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Original Article

Analysis and Optimization Strategies of Pedestrian Environment around TOD Rail Transit Stations in Guangzhou

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Abstract: This study extensively examines the urban dynamics of Guangzhou, a city that has notably embraced and incorporated the concept of Transit-Oriented Development (TOD) into its urban structure. Through a comprehensive and meticulously designed questionnaire survey, the research aims to understand different demographic groups' diverse preferences and needs. The main focus is comprehending individuals' views and experiences regarding the pedestrian environment near Transit-Oriented Development (TOD) stations. The study findings reveal a wide range of outcomes, indicating significant variations in walking distance tolerance and environmental satisfaction among different populations. Notably, walking distance emerged as a crucial factor, as a positive correlation was found between shorter perceived distances and higher levels of enjoyment. Evaluating pedestrian amenities reveals their insufficiency and emphasizes the need for improved pedestrian comfort and infrastructure. Various factors influence individuals' satisfaction with the walking environment. The assessment of pedestrian infrastructure in Guangzhou's Transit-Oriented Development (TOD) areas generally shows positive feedback, but there is still room for improvement. This study analyzes the current shortcomings in pedestrian infrastructure and proposes practical recommendations for enhancement. Its purpose is to provide a basis for policy formulation and future renovations to enhance pedestrian mobility near TOD train stations in Guangzhou.

Keywords: Transit-Oriented Development (TOD); Rail transit station; Pedestrian environment; Optimization Strategies; Guangzhou.

1. Introduction

The rapid growth of metropolitan areas has led to a significant increase in traffic and environmental congestion, largely due to the proliferation of compact automobiles. Enhancing access to public transit is crucial to address this issue. One approach to achieving this is implementing the Transit-Oriented Development (TOD) plan, which aims to promote the integration of rail transit and urban development. The TOD strategy seeks to stimulate high-density, mixed-use development near rail transit stations, encouraging

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more people to walk, cycle, and utilize public transportation (Qiang et al., 2022). China has made notable progress in expanding its urban rail transport infrastructure recently. For instance, by the end of 2021, the metro system in Guangzhou is projected to span 474 kilometers, encompass 276 stations, and serve over 10 million passengers daily. To fully utilize the capacity potential of rail transit (Raya et al., 2022; Yu et al., 2022), it is crucial to ensure good connectivity between the surrounding areas and the stations. It will facilitate safe and convenient access for various passengers and enable smooth travel from the first to the last minute.

Transit-oriented development (TOD), a widely accepted principle in rail transit planning, aims to create high-density, mixed-use, and walkable environments around train stations. According to Zemp et al. (2019), the pedestrian circumstances surrounding the station play a central role in TOD. These characteristics directly impact the station's accessibility and attractiveness. Previous studies have evaluated the walking environment from various perspectives, including safety, suitability, pleasantness, and convenience. GIS analysis, field observation, user surveys, and other assessments have guided decision-making (Adriana, 2022; Chae et al., 2021; Irsal et al., 2022; Xia et al., 2019).

As a representative case study for this investigation, Guangzhou was selected because it was one of China's first cities to adopt the transit-oriented development (TOD) concept. In line with this, the city has implemented the TOD Plan for Guangzhou Rail Transit Line Network, which focuses on integrating transit and pedestrian-based transportation modes by implementing TOD around the stations. Therefore, the research on the pedestrian environment in the TOD station area in Guangzhou can serve as a reference model for other cities.

2. Literature Review

As urban rail transport networks expand rapidly, the importance of pedestrian conditions linking stations to their surroundings is increasing. Transit-oriented development (TOD) has been widely utilized in urban rail transit planning to create high-density, efficient, and pedestrian-friendly station areas (Akbar, 2021). According to a study conducted by Nusyawal & Purwantiasning (2020), pedestrian environments play a crucial role in the accessibility and attractiveness of rail transport, thereby impacting the performance of TOD. Distance, safety, continuity, and amenities influence travelers' walking decisions. The minimum walking distances vary across countries, with wealthier nations typically having distances of 400-800 meters, while underdeveloped ones may be more flexible. These variations are primarily influenced by psychological factors such as an individual's tolerance for walking time and distance, as well as urban public transport and land use planning. In a study of Arsyad & Handayeni (2019), it is suggested to develop walking distance requirements based on urban environment studies. This approach can potentially enhance public transport coverage and capacity while reducing automobile usage (Qin et al., 2023).

Papagiannakis et al. (2021) conducted a study to explore individuals' satisfaction with their communities and their perception of the potential of Transit-Oriented Development (TOD) in revitalizing metropolitan areas. While TOD is widely acknowledged by academics, planners, and policymakers, understanding how citizens perceive its benefits remains challenging. The researchers employed a questionnaire in the service areas of two proposed metro stations, each with distinct physical and socio-economic attributes. The findings revealed that respondents from both regions expressed similar concerns regarding public spaces, walkability, access, and the potential of the Metro to enhance urban regeneration and development. However, there were statistically significant differences in their perceptions of key spatial characteristics within their neighborhoods.

The evaluation of TOD's pedestrian environment is a significant focus in urban planning and design. In recent years, numerous researchers have explored strategies to assess and enhance the pedestrian environment, aiming to promote environmentally friendly mobility and improve the quality of life for residents. According to Zhang et al. (2022), small and medium-sized cities in China play a crucial role in sustainable urban development. Walking is considered a healthy and eco-friendly mode of transportation. However, due to the increasing use of motorized vehicles and inadequate pedestrian infrastructure, residents often have unsatisfactory travel experiences. Researchers propose a pedestrian street spatial environment model based on a walking score to address this issue. This model considers visual perception, street function, and pedestrian volume, providing a theoretical framework for designing pedestrian-friendly street environments (Zhang et al., 2022). By adopting this approach, residents are encouraged to prioritize walking as their primary means of transportation. Additionally, studies on Melbourne's CBD indicate that the physical environment significantly influences pedestrian circulation in densely populated areas (Jiao et al., 2021; Shi & Fu, 2022). After analyzing land use, public transport station density, and job density, the researchers discovered a significant correlation between pedestrian flows. In their study from 2021, Jiao et al. found that land use and amenities positively impact pedestrian flow, while parking facility density has a negative impact.

