

Article

Investigating Threshold Distances and Behavioral Factors Affecting Railway Station Accessibility: A Case Study of the Seoul Metropolitan Area, South Korea

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Abstract: This study aimed to analyze the characteristics and influencing factors of the access trips of railway users in the Seoul Metropolitan Area, South Korea. A total of 11 metropolitan railway stations and 4 urban railway stations were selected, and data on users' travel characteristics—including access modes, travel purposes, demographic attributes, and whether they were accompanied by infants—were collected through one-on-one interviews. Based on 1683 collected cases, the data were analyzed using a multivariate analysis of variance (MANOVA). The results showed a statistically significant difference between bus access distances, which were 1.78 km for metropolitan railways and 1.59 km for urban railways. In contrast, the walking access distances were approximately 620 m for both, showing a minimal difference. The further analysis of factors influencing the access distance revealed that apartment ownership, users' income level, the presence of accompanying travelers, the distance between stations, the number of transfer routes, and whether users were traveling with infants had significant effects.



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1. Introduction

Railways contribute to addressing urban traffic issues associated with urban expansion, traffic congestion, and air pollution [1]. In terms of urban development, they also play an important role in policy measures to increase the utilization rate of public transportation, such as Transit-Oriented Development (TOD) [2]. In a study by Chen [3], an imbalance was confirmed through the calculation of the TOD convenience index of the subway in China. Through this, it was found that it is necessary to improve the pedestrian environment and accessibility around subway stations and reduce the access distance through linkages with public transportation.

Previous studies on railway systems have mostly focused on high-speed inter-regional accessibility and advanced systems. In terms of urban transportation, however, the connections between railway systems and the walking access distance involved in using railway systems are important. Understanding these factors requires research at microscopic spatial levels, such as on the characteristics of rail users [4]. Yang et al. [5] analyzed important conditions for passengers to use railway systems. They reported that the access distance had an importance of approximately 70%, while other conditions had an importance of approximately 10%, supporting the need for research at more microscopic spatial levels. This indicates that ensuring accessibility to railway systems is important even though an

improvement in the overall service quality of railway systems is essential. In addition, Li [6] also emphasized that the accessibility of railways is an important indicator for evaluating a railway's efficiency. This can vary depending on the scale of the station and is a more important indicator in small stations in particular.

To increase the railway utilization rate and public transportation mode share, it is necessary to improve railway accessibility for passengers. Specifically, access to stations near origins or destinations such as workplaces and schools should be facilitated. In this regard, basic research on the threshold for the access distance is essential. Of course, research on the access distance/egress distance has been conducted in studies related to measures and railway policies to improve the railway utilization rate for addressing urban traffic issues. Despite differences depending on the country, region, and demographic characteristics, however, the thresholds for the access distance presented in previous studies, such as walking access distances of 500 and 800 m, have been commonly applied [7].

Seoul, in Korea, has an area of 605 km², and the length of the urban rail network operated in the city amounts to 343 km. This is similar to a road length of approximately 380 km in New York. Additionally, Seoul has 589 bus routes, and the number of bus routes per square kilometer (0.97) ranks first globally. Compared to 0.64 in London and 0.62 in Paris, it presents a density approximately 50% higher. In Seoul, with a high public transportation density compared to other cities in the world, accessing the subway using bicycles instead of walking may increase the service coverage by 30% to 93.6% [8]. Despite the high density of public transportation systems in Seoul and the surrounding metropolitan area, relevant empirical research remains scarce, thereby reinforcing the critical need for this study.

This study investigated the access modes, access travel characteristics, and demographic characteristics of the passengers at 15 rail stations, including 11 metropolitan rail stations and 4 urban rail stations in the Seoul Metropolitan Area (SMA) of Korea. The interview survey was designed to secure a sample of approximately 100 individuals per station, and a total of 1683 interview surveys were conducted. Finally, the analysis focused on the relationships between the obtained survey data and the characteristics of the surveyed routes (e.g., distance between stations), as well as the relationships between the location characteristics of each station and the access modes and access distance characteristics of passengers. A multivariate analysis of variance (MANOVA) and a multi-level regression model were utilized as analysis methodologies.

2. Literature Review

Studies related to the establishment of the concept of a metropolitan pedestrian catchment area have been conducted since the mid-1990s. Cervero [9] conducted an initial study on users' walking access distance and rail use. Cervero examined the correlations between three major variables (density, land use type and diversity, and transit provision) and rail use and reported that the land use diversity had the largest impact. Alshalalfah and Shalaby researched the walking distance of passengers and its influencing factors [10]. They found that demographic characteristics had very sensitive impacts on the walking distance, which varied depending on the characteristics of passengers (e.g., age and disabilities). Zhao and Deng conducted research on the threshold distance based on such personal characteristics and modes of transport [11]. They mentioned that the threshold for the access distance may increase for access by bus during peak hours as the age of the passengers decreases. They found that the threshold increased by 200 to 300 m for access by bus compared to access by walking and that the threshold was 100 m longer when there was an overpass and it was used. He et al. classified the passengers of Nanjing Subway Line 2 into six groups based on statistical characteristics and examined the difference in their walking access distances [12].

