Research Paper

Research on the community living circle of the elderly in mountain city based on walkability

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Abstract

In the process of global aging, the precise configuration and diverse development of residents' daily living space face multiple challenges. The traditional Chinese residential planning is gradually transitioning to the community living circle planning. The community living circle is the basic carrier that carries the daily activities of the elderly, and it is also the spatial reflection of people-oriented needs, with multiple attributes such as time, location and space. With the "15-minute living circle" as the core, it is an effective way to develop high-quality urban space by demarcating the scope of community services and public facility allocation. Walking accessibility is the key to ensure the convenient and efficient use of community public services by residents, which directly affects the quality of urban community life. In mountain cities, the walking environment formed by special topographical conditions has a unique influence on the objective operation of the walking system and the subjective perception of elderly residents. And the space range of a 15-minute constant walking speed in the ideal environment cannot truly reflect the range that the aged can walk. Existing studies on community living circle are mostly aimed at plain cities and the general population, and lack of attention to the construction of living circles for the elderly in mountainous environments. This paper explores the role of the walking environment on the activity limitation and behavior guidance of the elderly from the two dimensions of walking accessibility and spatial preference. Taking the Yuzhong Peninsula of Chongqing as an example, it investigates 51 communities, uses ArcGIS to analyse the coverage of the community living circle of the elderly in a typical mountain environment. Meanwhile, observation and questionnaire are used to identify the spatial preference of elderly residents. Results show that: (1) the range of community living circle of the elderly is significantly smaller than that of young adults; (2) the slope gradient has a great impact on the walking range and travel willingness of elder people; (3) the aged are more willing to stay in semi-open space with gentle slopes. On this basis, the interactive relationship between walking accessibility and the construction of living circle is sorted out to provide construction strategies for the "scope delineation" and "layout operation" of community living circles in mountain city and promote optimization of walking environment for the elderly, which realize social equity.

Keywords

Community Living Circle, The Elderly, Mountain City, Walking Environment

1. Introduction

Population aging is a common problem faced by cities around the world, and it also brings new challenges to community planning. China is gradually moving towards an aging society. The elderly population has a large base and a rapid growth rate, which in turn has higher requirements for the quality of living space and facilities servicing for the elders (Xiong Jue, 2021). The community is the basic carrier of the daily activities of the aged people. With the promotion of the community-based home care model, the research on the daily activities of the elder around the community is attracted attention (Huang Jianzhong, 2019). However, the rigid planning standards relying on material and population indicators are unable to meet the needs of the elderly, and the emerging community living circle planning becomes a new trend for the research on the configuration of community facilities to solve these problems.

1.1. The rise and evolution of community living circle

The mode of community planning in China gradually transforms into living circle planning. With the development of society and the improvement of living standards, residents are no longer satisfied with the practical needs of the basic functions in residential areas, and begin to pursue non-material value experiences, such as comfort, social interaction, group culture, and community identity. The "residential district" model focuses on static planning and the index system and lacks the attention of residents' diverse living needs. Up to now, with the dismantling of the unit system and the advancement of the housing system reform, the traditional residential area planning is transitioned to the community living circle planning, realizing the transformation from “material-centered” to “people-centered”. According to the latest "Urban Residential District Planning and Design Standards" (GB20180-2018), the "living circle" concept is used to replace the "residential district, residential quarter and residential cluster" hierarchical model (Yu Yifan, 2019), emphasizing that different living circles meet different living needs. The more necessary and more commonly used facilities, the higher the convenience requirements, the smaller the service radius. From the perspective of humanism, scholars try to combine the theory of living circle with spatial planning, which focuses on people's behaviour, the daily needs of residents, and the living environment, so as to put forward different ways of dividing the living circle. In terms of urban residential planning research, the living circle can be divided into the "urban living circle" at the city level, the "basic living circle" at the residential level, and the "core living circle" centered on residents' families (Chen Qinghui & Xu Peiwei, 1987), and some researchers divide the city into basic living circle (20-minute living circle) and urban living circle (1-day living circle) (Xiong Wei, Xu Yilun, 2010); from the view of residents' daily life, “daily living circle” can be classified into three circles, namely the fundamental living circle (15-minute living circle), development living circle (1-day living circle) and the opportunity living circle (1-week living circle) (Yuan Jiadong, Sun Zhenjie, Zhang Na, 2010). In 2015, Chai proposed a community living circle (15-minute living circle) composed of the inner and adjacent areas of the community, a basic living circle (1-3 day living circle) consisting of several community living circles, a commuting living circle (1-day living circle) that includes employment places of residents and surrounding areas, an extended living circle (1-week living circle) contains metropolitan area and the suburban leisure area, and a collaborative living circle(1-month living circle) which covers connection area between the metropolitan region(Chai Yanwei, Zhang Xue, Sun Daosheng,2015). Among them, the concept of 15-minute community living circle is widely adopted and expanded. The "community living circle" is the most basic circle of the city's "daily living circle". As the basic space unit for constructing a comprehensive urban system, it should be regarded as an organic whole with multiple functions such as living, working and recreation. Specifically, the community living circle refers to the range of behaviours and spatial scope that carry out various home-centered activities for residents, including shopping, leisure, commuting, and social interaction in a day (Li Meng, 2015).

