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Is the Minimization of Travel Distances and Discomfort the Best Strategy for the Route-choice in Utilitarian Walking? A Case of Pedestrian Customers of Convenience Stores in Gwangju, Korea*

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Abstract

This study aims to test whether land gradient, as an environmental impediment, plays a critical role in decision-making related to pedestrians' trip planning. We assessed the travel behavior of pedestrian customers of convenience stores, a popular retailer in South Korean cities, concerning strategies to minimize trip distances and human energy consumption. We used data from survey questionnaires distributed to customers at several convenience stores in Gwangju Metropolitan City, South Korea. Using network analysis and Google Maps API, we estimated the trip lengths and required energy consumptions, providing information on the respondents' origins, stores, and destinations. We found that many respondents visited stores that did not guarantee the shortest trip length and the minimum energy expenditure, compared to other nearby stores. The minimum distance strategy is not always applicable to pedestrians' travel behavior or that of transportation riders on utilitarian trips. There is little evidence to support that the minimum energy strategy compensates longer journeys for pedestrians. Further research is needed to better understand the relationship between pedestrians' travel behavior and their environment, considering a wide range of demographic and socioeconomic characteristics.

Keywords Topography, Pedestrian Shopper, Convenience Stores, Energy Expenditure, Urban Morphology

Ⅰ. INTRODUCTION

For the last two decades, convenience stores in Korea have replaced traditional corner stores' roles and become representative retailers. The average density of convenience stores in the urbanized areas of the seven major metropolitan areas in South Korea in 2017 is 3.2 stores per square kilometers (Korean Statistical Information Service, 2019), and the average distance between convenience stores is about 300 meters (Korean Statistical Information Service, 2019). Thus, most convenience stores customers are in the vicinity of the stores, and the optimal service area of the convenience store is set to a radius of about 200 meters to catch pedestrian customers. Due to the rapid increase in the number of single-family households in Korea, convenience stores whose merchandising strategy fits the small-size purchasing and

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varieties of items have gained more popularity in the retail industry. Since many urbanites in Korea, including residents, workers, and visitors, tend to walk for their retail shopping, especially for convenience stores, understanding the travel behavior of customers of convenience stores provides the advantage of understanding utilitarian walking trips in more detail. Because utilitarian walking relates to natural impediments, including topography, understanding how the natural environment affects pedestrian customers' decision making in choosing a store, and en-routing their journey. It is necessary to study non-motorized transportation characteristics to comprehend customer behaviors in the locational decision-making process.

Non-motorized means of transportation, such as walking, cycling, and scooters, utilize more human muscular strength and require a significantly more significant amount of human energy than motorized transportation (Woodcock et al., 2007). Unlike recreational purposes, travel behavior with utilitarian purposes, including activity place search, mode choice, and route assignment, is determined by strategies to minimize the travel costs (Asensio, 2002; Khan, 2002; Limtanakool et al., 2006). With the growing interest in the role of active transportation as an alternative way of moving in daily life, many have considered the physical and mental comforts of travelers as a significant part of travel costs (Bertram, 2005; Iseki and Tingstrom, 2014). Thus, perceived and experienced environmental features, such as hilliness, shade, sunlight, and safety, affect the way-finding strategies and spatio-temporal traits (Lawton and Kallai, 2002; Soligo et al., 1998; Zacharias, 2001). Despite their essential role in travel behavior related to active transportation, there is little research to test how these environmental features affect pedestrians and cyclists' travel behaviors and discuss their urban planning implications.

This study aims to examine if pedestrians adopt the traditional route choice strategy to minimize the travel distance while walking to a place where a particular type of activity occurs. Since pedestrians use more muscular strength than motorized vehicle riders, they choose a place and a route, given a set of activity places and network, to minimize their caloric consumption, rather than the distance traveled. Therefore, this study also seeks to investigate if the minimum-energy strategy applies to destination and route choice, accounting for land gradient and pedestrians' physical traits, such as body mass.

We conducted a case study to find pedestrian customers of convenience stores in a hilly neighborhood in Gwangju, Korea. The on-site visitor questionnaire survey at several convenience stores that we conducted helped us understand where people come from to go to the store and leave for afterward, and customer behavioral characteristics. Given the departure places, the convenience stores, and the final destinations, we identify the potential shortest path for each respondent and each store and test if their choice of a particular store is the best strategy compared to other stores nearby, based on both distance- and calorie-minimization strategies through the topography-network analysis.