Steinmetz-Wood et al. (2019) demonstrated that technological advancements in Google Street View enable the assessment of distinct microenvironments. Virtual-STEPS, a remote assessment tool, allows researchers to evaluate benches, pavements, and signs of social disorder or criminality. This reference is crucial for urban planning and design (Redzuan et al., 2022). In this study, the walking environment around Guangzhou's TOD rail transit stations was evaluated using a questionnaire survey to gather perceptions and experiences from different groups. This study aimed to achieve more accurate and comprehensive evaluation outcomes. A comprehensive scientific assessment index system inspired by the questionnaire survey is being developed to describe the numerous qualities of walking appropriateness. By administering the survey, we hope to understand residents' needs and priorities better and provide targeted improvement proposals to enhance the walking environment of TOD train stations in Guangzhou.

3. Materials and Methods

3.1. Questionnaire Designs

In this study, a questionnaire was used to collect first-hand information. The questionnaire is divided into four parts, as shown in Table 1. The first part investigates the demographic characteristics, while the second focuses on traveling characteristics to understand the usage. The third part designs detailed satisfaction scale questions for multiple dimensions of the walking environment. Lastly, the fourth part collects suggestions through open-ended questions. The questionnaire contains categorical and quantitative variables, making it rich in data types. The satisfaction scale questions were based on Li (2005), who proposed a neighborhood walking environment audit score based on four dimensions: safety, convenience, comfort, and interest. A Likert scale was used to ensure the accuracy and consistency of the measurements. The questionnaire closely aligns with the research questions and sets specific measurement indicators for walking suitability. A total of 18 scale questions were designed based on the theoretical framework of the walking pyramid with particular variables such as accessibility, safety, comfort, and enjoyment considered, and the question items were closely aligned with the focus of the study. The questionnaire was designed following scientific principles, systematicity, and relevance. The transition and sequence of questions were logical.

Table 1. List of Questionnaire Design

Category	Code	Indicators
Demographic characteristics	Q1	Your gender is
	Q2	Your age group
	Q3	Your status is
	Q4	Your career status is
	Q5	Your household income (RMB):
	Q6	The number of your family members are:
Travelling characteristics	Q7	How often do you take the Metro per week?
	Q8	The purpose of your most recent trip by rail was
	Q9	What time of day do you usually use the Rail Transit s?
	Q10	Which rail station do you visit most often or which rail station did you use most recently (Departure or Destination)?
	Q11	What is your main reason for choosing to walk to the Rail Transit ?
	Q12	What aspects of the rail station area are you more concerned about in terms of coordination between pedestrian connections and other modes of transport?
	Q13	What is the acceptable walking distance from the rail station to the connection point (Departure, Destination, Bus stop, Car park, Temporary loading/unloading area for taxis and internet taxis) for your connection?
	Q14	How long of a walk would adding to your acceptable walking connection time add unnecessary stress to your trip?
Satisfaction	Q15	How satisfied are you with the smoothness of the site's pedestrian connections to the surrounding neighbourhood?
	Q16	How satisfied are you with the smooHow satisfied are you with the regional boundaries of walking paths and non-pedestrian spaces (carriageways, etc.) around the site?
	Q17	Do you find the walking distance between key locations (e.g. residential areas,

Category	Code	Indicators
		work areas, etc.) and rail stations convenient?
	Q18	How satisfied are you with the extent to which the footpath network around the site is well developed (density of the network)
	Q19	How satisfied are you with the connectivity of rail stations with other transport (e.g. buses, bike sharing)?
	Q20	How satisfied are you with the accessibility (e.g. ramps, guide paths, etc.) on the walking paths around the site?
	Q21	How satisfied are you with the way finding facilities (signage, maps, etc.) around the station?
	Q22	How satisfied are you with the motor vehicle speed reduction facilities and pedestrian crossing aids around the station?
	Q23	How satisfied are you with the night-time lighting facilities around the station?
	Q24	How satisfied are you with the width of walking streets around the station?
	Q25	How satisfied are you with the conditions of use (levelness, paving) of the pavements around the station?
	Q26	How satisfied are you with the shade/rain protection of the walking paths around the station?
	Q27	How satisfied are you with the number of walking breaks around the site?
	Q28	How satisfied are you with the shade coverage of trees on the walking paths around the site?
	Q29	How satisfied are you with the colour scheme of the buildings in the walking area around the site?
	Q30	How satisfied are you with the distinctive humanities vignettes (sculptures, installations) within the walking area of the site?
	Q31	How satisfied are you with your walking experience in street spaces with a high degree of interface enclosure around the site?
	Q32	How satisfied are you with the commercial environment in the streets within the rail station area?
Attitudes& Recommendations	Q33	What do you value in the process of walking connections to streets within the rail station area?
	Q34	What aspects of the pedestrian environment within the rail station area are you more concerned about when evaluating the pedestrian connection to the street?
	Q35	What facilities or services would you like to see provided in the station area pedestrian environment to enhance the walking experience?

The research areas are manifested in the structure of the survey instrument, which encompasses the development of distinct metrics to assess different dimensions of walking suitability. In accordance with the framework of walking demands, a comprehensive set of 18 scales was developed to assess several attributes, including accessibility, safety, comfort, and pleasure. Additionally, the inquiry items strongly aligned with the study's principal objective.