1.2. The community living circle from the perspective of walking behaviour and topography

Walking behaviour and spatial experience from a microscopic perspective are an important part of current community living circle planning. Walking is the most basic and important behaviour in living circles. Under the circumstance that urban design tends to be more refined, compared with the scope delineated by simple and abstract concentric circles, taking the walking behaviour as the standard to identify boundary of community living circle can microscopically take into account the traffic organization, spatial layout, functional combination and other factors, also pay more attention to the use status of pedestrians in different spaces. With regard to community living circle boundary measurement, many researchers combine various algorithms based on GPS data, including standard confidence ellipse calculation (Shen Yue & Chai Yanwei, 2013), Convex Hull method (Yin L, Lai Y, Epstein L, et al.,2013) to identify the spatial boundaries of residents' daily activities. Also, based on the residents' travel survey, a living circle structure of spatio-temporal density is established to measure the area of the community living circle (Sun Daosheng, et al.,2016). Such methods pay less attention to the differences in the coverage of community living circles caused by different terrains, ignore the differences in the scope of activities of different groups, and lack an understanding of spatial preferences for users.

Mountain environment has different planning requirements for community living circle compared with plain area, and has great influence on the travel range of the elderly. Residents' willingness to walk to be reduced with the increase of walking time and walking distance (Wu Jiansheng, et al.,2014). Steep terrain will decrease the scope of travel of residents, especially the elders. Some surveys focus on residents' activities range of different groups, including the range of children's activities around the community (Loebach J E, Gilliland J A,2016), the spatial relationship between concentrated and active area of young adults between the community (Yin L, Lai Y, Epstein L, et al., 2013) and the influencing factors of the elderly' behavioural preference for outdoor space (Lv Hongxiang& Peng Lin,2020), etc. However, few literatures discuss the coverage of community living circles in the mountain environment. Defining the impact range based on the actual walking distance at a specific time can more closely present actual urban space, especially the three -dimensional characteristics of mountain cities (Ma Ke,2016). Such differences between this irregular state of community living circle exist widely in cities with different topography, but it is currently overlooked.

It is noted that the application of community living circle concept in residents' walking space and facility layout is increasing in breadth and depth, basically focusing on residents ' behaviour patterns and boundary measures of community living circle in plain cities, but lacking attention to aged residents' walking environment and spatial preferences in mountain cities. While combined with terrain, road system and walking speed with model building in community living circle analysis is still rare. To fill the gap, a combined analytical framework is established based on the topographic data, road system and walking speed, which provides a novel perspective for in-depth understanding and interpreting the walking range and spatial preferences of elder residents. This is the first contribution of the paper. As for the second one, this paper conducts an empirical case study on the Chongqing City to identify the spatial boundary of aged residents' community living circles. One the one hand, this examination is useful for investigating the rationality of the proposed framework and model, on the other hand, the examined results are also helpful for assessing the implementations of community living circle planning and management in terms of bottom-up perspective.

The reminder of the paper is structured as follows. The section 2 is the methodological part, providing a detailed introduction on the new proposed analysing framework. The section 3 is the results part, which offers an empirical investigation of the proposed framework in the research area, while the section 4 mainly accounts for the conclusions and further discussions.

2. Methodology

2.1. Study area

The study sites are located in Yuzhong District, Chongqing City in China. Chongqing is the largest mountain city in China. The terrain is dominated by hills and mountains, of which 75.8% are mountains and 18.2% are hills. Its topographical conditions are complex, construction land resources are scarce, and road connectivity is weak. At the same time, Chongqing is also facing serious aging problems. The elderly population aged 65 and above is 5.7021 million (2021), and the population aging rate is 17.8% in this city (Chongqing Bureau of Statistics). Yuzhong District is the birthplace of Chongqing, and it is also the area with the highest urbanization rate (100%) and the highest population density (27,458 people/km2) in the central urban area. This district is located on a narrow and long shaped peninsula at the confluence of Jialing River and Yangtze River. With a large height difference (from 150 meters to 405 meters above sea level) and steep slope (more than 10% in most areas), Yuzhong District is divided into upper city and lower city. The upper city has a large number of new and modern high-rise buildings, while the lower half is filled with disorganized old and low-rise neighbourhoods that are in need of planning and management. It states that the Yuzhong District of Chongqing City is reliable and representative as a research object of community living circle from the perspective of the elderly in a mountainous environment.

2.2. Methods

To achieve the research purpose, this paper proposes a novel examining framework to analyse the walking range and spatial preference in the community living circle of aged people, and conducts an empirical test with the Yuzhong District (Figure 1) as the research object. Specifically, the entire framework can be divided into four parts, namely: (1) Identify the boundaries of the 15-minute community living circle for the elderly and young adults; (2) Define three evaluation indicators of the community living circle (Degree of road influence, Degree of terrain influence, Degree of walking speed influence); (3) Establish the measurement model of the community living circle coverage area based on walking speed and test 52 communities through ArcGIS; (4) Analyse the spatial preference of the elderly in community living circle area through the data obtained by the questionnaire survey. The 4 steps will be described in detail below.

