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Relationship Between Urban Decline and Walking Trips by Trip Purpose in Seoul Metropolitan City: Focused on Urban Decline Index*

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Abstract

Urban decline is a multifaceted problem, comprising numerous socio-spatial factors, and has a self-enforcing effect that aggravates already-declined areas. With a growing concern about the declining trend, the central government has actively used institutional interventions, including the Urban Regeneration New Deal Project, to revitalize the physical infrastructure and social capital. With regard to strategic approaches, fostering pedestrian-friendly environments is crucial for revitalization. This study aims to investigate the association between walking trips and urban decline. We use three types of measurements for urban decline: indices with individual subjects, comprehensive decline index with subject, and comprehensive index total. Using the 2016 Household Travel Diary Survey data, we obtained information on walking behaviors and categorized walking trips into utilitarian and leisure walking. Employing multilevel logistic regression with random intercept, we estimate the effects of urban decline factors on the likelihood of a person walking for the purpose of a trip. We find that a decline in the demographic and social environment is related to a decrease in the possibility of walking with utilitarian purposes. In addition, the more a neighborhood (a Dong) declined, the less a resident in the neighborhood walks with utilitarian purposes, while the more leisure walking trips tend to increase. This implies that central and local governments must consider demographic and socioeconomic decline trends in urban regeneration plans to promote walkability. Additionally, it is necessary to consider ways to support leisure walking in declined areas.

Keywords Walkability, Urban Decline, Utilitarian Walking, Leisure Walking, Random Intercept Logit Model
주제어 보행활성화, 도시쇠퇴, 실용보행, 여가보행, 임의절편로짓모형

Ⅰ. Introduction

Along with the paradigm shift in urban planning policies towards sustainable development, the importance of walking has been heightened. Walking is an act that connects every means of transportation and serves as a fundamental mode of the trip in recent urban planning and design concepts such as compact cities and transit-oriented development (TOD) for sustainable development (Choi et al., 2013). In addition to its role as a means of transport, walking is crucial in creating a sustainable city in reducing pollution, creating social capital, and revitalizing streets. (Kim et al., 2014; Sa and Lee, 2018).

Pedestrian policies subject only to the past transportation

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sector have gradually expanded to a rather extensive project associated with urban regeneration and other relevant fields (Lee and Jung, 2019). Indeed, pedestrian policies are considered one of the core strategies to revitalize declined cities in urban regeneration policies, since walking is the most crucial barometer in understanding how vibrant a city is and at the same time has excellent potential in revitalizing a city as a whole. Meanwhile, as the level of decline nationwide by Eup (Town), Myeon (Township), or Dong (Neighborhood), which are the units of the administrative division of the Republic of Korea, has aggravated from 64.5% in 2013 to 69% in 2017 (Korea Research Institute for Human Settlements, 2019), walking-related projects under the framework of urban regeneration policies for declined cities are expected to increase.

"Decline" is a spatial phenomenon occurring throughout different parts of a city, and the issues resulting from urban decline and interactions of various relevant factors could lead to a vicious, downward spiral. In general, the aspects of urban decline appear in social, economic, and physical sectors. According to Korea Urban Renaissance Center (KURC, 2010), it is possible to define urban decline as "A state in which a city is losing or has lost vitality in three areas: demographic society, industrial economy, and physical environment." In line with the understanding of urban decline as a phenomenon comprising social, economic, and physical aspects, some attempts to approach the urban decline with social and spatial factors. Earlier studies showed that the urban decline is closely related to several factors, including health and traffic accidents. (Jo et al., 2014; Park and Park, 2017).

Decisions regarding walking are made based on the socio-economic characteristics and walking environment of an individual, and the walking environment encompasses not only the physical elements but also social, economic, and demographic factors. Therefore, we need a comprehensive approach to carrying out studies on walking, taking various factors related to walking into account (Choi et al., 2013). Nevertheless, most empirical studies conducted domestically on walking tend to focus on the relations between walking and the physical environment, and those dealing with social, economic, and demographic factors are still insufficient. In particular, few studies have focused on walking and urban decline as a universal phenomenon, even though pedestrian policies have expanded thus far. Decrease in population, physical deterioration, weakened economic foundation, and spatial concentration of poverty are associated with walking. Also, to encourage walking activity and create a practical effect of walking by policy measures, it is necessary to identify and fine-tune the factors affecting walking activities (Sa and Lee, 2018). Along with the extensive walking-related projects being promoted recently by urban regeneration policies to tackle urban decline issues, studies clearly showing the relation between urban decline and walking should be further carried out.

Against this backdrop, this study aims to review the preceding literature on urban decline and walk and perform empirical analyses on the relation between urban decline and walking trips by purpose[1] based on 181,330 trips surveyed in 423 Dongs (administrative districts) in Seoul. Since Seoul Metropolitan City is one of the top places where urban regeneration projects and walking policies are being applied and taking place, this study's results can easily find utility in policymaking. This study has two broad purposes: The first is to analyze correlations between the decline phenomenon and walking trips by purpose. To that end, we attempt to identify the relation between urban decline factors and walking trips by purpose, controlling individuals' socio-economic characteristics and physical environment factors linked with walking trip choices from some prior studies. The second is to analyze the decline phenomenon's effect size at the Dong-level in purpose-specific walking trip choices, using the Proportional Reduction in Error (PRE)[2] in the Hierarchical Linear Model.

Ⅱ. Literature Review

1. Spatial characteristics of urban decline

Problems stemming from urban decline tend to be intensively in specific places in a city and are multi-faceted results generated from complex interactions of diverse social and spatial factors (KURC, 2010). Thus, the urban decline reflects not only physical aspects but also social and economic sides as well, both an empirical analysis and comprehensive interpretation are required to understand the phenomenon (Kim, 2010) fully. To identify the spatial characteristics of the urban decline phenomenon in this study, we looked into case studies in two fields of the subject: ones on the spatial pattern of decline and others dealing with the relation between urban decline and social and spatial factors.