3.2. Sample Selection

In order to verify the comprehensiveness of the obtained sample, a web-based questionnaire platform with severe constraints on full completion was employed. In order to conduct this academic research study, the non-probability sampling technique of simple random sampling was utilized. A total of 546 questionnaires were distributed, and all 546 were considered valid, yielding a recovery rate of 100%. The provided sample is anticipated to effectively reflect the prevailing characteristics of travelers in the station's proximity, hence establishing the credibility and soundness of the research outcomes.

3.3. Data Analysis

The data analysis in this study was conducted utilizing statistical tools, specifically SPSS. Initially, the data obtained for each research topic were synthesized and categorized based on the type of question. The

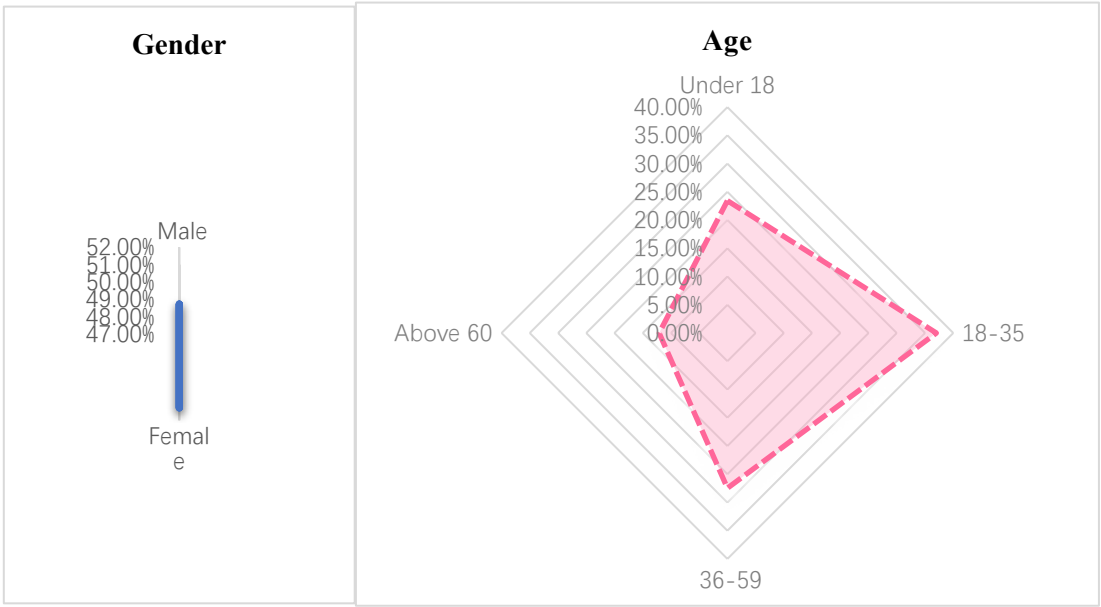
findings were visually represented using figures, tables, and textual descriptions. Subsequently, the acquired data was analyzed using software tools to conduct descriptive and inferential statistical analysis to identify underlying trends. Frequent distributions, percentages, and similar analytical techniques primarily examine descriptive statistics. Inferential statistical analyses employ cross-tabulations to investigate the association between distinct variables. The qualitative open-ended questions are investigated through the process of classifying and identifying the content, as well as determining the main areas of interest.

4. Results

4.1. Sample Characteristics

The sample for the study comprised a total of 546 individuals, as depicted in Figure 1. The predominant demographic in the sample consisted of young adults between the ages of 18 and 59, comprising 64.47% of the overall population. The demographic cohort of individuals under 18 was the second most substantial segment, accounting for 23.44% of the overall population. The senior population, aged 60 and over, was the third largest demographic group, accounting for 12.09% of the overall population. The observed distribution of metro riders is representative of the demographic makeup, primarily consisting of individuals in the young adult age group. Concerning gender, the male population constituted 48.72% of the labor force, whereas the female population constituted 51.28%, yielding a proportionate distribution between the genders. The population's demographic composition was primarily comprised of residents, accounting for 64.29% of the total.

International visitors comprised 26.74% of the population, while foreign businesspeople represented 7.14%. The results of this study suggest that a significant proportion of the participants in the sample are indigenous to the Guangzhou region. Most of the participants included in the samples are persons who are indigenous to the Guangzhou region. About employment, individuals engaged in office labor constituted 54.03% of the populace, encompassing both personnel affiliated with institutions and corporations. The student population was 23.63% of the total population, and retired senior individuals comprised 12.09%. Hence, the sample predominantly comprises individuals enrolled as students or employed in an office environment. Regarding household income, it is seen that 33.7% of households have an annual income of less than 100,000 Yuan. Additionally, 34.62% of households fall within the income range of 100,000 to 200,000 Yuan annually. Furthermore, 22.89% of households earn between 200,000 and 500,000 Yuan annually, while 8.79% have an income beyond 500,000 yuan annually. The composition of the primary income groups is characterized by persons who own middle-class and lower-class earnings, as is apparent.