Ⅱ. RELATED WORK

As suggested by many travel behavior studies, one of the travelers' goals, regardless of transportation mode, is to minimize travel costs in utilitarian trip transportation (Woodcock et al, 2007; Kim and Yang, 2019). The travel cost is closely related to the residential choice, and trip plan-making to decide destinations to perform activities and route choice (Parsons, 2006; Chowdhury et al., 2015; González et al., 2016; Thayn et al., 2016). Concerning the location of service providers in both the private and public sectors, travel costs play a role in determining where a non-residential service facility is located and how the facility provides services (Iseki and Tingstrom, 2014; Macias, 2016). Previous studies commonly suggest that physical lengths, time spent, the trips' monetary expenditure, and the level of physical and mental discomfort broadly constitute the travel costs. Studies conducted from the perspective of individual travels have focused on identifying the factors that are deemed necessary to walk. Perception survey interviews with several scenarios with the predetermined environmental settings are most used to find what factors people consider as affecting factors while walking or cycling. Hills, stairs, and the presence of shade are most often regarded as impediments for walking or cycling (Borst et al., 2008; Koh and Wong, 2013).

In particular, for active transportation-related trips, the importance of natural environmental features, including topography and climate, is paid attention (Rodríguez and Joo, 2004; Parkin et al., 2008; Daniels and Mulley, 2012). The application of kinematic modeling enables travel behavior studies to measure the amount of caloric consumption objectively and test its association with the natural environment (Ardigò, 2003; Iseki and Tingstrom, 2014; Macias, 2016). Related studies have recently focused mainly on cyclists and pedestrians, with the view that the natural environment acts as an impediment factor for utilitarian trips by active transportation. Employing the metabolic estimation model, they measure the caloric burdens on pedestrian and cyclists, regarding the relationship between the factors, such as speed, distance, duration, height, weight, and slope (Ardigò et al., 2003; Iseki and Tingstrom, 2014; Macias, 2016).

The literature on travel behavior related to active transportation in the context of topographic features mostly relies on place-based approaches to address the geographic extent of catchment areas or service areas of facilities. Iseki and Tingstom (2014) estimate the geographic extent to which transit stations are reachable by cyclist commuters considering the slopes and other physical barriers, including stops at traffic lights. Using metabolic requirement modeling, they estimate the caloric requirements on each road segment, given the segment's average slope and the predetermined physical conditions of an average cyclist commuter. With the caloric metric, they determine the catchment area, not exceeding the energy expenditure threshold. They found the calorie-based catchment areas of transit stations are significantly smaller than the traditional Euclidean-based catchment areas. Macias (2016) predicts the pedestrian catchment areas of light rail stations in Los Angeles, USA, taking into account the slopes, with similar methods to Iseki and Tingstom (2014). They obtained the average inclination using the Digital Elevation Model (DEM) data. The average inclination is given to each road network segment through the overlap analysis using Geographic Information Systems. The authors calculated the calories required for each segment using the average slope. For a sling trip reaches the threshold, the study predicts the range from the train station to geographic points to which the estimated cumulative energy expenditure. Because the two studies focus on the implications of the natural environment and its impacts on the service area, they have to simplify and generalize individual travelers' traits and preferences. The study still leaves the question of how topographic features affect an individual's place and route choices unanswered.

Research to date has focused on places and their catchment areas, rather than the behavior of individual pedestrians and bicycle riders. Although it means to suggest a more realistic methodology to overcome the limitations of the existing Euclidean method in service area estimation, there is still a research gap to find the attributes of travel behavior linked to the topographic characteristics, traveler's physical traits, and energy consumption. Travel behavior studies at the individual level often employ methods to identify specific places visited by a person and routes with various devices and structured questionnaire, including Global Positioning Systems (GPS) trackers and travel diaries. However, none of the studies consider land slopes as an impediment for trips.