First, we reviewed studies on the spatial pattern of urban decline. Kim, K. J.(2010) performed a qualitative study to identify the causes behind urban decline in Korea and its characteristics. According to its analyses on 84 cities nationwide, spatial concentration of poverty was found, including physical obsolescence of infrastructure, neglected properties, depressing sales, high vacancy, poverty and job loss, and the socially disadvantaged class's residence. Despite the problems due to poverty, those cities' social environments are relatively healthier than in Western countries. Lee, H. Y. et al. (2010) derived the multiple decline index (MDI), analyzing the conditions of decline and spatial patterns in 2,171 Dongs or Eups nationwide. They sampled the top 30% of the administrative divisions based on the MDI and found that Dongs or Eups in Seoul and other metropolitan cities took up a significantly large portion, signifying that the decline phenomenon is occurring universally regardless of the size of a city. Chae, H. W. (2013) analyzed the spatial patterns of urban decline within Seoul using the MDI and found that the decline pattern had shifted from the center of the city to the northern districts and that every Gu had the declined Dongs in the city. Next, studies examined the relationship between the urban decline and social or spatial factors. In order to find the relationship between the decline and health, Jo et al. (2014) analyzed how the MDIs in demography, economy, and physical environment are related to the health level of a region, with the health care characteristics of 228 Sis (Cities), Guns (Counties), and Gus (Districts) nationwide serving as controlled variables. The results showed that the higher the MDI rose, the lower the health performance was. Park, N. Y., and Park, B. H. (2017) examined the relations between individual indices of social, economic, and physical decline factors and the number of accidents that occurred in 251 Sis, Guns, and Gus nationwide to shed light on how the urban decline is related to traffic accidents. The results showed that the number of accidents per 1,000 persons became higher as the ratio of elderly population, annual average population growth rate, the ratio of aged dwelling units, percentage change in the number of businesses, and the number of employees in retail and wholesale per 1,000 persons grew higher than others.

2. Relation between socioeconomic characteristics and walking

Since the physical environment and socioeconomic, and other personal factors may affect walking, a relatively comprehensive approach must fully understand the relation (Choi et al., 2013). Preceding studies have defined socioeconomic characteristics by diverse variables, ranging from those at the individual/household level to neighborhood level, to resolve inequalities in walking activities due to socioeconomic characteristics.

Agrawal and Schimek (2007) found that individuals with different socioeconomic characteristics may choose different walking trips for different purposes. They that with higher levels of education, utilitarian and leisure walking increased accordingly. When the income level was high, the proportion of utilitarian walking was low, but leisure walking was high. The study also confirmed that Blacks were less likely to choose utilitarian walking than Whites even with variables such as income, education, density, and car-ownership factors controlled. Cerin et al. (2009) analyzed what impact socioeconomic characteristics have on walking as a means of mobility both directly and indirectly. The results showed that the higher the household income and neighborhood income level were, the longer the physical activity hours and leisure time for physical activity were, which indirectly impacted walking for mobility. However, there is no significant direct impact. Considering both the direct and indirect impact, walking for mobility increased as the household income decreased and increased neighborhood income. It implies that household income and neighborhood income bear different significance in terms of walking. Lee, Y. S. et al. (2013) examined the changes in pedestrian volumes in Seoul's neighborhood units and their relations with diverse urban variables. The urban characteristics variables included the search Dong's socioeconomic characteristics were classified primarily into land use, finance, income level, population, employment, and car ownership factors. The results showed that the land-use diversity index and factors related to population and employment influenced pedestrian volume changes, and as the diversity index and the employee density rose, walking increased. Sung, H. G. et al. (2015) investigated the determinants of walking activities for leisure and trip purposes focusing on individual and household level characteristics, and reported that walking activities for leisure and trip purposes were different. In particular, the differences in leisure purposes mainly arose from gaps in personal attributes, while the walking activity time for trip purposes differed not only by individual attributes but also by regional characteristics. The higher the level of education, the less time spent on leisure walking and walking for the trip, and the higher the personal income, the shorter the trip's walking time.

3. Relation between the physical environment and walking

Since the new urbanism and other planning-oriented approaches emerged in the 1990s, various empirical studies on the relationship between the physical environment and walking have been conducted, led mainly by American and other western researchers (Lee et al., 2014). Initially, researchers regarded walking as general pedestrian activities in analysis of its relationship with the physical environment (Lee and Ahn, 2007; Lee et al., 2014), but later some studies have widened its scope by categorizing the purpose of walking (Lee and Choi, 2018) or by segmenting the spatial types of walking (Lee et al., 2013).

This study examined the preceding literature, focusing on studies where the spatial scope was by Dongs. Lee, K. H., and Ahn, K. H. (2007) examine the association of neighborhood environment with walking times for 40 Dongs in Seoul, using Korea National Health and Nutrition Examination Survey data. They found that the land-use mix, multi-family row dwelling units, intersections per km, street connectivity, land gradient, and accessibility to parks and streams affect the walking time. Kim et al. (2014) examined the relations between the urban form and walking probability in Seoul. They consider more variables, including the location of neighborhood and regional attributes. The study shows that neighborhood and regional attributes affect the probability of walking, specifically population density, building coverage ratio, land use mix, street connectivity, intersection per km, land gradient, accessibility to the bus stop, and road ratio. Lee, K. H. et al. (2014) looked into the correlation between the neighborhood environment and pedestrian volume in 424 Dongs in Seoul using the National Household Travel Survey data and reported that the land use mix, intersections per km, and land gradient, were statistically significant variables. Lee, J. S., and Choi, H. M. (2018) investigated 423 Dongs in Seoul and reported that different physical environments of neighborhoods play a role according to the purpose of walking trips. Studies show that utilitarian walking is affected by road network density, population density, mix of business establishments, parks, accessible public sports facilities area. In contrast, leisure walking is related to accessibility to subway and bus stops, street connectivity, road network density, and parks' floor area.

4. What makes this study different

Findings from previous works can be summarized as follows:

First, the decline is a spatial phenomenon and results of multi-faceted interactions among social, economic, and physical factors, requiring empirical analysis and comprehensive interpretation to understand the urban decline phenomenon fully. Also, the decline can be measured using an individual index of urban decline or multiple decline indexes.[3)]

Meanwhile, the decisions on walking are made not only by the physical environment but also by socioeconomic characteristics. The physical and socioeconomic factors related to walking are different depending on the purpose of walking trips. Although some attempts to clarify the relation between walking and socioeconomic characteristics of a neighborhood in a somewhat limited scope, it appears insufficient to fully understand the relation between walking and decline only with such studies.

This study suggests different approaches from the primary research as follows:

First, we examined the relationship between decline and walking by extending the scope of variables to include urban decline factors, adding it to land use, urban form, and street environment, commonly employing physical environment factors in preceding research. Second, to understand the urban decline phenomenon's complexity, we analyzed the urban decline factors by categorizing them into individual urban decline index, multiple decline index by sector, and comprehensive multiple decline index.

