluster 5 represented 27.0% of the sample and may be labelled *high frequency leisure-time physical activity pattern*. The cluster was characterized by high frequency/medium duration of leisure-time physical activity, moderate amounts of total utilitarian activities and low amounts of total sedentary activities. This cluster participated in leisure-time physical activity most frequently relative to other clusters.

3.3. Outdoor activity patterns and physical activity levels

The second research aim involved examining the relationship between older adults' outdoor activity patterns and physical activity levels. Two measures of physical activity levels were significantly different across these five patterns (Table 4). Cluster 1 with a *utilitarian activity pattern* was the most active group, whereas Cluster 2 with a *low frequency/short duration leisure-time physical activity pattern* was the least active group. Cluster 3 with a *sedentary activity pattern* was the second least active group. The post-hoc tests confirmed that Cluster 3 was significantly higher than cluster 2 in terms of total physical activity levels, although individuals in cluster 3 spent the highest amount of time on sedentary activities. Cluster 4 with a *long duration leisure-time physical activity pattern* was the third most active group. Cluster 5 with a *high frequency leisure-time physical activity pattern* was the second most active group. The post-

Table 4
Difference in physical activity levels across clusters.

Variable	Cluster 1 *Utilitarian activity pattern*	Cluster 2 *Low frequency/short duration LTPA pattern*	Cluster 3 *Sedentary activity pattern*	Cluster 4 *Long duration LTPA pattern*	Cluster 5 *High frequency LTPA pattern*	Test results
TPAL ($MET \cdot min \cdot wk^{-1}$)	4568.0	1945.3[b]	2762.3	3574.5[c]	4292.0	$F = 48.8$ ($\rho < 0.001$)[a]
% with >mean of TPAL	71.1%	6.4%	26.3%	51.1%	62.2%	$\chi^2 = 87.7$ ($\rho < 0.001$)

Note.
Post-hoc test results.
[a] Here we used the Welch's p-value in SPSS instead of the regular ANOVA p-value due to heterogeneity of variances. LTPA = leisure-time physical activity; TPAL = total physical activity levels.
[b] Significantly lower than cluster 1, 4, and 5 at the 0.05 level and from cluster 3 at the 0.1 level.
[c] Significantly lower than cluster 1 and 5 at the 0.05 level.

hoc test results indicated that Cluster 4 was significantly lower than Cluster 5 in terms of total physical activity levels.

3.4. Social-ecological correlates of outdoor activity patterns

Based on a social-ecological framework (Sallis et al., 2008), we hypothesized that socio-demographic and neighborhood characteristics may be related to the differences in outdoor activity patterns. Using a multinomial logistic regression model, we compared the probability of a participant being classified into one of the four clusters with cluster 3 being the reference category, based on gender, age, education level, physical limitations, household structure, accessibility to local shops, and distance to the nearest park, footpath conditions, neighborhood aesthetics, traffic safety, crime safety, social capital and social cohesion (Table 5). Among the socio-demographic variables, income was not included in the model as it was strongly correlated with education. In addition, given that sample size guidelines for multinomial logistic regression indicate a minimum of 10 cases per independent variable and the sample contains a low percentage of people with low levels of satisfaction with neighborhood characteristics, all 5-point Likert scale items related to neighborhood characteristics were reduced into 3-category variables. The results indicated that individuals in the 80+ age group were significantly more likely to belong to Cluster 2 with a *low frequency/short duration leisure-time physical activity pattern* (the

Table 5
Correlates of outdoor activity participation patterns (n = 363).