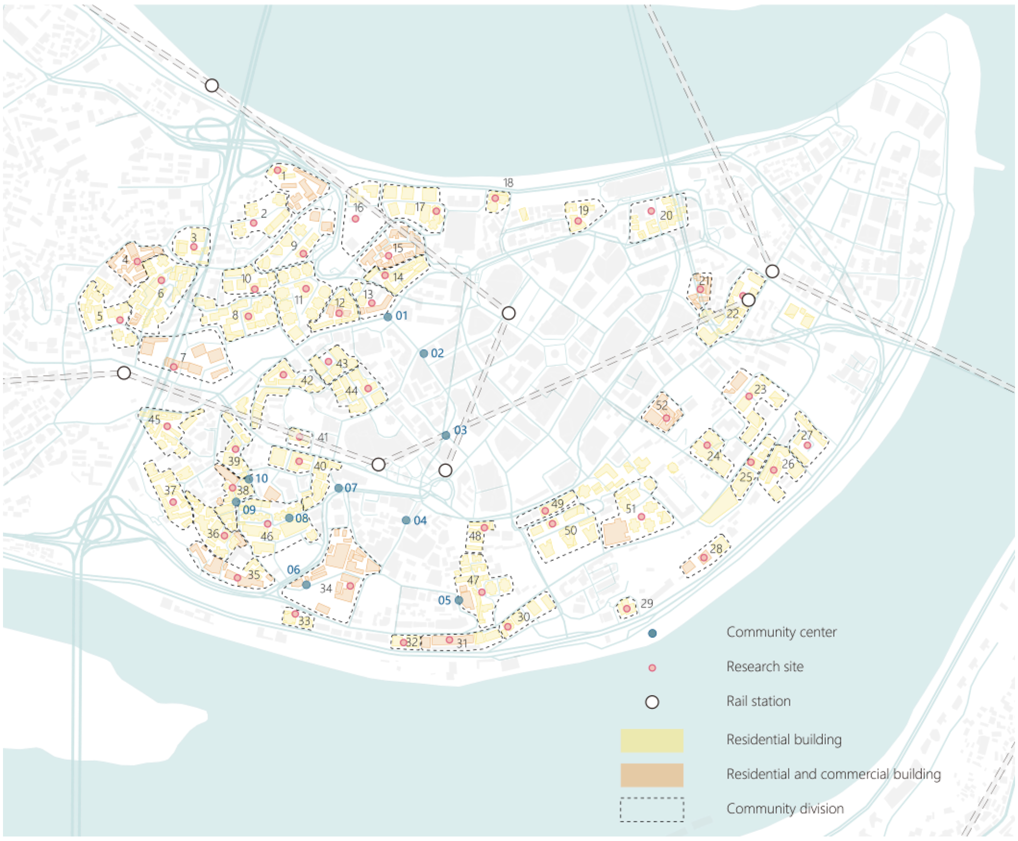

Figure 1. Communities in research site.

Source: Illustrated by the author.

2.2.1. Identify the community living circle

Walkability is one of the important criteria for evaluating a community living circle, emphasizing that residents can reach various facilities in the living circle within 15 minutes. The current planning method of the community living circle generally considers the walking speed of people as 1m/s, and the 15-minute community living circle is mostly regarded as a positive circular coverage area centered on the community with radiation radius of 900m. Planners will arrange living facilities in the ideal community living circle. But in fact, the walking range of pedestrians is also affected by the road system, terrain and the basic walking speed of the different people.

(1) Theoretical walking range

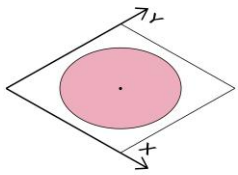

Figure 2. Theoretical walking range in ideal environment.

Source: Illustrated by the author.

As shown in Figure 2, in an ideal flat-land environment without any barrier, the theoretical reach of pedestrians in 15 minutes can form a circle with a radius of 900 meters (the average walking speed of people is 1 m/s).

（2）Walking range influenced by road

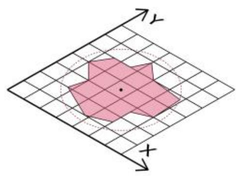

Figure 3. Walking range influenced by road in plain city.

Source: Illustrated by the author.

In the plain urban environment, people cannot reach the destination in a straight line due to the existence of buildings, roads and various facilities, so under the influence of these obstacles, the reachable range of people in 15 minutes will be reduced (Figure 3).

（3）Walking range influenced by topography

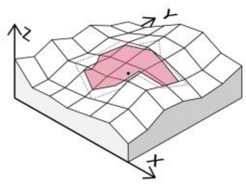

Figure 4. Walking range influenced by topography in mountain city.

Source: Illustrated by the author.

In the actual mountain city environment, the walking speed will change with the change of terrain, and the ups and downs of the terrain will further hinder people from reaching their destination, so the reachable walking range of people in 15 minutes will be further reduced (Figure 4).

（4）Walking range influenced by walking speed

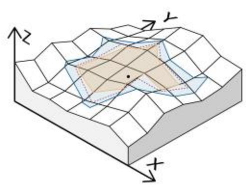

Figure 5. Walking range influenced by walking speed of different people in mountain city.

Source: Illustrated by the author.

Different groups of residents have different walking speed coefficients, and their walking speed is also affected by landform differently. So, the coverage of the community living circle of the elderly and young adults is different, and in general, the elders who walk more slowly have a smaller 15-minute range of activities than young adults (Figure 5).

2.2.2. Define the evaluation indicators

(1) Degree of road influence (DoR)

$$DoR = \frac{Walking\ range\ influenced\ by\ road}{Theoretical\ walking\ range} \quad (1)$$

The degree of road influence can show the impact of the road system on the coverage of the community living circle. The better the organization of the road network and the higher the density, the larger the walking range of residents and the greater DoR. Conversely, due to the influence of the road system, if the value of DoR is very small, the road system around the community should be reorganized.