Ⅲ. Research Methods

1. Analytical models

In this study, we construct analytical models using factors such as socio-economic characteristics of individuals (S), the physical environment of the neighborhood (N), and urban decline factors (D), taking note of the relations between the choices for walking by walking trip purpose ($W_{t,u,l}$) and decline.

$$W_{t,u,l}=f(S,N,D) \quad (1)$$

W_t : walking trip generated
W_u : utilitarian walking trip generated
W_l : leisure walking trip generated
S : socioeconomic status at individual level
N : environmental qualities of neighborhood
D : urban decline factors

Socioeconomic characteristics of individuals and the neighborhood's physical environment are crucial factors closely related to the choices for walking trips, as defined in other preceding studies.

We used the hierarchical linear models for analysis measures, enabling consideration of the individual and group levels simultaneously. It means that all observed values are included in all different levels, and therefore differences in all of those different levels should be controlled in quantitative analysis (Lee et al., 2014). In general, when calculating the hierarchically structured data by Least Squares Method (LSM), the assumptions to be complied by a regression model are disregarded. It will significantly reduce the standard error, making it highly likely that the null hypothesis is rejected (Lee and No, 2013). Besides, when using the hierarchical linear models, it is possible to analyze in detail at which level the explanatory variables show their effect and how significant such effect can be by level, based on variances by group, or "Random Effect", as shown in the hierarchical data (Baek, 2018). More specifically, this study performed the analyses with the random intercept models[4] the base model, and since the dependent variables are binary, we use the random intercept logit model. The random intercept logit model is a two-level model; the first level was the individual level and the second the neighborhood level (by dongs) in which the individual resides. We set the least significant difference level at 10% in analyses.

The model specification consists of total walking trips, utilitarian purpose walking trips, and leisure purpose walking trips, and each consists of six models in total (see Table 1). Model 1 is a basic model, which includes only constant terms. It is to see how the two-level variances change when a different explanatory variable is involved. Model 2 includes individuals' socioeconomic characteristics (level 1), designed to identify whether the neighborhood's physical environment has a statistically significant effect on walking trips by purpose, controlling individuals' socioeconomic characteristics. Model 3 includes the neighborhood's physical environment among the level 2 variables, aiming to see whether the urban decline factors are statistically significant for walking trips by purpose when the socioeconomic characteristics of individuals and the neighborhood's physical environment are controlled in subsequent analyses. In Model 4 through Model 6, the individual urban decline index (Model 4), the multiple decline index by sector (Model 5), and the comprehensive multiple decline indexes (Model 6) were added for analyses to identify the relations between decline and walking trips by purpose.

Table 1. Model specification

	Equations
Model 1	$y_{ij}=a+z_j$
Model 2	$y_{ij}=a+z_j+\sum_{k=1}^{l}\beta^k S_{ij}^k$
Model 3	$y_{ij}=a+z_j+\sum_{k=1}^{l}\beta^k S_{ij}^k+\sum_{s=1}^{m}\gamma^s N_j$
Model 4	$y_{ij}=a+z_j+\sum_{k=1}^{l}\beta^k S_{ij}^k+\sum_{s=1}^{m}\gamma^s N_j^s+\sum_{s=1}^{m}\zeta^s D_1 j^s$
Model 5	$y_{ij}=a+z_j+\sum_{k=1}^{l}\beta^k S_{ij}^k+\sum_{s=1}^{m}\gamma^s N_j^s+\sum_{s=1}^{m}\zeta^s D_2 j^s$
Model 6	$y_{ij}=a+z_j+\sum_{k=1}^{l}\beta^k S_{ij}^k+\sum_{s=1}^{m}\gamma^s N_j^s+\sum_{s=1}^{m}\zeta^s D_3 j^s$

y_{ij}: Possibility for an individual i in zone j to generate a walk trip
S_{ij}^k: Socioeconomic status of the individual i in zone j
N_j^s: Neighborhood environments of zone j
D_{1j}^s: Urban decline measures
D_{2j}^s: Comprehensive decline index by demography, economic activity, and physical environment
D_{3j}^s: Comprehensive decline index
a: Intercept; z_j: error term

2. Data and variables

Data used in this study are as follows:

First, data on walking trips by purpose was established by summing up the log of by-mode trips in the 2016 National Household Travel Survey[5)] data. For the decline phenomenon, the Eup-Myeon-Dong index[6)] in the measurement of urban decline was developed by KURC (2010). To develop the data sets, we used 2016 Seoul Public Data and 2016 GIS-based Building Integrated Information System data by the Ministry of Land, Infrastructure, and Transport (MOLIT), Republic of Korea. Table 2 shows the measurement of urban decline by KURC (2010). For the establishment of data regarding the physical environment of the neighborhood, we used 2016 Seoul Public Data, 2016 administrative district boundary information for the Statistical Geographic Information Service census, 2016 GIS-based Building Integrated Information System by the MOLIT, 2016 Road Name Addresses DB by the Ministry of the Interior and Safety (MOIS).

The walking trip occurrence by trip purpose as a dependent variable refers to "a walking trip by purpose by a resident within his/her residing dong for a day." The purposes of walking trips were divided into walking trips for utilitarian purposes and those for leisure purposes, based on the National Household Travel Survey data classification. Due to limited data available, we define the walking trips for leisure purposes in this study as "A walking trip as a transport mode for leisure activities."[7)]

The explanatory variables are composed of individuals' socioeconomic characteristics (Level 1) and the neighborhood's physical environment and urban decline factors (Level 2). Table 3 presents specific methods of measuring and descriptive statistics for each of the variables. For the socioeconomic characteristics of individuals (Level 1 variables), which are crucial factors in understanding the walking trip choices, we used the household status and the characteristics of the household members provided by the National Household Travel Survey data. To explain, the socioeconomic status of individuals in this study consists of Age, Sex, Income, Driver's license, Car ownership, Housing type, and Occupation.