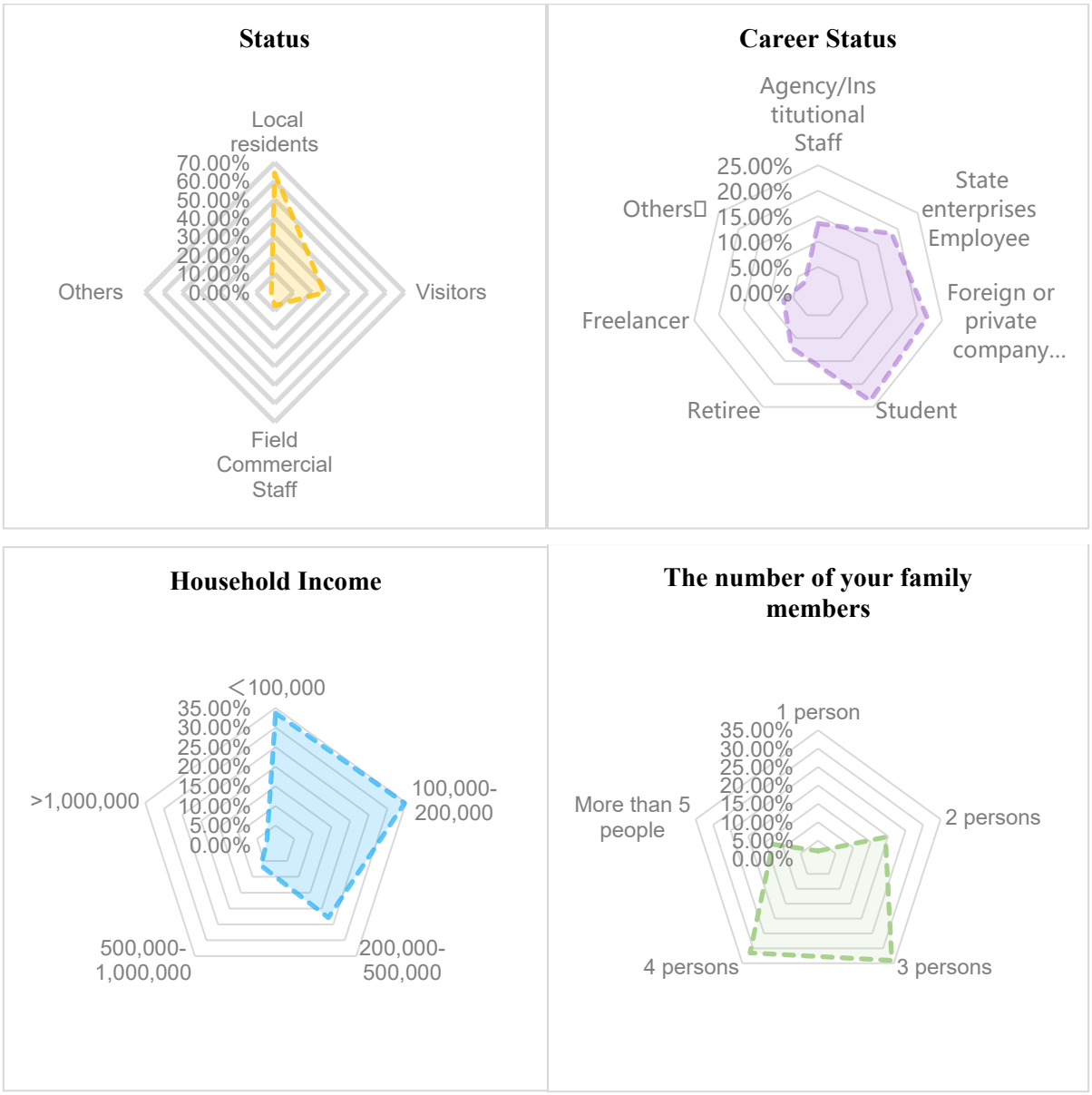


Figure 1: Demographic survey data

4.2. Traversing Traits and Characteristics

According to the data presented in Figure 2, a significant proportion of consumers (71.97%) indicate that they utilize the product weekly, with a frequency ranging from three to ten times. Individuals who utilize the train on a frequency of no more than once or twice per week constitute 21.43% of the total population, whereas those who avail the train service more than ten times per month account for 8.61% of the population. This category pertains to the intensive utilization of rail transportation. A total of 41.76% of the participants engaged in travel activities during peak hours, while 22.16% opted for off-peak hours throughout the daytime. Additionally, 26.37% of the respondents reported traveling during irregular hours. The percentages provided are contingent upon the specific time of day. This finding indicates that the participants are individuals who commute to their workplaces regularly and those who travel daily with varying schedules. The primary motivation for a significant proportion of individuals engaging in travel is entertainment consumption, constituting approximately 30.59% of all travel endeavors. Subsequently, individuals engage in social interactions with friends and family, constituting approximately 23.81% of all travels, while commuting to work represents 14.1%. This observation pertains to the characteristics of language usage in everyday situations. The biggest determinant for walking is the proximity to the destination, constituting 41.21% of the overall decision-making process. Subsequently, the inclination to optimize the procedure and avoid unnecessary transfers accounts for 21.25% of the total.