They mentioned that the middle class, in terms of their income, were highly dependent on the subway, and they tended to walk longer distances than other groups. In addition, the passengers' education level and occupation were found to be valid indicators of the distance walked to stations, but there was no correlation between gender and the walking access distance.

Similar results were found in Witchayaphong's study [13]. The study was conducted on Thailand, and the study also found that passengers' income level was the most influential factor in subway use. However, the study also found that gender was an influential factor, and women were found to be more dependent on the subway.

Daniels and Mulley analyzed the correlations between the access distance required to use public transportation and demographic characteristics (e.g., gender, age, and income), as well as travel characteristics (e.g., travel purpose, travel time, and fare) [7]. They found that the total travel distance was a significant factor influencing the choice of subway use among passengers and mentioned that passengers tended to use the subway when the total travel distance was approximately 19 km. In terms of demographic characteristics, they found that the threshold walking distance required to use the subway was high for young people aged between 19 and 49 years and that the threshold was higher for people with a driver's license compared to those without. They presented 400 m as the threshold for the walking distance but mentioned that the subway utilization rate increased when passengers' residences were closer to stations. Meanwhile, a study by Ronda found that passengers tended to use the subway when the total travel distance was 19 km, likely owing to the characteristics of the study area.

The threshold for the access distance also varies depending on the region. In a study by Olszewski and Wibowo conducted in Singapore, it was found that approximately 60% of passengers walk 600 m to access the subway [14]. In a study by Jiang and Mehndiratta [15] conducted on Mumbai rail users, however, the threshold for the access distance was found to be 1.50 m for 86% of passengers. There was also a difference in the threshold for the access distance between the United States and Canada, as the results were 300 to 900 m for the United States and 400 to 800 m for Canada.

As for studies conducted in Korea, Lee et al. analyzed the effects of socioeconomic conditions (e.g., personal income and workplace location) and key factors (e.g., access time and distance) on the public transportation accessibility using logistics models and found two major thresholds for the walking access distance (700 and 1100 m) [16]. Conversely, Lee et al. calculated the threshold walking distance for the use of public transportation using the socioeconomic indicators of individuals and households as well as logistic models, and the result was 440 to 460 m [17]. There was a difference in the threshold for the walking distance between the two studies, indicating a difference in regional characteristics even within the same country. Considering that personal mobility (PM) was introduced in mid-2010 and has been popular since 2020 in Korea, it can be said that this difference is affected by access to infrastructure, despite being found within the same area. In a study by Jun et al. [18] in Korea, it was found that the number of passengers and catchment area for each station varied depending on various elements, such as the population, employment density, land use diversity, and connectivity between transportation modes. They examined the land use characteristics of the pedestrian catchment area (PCA) based on the TOD principle. Based on their study using the population density and the commercial land use ratio, they suggested that a radius of 600 m should be used as the PCA in the public transportation environment of cities with high business, commercial, and population densities, such as Seoul.

Li et al. [19] calculated the walking time of passengers in relation to the characteristics of passengers, the time of day, the number of passengers according to the station, and

facility sizes using transportation card data. They found that there was a difference in the walking time of passengers depending on peak/non-peak hour characteristics and that the walking time was short during peak hours. In addition, Viggiano et al. calculated the average walking distance for passengers and the maximum access distance traveled by bicycle using card data for London. They found that the average walking distance varied depending on the number of transfers and the number of stops and that the walking distance category of 0 to 2 miles (3219 m) exhibited the highest proportion on average. In addition, the number of transit stops was not significant. In the case of transfers, there were some differences depending on the number of individual journeys, but the walking distance category of 0 to 2 miles invariably accounted for the highest proportion of the variance. A comparative study of the access distance for walking and cycling using card data in Nanjing, China, found that while both modes had the same access travel time of 8 min, the travel distance differed by about 1.3 times due to the difference in modes [20].

Jun et al. [18] divided factors that affect the access distance to rail stations into four main categories: land use and the built environment, socioeconomic variables, transit-related variables, and the location/accessibility/neighborhood [21].

Through various studies, it was possible to identify various factors that affect the threshold for the walking distance to rail stations. It was found that the threshold is closely related to geographic factors that vary depending on the country and city, as well as demographic characteristics.