For the physical environment of the neighborhood, one of two Level 2 variables, the variables were classified into Land use, Urban Form, and accessibility based on preceding works in which the spatial scope was by dongs (Lee and Ahn, 2007; Kim et al., 2014; Lee et al., 2014; Lee and Choi, 2018). Land use meant the accessibility to a destination and was measured using variables such as population density, land use mix, and commercial FAR. For the population density, we calculated the population's net density using the 2017 Urbanized Area data. The land use mix, which refers to the various land usage, was categorized into Residential, Commercial, Busi-

Table 2. Measurements of urban decline

Aspects	Measurement
Demographic profile	Annual population growth rate; aging index; % of single household elderly
Economic activity	Employed per 1,000 persons; employment per business establishment; % manufacturing employment; employed in retail and wholesales per 1,000 persons; % small dwelling units
Physical conditions	% aged dwelling units; % dwelling units, newly constructed

Korea Urban Renaissance Center, 2010

Table 3. Descriptive statistics

Variables				Mean/freq.	S.D./ratio	Min.	Max.
Dependent variables	Trip by mode	Waking	Yes	105,580	58.225	-	-
			No	75,750	41.775	-	-
		Utilitarian walking	Yes	76,582	42.233	-	-
			No	104,748	57.767	-	-
		Leisure walking	Yes	28,998	15.992	-	-
			No	152,332	84.008	-	-
First level-Individual	Socioeconomic status	Age		45.164	18.065	10.000	103.00
		Male	Yes	89,956	49.609	-	-
			No	91,374	50.391	-	-

(Continue on next page)

Variables				Mean/freq.	S.D./ratio	Min.	Max.
First level - Individual	Socioeconomic status	Income	1: 1 MKW or less 2: 1–2 MKW 3: 2–3 MKW 4: 3–5 MKW 5: 5–10 MKW 6: More than 10 MKW	3.819	1.256	1.000	9.000
		Driver's license holder	Yes	108,338	59.746	–	–
			No	72,992	40.254	–	–
		Car owner	Yes	125,442	69.179	–	–
			No	55,888	30.821	–	–
		Housing type–apartment	Yes	94,920	52.347	–	–
			No	86,410	47.653	–	–
		Occupation	Office worker	55,652	30.691	–	–
			Sales/service	43,014	23.721	–	–
			Laborer	11,635	6.416	–	–
			Housewife	23,667	13.052	–	–
			Student/unemployed*	47,362	26.119	–	–
Second level - Neighborhood	Land use measures	Population density (pop. per ha)		306.580	111.900	7.700	588.360
		Land use mix		0.570	0.160	0.070	0.960
		FAR, commercial		1.720	0.980	0.000	6.210
	Urban form	Intersections per km^2		97.020	72.860	0.000	427.850
		Land gradient, %		5.780	4.470	0.000	22.200
		Road surface, %		0.220	0.270	0.050	5.600
	Accessibility	The number of parks per km^2		3.690	2.840	0.000	16.070
		The number of sports facilities per km^2		0.560	1.140	0.000	9.040
		The number of bus stops per km^2		24.050	13.150	1.000	91.400
		Accessible area of subway stations (500m buffer area (km^2) per km^2)		0.460	0.290	0.000	1.000
	Urban decline measures	Annual average population growth rate (2011–2016)		-0.010	0.040	-0.430	0.340
		Aging index		87.050	34.160	24.070	313.330
		Ratio of single households, elderly		7.870	3.190	2.300	29.330
		Employees per 1,000 persons		765.880	2424.260	50.370	32879.110
		Employees per business establishment		5.430	3.120	1.820	19.760
		Ratio of employees in manufacturing		6.120	6.900	0.050	49.320
		Employees per 1,000 persons, retail/wholesale		225.900	769.420	8.350	9965.140
		Ratio of dwelling units, small-sized		73.570	14.300	9.940	100.000
		Ratio of dwelling units, aged		67.750	16.450	0.000	100.000
		Ratio of dwelling units, newly-completed		4.980	5.030	0.000	66.670
	Comprehensive decline index by	Demography		5.940	2.550	1.000	22.720
		Economic activity		47.360	3.760	13.440	52.440
		Physical environment		16.940	2.190	1.910	21.200
	Comprehensive decline index	Comprehensive decline index		70.230	5.050	43.350	82.850

Note: *reference
MKW: 1 million Korean Wons
FAR, commercial: Floor areas of commercial buildings÷lot size
Aging index: (Population, aged 65 or older÷Population, aged 14 or younger)×100

ness, Industrial, and Other buildings and measured using the Entropy index.[8] Floor areas of commercial buildings (FAR Commercial) are one of the walkability indices showing accessibility to commercial facilities. The higher the FAR Commercial becomes, the more commercial buildings concentrated in the space (Kang, 2013). Urban forms, referring to the connectivity to destinations and streets environment, were measured using intersections, average land gradient, and road surface ratio. We calculated the number of intersections by dividing the number of crossroads intersections by the surface area of urbanization. Simultaneously, the average land gradient was measured for the entire surface areas of dongs subject to this study, using the Digital Elevation Model (DEM) data. The road surface ratio was measured by comparing the actual-width roads' surface area to the urbanized surface area. For accessibility, we used the number of parks, public sports facilities, bus stops, and the accessible area of subway stations. For the accessibility to parks, public sports facilities, and bus stops, we calculated by dividing the number of such facilities by the urbanized area. We calibrated the accessibility to subway stations by applying a 500m buffer area around each station to estimate the accessible area of the surface (Jeon and Park, 2020).

The urban decline measures, one of the level 2 variables, were classified into the individual urban decline index, multiple decline index by subject, and comprehensive multiple decline index. First, the individual urban decline index's demography sector indicated the changes in urban population and demographic structure, socioeconomic growth potential, measured by using the annual average population growth rate, aging index, and ratio of the single elderly household. The annual average population growth rate is the mean value of the population growth rates between 2011 and 2016. The economic activity sector showed the size of the city's economy and economic base, employment opportunities, and capital accumulation. The employees per 1,000 persons measured it, employees per business establishment, the ratio of employees engaged in manufacturing, employees in retail/wholesale businesses per 1,000 persons, and small-sized dwelling units. The physical environment sector represents the deterioration of the physical environment and residential attractiveness, measured by the ratio of an aged dwelling unit and the ratio of newly-constructed dwelling units. The number of aged dwelling units was obtained by dividing the total number of dwelling units by the number of the units built-in no later than 1985, while the number of newly-constructed dwelling units referred to those built-in 2000 and after that. Next, the individual index of urban decline was comprehensively put together to calculate the multiple decline index by sector (Demography, Economic activity, and Physical environment) and the comprehensive multiple decline index. For the multiple decline index, each index's metric unit was converted into value Z for normalization, and to reflect the relative importance of the indices considered, each index was granted a weight based on the results of the factor analysis. A weighted linear combination method was applied to present the degree of urban decline by sector or comprehensive multiple decline index (KURC, 2010).