Variable	Cluster 1 *Utilitarian activity pattern*	Cluster 2 *Low frequency/short duration LTPA pattern*	Cluster 4 *Long duration LTPA pattern*	Cluster 5 *High frequency LTPA pattern*
	Coefficient	Coefficient	Coefficient	Coefficient
Constant	1.27	-0.19	2.87*	1.20
Gender (Ref. Female)				
Male	-0.48	-0.72	-0.76	0.18
Age (Ref. 65–69)				
60–64	0.83	0.77	-0.05	-0.20
70–74	-0.11	0.78	-0.49	0.00
75–79	-0.09	0.42	-1.14	0.65
80+	-0.28	1.62*	-0.02	0.46
Education level (Ref. College/university)				
Primary school or lower	-2.76**	-0.85	-2.13**	-1.50*
Middle school	-1.28	0.59	-1.06	-0.90
High school	-1.11	0.44	-1.10	-0.33
Physical limitations (Ref. No)				
Yes	-1.32*	-0.01	-0.64	-0.61
Household type (Ref. No grandchildren ≤12 years)				
With grandchildren ≤12 years	3.53**	1.83*	1.06	1.15
Accessibility to local shops (Ref. Over 15 min)				
0–5 min	-1.38	-0.23	0.17	0.19
6–10 min	-1.92*	0.21	0.35	0.65
11–15 min	-0.74	0.56	1.05	0.05
Distance to the nearest park (Ref. Over 1600 m)				
0–800 m	0.19	0.25	0.30	-0.02
800–1200 m	-1.22	-0.06	0.01	-0.24
1200–1600 m	-0.60	0.30	0.19	-0.20
Footpath conditions (Ref. Satisfied)				
Not satisfied	0.38	-0.05	-1.23	-0.36
Very satisfied	0.71	0.22	-0.36	-0.79
Neighborhood aesthetics (Ref. Satisfied)				
Not satisfied	0.78	-0.15	0.41	-0.30
Very satisfied	-0.56	-0.67	-0.85	-0.50
Traffic safety (Ref. Satisfied)				
Not satisfied	-0.81	-0.15	-0.08	-0.37
Very satisfied	-0.07	-0.74	-0.57	0.00
Crime safety (Ref. Satisfied)				
Not satisfied	-0.87	-0.34	-0.43	0.23
Very satisfied	0.84	1.68*	1.25	1.95**
Social capital (Ref. A lot)				
Some	0.37	1.80**	0.58	1.18*
Quite a lot	-0.11	0.52	0.04	0.61
Social cohesion (Ref. Good)				
Fair	0.37	-0.85	-0.72	-0.33
Very good	-0.76	-0.84	-1.50*	-0.99
Goodness of fit statistics				
Pearson χ^2/Significance				1356.08/0.317
Cox and Snell R-squared/Nagelkerke R-squared/McFadden Rho-squared				0.443/0.464/0.190

Note: * Significance at the 0.05 level; ** significance at the 0.01 level; Cluster 3 serves as the reference category.

Table 6
Summary of findings.

Variable	Cluster 1 *Utilitarian activity pattern*	Cluster 2 *Low frequency/short duration LTPA pattern*	Cluster 3 *Sedentary activity pattern*	Cluster 4 *Long duration LTPA pattern*	Cluster 5 *High frequency LTPA pattern*
Frequency of LTPA	Medium	Low	Medium	Medium	High
Duration of LTPA	Medium	Short	Medium	Long	Medium
Amount of utilitarian activities	High	Low	Low	Low	Low
Amount of sedentary activities	Low	Moderate	High	Moderate	Low
TPAL	Most active	Least active	Second least active	Third most active	Second most active
Socio-demographic characteristics	Higher education level; No physical limitations; Greater proportion lives with grandchildren	Cluster members are more often older elders; Greater proportion lives with grandchildren	Ref.	Higher education level	Higher education level
Neighborhood characteristics	Cluster members live more often in neighborhoods with shops accessible but further away from their homes (i.e., over 15 min)	Cluster members feel in general safe being out in their neighborhood; Cluster members know, less than average, people in their neighborhood to talk with	Ref.	Cluster members live in neighborhoods with good social cohesion	Cluster members feel, more than average, safe being out in their neighborhood; Cluster members know some people well enough to talk with in their neighborhood

Note: LTPA = leisure-time physical activity; TPAL = total physical activity levels.

least active group). The effect of education level showed that older adults with primary education or lower were significantly less likely to have a *utilitarian activity pattern*, a *long duration leisure-time physical activity pattern* or a *high frequency leisure-time physical activity pattern*, which were the top three most active activity patterns. Older adults with physical limitations were significantly less likely to belong to Cluster 1 with a *utilitarian activity pattern* (the most active group). Having grandchildren in the household had a positive effect on the probability of belonging to cluster 1 with a *utilitarian activity pattern*. The positive effect also held for Cluster 2 with a *low frequency/short duration leisure-time physical activity pattern* (the least active group). This is likely to be explained by the fact that older adults who have a grandchild aged 6–12 years may often escort their grandchild to school by walking and thus have higher amounts of utilitarian physical activities, while those who have a grandchild aged 0–5 years may mainly look after their grandchildren at home and thus participate less in leisure-time and utilitarian physical activities. Future physical activity research should differentiate between older adults with grandchildren aged 0–5 years and those with grandchildren aged 6–12 years.

Regarding the effects of neighborhood characteristics on outdoor activity participation patterns, the results suggested that individuals who perceive accessibility to local shops as under 10 min were less likely to belong to Cluster 1 with a *utilitarian activity pattern*. No significant associations were found between distance to the nearest park, footpath conditions, neighborhood aesthetics, traffic safety and older adults' outdoor activity participation patterns. The effect of crime safety indicated that older adults who were very satisfied with crime safety were more likely to belong to Cluster 5 (*high frequency leisure-time physical activity pattern*). The effect of crime safety also held for Cluster 2 (*low frequency/short duration leisure-time physical activity pattern*) which was more likely to be made up of older adults aged 80+ years. This result may be explained by the fact that older elders are willing to go out for activities, when they perceived their neighborhoods as very safe, but more likely to prefer a less active activity pattern due to their increased functional limitations. Older adults with low social capital were also more likely to belong to Cluster 2 and 5. Older adults reporting a very high level of social cohesion were less likely to belong to Cluster 4 with a *long duration leisure-time physical activity pattern*.