(2) Degree of terrain influence (DoT)

$$DoT = \frac{Walking\ range\ influenced\ by\ topography}{Walking\ range\ influenced\ by\ road} \quad (2)$$

The degree of terrain influence can reflect the influence of the mountain terrain on the coverage of the community living circle. The gentler the terrain, the smaller the impact on walking speed, the greater the walking range of residents, and the higher the DoT. In contrast, the more severe the terrain change, the lower the DoT, which means that the terrain change has a greater degree of influence on the walking range, and the walkability is lower. As a result, community spaces with low DoT require more optimization for topography and connectivity facilities.

(3) Degree of walking speed (DoWS)

$$DoWS = \frac{Walking\ range\ of\ elders}{Walking\ range\ of\ young\ adults} \quad (3)$$

This indicator can reflect how the walking speed of different of affects the coverage of the community living circle. The higher the DoWS, the more consistent the walking range between the elderly and young adults. On the contrary, the lower the DoWS, indicating that the surrounding environment of the community has a greater obstacle to the travel of the elderly. Neighbourhoods with low DoWS require more facilities that take into account the needs of older adults.

Through these three indicators, we can gradually judge the reasons that influence the coverage of the community living circle, so as to propose improvement strategies and measures.

2.2.3. Construct the walking model

(1) Degree of road influence (DoR)

The first step is to establish a recognition model of community living circle based on the walking speed. The 15-minute walk range can be affected by the road system the terrain and people's walking speed which can also be influenced by the slope. So, the Formula (4) present the relationship between walking speed and uphill slope, and the Formula (5) shows that of downhill slope (Zhang Qiaojia, 2020).

$$\frac{1}{V_{uphill}} = a_{uphill} + b_{uphill} * i \ (i \geq 0) \quad (4)$$

$$\frac{1}{V_{downhill}} = a_{downhill} + b_{downhill} * i + c_{downhill} * i^2 \ (i \geq 0) \quad (5)$$

Among them, i is the gradient (calculated by the percentage method), V_{uphill} and $V_{downhill}$ represent the uphill walking speed and downhill walking speed, respectively, a_{uphill} is the basic uphill walking speed coefficient, b_{uphill} is a fixed coefficient, and b_{uphill} = 10s /m; similarly, $a_{downhill}$ represents the downhill basic walking speed coefficient, $b_{downhill}$ and $c_{downhill}$ represent fixed coefficients, $b_{downhill}$ = 0.09s/m, $c_{downhill}$ = 14.6s/m.

Since ArcGIS does not have the function which can recognize directionality of walking behaviour, the average speed of uphill and downhill is taken according to the Formula (6) to describe that the walking speed will change with the change of the gradient. The Formula (6) for the average speed is as follows:

$$V_{average\ speed} = 2 * \frac{V_{uphill} * V_{downhill}}{V_{uphill} + V_{downhill}} \quad (6)$$

Substitute Formula (4) and (5) into Formula (6) to obtain a general Formula (7) describing the relationship among walking speed, uphill and downhill:

$$V_{average\ walking\ speed} = 2 * \frac{(a_{uphill} + b_{uphill} * i) * (a_{downhill} + b_{downhill} * i + c_{downhill} * i^2)}{(a_{uphill} + b_{uphill} * i) + (a_{downhill} + b_{downhill} * i + c_{downhill} * i^2)} \quad (7)$$

Then substitute the walking speed coefficients of different groups into the above Formula (7) to get the specific Formula for different groups. The above Formula can be adjusted according to the walking speed of people in different regions to obtain a model that conforms to regional characteristics. The walking speed of the elderly is set to 0.9m/s, and the walking speed of young adults is set to 1.2m/s (Chu Dongzhu, Lin Yanyu, 2015). Based on Formula (7), the walking model of the elderly (8) and the walking model of young adults (9) can be formed. Through Formula (8) and Formula (9), the coverage of the community living circle of the elderly and young adults can be calculated by ArcGIS.

$$V_{average\ walking\ speed\ of\ the\ elderly} = 2 * \frac{\left(\frac{1}{0.9} + 10 * i\right) * \left(\frac{1}{0.9} + 0.09 * i + 14.6 * i^2\right)}{\left(\frac{1}{0.9} + 10 * i\right) + \left(\frac{1}{0.9} + 0.09 * i + 14.6 * i^2\right)} \quad (8)$$

$$V_{average\ walking\ speed\ of\ young\ adults} = 2 * \frac{\left(\frac{1}{1.2} + 10 * i\right) * \left(\frac{1}{1.2} + 0.09 * i + 14.6 * i^2\right)}{\left(\frac{1}{1.2} + 10 * i\right) + \left(\frac{1}{1.2} + 0.09 * i + 14.6 * i^2\right)} \quad (9)$$

2.2.4. Evaluate the spatial quality and spatial preference

The coverage of different community living circles has a lot of overlap, and the areas covered by high frequency can be regarded as hotspot sharing areas. This paper selects 10 typical shared areas in the site for further observation and analysis, interviews 63 elderly people who pass by or stay in the target area, and obtains the evaluation of the spatial quality and spatial preference of the relevant sites (Figure 1). In the measurement of physical environment, this paper selects 4 spatial elements for evaluation, namely light, landscape, facilities and cleanliness; in the measurement of spatial preference, the two indicators of staying intention and passing intention are used to evaluate the elderly's preference for the area. These six elements will be explained in detail below. Light elements include artificial light and natural light; landscape elements refer to the evaluation of vegetation arrangement; facility mainly refers to urban furniture and some other public facilities; cleanliness is used to describe the urban walking space which is clean or not; the stay intention and the pass intention can reflect the willingness to stay and frequency of the elderly passing through this area, respectively. The above elements are divided into 5 levels.