Ⅳ. Results

1. Descriptive statistics

The total number of trips in Seoul used in this study was 181,330, with missing values removed, of which 105,580 (58%) were walking trips. As for the ratio of walking trips by purpose, 76,582 (72%) were walking trips for utilitarian purposes and 28,998 (28%) for leisure purposes. The respondents' average age to the National Household Travel Survey data was 45.16 years old, with male 49.61%, driver's license holder 59.75%, vehicle owner 69.18%, and residents in apartment 52.35%. Regarding occupations, 30.69% were professional/office workers, 23.72% in service/sales, 6.42% manual labor, 13.05% housewives, and 26.12% student/unemployed.

As for the average value of the physical and environmental factors of 423 dongs in Seoul, the population density was 306.58 persons/ha, the land use mix 0.57, and the commercial FAR 172%. The number of intersections was 97.02/km^2, the average land gradient 5.78%, and the road surface ratio 22%. The number of urban parks was 3.69/km^2, and the number of public sports facilities was 0.56/km^2. The number of bus stops was 24.05/km^2 and accessibility to subway station 0.45, indicating that about half of the urbanized area appeared to locate in the primary station influence area (SIA). For the average value of the urban decline factors, the average annual population growth rate was -0.01%, the aging index 87.05%, the ratio of single elderly households 7.87%. The number of employees per 1,000 persons was 765.88, the number of employees per business 5.43, the ratio of employees in the manufacturing industry 6.12%, and the number of employees in the retail/wholesale business per 1000 persons were 255.90. The ratio of small-sized dwelling units was 73.57%, the ratio of aged dwelling units 67.75%, and the ratio of newly-built dwelling units 4.98%. Finally, the multiple decline index in the demography sector was 5.94 while that of the economic activity and physical environment sectors was 47.36 and 16.94, respectively. The comprehensive multiple decline index was 70.23.

2. Suitability review on the hierarchical linear model

The results of model 1~model 3 are presented in Table 4. Model 1 shows the results of walking trips, utilitarian walking trips, and leisure walking trips models only with constant terms. All three models show that the level 2 variance bears

statistical significance, indicating a difference in choices for walking trips by purpose among dongs (Model 1-t, Model 1-u, Model 1-l).

The results of Model 2 represent the individual's socioeconomic characteristics (level 1 variable), added to Model 1. The level 2 variance decreased in all analysis models, indicating that individuals' socioeconomic characteristics account for the difference in purpose-specific walking trip choice by dong. Also, it showed that the Alsos' socioeconomic characteristics accounted for 20%, 1%, and 10% of the level 2 variance through PRE by analysis model. In particular, in utilitarian-purpose walking trips, the PRE was lower than that of other-purpose trips (Model 2-t, Model 2-u, Model 2-l).

Model 3 is a model in which the neighborhood's physical environment, one of the level 2 variables, is added to Model 2. The PRE of total walking trips was 0.0826, and that of utilitarian and leisure walking trips was 0.0498 and 0.0651, respectively, accounting for 8%, 5%, and 7% of the level 2 variance, respectively (Model 3- t, model 3-u, model 3-l).

Models 1 to 3 show that the level 2 variance of Model 1 was statistically significant,[9] and the explanatory variables of Models 2 and 3 were found to reduce the level 2 variance, indicating that it is appropriate to use the hierarchical linear model in this study. The multicollinearity tests suggest that the Variance Inflation Factor (VIF) maximum value was 5.65, which did not exceed 10, and the tolerance (1/VIF) was more significant than 0.1, confirming that there was no multicollinearity issue to be considered.

3. Relations between the decline phenomenon and walking trips by purpose

The results of model 4~model 6 are shown in Table 5. We the individual urban decline index, multiple decline indexes by sector, and comprehensive multiple decline index in the total walking trips model (Model 3-t) for analyses. The results showed that the level 2 variance decreased in all models, and the corresponding PRE in Models 1, 2, and 3 was 0.0550, 0.0179, and 0.0076, respectively. Concerning the relations between urban decline factors and choices in total walking trips, we found that more chose walking trips when the number of employees per 1,000 persons was large, and the ratio of employees in manufacturing and the number of wholesale and retail employees per 1,000 persons were small. In other words, when the number of employees per 1,000 persons is large, the employees are highly likely to choose walking trips due to the mobility of workers (Lee et al., 2013). Besides, when the proportion of employees in the manufacturing industry and the number of wholesale and retail sector employees per 1,000 persons were low, more people seemed to opt for walking trips. Since the ratio of employees in manufacturing and wholesale/retail sectors per 1,000 persons can translate into the region's economic base and scale, it implies that more people tend to choose walking trips where the economic situation is relatively unfavorable. These results correspond to the results of a study showing that residents living in socio-economically disadvantaged areas are more likely to choose walking (Turrell et al., 2013) and are in line with other preceding studies reporting that the lower the household income level, the more walking trips are chosen (Lee et al., 2014; Kim et al., 2014). Next, among the comprehensive decline indices by sector, only the economic activity sector appeared to bear statistical significance, which is consistent with the results of a previous study that income is a significant factor among the socio-economic characteristics associated with walking (Sallis et al., 2009). In more detail, many chose walking trips when the comprehensive decline index in the economic

Table 4. Results of model 1~model 3

	Walking, total			Walking, utilitarian			Walking, leisure		
	Model 1-t	Model 2-t	Model 3-t	Model 1-u	Model 2-u	Model 3-u	Model 1-l	Model 2-l	Model 3-l
	Coeff.	Coeff.	Coeff.	Coeff.	Coeff.	Coeff.	Coeff.	Coeff.	Coeff.
First level-Individual									
Socioeconomic status									
Age		-0.0002	-0.0002		-0.0316***	-0.0315***		0.0515***	0.0515***
Male		-0.2291***	-0.2294***		-0.1439***	-0.1440***		-0.2411***	-0.2416***
Income		-0.0138***	-0.0141***		0.0569***	0.0570***		-0.0719***	-0.0725***
Driver's license		-0.3579***	-0.3580***		-0.4981***	-0.4982***		0.3514***	0.3515***
Car ownership		-0.2609***	-0.2595***		-0.1196***	-0.1194***		-0.2504***	-0.2485***
Housing type-Apartment		-0.0934***	-0.0908***		-0.0384***	-0.0416***		-0.2059***	-0.1953***
Occupation-office worker		-0.6018***	-0.6021***		0.5600***	0.5599***		-2.8762***	-2.8766***
Occupation-sales/ service		-0.4036***	-0.4044***		0.9825***	0.9822***		-2.9592***	-2.9600***
Occupation-laborer		-0.5501***	-0.5499***		1.0876***	1.0872***		-3.2510***	-3.2501***
Occupation-housewife		0.1165***	0.1160***		-3.2051***	-3.2052***		1.2941***	1.2935***
Second level-Neighborhood									
Land use measures									
Pop. density			0.0002*			0.0002*			0.0002
Land use mix			0.2028**			0.1610*			0.2357
FAR, commercial			0.0273**			0.0219*			0.0133
Urban form									
Intersections per km^2			0.0000			-0.0005**			0.0010***
Land gradient, %			0.0052**			0.0018			0.0102*
Road surface, %			-0.0208			-0.0043			-0.0282
Accessibility									
Parks per km^2			-0.0026			0.0024			-0.0173**
Sports facilities per km^2			0.0075			0.0128			-0.0095
Bus stops per km^2			0.0002			0.0005			0.0009
Subway stations accessibility			0.0995***			0.0659			0.1306
Intercept	0.3350***	1.2097***	1.2080***	-0.3196***	-0.2143***	-0.2127***	-1.7261***	-0.9171	-0.9259
Neighborhood-level variance	0.0463	0.0371	0.0340	0.0535	0.0528	0.0502	0.2220	0.1997	0.1886
Proportional Reduction in Error		0.2001	0.0826		0.0131	0.0498		0.1005	0.0651
N					181,330				