The studies reviewed in this study can be found in Table 1. The studies indicated that the population density, employment density, land use diversity, and the intermodal connectivity estimated using the number of bus stops showed a positive correlation with the subway utilization rate. Chia [22] distinguished eight groups using various demographic indicators and analyzed their sensitivity to the walking access time. Regarding the results, part-time workers, high-income earners, and the elderly were the most sensitive to the walking time, while students and office workers were the least sensitive. Based on the various studies examined above, it was found that public transportation accessibility is significantly different depending on personal characteristics.

Table 1. Summary of review.

Author (Year)	Target Area	Method	Dependent Variable	PCA	Findings
Cevero [9]	MD, USA	OLS	Boarding at 34 stations	N/A	Employment density; residential density; land use diversity; residential orientation; terminal
Lee et al. [17]	New towns, Republic of Korea	ANOVA	Walking distance	700 m	Annual incomes under 50 million won; middle class; possession of vehicles; age
Olszewski and Wobowo [14]	Singapore	OLS	Boarding at 11 stations	608 m	Number of road crossings; traffic conflicts; number of ascending steps
Alshalalfah and Shalaby [10]	Toronto, ON, Canada	OLS	Morning peak boarding	300 m	Dwelling type of the household; number of vehicles in the household; transit service frequency
Jiang et al. [15]	Jinan, China	OLS	Boarding at 3 stations	1350 m	Transfer station; shaded corridors; peak time
Zhao et al. [11]	Nanjing, China	OLS	Average boarding	200–300 m	Morning peak time; younger commuters; increasing household income; accessibility
Daniels and Mulley [7]	Sydney, Australia	GWR	Walking distance to buses and trains	400 m	Walking trips to train station were longer than those to bus stop; walking distance in sub-urban areas was longer; trip purpose; age
Jun et al. [18]	Seoul, Republic of Korea	GWR	Average boarding	600 m	Level of mixed-use land; population and employment densities; land use diversity; intermodal connectivity
Viggiano et al. [21]	Oyster, London	ANOVA	Card data on a.m. peak	0–2 mile	Number of journeys; number of stops
Chia et al. [22]	Brisbane, Australia	ANOVA	Household travel survey	400 m	Age; income; labor force

Table 1. Cont.

Author (Year)	Target Area	Method	Dependent Variable	PCA	Findings
He et al. [12]	Nanjing, China	ANOVA	Walking distance	N/A	Age; middle-class household income; travel frequency; travel purpose; education; exchange station; spatial factors
Li et al. [19]	Nanjing, China	MLE	Smart card data	N/A	Travel time; time of day (travel at peak time took longer); elderly or disabled passengers had longer walking distances
Lee et al. [17]	Seoul, Republic of Korea	ECDF	Average boarding	600 m	Number of transfers; total distance of trip; access walking distance

This study set itself apart from previous studies in the following ways: First, it attempted to comprehensively consider the accessibility of rail stations, transportation characteristics, and the characteristics of railway routes, including the number of trunk lines, feeder lines, and metropolitan bus routes that are connected to rail stations as well as rail station sizes, in addition to the demographic characteristics of rail users. Second, based on this, various influencing factors were identified, and their relative influence was quantitatively presented. Third, an attempt was made to present rich insights into the walking access distances required for rail use, even though the scope was limited to the SMA.

3. Data and Methods

As for the routes and stations to be surveyed, 11 metropolitan rail stations, including Geomam, Gyeyang, Nogyang, Deokgye, Digital Media City, and Sangbong stations, and 4 urban rail stations, including Seolleung and Hongje stations, were selected. For selecting survey targets (routes and stops), stations included in the route across Seoul that had a similar land use and residential population density near the station and were sufficiently distant (approximately 10 km or more) from other survey stations were selected. The survey method was a one-on-one interview method designed to provide a sample of approximately 100 for each rail station in the Figure 1. Table 2 displays the number of samples collected for each rail station and location of the rail station is displayed in Figure 2. The survey items included individual and household characteristics, such as gender, income, and the number of household members, and rail station use and access characteristics, such as the travel purpose, travel mode, and travel time. Data collection was carried out across both peak and off-peak times on weekdays, including typical morning and evening commute times.