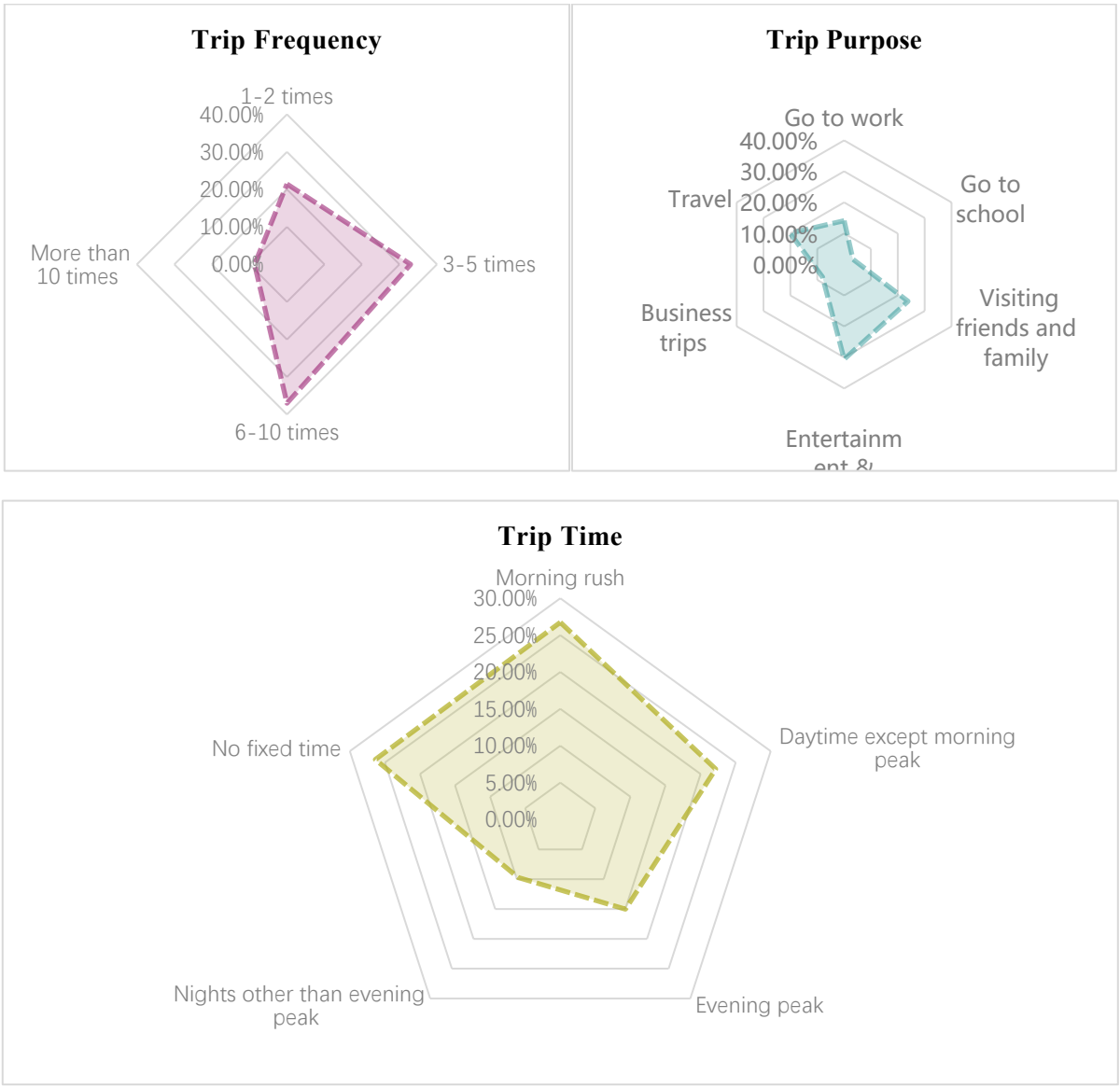


Figure 2. Travel Characteristics Survey data

4.3. Satisfaction Rating

The Cronbach's alpha value for Q15-Q32 was 0.963, which implies that the group of questions has very high internal consistency. The overall correlation coefficients CITC of the corrected items for each question are above 0.710, which is higher than the standard of 0.3, indicating that each question item can effectively reflect the change of the overall scale, has a strong positive correlation with the total score and has a good differentiation of the questions. Therefore, this group of questions can be considered as a reliable scale. On a scale from 1 to 5, the scores of the different satisfaction measures ranged from 3.76 to 3.88, with an average value of roughly 3.8 points. It suggests that a good appraisal of the existing walking environment may be made generally, even though it is not especially satisfying. The satisfaction ratings of safety and pleasantness are higher, coming up at 3.825 and 3.822, respectively, which are both in the positive zone of the scale. It demonstrates that respondents are typically more content with the level of safety and security as well as the pleasantness of the surroundings at train stations. On the other hand, the score for comfort is lower, coming in at just 3.8 out of 10, which indicates that there are still issues with walking comfort. To be more specific, the level of satisfaction with barrier-free facilities and humanistic landscapes is poor, scoring just 3.77 and 3.79 marks, respectively, as shown in Table 2.

Table 2. Overall Satisfaction with the Walking Environment in Guangzhou Rail Transit Station Areas

Dimensions	Code	Indicator	Score	Total Score
Feasibility	Q13	Pedestrian connection distance	-	-
	Q14	Distance can be increased within pressure	-	
	Q15	Pedestrian accessibility	3.82	
	Q16	Regional boundaries between walking paths and non-pedestrian spaces	3.81	
Accessibility	Q17	Walkability	3.88	3.818
	Q18	Degree of development of the pedestrian network	3.82	
	Q19	Interface with other transport	3.79	
	Q20	Barrier-free facilities	3.77	
	Q21	Signage and guidance facilities (signage, maps, etc.)	3.84	
Safety	Q22	Motor vehicle speed reduction facilities and pedestrian crossing aids	3.82	3.825
	Q23	Night-time lighting facilities	3.83	
Comfort	Q24	Width of the pedestrianized street space	3.84	3.8
	Q25	Pavement use conditions	3.82	
	Q26	Shade/rain protection facilities	3.8	
	Q27	Number of rest facilities	3.76	
	Q28	Area covered by trees for shade	3.85	
Pleasure	Q29	Colour scheme of the building	3.82	3.822
	Q30	Characteristic humanistic vignettes	3.79	
	Q31	High degree of interface enclosure	3.8	
	Q32	Surrounding commercial environment	3.85	

4.4 Statistical Analysis and Interpretation

4.4.1. Investigation of the Demographic Correlations

In order to study the link between the demographic factors of interest and the assessment aspects of walking environment satisfaction, a Pearson correlation analysis was carried out. The results in Figure 3 show a negative association with age, and the coefficients ranged from -0.089 to -0.177; also, the degree of pleasure declined with age. There is an inverse relationship between identity and satisfaction, with coefficients ranging from -0.119 to -0.224, and the amount of satisfaction experienced by non-locals is lower. The link between income and satisfaction levels is smaller, with correlations ranging from -0.064 to -0.144, yet those in higher income brackets report a little greater sense of fulfillment. Other factors, including gender, members of a family, and travel times, do not significantly correlate with happiness. Accordingly, age, place of origin, and income are the primary demographic characteristics that impact levels of contentment. Persons of advanced age, persons traveling from other countries, and those living in poverty are examples of particular groups who report lower levels of satisfaction, and their requirements must be given priority.