3. Results

3.1. Measurement of the boundary and coverage area of community living circle

In this paper, 52 communities in Yuzhong District are simulated and calculated, except for an outlier value (community 47), the effective data of 51 communities are obtained. The results are shown in Figure 6 and Table 1.

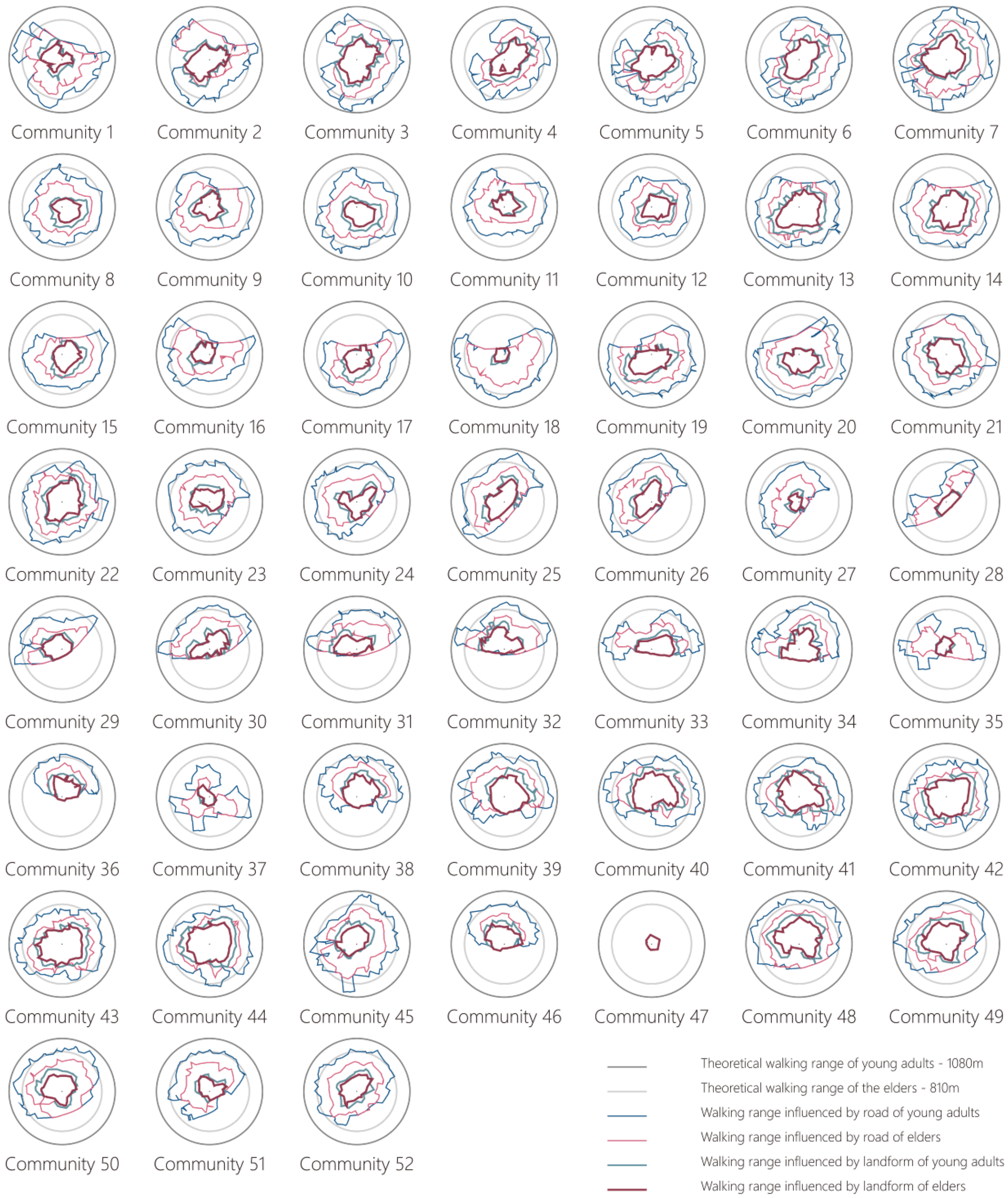

Figure 6. The coverage of community living circle affected by different elements.

Source: Illustrated by the author.

