Evaluation and Planning Strategy of Walkability in Harbin Residential Area

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Abstract: The concept of walkability is introduced. A total of 12 public service facilities were selected for the evaluation, including a food market, a fruit shop, a bus station, a department store, a small and medium supermarket, a restaurant, an entertainment facility, a child care school, a barber shop, a park green space, a Chinese and western drug store, and a bank post office. The walkability index model and ArcGIS software were used to evaluate and visualize the walkability of the residential areas, and the evaluation results were analyzed. Based on this, the walkability planning strategies for residential areas are described at the macro, meso and micro levels. It mainly includes implementing low-carbon concepts, encouraging mixed functions, optimizing road network structure, improving pedestrian traffic, strengthening interface design, optimizing plant community layout, creating diverse composite spaces, and inclusive designs. The walkability planning strategy provides a theoretical reference for improving walkability in residential areas.

1. Introduction
At the same time, affected by climate, social and economic factors, the pedestrian environment in the residential area is monotonous and unattractive, which is not conducive to the improvement of living quality and vitality in the residential area, which seriously restricts the sustainable and healthy development of the city. With the advancement of low-carbon city construction, walkability has gradually attracted attention in urban development [1], and walkability has become one of the important indicators to measure the walking environment and facilities. Therefore, the evaluation of the walkability of residential areas and the study of planning strategies have important practical significance.

2. Walkability evaluation of residential areas

2.1. The concept of walkability
Walkability originated from the concept of sustainable urban design. Due to the close relationship with the quality and vitality of the pedestrian space such as cities and streets, it was generally summarized by urban research scholars as “the friendship degree of the city or street environment to walking, and the experience of the walker in the environment” [2]. After a lot of practical research, it was further summarized as "the extent to which a built environment and land use in a region is beneficial to residents and tourists in the region by walk to relax, exercise, obtain commercial and public services, and commute" [3].
For urban residential areas, walkability is the ability to describe the layout of public service facilities around urban settlements to guide residents to walk, specifically the safety, the convenience and the comfort of walking activities such as commuting, shopping, dining, recreation, etc. within 1Km of the surrounding area. As a starting and ending point for walking, public service facilities are closely related to residents' lives. Therefore, the study of the pedestrianization of urban settlements based on public service facilities is of great significance for optimizing the layout of residential facilities and improving the convenience of residents' walking trip.

2.2. Evaluation index selection and evaluation model construction

2.2.1. Selection of evaluation indicators. Due to the difference of spatial attributes, in the application process, the corresponding walking evaluation factors should be selected according to the objective scale of the description subject to verify the convenience and comfort of residents in daily life. Specifically, the impact factor of walkability mainly includes three aspects. The first is the walking environment, which covers the types and layout of landscape greening, the design techniques and forms of the spatial interface, and the spatial quality of the street. The second is the degree of mixed land use, in other words, the diversity of land mix functions, the intensity of road networks, and the integrity of supporting public service facilities. The third is the state of road traffic operation, which refers to the motor vehicle flow rate and vehicle speed, the traffic light phase difference, and the road section form.

Public service facilities have become one of the important indicators for the quantitative evaluation of walkability in North America in 2007 due to their objective and small changes. Public service facilities, as a destination to guide residents to travel, have a reasonable layout that directly affects the way residents travel, the type of activities, and travel time. Therefore, based on the living habits of residents, the selection principle of evaluation indicators is that the frequency of use is high, the distance is close, and the facilities are rich. In-depth investigation of the use of public service facilities around the three residential areas of Harbin Zhengdalongsheng, Hongqi and Hebai. A total of 12 kinds of public service facilities including vegetable market, fruit shop, bus station, department store, small and medium-sized supermarket, restaurant, entertainment facilities, child care primary school, barber shop, park green space, pharmacy, and bank post office were selected as evaluation indicators.

2.2.2. Evaluation model construction. At present, the effectiveness of walking index test walkability has been confirmed by scholars such as Dustin T. Duncan [4]. The walking index has become one of the internationally important quantitative standards for evaluating walkability, and it is mainly calculated based on the type and spatial layout of public service facilities. It is divided into five grades, in which the higher the walking index, the better the accessibility of the walking system, the better the surrounding facilities, the more residents rely on walking in daily life; on the contrary, the walking system is not perfect, the surrounding facilities are short, and the residents are more inclined to travel in small cars in their daily lives. See Table 1 for details.

| Walking index | Description |
|---------------|-------------|
| 90~100        | Walker Paradise: Daily travel can be solved by walking |
| 70~89         | Great for walking: most daily trips can be reached on foot |
| 50~69         | Walking is normal: some facilities are within walking distance |
| 25~49         | Poor walking: less facilities within walking distance |
| 0~24          | Relying on cars: almost all travel depends on cars |

Table 1. The evaluation form of walkscore.

In the evaluation process, the demand level (Ri) of various public service facilities in the settlement
should be calculated according to the frequency of use of the facility, the distance attenuation coefficient and the diversity of use. Secondly, the walking index (Wi) of various public service facilities is calculated. Finally, the weighted average of the walking index of 12 public service facilities is calculated, and the average value is the walking index (Ws) of the residential area.