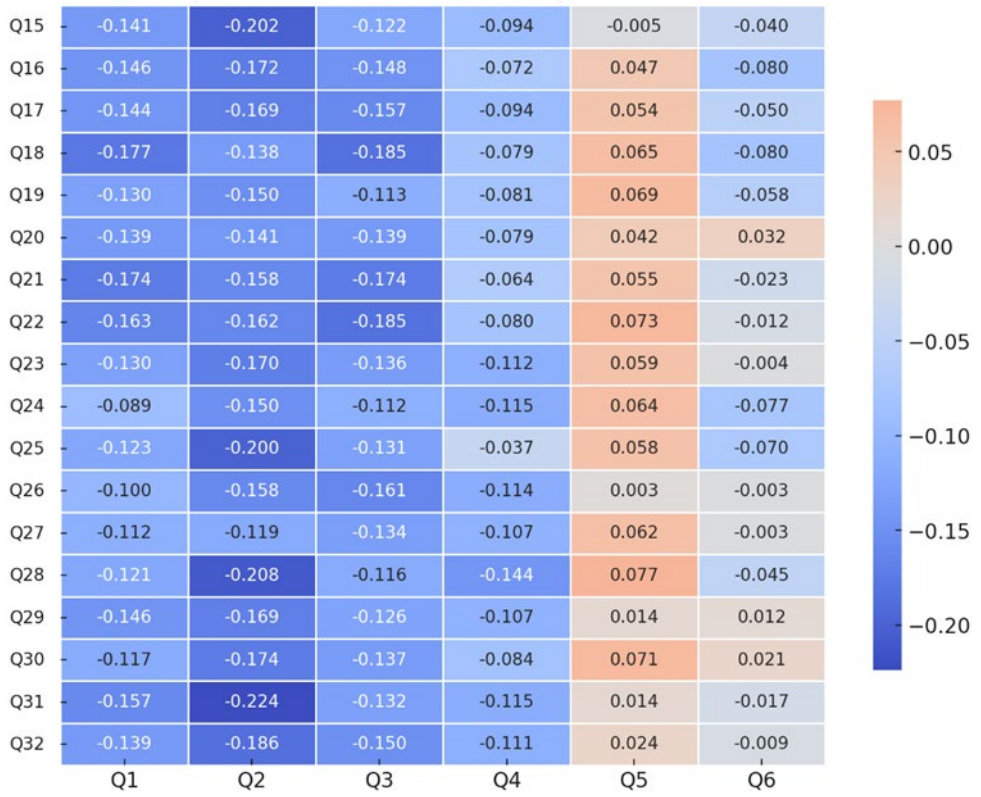


Figure 3: Demographics and Satisfaction Relevance Analysis

4.4.2. Analysis of the Correlation of Walking Distance

There is a moderate negative correlation between walking distance and satisfaction. The correlation coefficients between "acceptable walking distance" and "smoothness of station connection" are -0.748, and the correlation coefficients with "density of pedestrian network" are -0.745. The correlation coefficient between "walking distance" and "accessibility" is -0.748, and the correlation coefficient with "walking network density" is -0.745, which indicates that if the acceptable walking distance is shorter, the users will be less satisfied with the environment. The correlation coefficients between pressure to increase walking distance and satisfaction range from -0.551 to -0.633. As shown in Figure 4, there was a significant negative correlation between walking distance and environmental satisfaction. The shorter the distance perception, the higher the satisfaction level. Walking distance tolerance directly affects the evaluation of environmental quality.

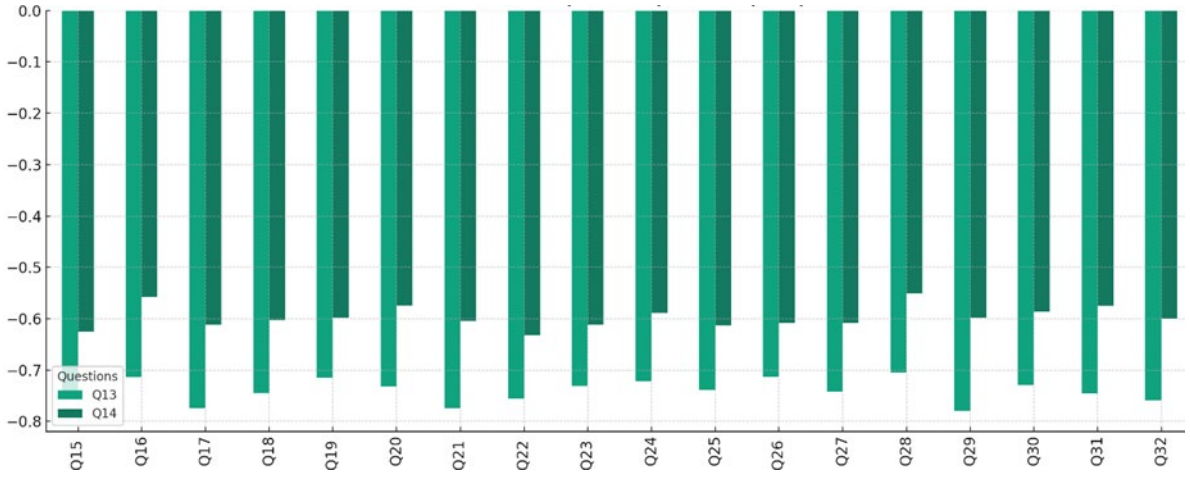


Figure 4. Relevance Analysis of Walking Distance to Satisfaction

4.4.3. Examination of Clusters

The K-prototype clustering algorithm categorizes the samples to determine the demand preference of various population features. Iterative computation allows the algorithm to cluster quantitative and qualitative data together simultaneously, delivering the desired result. During the clustering phase, gender variables without significant differences across groups were omitted from consideration. After much deliberation, the samples were ultimately divided into three distinct groups, as shown in Table 3, each of which had relative proportions of 205 (37.55%), 150 (27.47%), and 191 (34.98%) instances. The clustering effect is better overall because the distribution of the three groups is more uniform, which implies that the impact is better overall. The samples were categorized into three different groups using the K-mean clustering technique. These three groups were medium-frequency flexible users, high-frequency off-peak users, and low-frequency peak users. The three groups of users differed in their satisfaction with the walking environment ratings.