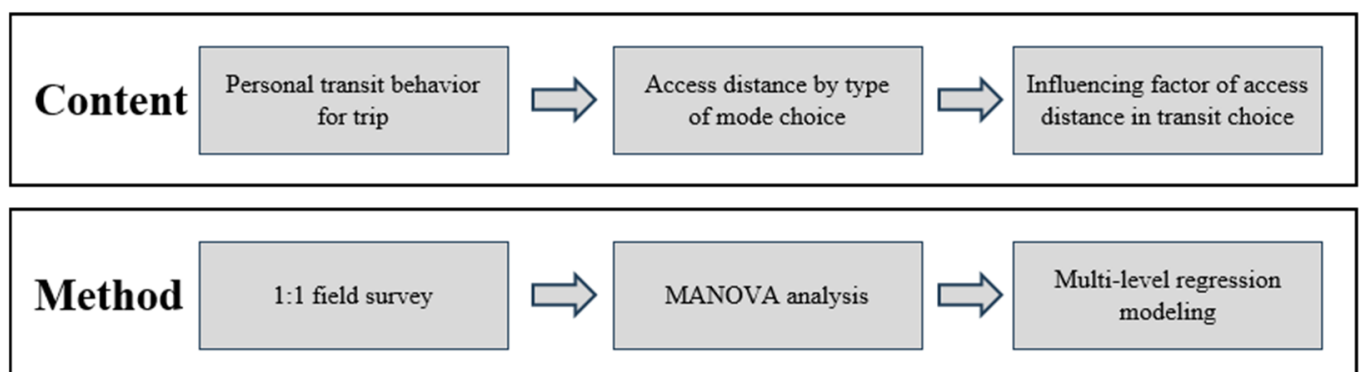


Figure 1. Research method.

To minimize bias in the data due to the sample design, stratified sampling was performed regarding the gender and access mode of survey subjects for each rail station. Accordingly, the survey was designed to ensure that 50% of the subjects were males and

50% were females and that 50% of the subjects had used a bus access mode and 50% had used a walking access mode.

Table 2. Sample size for each station surveyed.

Type	Rail Station	Code	N	Type	Rail Station	Code	N
Metropolitan rail	Geom am	1	113	Metropolitan rail	Toegyewon	10	116
	Gyeyang	2	147		Pyongnae hopyong	11	117
	Nogyang	3	107		Sub-total	-	1302
	Deok gye	4	150	Urban rail	Seol leung	12	92
	Digital Media City	5	143		Hong je	13	95
	Sang bong	6	111		Chang-dong	14	100
	Hoegi	7	114		Kkachisan	15	94
	Unjeong	8	81		Sub-total	-	381
	Tan hyeon	9	103				1683

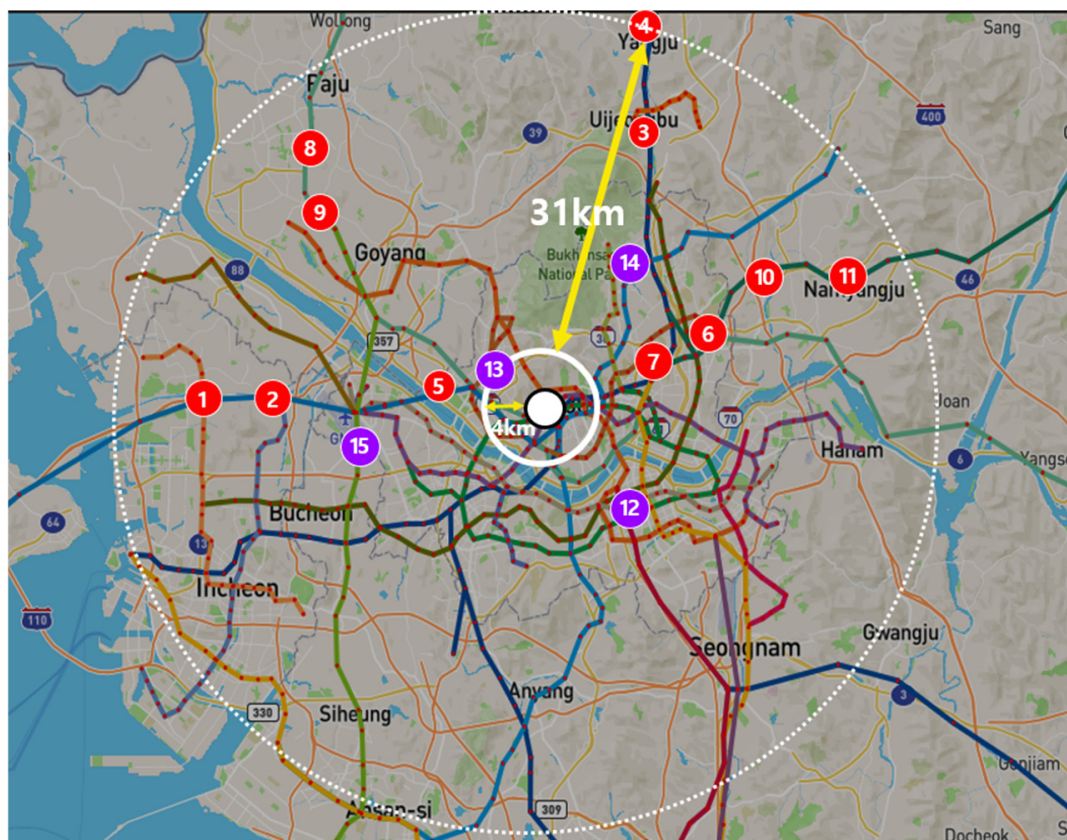


Figure 2. Location of surveyed stations.

