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The influence of community walking adaptability on service level and urban spatial equality: A case study of sports service in three districts of Shanghai

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Abstract. Numerous studies have shown that physical activity in walkable communities reduces the risk of obesity and noncommunicable diseases (NCD). The Chinese government advocates the construction of 15-minute walking blocks to provide citizens with a 15-minute walk to access basic public services, ultimately improving walking behavior and overall health. Based on the walking score index, this paper proposes an improved method to measure the adaptability of neighborhood walking and applies it to Shanghai, China. Based on the physical education resource allocation requirements of the community, the assessment takes into account the walking needs of different pedestrian groups (i.e.,the entire population, senior, children), physical fitness facility attributes (size and category) and actual traffic conditions. The results show that there are significant differences in the scores of community walking trips among different pedestrian groups. On the whole, the communities with high walking score mainly concentrated in the central city; And hard-to-walk neighborhoods are scattered in the outer suburbs. The overall population and the elderly showed higher walking ability for more neighborhoods and lower walking ability when viewed from the perspective of the children group. This study provides a reference for future studies to evaluate various aspects of neighborhood walking adaptability. It is necessary to pay attention to the social inequality caused by different neighborhood walking adaptability, and to intervene in the planning and implementation of building healthy communities in China.

Keywords: Walkiblity;Walk score;Social inequality;Shanghai urban

1. Introduction

Physical activity (PA) can prevent many physical and mental diseases, such as coronary heart disease, type 2 diabetes, depression, breast cancer and colon cancer, and is an effective means to reduce public health costs. At present, as judged by the World Health Organization, lack of physical activity is an independent high-risk factor leading to chronic diseases [1]. Walkability is defined as the adaptation degree of walking in the built environment. Scholars have reached a consensus on the measurement of neighborhood walkability: Better neighborhood walkability should improve physical activity (including leisure time physical activity), active transportation and mental health [2]. More walkable communities should include support for physical activity (including physical activity during leisure time), ease of travel and mental health [3]. Numerous studies have revealed the association between built environment, walking accessibility and physical health.

The aim of this paper is to address the above limitations in the measurement of walking accessibility in Chinese community Settings. In the central government put forward "national fitness campaign" in order to improve the level of community sports fitness, it is of great significance to use a suitable evaluation method to evaluate the level of community sports fitness resources allocation. Specific objectives: (1) To propose a method to measure the community walking score by revising the walking score index; (2) To determine the social inequality in the allocation of community sports and fitness resources; (3) To provide practical suggestions for improving the level of physical fitness in urban communities in China.

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2. Literature Review

2.1 Measurement of Walkibility

Researchers have proposed a variety of models and indicators for assessing walking accessibility, including subjective perception and objective dimensions. Existing research results show that social questionnaires, interviews and surveys, trajectory sensors and GIS-based methods are the mainstream evaluation methods at present. The walking travel score, especially the indicator proposed for OD travel, has been widely recognized because its effectiveness in measuring accessibility at the community level in different regions has been verified [4]. However, there is no uniform standard for the measurement of walkability, which must be adjusted according to local conditions. Therefore, when facing China's urban environment, attention should be paid to the existing restrictions in three aspects [5]. First of all, as a developing country, the theoretical gap of walking accessibility to local communities still needs to be filled, and the current urban community environment is very different from that of western countries [6]. Second, although in recent years, the walking distance score program has been using the Internet instead of Euclidean distance, but most of the research makes a critical value rather than the buffer as a measure, ignoring the residents' actual travel have limited tolerance of sexual characteristics, academics have attenuation function is used to calculate the community walking by building residents travel to score [7]. Finally, the differences in the evaluation results of walking accessibility caused by the single criterion of group division in social surveys have not been paid attention to to some extent.

2.2 Social Inequalities in Walkability

Existing studies have begun to pay more attention to the residential mismatch of service resource allocation in walkable communities. More and more studies have studied the neighborhood walkability and residential mismatch from the perspectives of space and statistics. Existing studies have used simulation and relationship hypothesis to measure the situation of community housing mismatch [8]. Mokhtarian et al. found in the evaluation of the impact of imbalance of community leisure site resource allocation on residential satisfaction of Atlanta residents that residents in the mismatched areas had lower residential satisfaction, which led to a decline in life satisfaction and mental health.

However, it is worth noting that numerous studies have aimed to reveal whether there are social inequalities in neighborhood walkability, but the results vary depending on the urban context. Current research should pay close attention to the characteristics of different populations. For example, people with different sports habits may have different preferences and needs for accessibility to various sports venues [9]. In addition, urban and rural migrants face social and geographical isolation in terms of residence and public services [10]. Unless different socioeconomic characteristics are taken into account, any tool for assessing walkability will not help planners take targeted measures to build fairer and more walkable cities. With these issues in mind, it is imperative to examine whether different socioeconomic groups have equal access to desirable facilities in the community.

3. Study Design

3.1 Data Source

The road network data is in order to calculate the supply status of various sports facilities in the study area in Shanghai, at the beginning, we used the spatial data of the relevant areas in Shanghai where the study area is located in 2020, which was sourced from the open API platform of AmAP.