4. Conclusions and discussion

This study evaluated the patterns of outdoor activity among older adults, and examined their relationship to outdoor physical activity levels and correlates of these outdoor activity patterns, based on data collected in Dalian, China, among 363 respondents aged 60 or older. Table 6 presents a summary of the findings.

The analyses of the relationship between older adults' outdoor activity patterns and outdoor physical activity levels indicated that the *utilitarian activity pattern* in Cluster 1 represented the most physically active pattern. Note that individuals in this group on average not only accumulated the highest levels of utilitarian activities (active travel), but also had a medium frequency/medium duration pattern of participation in leisure-time physical activity. It appears that higher levels of utilitarian activities (active travel) co-exist with relatively higher levels of leisure-time physical activity. In other words, an increase in utilitarian activities may not necessarily result in a substantial decrease in leisure-time physical activity. This finding is similar to some previous research which reported that changes in active travel were not accompanied by compensatory changes in leisure-time physical activity (Foley et al., 2015; Sahlqvist et al., 2013).

The *low frequency/short duration leisure-time physical activity pattern* in Cluster 2 represented the least physically active pattern. It seems that only a moderate amount of time spent on utilitarian activities could not make a substantial contribution to the accumulation of greater total physical activity. Relative to individuals in Cluster 2, individuals with the *utilitarian activity pattern* in Cluster 3 achieved significantly greater outdoor physical activity levels, although they spent more amounts of time on sedentary activities. This suggests that physically active and inactive behaviors may co-exist in older adults' outdoor activity routine. It is quite likely that the result is associated with the fact that many Chinese older adults have both the need to improve and maintain health through participation in moderate-to-vigorous leisure-time physical activity and the need for leisure or social contacts through participation in sedentary activities such as sitting and sightseeing, playing cards or mahjong, etc.

Compared to individuals with the *long duration leisure-time physical activity pattern* in Cluster 4, individuals with the *high frequency leisure-time physical activity pattern* in Cluster 5 accumulated significantly greater levels of outdoor physical activity. It appears that older adults are more likely to achieve greater total outdoor physical activity levels through participation in high frequency/medium duration of leisure-time physical activity than medium frequency/long duration of leisure-time physical activity, although in theory similar physical activity levels can be accrued through these two different patterns. These findings support the argument that only reviewing a summary score of physical activity level omits valuable information that can inform specific physical activity interventions (Lee et al., 2018).

In the multinomial logistic regression analysis, we found that individuals in the 80+ age group appeared to be more likely to belong to Cluster 2 with a *low frequency/short duration leisure-time physical activity pattern*. Some previous research has reported that physical activity levels were lower among older elders than younger elders (Milanovic et al., 2013; Yi et al., 2016). Our research provided insights into why older adults aged 80+ years are less physically active from the perspective of outdoor activity participation patterns. Older adults with primary education or lower were significantly less likely to have a *utilitarian activity pattern*, a *long duration leisure-time physical activity pattern* or a *high frequency leisure-time physical activity pattern*, which were the top three most active activity patterns. This is somewhat in line with previous studies indicating that lower educational levels were associated with lower levels of physical activity for older adults (Droomers et al., 2001; Janke et al., 2006; Weiss et al., 2007). Older adults with physical limitations had a lower probability of being in Cluster 1 with a *utilitarian activity pattern*. There is existing research showing that older adults who have physical limitations were less likely to achieve higher levels of physical activity (Chaudhury et al., 2016). However, such research cannot explain whether physical limitations result in lower physical activity levels through influencing leisure-time physical activity or utilitarian physical activity participation. Our finding highlights that physical limitations may mainly negatively relate to older adults'

participation in utilitarian physical activity and thus have relation to lower levels of physical activity.