4. Descriptive Analyses

The rail stations under survey had an average daily passenger count of 14,285. The number of connected bus routes was eighteen, and the number of transfer routes was one. When the passenger characteristics for the 11 target stations were analyzed, apartment residents represented 76% of the sample, office workers 55%, and vehicle owners 39%. The average number of transfers was 1.1, and 76% of the passengers used the rail stations for commuting to work. Specific figures can be found in Table 3.

Table 3. Descriptive statistics for survey data.

	Variable		Type	N.	Ave.	Std.
Dependent variables	Distance	LD1	Continuous	1683	2.91	0.32
	(all modes)	LD2	Continuous	539	3.13	0.24
	Distance by bus	LD3	Continuous	898	2.72	0.26
	Walking distance	LD4	Continuous	246	3.10	0.27
	Distance traveled via multiple modes	D5	1: bus or multiple; 0: walking	1686	0.50	
Independent variables	Gender	I1	1: male; 0: female	1683	0.49	
	Residence type	I2	1: apartment; 0: other	1683	0.76	
	Job	I3	1: worker; 0: other	1683	0.55	
	Marital status	I4	1: married; 0: not married	1683	0.60	
	Number of people in the household	I5	Continuous	1683	3.52	1.06
	Number of children	I6	Continuous	1683	0.20	0.50
	Number of workers	I7	Continuous	1683	1.76	0.71
	Driver's license	I8	1: yes; 0: no	1666	0.64	
	Vehicle ownership	I9	1: yes; 0: no	1683	0.39	
	Housing tenure	I10	1: owner occupancy; 0: other	1683	0.53	0.50
	Income (per year)	I11	1: over KRW 500 million; 0: other	1683	0.47	
	Age	I12	Discrete	1683	2.10	1.08
	Trip purpose	I13	1: commute to work/school; 0: shopping/leisure	1683	0.76	
	Number of transfers	I14	Continuous	1683	1.10	0.31
	Average passengers (per day)	I15	Continuous	15	14,285	15,735
Station characteristics	Station spacing (m)	I16	Continuous	15	2796	2767
	Number of bus routes	I17	Continuous	15	18.53	13.24
	Number of rapid bus routes	I18	Continuous	15	3.17	3.85
	Number of trunk line bus routes	I19	Continuous	15	4.78	6.00
	Number of feeder bus routes	I20	Continuous	15	5.57	6.36
	Number of local bus routes	I21	Continuous	15	1.14	1.80
	Number of subway transfer lines	I22	Continuous	15	0.98	1.21
	Number of exits	I23	Continuous	15	3.50	2.90
Route characteristics	Station structure	I24	1: ground-level; 0: underground	15	0.83	
	Type of rail service	I25	1: metropolitan; 0: urban	11	0.77	

5. Results

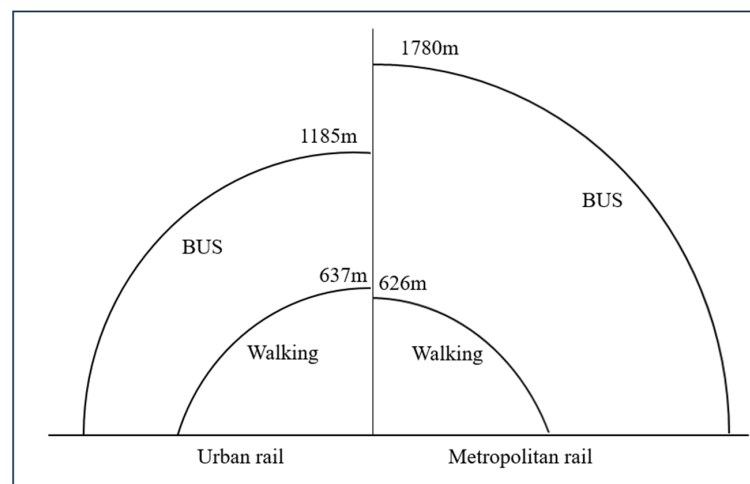
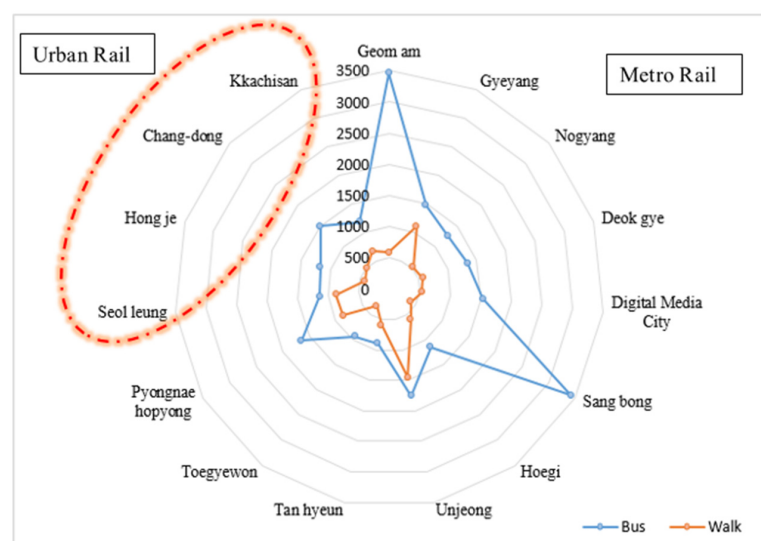
5.1. Verification of Differences in Access Distance by Rail Station