Ⅲ. METHODOLOGY

1. Decision Making in Route Choice to Visit a Store

The study area comprises Jinwol-dong and Juwol-dong, municipal districts in Gwangju Metropolitan City, South Korea. Gwangju Metropolitan City is the sixth-largest city in South Korea by population (about 1.5 million) and is apart approximately 270 kilometers south of Seoul Metropolitan City. As with other Korean cities, mountain ranges surround Gwangju, forming basins with some inner-city hills. When the city expanded its urbanized area in the 1990s, some residential developments emerged close to mountain ranges that were regarded as part of the city boundary. The study area is a typical residential neighborhood on hills located in the south-east of Gwangju adjacent to Mount Mudeung. The north part of the area has been traditionally formed with single-family houses. Newly constructed multi-family housing complexes are located in the south. The area is a valley between two hill ranges, running east and west along its sides. The areas' topographic features, streets, and pedestrian paths in the east-west direction are steeper than those running north-south. A commercial corridor is formed alongside the main arterial running north and south, dividing the neighborhood into two sections in the middle. Except for the commercial corridor, single- and multiple-family houses take up most of the area's land (Figure 1). Small corner stores and convenience stores are densely located in the neighborhood. The area is well-known for quality K-12 education in the city. Many primary

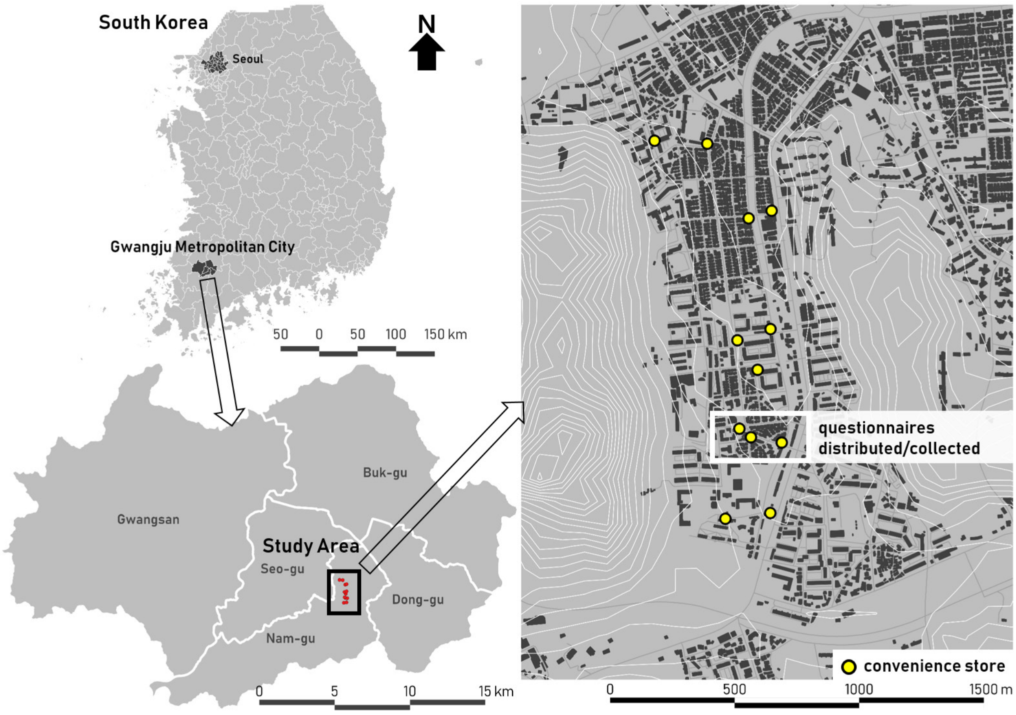

Figure 1. Study area

and secondary schools with higher academic performance and cram schools and supplementary institutes populate the area. Primary and secondary schools are clustered on the east side of the neighborhood, the steep hillside area, whereas crammers are located alongside the commercial strip. These environmental and social settings of the area provide one of the prototypes of the urban landscape in residential neighborhoods in a compact-city style. The high density of retail stores in a hilly residential area is the best experimental setting to test if the pedestrian customers choose their routes based on their comfort in walking to and from the stores.