In 2022, we obtained the health, sports behavior and subjective ratings of the residents in the study area by issuing paper questionnaires. A total of 500 Shanghai residents aged 15 and above were randomly selected from the study area. 304 people (60.8 percent) participated in the survey. In

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addition to gender and age, the respondents also provided their highest education level in the following options: primary to junior high school, vocational high school and regular high school, junior college, bachelor's degree or above. Although these measures may be potentially biased due to the limited sample, they can provide useful information for understanding respondents' perceptions of deprivation

Facility data includes infrastructure point data and POI data. The infrastructure point data is from the Shanghai Urban Planning and Design database, and the POI data is from the 2022 AmAP API open platform. After filtering the POI data and eliminating duplications, various facilities that were not classified as physical fitness facilities were eliminated.

3.2 Methods

3.2.1 Measurement of the importance in different types of sports facilities

Through the corresponding questions in the questionnaire, the respondents' exercise methods and evaluation of various sports facilities were obtained. After the reliability and validity tests, the table 1shows the entropy weight method was used to determine the proportion of the importance of various sports facilities in the resident group represented by the respondents.

3.2.2 Travel time circulation

In this section, the supply of various sports facilities in the study area is measured by using the network analysis extension module in the ESRI ArcGIS software package (version 10.8.1). First, each residential block is used as a starting point to calculate the time it takes to reach the nearest different functional facilities. Therefore, even residents of adjacent residential communities may not have the same access to public sports services at the same time. Secondly, the travel range of residents is not a simple European distance division, but based on the distance of the road network, which can more truly reflect the actual activity range of residents. With reference to the concept of 15-minute community life circle, the travel mode is set as walking, and the travel speed is 5km/h. When there is no type of sports facilities in the search range, the arrival time is returned as a maximum constant, so as to study the difference of public sports service facilities obtained by different communities under the same travel time.

Table 1. Amenities for walkibility neighborhoods measurement of entire population (a),seniors(b), children(c).

(a)		
Principle category		
Basic guarantee type	Sub-category	Weight(%)
	sports points	20.71
Quality improvement type	sports field	28.20
	Integrative gym	26.98
(b)	Natatorium	24.10
Principle category		
Basic guarantee type	Sub-category	Weight(%)
	sports points	34.65
Quality improvement type	sports field	26.43
	Integrative gym	18.27
(c)	Natatorium	20.66
Principle category		
Basic guarantee type	Sub-category	Weight(%)
	sports points	23.64
Quality improvement type	sports field	32.11
	Integrative gym	18.24
	Natatorium	26.01

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3.2.3 Decay Function

Considering the mobility of residents and functional differences of facilities during walking, we used the tolerance time method to determine the decay function of various facilities. Tolerance time represents the threshold at which residents can accept the time it takes to reach the facility. Walking time is divided into three periods: < 5 minutes, 5-10 minutes,10-15 minutes and 15-30 minutes.

The decay rate R (t) is calculated from equation (1). In addition, given that high quality facilities such as swimming pools represent people's pursuit of a high quality of life, we assume that such facilities will still attract people to use them over longer distances. So we measure the decay function of the swimming pool, which decays at a slower rate. In general, the different LTPA groups had the same attenuation phenomenon in the willingness to spend time to arrive at the facility.

$$R(t)=\begin{cases} 1 & if\ t \le 5min \\ y_0 + ae^{-\frac{(t-b)^2}{2c^2}} & if\ 5 \le t \le 30\ min \end{cases}$$

where y_0, a, b, and c are real constants, expected value $\mu = b$, b=5, and variance$\sigma=c^2$

3.2.4 Calculate the score of community access to public sports service resources

After obtaining the initial assessment scores, we converted the scores to a scale of 0-100 by normalization. Overall, a higher score means that the community can get better physical fitness resources under the walking mode. Therefore, we measured the walking physical fitness resource scores of the whole population, low LTPA and high LTPA respectively.

Table 2 Grade of the 15-min walkable neighborhoods score

Score	Description
90-100	Highly walkable. Daily trips do not rely on a vehicle.
70-89	Very walkable. The majority of daily trips rely on walking.
50-69	Moderately walkable. Part of daily trips rely on walking.
25-49	Somewhat walkable. The majority of daily trips rely on a vehicle.
0-24	Car-Dependent. Nearly all daily trips rely on a vehicle.

4. Result

Figure1 shows the uneven distribution of sports and fitness facilities resources around communities of different groups through the visualization of community physical exercise environment scores.

For the population as a whole, neighborhoods that are very walkable for exercise (physical activity environment score $\geqslant 90$) covers most of the central urban area and extends to the near suburbs. The outer suburbs show that sports facilities and resources are concentrated in the suburban center, and the surrounding communities have low physical exercise environment scores (environmental scores $\leqslant 24$), so they do not have the conditions to carry out various physical exercises by walking. For seniors with stronger desire for exercise, their perception of physical exercise environment in central urban areas was more obvious. The number of communities with better exercise environment (environment score $\geqslant 90$) was less than the range recognized by the overall population, mainly concentrated in the inner urban areas and suburban centers. Non-walkable communities (environmental scores $\leqslant 24$) are scattered outside the central urban area.