Upon analyzing the access distances of passengers who reached the rail stations by bus, it was found that there was a difference in the access distance depending on the type of rail service, as the results were 1.78 km for the metropolitan rail stations and 1.59 km for the urban rail stations. Moreover, there were differences in the bus access distance even between the metropolitan rail stations. For example, there was a large difference in the access distance between the Geomam and Tanhyeun stations, as the results were 3.5 km and 0.9 km, respectively. These data indicate that the choice of residential location and the resulting bus access distance varied depending on the type of rail service and the attractiveness of the rail stations.

When the access distances of passengers who reached the rail stations on foot were analyzed, they were found to be similar between the metropolitan and urban rail stations, as the results were 626 and 629 m, respectively, as shown in Table 4. There were, however, significant differences in the walking access distance by the rail station as shown in Figure 3. For example, the walking access distance to Unjeong station was 1.5 km, while the walking access distance to Toegyewon station was 341 m. These results for other stations can be seen numerically in Table 4, and these differences can be seen graphically in Figure 4. This appears to have been because the residential location characteristics were different depending on the location and type of the rail stations.

Table 4. Differences in access distance by type of mode choice.

Type	Rail Station	Bus (m)		Walking (m)	
		Ave.	Std.	Ave.	Std.
Metropolitan rail	Geom am	3463	1302	587	290
	Gyeyang	1467	605	1100	388
	Nogyang	1279	473	525	261
	Deok gye	1340	453	583	252
	Digital Media City	1539	459	534	181
	Sang bong	3422	243	405	171
	Hoegi	1154	283	603	321
	Unjeong	1752	620	1446	565
	Tan hyeun	893	334	587	393
	Toegyewon	943	137	341	170
	Pyongnae hopyong	1650	878	861	441
	Sub-total	1780	1143	626	422
	Seol leung	1131	271	868	444
Urban rail	Hong je	1173	815	410	172
	Chang-dong	1510	541	489	241
	Kkachisan	1174	527	668	202
	Sub-total	1185	660	637	356
Total		1597	1055	629	409

**Figure 3.** Differences in access distance by type of rail service and mode choice.**Figure 4.** Differences in access distance by type of mode choice.

A review of previous studies conducted in South Korea revealed that Lee et al. [16] proposed pedestrian access thresholds of 700 m and 1100 m, while Jun et al. [18] suggested a 600 m pedestrian catchment area. In the present study, the pedestrian access distances were found to be within a comparable range. Furthermore, the variations in the walking access distances across individual stations were also observed to fall within the ranges reported in the aforementioned studies.

For the statistical verification of the difference in the access distance depending on the rail station and access mode, the MANOVA technique was utilized by setting the access distance as a dependent variable. A MANOVA is used to compare the vectors of group means when there are multiple dependent variables. If the correlations among the dependent variables are high, this demonstrates that conducting a MANOVA is desirable instead of conducting an analysis of variance (ANOVA) several times. This is because a repeated ANOVA may increase the probability of type 1 errors. Therefore, a MANOVA was conducted after setting “the average vectors of all rail station groups are the same” as a null hypothesis.

The analysis results revealed that the significance level was less than 0.05 for all four statistics, as illustrated in Table 5, indicating that there was a significant difference in the access distance depending on the rail station. The squared value of the bus access distance was found to be the highest among the access modes, indicating that bus service access management is important in promoting the use of the rail stations, as shown in Table 6. There was, however, no significant difference in the walking access distance depending on the type of rail service (significance level: 0.188).

Table 5. Multivariate analysis of variance results.