Convenience stores in South Korea tend to serve customers within walking distance, and a significant portion of visitors are pedestrians and other active-transport riders, such as cyclists, skateboarders, and scooter riders. We assume that a shopping trip to and from a convenience store as a utilitarian trip takes place in circumstances that help minimize travel costs. The conventional way to minimize travel costs for active-transportation tends to be similar to the motorized mode of transportation, such as time and distance, whereas this study considers traveler comfort to calculate travel costs. Hence, the route choice for pedestrians and active-transportation riders to visit convenience stores is determined in a way to minimize effort or energy expenditure, rather than the trip length. If the slope as a driver of energy expenditure is not critical in route choice, a pedestrian customer visits a store that provides the shortest distance, compared to other stores nearby. The study's purpose is to test whether a store visited by a pedestrian customer is the closest to the person's original place among all the convenience stores in the study areas. Using a metabolic requirement model, caloric consumption for an individual on a route is used as criteria to determine if the person visited the store in a way to minimize energy expenditure as travel cost.

2. Trip Chain Type

A single trip chain related to shopping at a convenience store is made up of two trips. The first single trip is a journey from a place, regarded as an origin, to the store. The second trip is supposed to be generated from the store to leave for somewhere else after shopping. The shopping trip is generated from the original place and ends up at a place after the store. For the case in which the shopper returns to the origin, the place where the entire shopping trip terminates is the same as the origin, whereas, in the shopping trip chain, the final terminal point is different from the origin (Figure 2).

This classification is more useful regarding decision-making to select which convenience store provides the best route to minimize the travel distance. If a customer's destination after shopping is not the same as the origin, s/he does not always choose a store because of its shortest distance between the origin. Instead, the shopper considers choosing a store, making the total distance to another place after shopping at the store minimized. To get the environmental characteristics, it is necessary to identify the features of inbound and outbound trips to/from convenience stores. In addition to characterization of the inbound/outbound ways, it is also essential to characterize to check if the inbound and outbound path take the same route, in other words, checking whether the departure points in the series of trips is the same as the arrival points after shopping or not. We identify a trip chain in which a convenience store is considered an intermediate stop by a consumer into two categories. The Type 1 trip chain is defined as a series of trip segments, consisting of a departure trip from a point to a convenience store, and the return trip to the original departure point. In this case, this study presumes that the departure trip and return trip have the same route. The Type 2 trip chain represents a series of trips whose departure point is different from the endpoint after shopping. For the trip chain, there is no return trip.

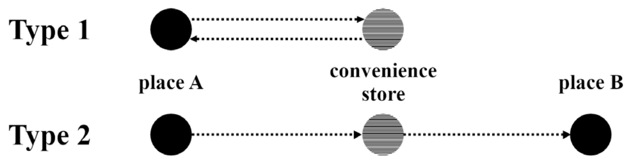

Figure 2. Classification of trip chain

3. Network Analysis

Employing network analysis modules of PyQGIS, a python program customized for Quantum GIS, we automated the calculation of the shortest path for a shopper, given three pieces of information, such as the departing point, convenience store, and destination. We estimate the total caloric requirement to apply topographic features to segments of the path and the individual's body mass.

For the Type 1 trip chain made by a person, departing from a place to a store and coming back to the same place, the shortest distance calculations take place for the place and twelve stores, and each optimized path has a distance value. This approach allows us to assign an individual the twelve possible shortest routes to stores in the neighborhood. For the geometry calculation, the shortest distance for an individual between the departing place A and convenience store 1 is twofold to the one-way distance (2DA1, in Figure 3). We repeat the calculation for each survey participant's departing point as many as the neighborhood's number of convenience stores. We have twelve shortest paths from a place to twelve stores for each survey participant from the processes.