*p < 0.1, **p < 0.05, ***p < 0.01

activity sector was high, indicating that walking trips take place frequently where economic decline is evident. Finally, it shows that the comprehensive multiple decline indices were not statistically significant (see Model 4-t, Model 5-t, Model 6-t).

Including the individual urban decline index, multiple

Table 5. Results of model 4~model 6

	Walking, total			Walking, utilitarian			Walking, leisure		
	Model 4-t	Model 5-t	Model 6-t	Model 4-u	Model 5-u	Model 6-u	Model 4-l	Model 5-l	Model 6-l
	Coeff.	Coeff.	Coeff.	Coeff.	Coeff.	Coeff.	Coeff.	Coeff.	Coeff.
First level-Individual									
Socioeconomic status									
Age	-0.0002	-0.0002	-0.0002	-0.0316***	-0.0316***	-0.0315***	0.0515***	0.0515***	0.0515***
Male	-0.2294***	-0.2295***	-0.2295***	-0.1436***	-0.1437***	-0.1440***	-0.2418***	-0.2424***	-0.2420***
Income	-0.0144***	-0.0144***	-0.0143***	0.0577***	0.0577***	0.0570***	-0.0731***	-0.0732***	-0.0728***
Driver's license	-0.3577***	-0.3576***	-0.3578***	-0.4987***	-0.4988***	-0.4982***	0.3531***	0.3532***	0.3525***
Car ownership	-0.2587***	-0.2580***	-0.2588***	-0.1225***	-0.1218***	-0.1194***	-0.2436***	-0.2430***	-0.2453***
Housing type-Apartment	-0.0880***	-0.0892***	-0.0905***	-0.0432***	-0.0444***	-0.0416***	-0.1913***	-0.1906***	-0.1941***
Occupation - office worker	-0.6023***	-0.6022***	-0.6021***	0.5602***	0.5601***	0.5599***	-2.8770***	-2.8767***	-2.8760***
Occupation-sales/ service	-0.4053***	-0.4051***	-0.4046***	0.9837***	0.9835***	0.9822***	-2.9640***	-2.9630***	-2.9600***
Occupation-laborer	-0.5514***	-0.5513***	-0.5504***	1.0900***	1.0894***	1.0872***	-3.2540***	-3.2544***	-3.2510***
Occupation-housewife	0.1150***	0.1155***	0.1158***	-3.2040***	-3.2040***	-3.2052***	1.2930***	1.2935***	1.2930***
Second level-Neighborhood									
Land use measures									
Pop. density	0.0003**	0.0003**	0.0002*	0.0003*	0.0003	0.0003**	0.0004	0.0004	0.0000
Land use mix	0.2672***	0.1916**	0.2115***	0.2366**	0.1447	0.1283	0.2452	0.2189	0.3008*
FAR, commercial	0.0217**	0.0242**	0.0265**	0.0253**	0.0261**	0.0247*	-0.0074	-0.0025	0.0076
Urban form									
Intersections per km^2	-0.0000	-0.0000	-0.0000	-0.0005**	-0.0004*	-0.0004**	0.0010***	0.0007**	0.0009***
Land gradient, %	0.0040*	0.0040	0.0049*	0.0046*	0.0041	0.0032	0.0021	0.0033	0.0074
Road surface, %	-0.0173	-0.0247	-0.0200	-0.0062	-0.0057	-0.0071	-0.0130	-0.0403	-0.0227
Accessibility									
Parks per km^2	-0.0017	-0.0007	-0.0021	0.0006	-0.0006	0.0003	-0.0135	-0.0073	-0.0131
Sports facilities per km^2	0.0121	0.0104	0.0077	0.0101	0.0104	0.0121	0.0093	0.0027	-0.0083
Bus stops per km^2	0.0003	0.0003	0.0003	0.0007	0.0002	0.0002	0.0007	0.0016	0.0014
Subway stations accessibility	0.0822**	0.0864**	0.1019***	0.0777*	0.0688	0.0576	0.0486	0.0752	0.1462*
Urban decline measures									
Pop. growth rate	-0.4244			-0.4158			-0.0929		
Aging index	0.0003			-0.0011			0.0026**		
Ratio, single HHs, elderly	0.0037			-0.0048			0.0187		
Emp./1k persons	0.0000***			0.0000			0.0001***		
Emp./biz estab.	-0.0065			-0.0037			-0.0068		
Ratio, Emp. in manufacturing	-0.0035**			0.0006			-0.0115***		

(Continue on next page)

	Walking, total			Walking, utilitarian			Walking, leisure		
	Model 4-t	Model 5-t	Model 6-t	Model 4-u	Model 5-u	Model 6-u	Model 4-l	Model 5-l	Model 6-l
	Coeff.	Coeff.	Coeff.	Coeff.	Coeff.	Coeff.	Coeff.	Coeff.	Coeff.
Emp./1k persons, retail/wholesales	-0.0001***			-0.0000			-0.0002**		
Ratio, dwelling unit, small-sized	-0.0003			-0.0026***			0.0037**		
Ratio, dwelling unit, aged	0.0005			-0.0006			0.0021		
Ratio, dwelling unit, new	0.0019			0.0023			0.0024		
CDI by									
Demography		-0.0020			-0.0074			0.0012	
Economic activity		0.0115**			-0.0172***			0.0585***	
Physical environment		-0.0005			-0.0034			0.0003	
CDI									
CDI			0.0024			-0.0090***			0.0178***
Intercept	1.2080***	1.2070***	1.2070***	-0.2105***	-0.2102**	-0.2105***	-0.9253***	-0.9260***	-0.9267***
Neighborhood-level variance	0.0321	0.0334	0.0337	0.0477	0.0486	0.0489	0.1599	0.1699	0.1787
Proportional Reduction in Error	0.0550	0.0179	0.0076	0.0498	0.0309	0.0251	0.1435	0.0900	0.0428
N	181,330								