	Effect	Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared	Observed Power
Intercept	Pillai's Trace	0.989	49,994	3.000	1679.000	0.000 **	0.989	1.000
	Wilks' Lambda	0.011	49,994	3.000	1679.000	0.000 **	0.989	1.000
	Hotelling's Trace	89.33	49,994	3.000	1679.000	0.000 **	0.989	1.000
	Roy's Largest Root	89.33	49,994	3.000	1679.000	0.000 **	0.989	1.000
Type of rail service	Pillai's Trace	0.031	17.99	3.000	1679.000	0.000 **	0.031	1.000
	Wilks' Lambda	0.969	17.994	3.000	1679.000	0.000 **	0.031	1.000
	Hotelling's Trace	0.032	17.994	3.000	1679.000	0.000 **	0.031	1.000
	Roy's Largest Root	0.032	17.994	3.000	1679.000	0.000 **	0.031	1.000

** = $p < 0.05$.

Table 6. Results from tests of between-subjects effects.

	Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Observed Power
Corrected Model	Distance (all modes)	0.420	1	0.420	4.016	0.045	0.002	0.517
	Distance by bus	48.604	1	48.604	22.856	0.000 **	0.013	0.998
	Walking distance	3.253	1	3.253	1.732	0.188	0.001	0.260
Intercept	Distance (All modes)	9892.368	1	9892.368	94,633.47	0.000 **	0.983	1.000
	Distance by bus	1462.906	1	1462.906	687.922	0.000 **	0.290	1.000
	Walking distance	2387.302	1	2387.302	1270.969	0.000 **	0.431	1.000
Type of Rail Service	Distance (All modes)	0.420	1	0.420	4.016	0.045	0.002	0.517
	Distance by bus	48.604	1	48.604	22.856	0.000 **	0.013	0.998
	Walking distance	3.253	1	3.253	1.732	0.188	0.001	0.260

Table 6. Cont.

	Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Observed Power
Error	Distance (All modes)	175.721	1681	0.105				
	Distance by bus	3574.741	1681	2.127				
	Walking distance	3157.477	1681	1.878				
Total	Distance (All modes)	14,398.228	1683					
	Distance by bus	5315.799	1683					
	Walking distance	6707.653	1683					
Corrected Total	Distance (All modes)	176.141	1682					
	Distance by bus	3623.346	1682					
	Walking distance	3160.730	1682					

** = $p < 0.05$.

5.2. Comparison of Access Distance Estimation Models

It was found that there were statistically significant differences in the access distance depending on the rail station and access mode. To analyze factors that affected the access distance, a multi-level regression model was constructed using the access distance as the dependent variable and the individual, household, and rail station characteristics as independent variables, as shown in Table 7. The coefficients for each influencing factor were estimated. The model was constructed by using logarithms to normalize the distribution of the access distance, which was a positive value.

Table 7. Comparison of models estimating access distance by mode.

			Access Distance (All Modes)		Distance by Bus		Walking Distance	
			Coef.	t	Coef.	t	Coef.	t
Personal/household characteristics	Access mode	D5	−0.347	−25.180 ***				
	Gender	I1	−0.018	−1.548	−0.018	−1.121	−0.015	−0.907
	Residence type	I2	−0.058	−4.088 ***	−0.046	−2.399 **	−0.045	−2.306 **
	Job	I3	0.014	0.992	−0.020	−1.035	0.044	2.294 **
	Marital status	I4	0.094	1.619	0.135	1.061		
	Number of people in the household	I5	0.009	1.444	0.014	1.618	0.002	0.218
	Number of children	I6	0.013	1.165	−0.040	−2.448 **	0.030	2.044 **
	Number of workers	I7	0.003	0.280	−0.004	−0.262	0.013	1.084
	Driver's license	I8	0.009	0.642	−0.016	−0.816	0.015	0.831
	Vehicle ownership	I9	−0.003	−0.220	0.026	1.317	−0.016	−0.871
	Housing tenure	I10	−0.000	−0.006	0.001	0.071	−0.010	−0.580
	Income	I11	0.027	2.139 **	0.034	1.864	0.028	1.622
	Age	I12	−0.007	−1.122	−0.007	−0.763	−0.003	−0.382
	Trip purpose	I13	0.007	0.497	0.004	0.203	0.012	0.557
	Number of transfers	I14	−0.103	−1.841				

Table 7. Cont.