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W_s = \sum_{i=1}^{12} R W_i 
\]

Ri -- The satisfaction of the demand for public service facilities.

i -- The type of public service facility.

Wi -- The walking index of a single public service facility.

2.3. Walkability evaluation

2.3.1. Frequency of use of public service facilities. Through the collation of survey data, the frequency of use of 12 types of public service facilities such as fruit shops, vegetable markets and bus stations in three settlements was obtained. Referring to the standard of public service facilities [5], according to the actual number of use of public service facilities and the degree of importance, divides the facilities that use 1.5 times or more, 0.5~1.5 times, and 0.5 times or less a week into high frequency service facilities, intermediate frequency service facilities and low frequency service facilities.

2.3.2. Attenuation law of public service facilities. Refer to the walking tolerance time division standard [6], according to the walking characteristics of the selected indicators, sets 0-5min, 5-10min, 10-15min, 15-20min, 20-25min, 25-30min, 30-45min, 45-60min for a total of 8 time periods, and count the residents' tolerance time to walk to different facilities according to their daily life experience. According to the walking speed of 1m/s, the walking tolerance period of the above various facilities is converted into walking distance, and the distance attenuation coefficient is determined according to the ratio of the number of people corresponding to the facility tolerance time to the total number of samples. Because the closer the general distance is, the higher the willingness of residents to travel, the distance attenuation coefficient of walking distance not exceeding 300m is set to 1. But as the travel distance increases, the attenuation coefficient will gradually decrease, even 0.

2.3.3. Diversity of use of public service facilities. Numbered from near to far according to the distance of the facility, let the residents of the three settlements select the demand quantity of each public service facility from 1 to 10. And by calculating the proportion of the number of people corresponding to the demand for each facility to the total number of people, the ratio of the demand for various facilities is obtained. In general, when residents choose a daily service facility that is far away, it means that they can accept nearer facilities. According to this situation, when the sum of the ratios of the near and far facilities is more than 90%, the corresponding number is the number of residents who can meet the needs of more than 90% of the facilities, that is, the value of diversity.

2.3.4. Calculate the residential pedestrian index. Calculate the ratio of the frequency of use of each facility to the sum of the frequency of use of 12 facilities, and obtain the demand for public service facilities that meet the daily life of residents. Combined with the determined distance attenuation coefficient of various public service facilities, the distribution of satisfaction values of various public service facilities is calculated within the range of the diversity of the 12 public service facilities.

Based on the layout of public service facilities in three settlements (as shown in figure 1), using ArcGIS to analyze the walkability of three settlements. First, use the Multiple Ring Buffer tool to create multi-ring buffers of various facilities with radii of 300m, 600m, 900m, 1200m, 1500m, 1800m, 2400m, and 3600m. And use the Polygon to Raster tool to convert the completed public service buffer map into a raster map. Then, with reference to Table 1, each walking distance is assigned, in which 300m is given 100 points, 600m is given 90 points, 900m is given 80 points, 1200m is given 70 points, 1500m is given 60 points, 1800m is given 50 points, 2400m is given 20 points and 3600m is given 0 points.
point. The public service facility raster map is reclassified to obtain a facility walk index map. Finally, Map Alglar is used to multiply the walking index maps of various facilities by their respective demand levels to obtain the walkability evaluation map of each residential area, as shown in figure 2.

![Figure 1. Distribution map of public service facilities in residential areas](image1)

![Figure 2. Walkability evaluation map of residential areas](image2)

### 2.4. Analysis of evaluation results

According to calculations, the walking indexes of Zhengdalongsheng, Hongqi and Hebai were 86.3 points, 76.5 points and 69.2 points respectively. The statistics show that the ages of the residents in the three settlements are similar, indicating that the daily needs of residents are roughly the same in a certain sense. Taking the public service facilities as a variable, the layout of the facilities in each residential area and the walking index were analyzed.

#### 2.4.1. The walkability of open residential areas is higher than the walkability of closed residential areas.

Compared with closed residential areas, open residential areas emphasize connectivity and sharing within and outside the residential area. Comparing the types and quantity of public service facilities around the three different modes of residential area, the public service facilities around the open Zhengdalongsheng are significantly improved compared with the semi-open Hongqi and the closed Heibai. Not only are the types rich and numerous, but they are also arranged centrally along the street network and spread out in a balanced manner. By shortening the daily travel distance, communication between the residential area and the surrounding area is greatly enhanced. Moreover, the walking index of Zhengdalongsheng is higher than the walking index of Hongqi and Hebai.

#### 2.4.2. Residential areas with dense street network have high walkability.

Most of the streets around Zhengdalongsheng are mainly living roads. The streets are narrow and dense, and the branches are
connected to each other. It is a pedestrian network system with high accessibility. Especially in the old street area of Daowai, the small grid type road network structure can increase the commercial frontage of the street, shorten the walking distance and have higher walkability. The overall road network of Hongqi is dense, but it is blocked by large sports fields and national power plants, resulting in large local street scales, increased walking distance and reduced walkability. The proportion of motorized traffic roads around Hebai is relatively heavy, the road network density is small, and the traffic volume is large, which is not suitable for walking. It can be seen that the residential areas with dense street roads are generally more walkable.