*p < 0.1, **p < 0.05, ***p < 0.01

decline index by sector, and comprehensive multiple decline index to the utilitarian walking trips model (Model 3-u), it was found that the decline phenomenon was serving as an explanatory variable for the difference in the level of choice for utilitarian walking trips by dong. PRE for individual urban decline index, multiple decline index by sector, and comprehensive multiple decline index was 0.0498, 0.0309, and 0.0251, respectively, while its effect size on the level 2 variances was 5%, 3%, and 3%, respectively. Looking at the relations between the urban decline factors and utilitarian walking trips, only the ratio of small-sized dwelling units among the individual-level index showed statistically significant results. Specifically, we found few choices for utilitarian walking trips made when the ratio of small-sized dwelling units was high. Since the ratio of small-sized dwelling units is an indicator to measure the region's income level indirectly, a higher ratio of small-scale dwelling units means the region's level of income should be low. Therefore, the lower the neighborhood's income level, the smaller the number of walking trips is. Next, we found few choices made for utilitarian walking trips when the multiple decline index in the economic activity sector was high. It means that few people would opt for utilitarian walking trips when the region's economic activities have declined. This result is contrary to a preceding study that considers utilitarian walking as an inferior good, and hence the higher the income level, the less walking for utilitarian purposes (Agrawal and Schimek 2007; Sung et al., 2015).

On the other hand, Plaut (2005) reported that the higher the income level in densely-populated regions, the more utilitarian walking trips tended to be selected. Cerin et al. (2009) found that when controlling accessibility to destinations, more chose the utilitarian walking trips in areas with high-income levels. In particular, Seoul is a highly dense and mixed city compared to Western cities, and therefore these conflicting results can be understood as attributable to Seoul's urban context. Lastly, we found that utilitarian-purpose walking trips were low when the comprehensive multiple decline index was high, indicating that the probability of choosing utilitarian-purpose walking trips in a declined city is low (see Model 4-u, Model 5-u, and Model 6-u).

Regarding the relation between walking trips for leisure purposes and the decline phenomenon, the difference in level for each dong in terms of choices for leisure-purpose walking trips turned out to be explained by 14%, 9%, and 4% by the individual urban decline index, the multiple decline index by sector, and the comprehensive multiple decline index, respectively. In particular, we found that the PRE of the individual index and the by-sector multiple decline index is higher than that of the physical environment of the neighborhood, indicating that the individual urban decline index and the multiple decline index by sector were essential factors in walking trip choices for leisure purposes by dong. In the individual urban decline indices, the aging index, the number of employees per 1,000 persons, the ratio of employees in the manufacturing sector, the number of employees in the wholesale and retail business per 1,000 persons, and the ratio of small-sized dwelling units are statistically significant variables. In detail, we found that walking trips for leisure purposes were high when the aging index was high; this is probably because, for the elderly, most leisure activities occur on foot within their neighborhood (Kim, 2012). Meanwhile, more chose leisure-purpose walking trips if the number of employees per 1,000 persons was significant, which indicates that more tend to opt for walking trips for leisure when the mobility of employees within the region is more significant. Also, the higher the ratio of employees in the manufacturing sector and the number of employees in the wholesale and retail business per 1,000 persons and the lower the ratio of small-sized dwelling units, the lower the likelihood of choosing walking trips for leisure purposes. Since the ratio of employees in manufacturing, the number of employees in the wholesale and retail business per 1,000 persons, as well as the ratio of small-sized dwelling units, show the income level of the neighborhood, the lower the income level of the neighborhood is, the higher leisure-purpose walking trips occur. These results are contrary to a study that considered leisure-purpose walking like a normal good, reporting that the higher the income level, the more leisure walking trips were made (Agrawal and Schimek 2007). However, one study that analyzed leisure walking trips in Seoul showed that in the case of "non-producers" such as housewives, the unemployed, and students, leisure activities were done within the range of their living area around their place of residence (Lee and Choi, 2020).

Furthermore, in Korea, the higher the income level, the more physical activity tends to occur in indoor facilities such as fitness centers or yoga training centers rather than in the form of walking (Ministry of Culture, Sports and Tourism, 2014). Therefore, these conflicting results appear to be attributable to the cultural differences of each nation. The higher the multiple decline indexes in the economic activities sector, the more walking trips for leisure purposes occur. It implies that leisure-purpose walking trips are relatively prevalent in a city with poor economic activities. Lastly, we found that leisure-purpose walking trips were also high when the comprehensive multiple decline index was high, indicating that the probability of choosing leisure-purpose walking trips in a declined city is high (see Model 4-I, Model 5-I, and Model 6-I).

V. Conclusion

Jane Jacobs (1961), taking note of the phenomenon of decline in 1961, defined the innate feature of slums as a "lack of lively urban life" and proposed to create lively streets where people can fully and safely enjoy walking as a basis for tackling slums. It may not be coincidental that after about 60 years have passed, walking is emerging as a solution to our cities' problem again after going through rapid industrialization and urbanization. If Korea's urban decline refers to the state of a city with no vitality or is losing it, walking is the most potent means of injecting vitality to the city and evaluating the level of its vitality. Promoting walking activities is regarded as a critical strategy in urban regeneration policies to solve the urban decline issue. In line with this, pedestrian projects have actively promoted revitalizing walking within the city since enacting the Special Act on the Promotion and Support of Urban Regeneration in 2013. However, the urban decline in Korea has been worsening over time, leaving us with room for thought on whether the complex interactions between the social/spatial factors and the decline problem have accelerated a vicious downward cycle in our society. Against this backdrop, this study has analyzed the relations between the purpose-specific walking trips and individual urban decline index, multiple decline index by sector, and comprehensive multiple decline index on 181,330 walking trips surveyed in 423 dongs in Seoul to understand the correlation between the decline phenomenon and people's choices for walking trips.