Community ID	Walking range influenced by road system		Walking range influenced by topography		Walking range influenced by walking speed	
	Young Adults(%)	Elders(%)	Young Adults(%)	Elders(%)	Road affecting part(%)	Terrain affecting part(%)
1	46.0	47.8	17.4	18.8	58.4	63.1
2	45.9	46.0	29.9	38.3	56.3	72.2
3	52.1	53.2	31.6	39.5	57.4	71.9
4	43.3	40.1	28.9	38.8	52.2	70.1
5	49.4	48.3	30.2	37.3	55.0	67.9
6	51.3	48.8	29.1	36.4	53.4	66.6
7	60.6	64.6	30.6	34.7	60.0	68.0
8	45.5	42.4	21.3	21.9	52.3	53.9
9	47.4	45.4	16.2	21.0	53.9	70.0
10	49.4	47.7	22.1	22.6	54.2	55.6
11	43.2	39.6	13.0	19.9	51.5	78.8
12	38.9	31.5	25.9	30.6	45.5	53.6
13	52.1	50.0	39.9	45.7	54.0	61.9
14	49.8	50.1	32.2	35.5	56.6	62.5
15	39.3	34.7	25.1	31.6	49.7	62.6
16	39.5	37.1	12.7	18.5	52.8	77.1
17	36.7	34.0	22.9	28.2	52.1	64.1
18	47.4	44.1	5.3	7.2	52.4	72.0
19	47.8	45.8	27.6	32.6	53.8	63.6
20	52.9	54.9	19.0	22.0	58.3	67.7
21	54.2	54.8	26.1	32.2	56.8	70.0
22	51.7	53.8	31.6	38.6	58.5	71.4
23	43.5	42.0	20.7	25.3	54.4	66.6
24	44.1	41.9	20.8	27.5	53.5	70.5
25	42.7	41.1	24.4	34.3	54.2	76.3
26	39.4	38.1	22.5	29.9	54.5	72.3
27	30.3	26.7	10.2	11.6	49.6	56.7
28	21.1	21.1	15.0	26.1	56.1	97.3
29	28.0	26.8	24.4	36.4	53.9	80.6
30	35.4	38.4	25.3	29.6	60.9	71.4
31	32.4	33.9	24.3	30.6	58.8	74.2
32	33.3	34.3	28.8	39.9	57.9	80.1
33	29.0	28.6	29.0	38.1	55.4	72.8
34	36.4	35.3	30.9	43.6	54.6	77.0
35	24.9	23.0	10.1	17.9	51.9	92.0
36	23.4	20.1	32.8	44.2	48.3	65.1
37	26.6	21.3	9.1	19.9	45.0	97.9
38	36.3	34.5	34.1	47.7	53.5	74.9
39	48.3	47.6	32.7	43.8	55.4	74.2
40	51.1	49.0	42.7	49.9	53.9	63.0
41	45.7	44.5	44.1	50.2	54.8	62.4
42	50.3	50.9	41.2	50.4	57.0	69.7
43	52.5	52.1	37.9	48.2	55.8	70.8
44	53.1	51.3	43.6	53.6	54.3	66.8
45	52.7	55.2	20.5	22.1	59.0	63.7
46	27.1	22.5	32.9	55.8	46.6	79.0
48	53.8	60.2	36.5	37.3	62.9	64.4
49	51.8	53.8	32.7	37.6	58.5	67.4
50	48.2	49.7	24.8	27.6	58.0	64.6
51	36.6	43.7	16.2	17.9	67.2	73.9
52	44.6	43.7	21.7	25.16	78.8	86.9
Mean	42.9	42.1	26.0	32.8	55.3	70.5
Std	9.49	10.72	9.20	11.24	5.25	9.38
Overall mean	42.5		29.4		none	

Table 1. The calculation results of DoR, DoT and DoWS.

Source: Illustrated by the author.

It can be seen from the data that the average value of the DoR of the communities in Yuzhong District is 42.5%, which is relatively low, indicating that due to the organization of the roads, the residents' community living circle activity range drops significantly. The mean value of the DoR of the elderly and young adults is 42.1% and 42.9%, respectively, showing that the impact of roads on different groups o is similar. The DoR of two groups in Community 28, Community 29, Community 35, Community 36, Community 37, and Community 46 are below 30%. In addition, for the elderly group, its DoR are also lower than 30% in Community 27 and Community 33. The road system of above communities needs to reorganized. In contrast, two groups' DoR of Community 7 is all higher than 60%, and the road organization around this community is in good condition.

The mean value of the degree of terrain influence in this district is very low, which is 29.4%, indicating that the mountain terrain has a very large influence on the walking range of residents, and the range of the walking-based 15-minute community living circle is drastically reduced. The DoT for the elderly and young adults is 32.8% and 21.7%, respectively, and the mountain environment makes the activity range of the young to shrink more than the elderly. The DoT of two types in Community 1, Community 11, Community 16, Community 18, Community 27, Community 35, Community 37, and Community 51 are all lower than 20%, stating that the landform of the above-mentioned communities has a huge impact on walking speed; the DoT of community 18 is even lower than 10%, where the terrain is steep and the vertical traffic system needs to be optimized. Correspondingly, the Dot of two groups in Community 40, Community 41, Community 42, and Community 44 are all greater than 40%, which shows that the terrain in this area has little impact on residents' travel.

The average DoWS of the road is 55.3%, and the DoWS of terrain is 70.5. The former is much lower than the latter, showing that in Yuzhong District, road organization and terrain have different effects on the range of activities of the elderly and young adults, and the terrain elements have greater impact on young adults' walking range. In terms of road system, the dispersion of DoWS data is small. The DoWS of Community 12, Community 15, Community 27, Community 36, Community 37, Community 46 is less than 50%, while the DoWS of Community 7, Community 30, Community 48, Community 51, Community 52 is greater than 60%. For the former group of communities, the road system has a greater influence on the walking range of the elderly, while the latter group has less impact. In the aspect of terrain, the DoT of Community 8, Community 10, Community 12, Community 27 is less than 50%, which means that the terrain in this area has a far greater influence on the elderly than on the young adults, and more facilities for the aged people are needed. By contrast, the degree of walking speed of Community 28, Community 29, Community 32, Community 35, Community 52 is greater than 80%, indicating that the walking range of young adults and older adults is relatively consistent, and the impact of terrain on these two groups is equal. Besides, the DoWS affected by road of Community 28, Community 35 and Community 37 is all around 50%, while that affected by terrain is more than 90%, showing that mountain terrain has a significant influence on the elderly and young adults, drastically reducing the walking range of two groups, while the impact on young group is greater.

3.2. Evaluation of spatial quality and spatial preference of community living circle

By sorting out the questionnaires of 63 elderly people, the elderly's evaluation and spatial preference of 10 survey sites show different characteristics (Figure 7).