2.4.3. Walkability is positively correlated with the degree of perfection of public service facilities. As a destination to guide residents' travel, the type and distribution of public service facilities are the main factors determining the way residents travel. Comparing the layout and walkability of public service facilities around the three residential areas, the public service facilities around Zhengda Longsheng are of various types and sufficient quantities, and are evenly arranged within the walking tolerance time, which can meet the daily needs of residents to a large extent. In turn, attract residents to walk. In contrast, Hongqi and Hebai have fewer public service facilities during the pedestrian tolerance period, and the distribution is uneven, and the ability to guide walking is weak.

3. Planning strategy for pedestrian walking in residential areas

3.1. Strengthening land use diversity and encouraging functional mix
At present, the one-sided functional zoning plan has made residents have to rely on cars for travel, causing urban problems such as traffic congestion and waste of land resources. The diversity of land use is conducive to the establishment of a walkable system [6]. Therefore, on the one hand, China must be promoted to implement "multi-planning united", strengthen powers and responsibilities, and implement it efficiently. On the other hand, the top-level design of the city should be implemented. Starting from the overall urban planning, the small modules divide the land in multiple layers, increase the diversity of land use, and blur the functional division. The intensity of land development is coordinated with the surrounding traffic carrying capacity.

3.2. Promote open block and optimize road network structure
Jane Jacobs believes that the more vibrant the city blocks, the more energetic the city is [7]. At present, most residential areas have a single function, a large area, and a sparse road network, resulting in a uniformity and lack of vitality in the settlements, which restricts the activities of residents in urban residential areas. Therefore, it is urgent for residential areas to create a narrow and dense road network structure, to clarify road grades, and to form an orderly development and level-coordinated street network [8]. At the same time, the accessibility, connectivity and permeability of the road are improved, and an open, small-scale and convenient residential area is formed to attract residents to walk. This not only provides a variety of path choices for residents to walk, but also alleviates the excessive use of motorized traffic, thereby improving the opportunities for interaction between neighbors and creating a harmonious and livable inward-looking living environment.

3.3. Improve pedestrian traffic to seamlessly connect with other modes of transportation
No matter which way you travel, walking is the most effective way to connect to other modes of transportation. At the same time, the development of urban traffic and neighborhoods is closely related to the walkability of space [9]. Therefore, road rights should be clearly defined, space interface should be optimized, pedestrian network density should be increased, pedestrian service facilities should be improved, and a safe, coherent and sound walking system should be established. Meanwhile, the implementation of the "walking + public transportation" green transportation mode, the bicycle, subway, bus and other transfer locations are reasonably arranged within the walking range, improve the penetration and connectivity of the walking road, and promote low-carbon travel of residents from the source. More importantly, beautifying the station to the "last kilometer" walking environment in
the settlement, attracting residents to “go out” spontaneously, while people and things move, but also enjoy a quiet life, as shown in figure 3.

![Figure 3. Road network optimization diagram](image)

3.4. Design inclusive public service facilities to guide residents to walk
As a "magnetizer" that attracts residents to walk, public service facilities have an important role in meeting the physical and mental needs of residents and guiding the interaction between different groups. Therefore, it is necessary to clarify the required supply amount by step, and reasonably configure the facilities according to the frequency of use of the facilities and the pedestrian tolerance time, and eliminate the structural difference of the daily needs of the residents. Simultaneously, sort out differences elderly, the daily activity patterns of children, adults, activity type and activity time, activity in accordance with the characteristics of the population using rational design and layout of public service facilities. In addition, in order to improve the travel situation, anti-slip floor tiles or anti-slip strips are laid in the active venues with high frequency of use, and road service facilities such as landscape and leisure items, night lighting, signage, and garbage cans are integrated. The result is a safe, comfortable, convenient and continuous pedestrian network system that attracts residents to walk and create a low-carbon, pleasant and vibrant residential area.

4. Conclusions
The rapid development of the city has led to an unbalanced land use structure, and the street space carrying the walk has slowly disappeared, which has seriously affected the walkability of the residential area. The author proposes a pedestrian walking planning strategy from four aspects: encouraging the mixing of functions, optimizing the structure of the road network, seamlessly connecting pedestrian traffic with other traffic, and guiding residents to walk. In addition, at present, the use of ice and snow resources in cold urban settlements is less, and the research on the combination of ice and snow resources and the planning and construction of the pedestrian environment in cold residential areas should also be paid attention. This will help to show the regional, human and ecological aspects of the walking environment in the cold residential area, and to construct a beautiful and interesting cold area residential walking system.

Acknowledgements
The authors gratefully acknowledge the financial support of the Natural Science Foundation of Heilongjiang Province of China (Grant No. E2016065).

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