For the Type 2 trip chain, departing from a place to a store and leaving for another place (Figure 3, right), we separate the network analysis into two cases, namely coming to the store on the one hand and leaving from the store to another place on the other. We calculate the total distance of part 1 and part 2 trips and regard it as the shortest distance between the departing place, the convenience store, and the other destination. For example, in Figure 3, we calculate the shortest

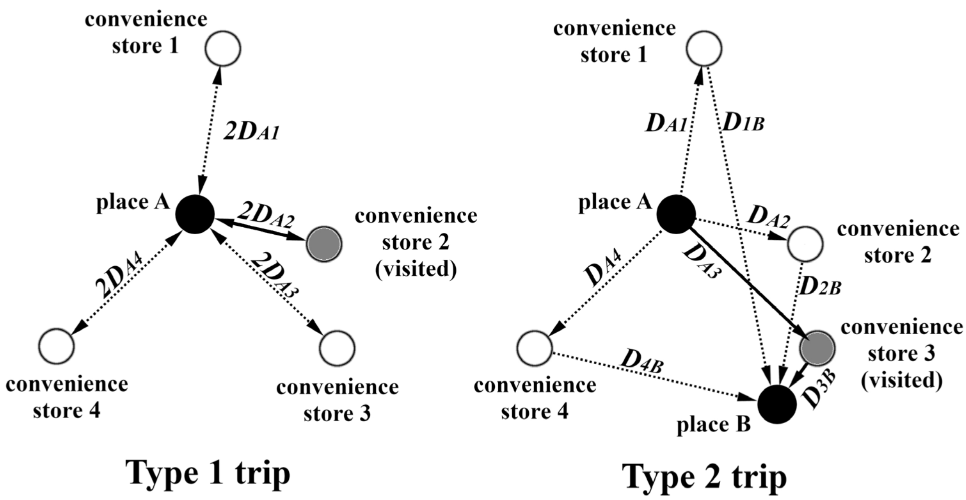

Figure 3. Distance calculation to/from convenience stores by trip type

path to each convenient store, the same, and Type 1 trip, and another shortest path from the store to another destination.

Given 12 stores in the area, a particular place has a set of 12 optimal paths. The person decides to choose one store with the shortest length between the travel costs set. Since we conducted the survey interview in three fixed stores, we know which path was chosen from the twelve shortest paths. This method allows testing if the convenience store is always chosen to minimize distance. If the premise, people plan their trips to minimize distance, is right, the shortest distance involving the visited store should always be the shortest, given 12 shortest paths.

4. Slope and Caloric Requirement Calculation

In addition to calculating the shortest path for each convenience store's possible shopping trip, we estimate the caloric requirements for the journey, taking into account the gradient and body mass of an individual who is supposed to take the route. We obtain the slopes of the 12 shortest paths obtained from the network analysis in the following way (Figure 4). First, the nodal points of each path are obtained with GIS programming. Second, we retrieve the coordinates of the nodes in pairs of latitude and longitude. Third, we use the geographic coordinates to obtain the corresponding node's elevation, using the GoogleMaps API method. These works are conducted at the nodal point level. Once the elevation is identified for each node, the line segment's gradient between the nodes can be determined. Utilizing python programming, we identify the distance between two nodes in a line. Second, we calculate the slope gradient of each segment, considering the direction of the trip. As shown in Figure 4, the shortest path from a particular point A to B is made of uphill and downhill. In the first line segment, a person climbs uphill. In this case, the difference between the elevation of the second nodal point (n2) and the first nodal point (n1) is e2 - e1, and the slope is the difference of the elevation divided by the length (l12) of the corresponding line segment. Since e2 is more significant than e1, the first segment has a positive slope. For the second segment, the trip starts at node n2 and ends at n3, with the elevation difference being e3 - e2. The slope of the line segment l23 has a negative value. Since the altitude varies according to the walking direction, the topographic resistance value is actually reflected in the calorie calculation. The number of calories required for walking can be calculated based on the slope given by each segment and the weight of the survey participants.

The estimation of caloric consumption for walking incorporates the terrain's topographic features, a pedestrian's body mass, velocity, and walking duration (American College of Sports Medicine, 2000; Iseki and Tingstrom, 2014; Macias, 2016). The equational model provided the American College of Sports Medicine (2000) is used to estimate the energy expenditure per road segment expressed in kilocalories (Kcal) as follows:

$$EP_{kcal} = (S \div l) \times (0.1S + 1.8S \cdot G + 3.5) \times BM_{kg} \times 0.005$$

where

EP_{kcal}: energy expenditure (kilocalorie)

S: walking speed (1.065 m/s)

l: total length of trip (m)

G: slope gradient

BM_{kg} : body mass (kg)