4.4.4. Analysis of Group Differences

The chi-square test was used on 18 clustering group satisfaction items. A study indicated substantial differences ($p<0.01$) in distributions among the three groups for each question. It shows that different user groups view the walking environment differently. Medium-frequency users are the most satisfied and tolerant, high-frequency users have the highest wants and most critical evaluation, and low-frequency users are in between. Comparing cluster answer distributions on different themes reveals more details. For instance, 45% of high-frequency off-peak travelers chose "unsatisfactory" for rail transit station-area connections, whereas 79.51% of medium-frequency and low-frequency peak travelers chose "very satisfactory." Significantly higher than usual. 31.33% of high-frequency non-peak travelers were "not very satisfied" with night-time walking lighting, far higher than average. Similar variances exist across themes.

The "high satisfaction group" MF-LF-peak passengers are satisfied with all questions, although maintaining this may be difficult. Most areas need improvement for the "low satisfaction group" of high-frequency non-peak tourists. The "intermediate group" of low-frequency peak travelers needs topical improvement and average satisfaction. The high-frequency off-peak group has a stronger demand for walking, pays more attention to amenities, comfort, and other environmental factors, and has higher needs that are harder to satisfy than the mid-frequency, low-frequency peak traveler group. These differences directly affected the three groups' walking environment satisfaction ratings. Group differences assist in building walking environments for different groups.

The high-frequency traveler group has lower requirements for all aspects of environmental quality, places more emphasis on walking distance, spends more time walking daily, and has lower needs that are easier to satisfy; the low-frequency traveler group has stronger walking needs, pays more attention to facilities, comfort, and other aspects, and has higher needs that are harder to satisfy. The flexible traveler group's, i.e., the data shows high-frequency travelers have reduced criteria for all aspects. Due to these differences, the three groups' walking environment satisfaction ratings ranged greatly. The group differences provide a significant reference for constructing the walking environment to meet the needs of different groups.

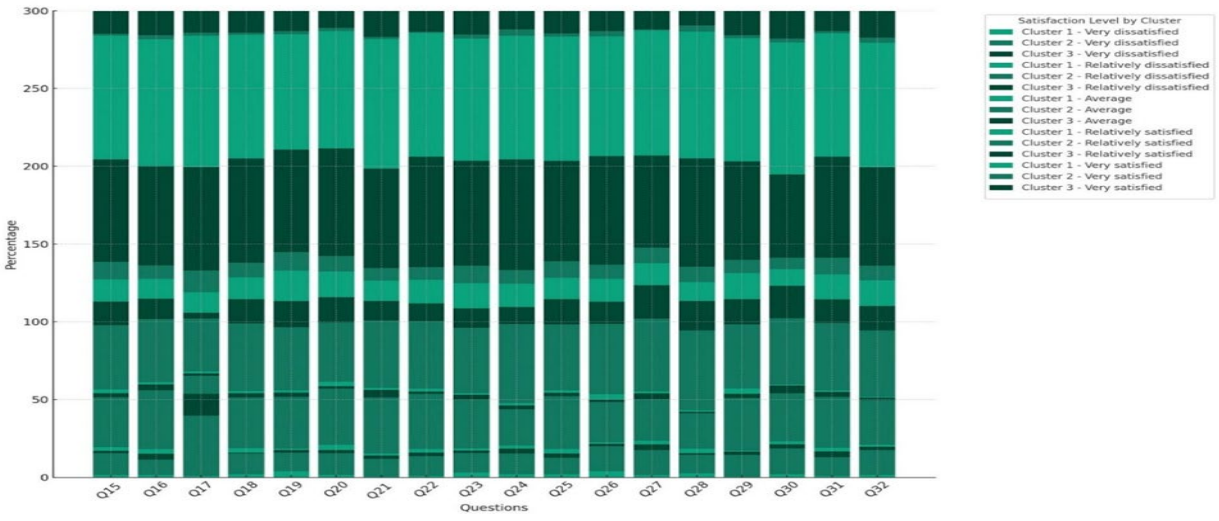


Figure 5. Average Satisfaction Distribution across Questions Clusters

4.5. Examination of the Qualitative Remarks

Open-ended questions were used in this research project to elicit comments from participants about how to enhance the environment in which people walk. The feedback was coded and conceptualized via qualitative content analysis, and the following primary kinds were included.

- Satisfy the functionality requirements by providing rest places, public restrooms, outdoor exercise facilities, and other amenities that enhance functioning.
- Accessible requirements: Ensure that persons with mobility impairments may move without obstacles by improving accessible amenities such as slopes, handrails, and tactile tiles, among other things.
- Satisfying the requirements of the surrounding environment by supplying potable water, charging stations, Wi-Fi, and other amenities, as well as by playing music to create a more pleasurable ambiance.
- Incorporate public art and cultural landscapes to enhance the overall appeal of the interface to satisfy "soft cultural needs." To make things more enjoyable, plan some cultural pursuits.

The quantitative findings from the earlier study are supplemented and validated by qualitative input, offering a more in-depth insight into areas to make enhancements. For instance, the difficulty of a monotonous environment is reflected in the functional demands, while the absence of barrier-free facilities is reflected in the soft cultural needs. Having this information allows for the future formulation of more focused suggestions.