With regard to neighborhood characteristics, we found that individuals who perceived accessibility to local shops as under 10 min were less likely to belong to Cluster 1 with a *utilitarian activity pattern*. This may imply that higher accessibility to local shops which is deemed to facilitate the frequency of walking to the shops (Cao et al., 2006) does not necessarily promote a higher amount of utilitarian activity, if the duration of walking for shopping per trip is shorter. The effect of crime safety indicated that older adults who felt very safe in their neighborhoods were more likely to belong to Cluster 5 with a *high frequency leisure-time physical activity pattern*. Similarly, other research has reported that higher crime safety was associated with more leisure-time physical activity (Cerin et al., 2013). Older adults with low social capital were also more likely to have a *low frequency/short duration leisure-time physical activity pattern* or a *high frequency leisure-time physical activity pattern*. The result suggested that there might be two possibilities for the associations between social capital and the patterns of activity participation. Specifically, given a low level of social capital which provides people with few companions with whom to do activities, some people may choose to decrease the frequency and duration of participation in leisure-time physical activity (i.e., *low frequency/short duration leisure-time physical activity pattern* in Cluster 2), while others may elect the *high frequency leisure-time physical activity pattern* (i.e., cluster 5) in which leisure-time physical activity is frequent and of relatively short duration. Although some studies found that social cohesion was associated with increased physical activity among older adults in Western countries (Annear et al., 2009; Fisher et al., 2004), we found that older adults reporting a very high level of social cohesion were less likely to belong to Cluster 4 with a *high frequency leisure-time physical activity pattern*. This may imply that good social cohesion is less likely to promote Chinese older adults to achieve higher levels of physical activity by increasing the duration of leisure-time physical activity. Chinese older adults may prefer a medium frequency/medium duration pattern of participation in leisure-time physical activity to achieve higher levels of physical activity, when they lived in neighborhoods with good social cohesion.

5. Implications

These findings have important implications for public health and urban policies aimed at creating physical activity-supportive environments for older adults. First, physical activity interventions in terms of duration and frequency of leisure-time physical activity and amounts of utilitarian activity for older adults may need to be customized by their socio-demographic characteristics. For example, regularly participating in short- or medium-duration leisure-time physical activity could be more attainable than performing higher amounts of utilitarian physical activities for older adults with physical limitations. Second, different types of environmental interventions should be developed and implemented so that they are optimally matched to the physical activity patterns of different groups of older adults. For example, interventions that strive to increase perceptions of crime safety would be more useful to support older adults with a college/university-level education to maintain their high frequency leisure-time physical activity patterns, while interventions aimed to improve neighborhood social cohesion should be targeted to support older adults with physical limitations to maintain their medium frequency/medium duration patterns of participation in leisure-time physical activity.

6. Limitations and future studies

This study had several limitations that should be noted. Firstly, the sample was purposely selected at various outdoor sites to guarantee that there is high enough variability in physical settings in which the activity occurs to have any meaningful association with the participants' physical activity patterns. This implies that the sample might be more active generally, as they are more likely to be spending time outside with a greater likelihood of being approached for the study, which potentially limits the generalizability of our results. However, we believe that although respondents were not approached at home, older adults who are physically inactive are not largely ignored in this study except those who are bed-bound. Inactive Chinese older adults usually still go out for activities, however, they mainly conduct sedentary activities around their residential buildings. Secondly, the traditional Chinese leisure culture that involves passive leisure activities in combination with the growing awareness of the importance of physical activity among Chinese may contribute to the co-existence of physically active and inactive activities in a group of Chinese older adults. Thus, the generalizability of our results to other cultures requires caution. Future research is needed to assess the generalizability of these findings and the validity of interpretations across diverse cultural settings. Thirdly, the measures of outdoor activity relied on self-reports which are often subject to recall bias. However, as we used a guided memory technique in which interviewees are encouraged to think of their typical week as a continuous series of episodes in a film and then to answer structured questions about each episode in chronologic order and this technique has been shown to be beneficial to provide a more accurate recall (Kahneman et al., 2004), we feel the recall bias is small. Finally, seven single items that we used to measure Chinese older adults' perceived neighborhood characteristics have not been validated. While not expected to be as valid as validated instruments (e.g., Neighborhood Environment Walkability Scale with 68 items), we believe these brief questions are desirable in order to reduce respondent burden and thereby increase response rates, especially in the case where we have had an extensive questionnaire on outdoor activity. In addition, the questionnaire on neighborhood characteristics still drew on validated instruments reported by Cerin et al. (2010) and SIP 4-99 Research Group (2002) and was finalized after a pilot survey, thus, we feel the validity threat is less. Future work is needed to develop and validate a brief questionnaire of perceived neighborhood characteristics related to outdoor activities appropriate for Chinese and other Asian older adults.

7. Conclusions

This study identified distinct outdoor activity patterns which were associated with older adults' socio-demographics and their

neighborhood characteristics. Unlike most other studies focusing on a summary score of physical activity levels, the present study provided insights into potential interactions between the frequency and duration of leisure-time physical activity, amounts of utilitarian activities and amounts of sedentary activities. The findings can help health professionals to develop tailored physical activity interventions and urban planners to determine which environmental factors should be prioritized to support outdoor activity patterns of specific subgroups of older adults.

Author contributions

ZL performed the data collection and analyses, and drafted the manuscript. AK and HT critically commented on the study design and revised the manuscript. All authors read and approved the final manuscript.

Declaration of competing interest

The authors declare no conflict of interest.

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