Results in children and the seniors appear similar patterns, namely, the center of the city community sports exercise environment score than in the suburbs, but on the outskirts of community physical training environment evaluation is generally lower than seniors group, this also showed the children group compared with elderly people, for the way to the sports facilities by walking tolerance is lower

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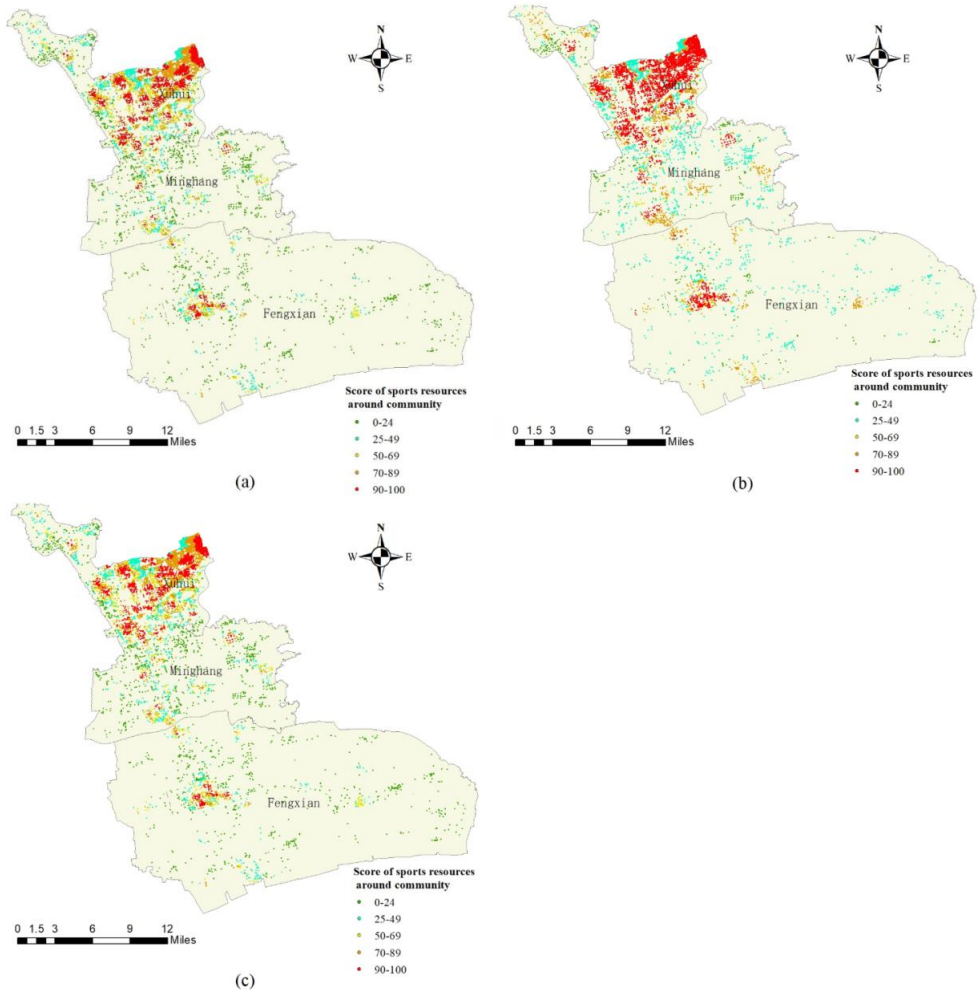

Fig. 1. 15-minute walkable neighborhoods score for entire population (a), seniors (b), children (c).

The measurement of walkability is largely influenced by the needs of different pedestrian groups. This study improved a practical approach to measure 15-minute walkable neighborhoods by modifying the walking score index. The measurement takes into account different behavioral characteristics and facility attributes (size and category) of three pedestrian groups (whole population, elderly, children). It corresponds to the previous requirement that variability in walkability measures should be examined in relation to subject, walking purpose, and living conditions. In particular, we've made three basic improvements in the walkability measure. Firstly, we used a questionnaire survey to determine the common sports and fitness facilities and their weights of different pedestrian groups (the whole population, the elderly and children). Second, the actual travel time obtained from GIS network analysis is used to replace the Euclidean distance from the community to each destination. Finally, we use the tolerance time method to establish attenuation functions for different pedestrian groups and different categories of amenities.

We further examined the geographic differences in 15-minute walk neighborhoods in Shanghai, China. The neighborhoods with high walkability are mainly concentrated in the central city, while the neighborhoods with poor walkability are scattered in the outer suburbs. This trend has been observed in three groups, including the entire population, the elderly and children. This finding is consistent with previous studies conducted by Western scholars in urban communities of Shenzhen, China [11]. It also supports the view that the old center of Shanghai is pedestrian-friendly because of its small neighborhoods and dense streets [12].

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