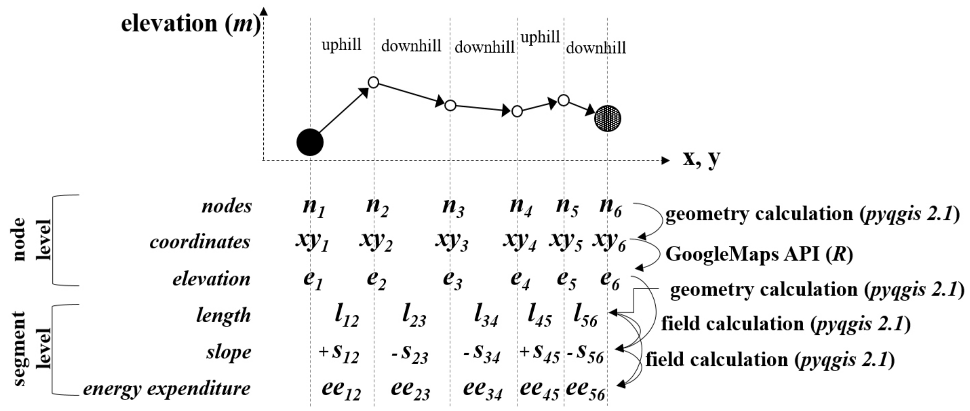

Figure 4. Slope and caloric-requirement calculation

We were employing the metabolic equational model, estimating the caloric consumption on-road segment with combined topographic gradient and body mass for each respondent. The equation is used for each shortest path a customer was supposed to take between a specific place and a convenience store.

5. Rank Score Assignment and Test

There are 12 stores in the study area. We can calculate the travel distances and energy consumptions for each respondent required for traveling to/from the 12 stores. Thus, it enables us to find which convenience store is the most or least preferable for a respondent to minimize travel costs. Given the calculated travel distances and energy consumptions, we rank each store's superiority for each respondent from 1 as the most preferable to 12 as the least preferable. Regarding the distance-based measurement, a store with the shortest distance for a specific pedestrian customer in the study area is superior to other stores and ranked as 1, whereas a store with the longest travel distance is marked 12. This rule also applies to the caloric-based measurement. It is marked as one if a store whose energy requirement for a pedestrian to walk is the smallest in the study area. As the energy consumption requirement increases, the rank score increases, meaning less preferable.

We test whether a convenience store visited by a pedestrian customer is the best one that the shopper chooses because it makes the shopper walk the shortest distance, compared to other stores nearby. If pedestrian shoppers take the minimum distance strategies for choosing a store, the average rank score tends to close to 1. In order to find the impact of land gradient on the store choice, we also test whether the average rank score, based on the minimum energy strategy, is close to 1, which means pedestrian shoppers tend to choose a store, ensuring the minimum energy consumption.

6. Questionnaire Design

We designed the questionnaire to find where customers of convenience stores are visiting from, and where they are heading afterward, by inquiring of the mailing addresses of the places or relevant information, such as intersections and landmarks, if they are concerned about privacy. They were asked to provide the location information either on the questionnaire or on maps, and all provided it on the questionnaires. If a customer walks to a store from a place and comes back to the same place, they provide the same mailing address in the first place and the second-place slots. Developing questions on locations, we clarify the meaning of 'the place' as a physical location where all possible activities can be undertaken. Survey distributors also notice that waiting at a transit stop is one activity, so that transit stops should be considered a place. The subjects were warned and clarified both these pre-determined ambiguities on the questions and verbal expressions by the questionnaire distributors.

The second section of the questionnaire comprises questions dealing with drivers in the decision-making processes to choose one particular store to visit other stores. In contrast to choices selected from the literature review, the questionnaire question had respondents select the main reasons to visit the stores concerning urban form, including distance, slopes, and non-spatial, marketing-related features, including diversity of products, quality, and promotions of productions. Visiting time and frequencies of visits are included in the questionnaire.

7. Survey Interview and Coding

The questionnaires were handed out to customers visiting each targeted store on July 23rd during (1:00 – 9:00) pm and July 24th during (10:00 am – 1:00 pm) with efforts undertaken to have the survey respondents representative of the population. Customers who finished shopping were approached, requested to participate in the survey, and informed about the questionnaire distributer's name, affiliation, purposes of the study, and a brief outline of the survey. Each respondent provided information inside the store and returned their answers shortly after finishing their survey. With the willingness to provide information, 168 customers fill out the survey questionnaires.