5. Discussion

The researchers in this study examine the satisfaction of the pedestrian environment surrounding the Transit-Oriented Development (TOD) stations in Guangzhou from multiple perspectives. The results suggest differences in walking needs across different demographic groups. Persons who utilize Rail Transit regularly exhibit a higher propensity for satisfaction. At the same time, those who have infrequent usage patterns tend to possess more discerning expectations and exhibit a stronger inclination toward critical evaluation. Given the notable disparity between the criteria for pedestrian mobility and the varying levels of satisfaction that different age cohorts perceive in their immediate surroundings, we must acknowledge the heterogeneous walking needs and devise enhancement strategies that effectively cater to the distinct requirements of each age demographic. The magnitude of the walking distance has significant importance in the context under consideration, with customers expressing heightened levels of satisfaction when perceiving the journey to be of shorter duration. Consequently, it is vital to exert diligence in effectively organizing the assortment of pedestrian amenities accessible close to transportation hubs. The prevailing consensus among individuals is that their tolerance for walking distances typically ranges from 400 to 800 meters. This observation implies a need to prioritize enhancing comfort as walking distances extend. The proximity of the station and the limited amount of time people are willing to travel indicate that there is room for improvement in terms of walking comfort.

Simultaneously, an intrinsic correlation exists between the various assessment attributes and an individual's overall satisfaction with the pedestrian environment. This link is established through the collective viewpoint of the walking individuals. When a particular dimension has a high rating, it will positively influence the ratings of the other dimensions. This observation suggests that various factors influence satisfaction with one's environment during a walk and that the various elements that contribute to one's overall perception shape the walking experience. The results of this study suggest that the walking environment is generally recognized to some extent, while there is potential for enhancement in terms of both comfort levels and the overall humanistic ambiance. In order to enhance the overall walking experience, it is imperative to undertake planning and transformation measures regarding pavement conditions, rest facilities, barrier-free accessibility, and landscaping assistance along the designated path. This premise is predicated on the assurance that a high standard of safety would be upheld. Four potential optimization strategies can be implemented to enhance the pedestrian environment within rail transit stations.

5.1. The Importance of Attending to Individuals with Special Needs and Offering Services

It is imperative to recognize the distinct needs of different groups of individuals and ensure the provision of suitable services. For example, it is imperative to provide defined recreational spaces for children and establish dedicated resting zones for elderly individuals. Furthermore, it is imperative to tailor the measures mentioned above to meet the specific demands of diverse functional sectors while also establishing pedestrian infrastructure that aligns with the unique characteristics of each respective location.

5.2. The Linkages of Public Transport Networks in Enhancing the Efficacy of Multimodal Travel

To fully harness the potential of multimodal transportation, it is imperative to enhance the integration with public transit. Ensuring the implementation of rational design principles for bus stops, entrances and exits, as well as the provision of transparent transfer guidance systems and the establishment of barrier-free connections between sidewalks and bus stops, holds significant importance. There is potential for this to enhance the convenience and accessibility of the environment for pedestrians.

5.3. Enhancement and Expansion of Pedestrian Amenities

To increase the overall quantity, it is imperative to prioritize developing pedestrian amenities. The supply can be augmented by implementing various measures, such as installing slopes, wheelchair ramps, guide bricks, and auxiliary facilities. Additionally, widening the pavements, incorporating new rest areas, and providing drinking water points, seats, shade facilities, and other amenities can enhance the overall configuration of rest facilities. Furthermore, enhancing barrier-free facilities can also contribute to the increase in supply. Expanding the dimensions of the pavements represents a viable approach to augmenting the supply. Additional strategies could involve the implementation of supplementary rest places, provision of drinking water stations, installation of seating arrangements, and establishment of shaded facilities. Simultaneously, it is imperative to implement considerate design strategies for pedestrian amenities. Simultaneously, it is important to establish a coherent structure for the pedestrian network, construct an interconnected system of walkways, fill in any gaps in the existing pedestrian routes, and ensure the comprehensive provision of the walking network. iii. Enhance the ambiance by incorporating elements of warmth and cosine while striving to enhance its overall quality.

5.4. Enhancement the Ecological Conditions via Aesthetic Appeal of the Area

In order to enhance the visual appeal and cultural ambiance of the region, it is imperative to employ landscaping techniques and incorporate public art to create a more tranquil mood. The enhancement of spatial awareness can be achieved by constructing flower beds and green belts and integrating art installations, sculptures, and paintings that reflect local qualities. A continuous network of street trees can be implemented strategically to establish interconnected green corridors, which can be intentionally constructed to create cohesive green corridors. Additionally, the utilization of color and lighting can be employed to enhance the aesthetic appeal of the place.

6. Conclusions

The local government needs to appreciate the value of a good walking environment thoroughly, coordinate the resources of different departments, and consistently encourage the creation of a TOD walking environment to ensure the effective implementation of TOD. A good walking environment is the key to successfully implementing TOD. This study has conducted comprehensive and in-depth research and analysis on the walking satisfaction of different types of people. It has not only found the problems of the walking environment, but it has also put forward suggestions to improve the walking environment according to the characteristics and needs of different groups, and the results of this study have an important reference for the government to improve the walking environment of the city further and promote the sustain. However, this study has several drawbacks, such as the absence of representativeness due to the small sample size, the absence of in-depth qualitative research on the factors that influence the outcome, and the restricted number of investigated variables. Therefore, future research needs to adopt a mixed research paradigm to ensure representativeness on the basis of a larger sample size, construct a complete theoretical framework, and explore the influencing variables in depth to produce research findings that are more substantive, more scientific, and more convincing.

In conclusion, this study not only identifies the existing problems but also puts forward targeted suggestions according to the characteristics of different groups by evaluating the satisfaction of the walking environment around the TOD stations in Guangzhou. Additionally, the conclusions of this study have important implications for further improving the walking environment and promoting the sustainable development of urban transport construction. In order to generate more convincing scientific conclusions that can better guide the construction of walking environments around rail transit stations, subsequent studies need to optimize the research design, adopt mixed research methods, and expand the sample representativeness. It is necessary to meet the walking needs of various groups. In order to formulate a design approach that is more scientific and methodical, future study should continue to investigate the influence that functional mixing within TOD has on the layout of pedestrian space.

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