			Access Distance (All Modes)		Distance by Bus		Walking Distance	
			Coef.	t	Coef.	t	Coef.	t
Station characteristics	Average passengers per day	I15	0.007	2.131 **	−0.000	−0.125	0.012	2.314 **
	Station spacing	I16	0.009	3.028 **	0.010	4.457 ***	0.011	2.244 **
	Number of bus routes	I17			−0.015	−2.282 **		
	Number of rapid bus routes	I18	−0.006	−0.570			−0.009	−0.481
	Number of trunk line bus routes	I19	−0.025	−1.864			−0.053	−2.487 **
	Number of feeder bus routes	I20	0.003	0.412	0.025	2.447 **	0.002	0.202
	Number of local bus routes	I21	0.051	3.064 **	0.050	2.867 **	0.060	2.268 **
	Number of subway transfer lines	I22	0.143	2.252 **	0.204	3.425 ***	0.248	2.412 **
	Number of exits	I23	0.005	0.332	0.018	1.180	−0.005	−0.212
	Station structure	I24	−0.108	−0.818	−0.448	−3.130 **	−0.135	−0.637
Route characteristics	Type of rail service	I25	−0.145	−0.992	0.383	2.438 **	−0.315	−1.356
Model statistics	AIC			−141.608		−194.385		−8.698
	BIC			−130.789		−185.917		0.836

** = $p < 0.05$, *** = $p < 0.01$.

It was found that the access distance to the rail stations was long for non-apartment residents, high-income residents, and rail stations with many passengers, routes with long distances between stations, and routes with many transfers. This appears to have been because multi-family houses and row houses are usually the closest to rail stations in Korea, and high-income residents mostly live in eco-friendly areas rather than relatively crowded commercial districts due to their high share of passenger cars. The access distance for passengers was relatively long for rail stations with many passengers and routes with long distances between stations. As shown in Table 7, the station spacing was found to have a statistically significant positive effect on the access distance (Coef. = 0.009, $t = 3.028$). This suggests that as the distance between stations increased, users tended to travel farther to access rail stations. Furthermore, the number of subway transfer lines (Coef. = 0.143, $t = 2.252$) and the number of local bus routes (Coef. = 0.051, $t = 3.064$) were also positively associated with longer access distances, implying that greater station connectivity and accessibility enhance the attractiveness of stations, thereby influencing residential location choices and travel behavior.

In the case of the bus access distance to the rail stations, it was found that the access distance decreased as the number of children in a family increased. This appears to have been because people traveling with children are highly resistant to transfers, especially between public transportation modes. The bus access distance flexibly increased for the rail stations with many connected bus routes. This finding confirms the significance of connected transportation systems in promoting the use of rail stations. In particular, the bus access distance to the metropolitan rail stations was found to be significantly longer than that to the urban rail stations. This confirms that the job–housing proximity range is different depending on the type of rail service and that it is necessary to connect differentiated transportation and urban facilities.

In the case of the walking access distance to the rail stations, the access distance when commuting to work flexibly increased. Unlike the bus access distance, the walking access distance became longer as the number of children increased. This variation appears to have been due to the fares associated with the access modes and the inconvenience of transfers.

As with the bus access distance, the walking access distance grew longer as the distance between stations and the number of transfer routes increased. It was found that the bus access distance to the above-ground stations was longer than that to the underground stations. This appears to have been because underground stations are generally located in residential or commercial areas, whereas aboveground stations are constructed in areas with a low land use density.

6. Conclusions and Discussion

In this study, eleven metropolitan rail stations and four urban rail stations were selected, and data on demographic and travel characteristics (e.g., rail access characteristics, gender, household characteristics, and access modes) were collected using a one-on-one interview method. Upon analyzing the access distance for rail use, the bus access distances were found to be 1.78 km for the metropolitan rail stations and 1.59 km for the urban rail stations, showing a statistically significant difference. This evidence indicates that bus connections are important in improving the railway utilization rate. When the walking access distance for rail use was analyzed, the results were 636 m for the metropolitan rail stations and 629 m for the urban rail stations, showing similar levels for the two and no statistically significant difference. When the factors influencing the access distance were examined, it was found that the access distance to the rail stations was long for non-apartment residents, high-income residents, rail stations with many passengers, routes with long distances between stations, and routes with many transfers. The observation that non-apartment residents tended to have longer walking access distances compared to apartment residents suggests a meaningful association with the spatial distribution of high-density apartment complexes near railway stations. This finding supports the rationale of Transit-Oriented Development (TOD), which advocates for the strategic placement of high-density residential developments and the integration of feeder bus networks around stations (transit hubs).

Especially in the case of the bus access distance, the access distance decreased as the number of children in a family increased. These data indicates that travelers with children are highly resistant to transfers. The walking access distance was found to be long for commuting to work and traveling with children.

This study reviewed previous studies on the rail access distance and derived conclusions using a more microscopic approach by obtaining data through in-depth interviews. Metropolitan and urban rail stations were distinguished in this approach, and both bus and walking access distances were covered, with comprehensive discussions on the factors influencing them. Unlike in previous studies, the residential and household characteristics of rail users were considered. Based on the analysis of these factors, policy measures to improve the railway utilization rate were discussed. These factors differentiate this study from previous studies.

Finally, this study is expected to contribute to the development of policies for improving railway utilization rates in Korea and other countries.

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