The results can be summarized as follows:

First, we found that the decline phenomenon accounted for the difference in the choices of walking trips by purpose among the subject dongs, even after controlling the socio-economic characteristics of individuals and the neighborhood's physical environment. Such results indicate that urban decline and walking trip choices are correlated. Regarding the relation between decline and walking trip choices, different relations were observed by the declining sector and walking purpose.

Second, it was found in the comprehensive walking trips analysis model that the number of employee per 1,000 persons, the ratio of employees in the manufacturing sector, the number of employees in the wholesale and retail business per 1,000 persons, and the multiple decline index in economic activities sector were relevant factors in walking trip choices. Nevertheless, the ratio of employees in the manufacturing sector, the number of employees in the wholesale and retail business per 1,000 persons, and the multiple decline indexes in the economic activities sector, excluding the number of employees per 1,000 persons, showed conflicting results preceding studies. Therefore, neglecting these aspects in understanding the relationship between decline and walking trips may lead to unreasonable observations.

Third, different purposes for walking showed different results in urban decline factors related to walking trip choices. While few chose utilitarian walking trips in a declined city, more tended to opt for walking trips for leisure purposes. The results corresponded to previous studies (Lee et al. 2013, Lee and Choi, 2020), indicating that employees' mobility contracted when socio-economic factors became worse and that most of the leisure activities occurred within the range of one's living area. Nonetheless, we need additional empirical studies on this aspect to understand this aspect clearly. We also found that walking trips for leisure purposes were still brisk in a declining city. Unlike in the West, Korean cities, including Seoul, maintain a somewhat healthy social environment for pedestrian safety, despite the urban decline problem (Kim, 2010).

Fourth, the economic activities sector was most closely related to walking trips among the declining sector. It means the income level serves as a crucial factor in choices for purpose-specific walking trips. It is consistent with the results of a previous study that reported that income is a significant factor among walking's socio-economic characteristics (Sallis et al., 2009).

Fifth, the effect size of the explanatory variables on the neighborhood level variance was measured using PRE. Regarding the walking trips for utilitarian purposes, the PRE of the individual's socio-economic characteristic was 0.0131, which was lower than PRE 0.1005 for leisurely walking trips. The walking trips for utilitarian purposes are not a choice but an essential activity, indicating that individuals' socio-economic characteristics appear to be less affected by the neighborhood. In walking for leisure purposes, the PRE of the individual urban decline index was 0.1435, accounting for the neighborhood level's variance by 14%. This value is higher than that of the neighborhood's physical environment, indicating that the individual urban decline indices can explain the variance of neighborhood-level in terms of the choices of walking trips for leisure purposes.

Based on the results of this study, the following implications can be drawn:

It is necessary to reflect the decline in demography and economic activities sectors when establishing urban regeneration plans or improving the pedestrian environment through urban regeneration projects. We need to consider the purposes of walking should as well, and since the leisure activities in a declined city tend to take place within the neighborhood around one's place of residence, thorough planning and strategies on leisure purpose walking should be established.

This study is meaningful because it has empirically identified the relationship between the decline phenomenon and walking trips for different purposes, which has not been dealt with in the preceding domestic studies. Nevertheless, it still has some limitations, which require proper follow-up studies in the future. First, this study was a cross-sectional study, and no analysis was conducted on a before-and-after comparison. Therefore, we hope that a study in which the changes in urban decline phenomenon and walking trips before and after the urban regeneration projects are measured will follow so that the causality between the two variables can be adequately analyzed. Second, as for interpreting the effect sizes of explanatory variables for walking trip choices for different purposes into PRE values, the relevant empirical studies carried out thus far were still insufficient, making it hard to build a respectable theory out of it. Therefore, more empirical studies using PRE should be conducted as well. Finally, it is difficult to generalize this study's results, the spatial subject of Seoul and its administrative districts ("dong"), since the declining level may differ, depending on the type of city. Therefore, we hope that more studies will be conducted on diverse types of cities in the future.

Note 1. In general, the purpose of walking is divided into utilitarian walking (a means of transport), and leisure walking (the purpose of which is leisure activity or walking itself). However, the specific classification criteria and definitions may differ, depending on the researcher, because the boundary between leisure and other activities is not clear. In this study, the utilitarian purpose and leisure purpose were classified by referring to Lee and Choi (2018).

Note 2. PRE shows how much variance was explained by the explanatory variable added at each measurement level. In addition, PRE has the same concept as the Interclass Correlation Coefficient (ICC), and is similar to the explanatory variance in the OLS regression model (Baek, 2018).

Note 3. Decline is not unilateral and biased but a complex and relative concept, so the concept of multiple decline was introduced to measure the degree of decline (KURC, 2010).

Note 4. In the random-intercept logit model, only the intercept is considered to be random. Therefore, the interpretations of the fixed effect of the intra-group models and the estimated values of the regression coefficient can be done in the same way as the logistic regression analysis (Kwak, 2003).

Note 5. Since the data of the National Household Travel Survey are classified as "trips by mode" and "trips by purpose", it is necessary to abbreviate the data and modify the values of some items to suit the purpose of the study (Kim et al, 2014). In order to measure the trips that took place within a dong where one's place of resident is located, this study was conducted only on the trips that were made by those residing in Seoul and that the address of one's residence and that of his/her origin or destination are the same, and the returning home or workplace trips, which may be redundant with other purpose walking trips, were excluded as well. In addition, to analyze the walking trips for all purposes within the applicable dong, this study only used a portion of walking trips made by the same person.

Note 6. The measurement of urban decline by KURC (2010) was developed through a study titled "Establishment of urban decline status data and comprehensive information system" conducted as part of the Ministry of Land, Infrastructure and Transport (MOLIT) Urban Regeneration R&D project. It is used as a quantitative indicator of decline measurements in the Urban Regeneration Strategy and Planning Guidelines by MOLIT (2014). For this reason, we found that it would be convenient to utilize the results of this study in policy-making process if we used the KURC measurement of urban decline in this study.

Note 7. In general, leisure walking refers to walking with the purpose of leisure activity or walking itself. Due to a lack of data, however, in this study, leisure walking means walking as a means of transportation for leisure activities, according to the purpose of trip classified in the National Household Travel Survey.

Note 8. In theory, the entropy index has a value between 0 and 1; if the target area to be measured is composed of a single purpose, the entropy value is 0, and if the target area has all types of uses mixed in equal proportions, the value becomes 1 (Rhim, 2006).

Note 9. The statistical significance of the 2nd level variance of the basic model can be a criterion in verifying the appropriateness of constructing a hierarchical linear model (Ko, 2014).

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