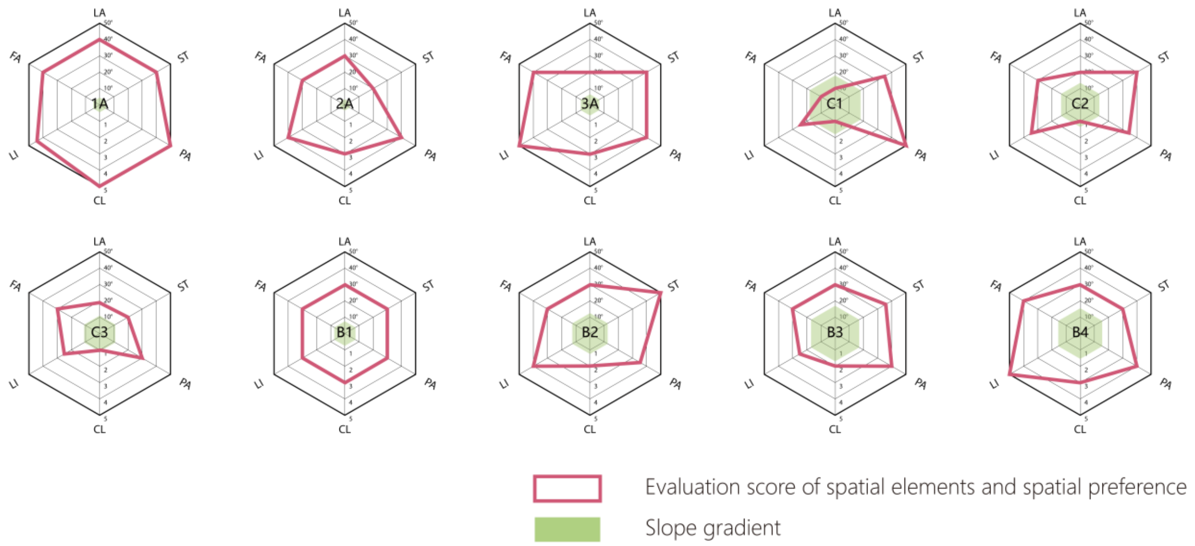

Figure 7. The evaluation score and slope of 10 research sites.

Source: Illustrated by the author.

In terms of physical environment, the elderly gives high evaluations to Site 1, Site 2, and Site 3, and their average scores are all greater than 3, while the evaluation of Site 4 and Site 6 is low. With regard to slope, the slopes of Site 1, Site 2, and Site 3 are lower than 8°, which is relatively gentle, while the slopes of Site 4, Site 9, and Site 10 are more than 15 °, which is not conducive to travel.

With respect to spatial preference, the elderly have high passing intentions for all sites, and their pass scores are all greater than 3, which is in line with the characteristics that these shared areas are covered by a lot of community living circles. Regarding the intention to pass, the elders are most inclined to pass Site 1, Site 2, Site 3, Site 4, Site 9, and Site 10. Among them, Site 1, Site 2, and Site 3 are located on the main road of this district, which have high overall evaluation, gentler slope and the highest willingness of elders to pass. Furthermore, Site 4, Site 9, and Site 10 have lower environmental evaluations and steeper slopes, but there are tourist attractions and schools. Under the influence of site functions, the elderly will also choose to pass through these sites. It shows that the location, terrain slope and function have an obvious impact on the space that the elderly choose to pass. Regarding the intention to stay, the elderly tend to stay at Site 1, Site 3, Site 5, and Site 8. Among them, Sites 1 and Site 3 are situated in the square space next to the main road. The terrain is relatively flat and the spatial equality is better, which is suitable for the leisure and recreation of the elderly. Although Site 5 and Site 8 have steep slopes, they are the talent market and community activity centre respectively, so there are also a large number of elderly people who are willing to stay in this area. It indicates that the elderly is willing to stay in the space with high spatial quality, flat terrain and open space. At the same time, the spaces with function also attract the elderly to stay.

4. Conclusion and discussion

Under the premise of clarifying the transformation of urban residential area planning, relevant research should focus more on the interaction between community space and residents' activities. However, the matching of residential area planning and residents' needs in China's mountainous cities is not optimistic. Residential planning based on macroscopic pattern is currently difficult to meet people's diverse living needs, while emerging community living circle tend to refine urban design, pay attention to people's walking experience, and have a significant impetus to achieve precise allocation of public resources and optimize urban spatial structure effect. On this basis, keeping an eye on the walking activities of the elderly is conducive to promoting the spatial optimization of community living circles in mountain cities and realizing spatial justice and social equity.

Based on the data panel of road system, topography and population attributes in Yuzhong District, Chongqing, this paper redefines the influence scope of community living circle, introduces indicators such as degree of road influence, degree of terrain influence and degree of walking speed influence, constructs a walkability assessment model, which is used to evaluate community living circles of 51 communities in Yuzhong District. The results show that:

(1) The range of community living circle of the elderly is significantly smaller than that of young adults. The elders' basic walking coefficient is lower than young adults' data, so that their activity ranges will naturally be smaller than that of young people. However, in the measurement of the range of 51 community living circles, it is found that road organization has an equal impact on the walking ranges of elderly and young adults, while the impact of topography on the elderly is greater than that of the young and middle-aged.

(2) The terrain slope has a great effect on the walking range and walking willingness of the elderly. In areas with steeper road gradients, the walking range of the elderly shrinks sharply. And through a questionnaire survey, it is found that the aged people are not willing to pass through steep slopes or stair spaces.

(3) The elders are more willing to stay in semi-open spaces with gentle slopes. Spatial preference analysis shows that older people prefer spaces which are flat, whether passing or staying. When the space is accompanied by function and high-quality urban design, it will attract the elderly to stay.

Overall, inefficient road systems and complex mountainous terrain will reduce the walking range of the elderly, making travel more inconvenient. The higher the road density, the gentler the slope, the higher the quality of the walking environment, and the more diverse ways of passing, the more beneficial to improve the community living circle coverage of the elderly and improving their spatial experience. Based on above analysis, this paper divides the problems into three categories according to the empirical results and the current situation of Chongqing, and proposes the following measures:

For road problems: (1) Increase the density of the road network to make the path for the elders to the destination shorter and reduce the walking time. (2) Open and link dead ends. Improve the efficiency of road traffic by reorganizing existing inefficient roads. (3) Add community entrances and exits appropriately. Reasonable placement of entrances and exits in gated communities can improve the connectivity of roads inside and outside the community, provide more routing options, and reduce detour times within the community.

For terrain problems: (1) Optimize the vertical traffic system. When there is a large height difference between the surrounding space and the community, the installation of vertical public elevators can significantly reduce the walking time. At the same time, converting existing private elevators into semi-public elevators can use resources more efficiently and increase connectivity between the upper and lower halves of the city. (2) Set up overpasses or corridors. Skybridges and corridors connect buildings to other platforms of varying heights, providing more traversable paths and improving accessibility to the site. (3) Set up underground passages. Underground passages help older residents avoid obstacles and directly reach the surrounding destination space.

For crowd problems: (1) Establish more leisure platforms and create specific gentle slope paths to improve the spatial experience and travel willingness of the elderly on foot. (2) Add leisure facilities and urban furniture to facilitate the elderly to take a rest during walking.

5. References

Xiong, Y. (2017). Research on spatial organization of community life circle based on spatiotemporal behaviour of the elderly--Taking Nanyuanmen Street of Xi'an city as an example. Xi'an: Xi'an University of Science and Technology.

Yu, Y. (2019) "From traditional residential area planning to community living circle planning," Urban Planning, 43(05), pp. 17–22. Available at: DOI:10.11819/cpr20190504a.

Chen, Q. and Xu, P. (1987) "Preliminary study on evaluation method of urban living environment quality," Urban Planning, (05), pp. 52–58.

Xiong, W. and Xu, Y. (2010) "Research on Urban Settlement Environment from the perspective of Public Facilities--A case study of Nanjing City," Urban Planning, 25(12), pp.35–42. Available at: DOI: 10.3969/j.issn.1009-6000.2010.12.006.

Yuan, J. et al. (2005) "The reconstruction of the urban regional system in China based on Daily Living Circle," Urban Planning, 25(1), pp.17–22. Available at: DOI: 10.3969/j.issn.1000-0690.2005.01.003.

Chai, Y. et al. (2015) "Research on the Planning of Urban Life Circle based on Time-space behavior: A case study of Beijing," Urban Planning Forum, (03), pp.61–69. Available at: DOI: 10.16361/j.upf.201503008.

Li, M. (2015) “Research on the planning strategy of 15-minute Community Life Circle based on the characteristics of residents' behavioral needs,” Urban Planning Forum, (01), pp. 111–118. Available at: DOI: 10.3969/j.issn.1006-3862.2017.09.002.

Shen, Y. and Chai, Y. (2013) “Daily activity space of suburban mega-community residents in Beijing based on GPS data,” Acta Geographica Sinica, 68(4), pp. 506–516. Available at: DOI:10.11821/xb201304006.

Sun, D. et al. (2016) “Definition and measurement of community life circle——a case study of Beijing Qinghe district,” Urban Development Studies, 23(9), pp. 1-9. Available at: DOI: 10.3969/j.issn.1006-3862.2017.09.002.

Wu, J. et al. (2014) “Evaluation of the rationality of urban daily living facilities allocation based on walking index: A case study of Futian District, Shenzhen,” Urban Development Studies, 21(10), pp. 49–56. Available at: DOI: 10.3969/j.issn.1006-3862.2014.10.008.

Loebach, J.E. and Gilliland, J.A. (2014) “Free range kids? using GPS-derived activity spaces to examine children’s neighborhood activity and mobility,” Environment and Behavior, 48(3), pp. 421–453. Available at: https://doi.org/10.1177/0013916514543177.

Yin, L. et al. (2013) “Neighbourhood for playing: Using GPS, GIS and accelerometery to delineate areas within which youth are physically active,” Urban Studies, 50(14), pp. 2922–2939. Available at: https://doi.org/10.1177/0042098013482510.

Xiong, Y. (2016). Analysis of disuse behavior in influence domain of rail transit stations and Research on Refined urban design strategy. Chongqing: Chongqing University.

Chu, D. and Lin, Y. (2015) “Characteristics, models and Methods: A Preliminary study on Microsimulation of pedestrians in the influence area of urban rail transit stations,” Architectural Journal, (03), pp.24–29. Available at: DOI: 10.3969/j.issn.0529-1399.2015.03.006.

Zhang, Q. (2020) “The Spatial Coupling of Station Influencing Realm and Community Living Circle,” Journal of Chongqing University of Technology (Natural Science), 34(10), pp. 202–210. Available at: DOI: 10.3969/j.issn.1674-8425(z).2020.10.027.