All responses from the questionnaires were entered into Microsoft Excel. The dataset is designed to have each respondent attribute field, including the mailing address of origin, the mailing address of the convenience store the respondent visited, the second place the participant was heading to after shopping, and other socioeconomic background and related information.

Ⅳ. FINDINGS

1. Demographic and Socioeconomic Profile

In a survey conducted at three convenience stores, 168 respondents answered questions about using convenience stores. We had a lower response rate for the survey. The percentage of visitors agreeing to participate in the survey was lower than 5% from three convenience stores. The percentages of female and male respondents were 51.4 and 48.6, respectively. In terms of age and occupation, most respondents were teenage students (Table 1). There are three elementary schools, three junior high schools, and three high schools around the three convenience stores. Also, the ratio of respondents in the 10th grade was high because cram schools are concentrated in the study area.

2. Consumer Behavioral Characteristics

Survey respondents, in general, visited the convenience store from home or school. Approximately 93 % of the participants visited the store from home or school. Of 86 student respondents, 55 respondents departed from school, whereas 31 respondents left their homes. Since they live close to their schools in the study area, it is possible to find many students visit stores from home. We also found that after shopping at the store, most respondents headed home or to school. The percentage of participants who left the convenience store for home was higher than those visiting the home. We also confirmed that there were more trips from store to home than those from home to store. Since most of the respondents were teenage students, and we had higher response rates in the middle of the afternoon, we anticipated the higher percentage of customers who headed home after shopping. Almost half of the customers answered that they usually visit the convenience store from noon to 6 pm. A significant portion of respondents visited convenience stores during the evening and at night. It was confirmed that they visit the convenience store 3.8 times a week on average. The customers purchased most items were beverages, snacks, and home meal replacements, and the average customer spent 2,571 Korean Won (equivalent to about 2 USD) per visit (Table 2). Regarding the reason for visiting the convenience store, the diversity of sales products was the most pointed out, and there was no event planning product or convenience store nearby. In terms of the physical environment, they also mentioned the gentle slope and the safety of coming and going, but the ratio was significantly low.

Table 1. Demographic and socioeconomic profile

Variable	Freq.	Percentage (%)
Gender		
Female	56	51.4
Male	53	48.6
Occupation		
Self-employed / Freelancer	4	3.7
Employed worker	9	8.3
Housewife	4	3.7
Students*	86	78.9
Unemployed	4	3.7
Other	2	1.8
Age (years)		
10 – 19	74	67.9
20 – 29	17	15.6
30 or older	18	16.5
Eduction		
Middle school or lower	63	59.4
High school	28	26.4
College graduate or higher	15	14.2

*Currently attending primary-, secondary-, high-school, college, or higher educational institutions

3. Travel Behavioral Characteristics

109 out of 168 respondents provided correct addresses for both their departure places and destinations. Their journeys were classified as Type 1 or Type 2, depending on whether they matched the starting and ending point addresses. Some 56.5 percent of the respondents answered they had returned to their original starting point from the convenience store after shopping (Type 1), while 49.5 percent of the respondents visited the convenience store before departing elsewhere (Type 2). From the network analysis, we found that an average participant walked 740 meters to complete their shopping. This is similar to double the one-way walking distance threshold of 400 meters (about 1/2 mile) to commercial services and transit stops. Taking the slope and weight into account, we estimated the required amount of calories

to cover the geometric shortest distance to the convenience store to be 29.2 kcal on average (Table 2).

We tested whether the rank of the convenience store visited by a respondent was always 1, according to the minimum distance strategy, and found that the convenience store's rank scores of 59 out of 109 participants visited were more significant than 1 (Table 3). About 54 percent of the survey participants visited the stores that did not guarantee the shortest distance compared to other convenience stores in the study area. Regarding trip length, the average rank score of participants, who did not take the minimum length strategy, was 3.31. Unlike our expectation, the same respondents did not have benefits from the minimum calorie strategy. Based on the energy consumption, the average rank score for the same group of the participants was 3.29. There is no significant difference in rank scores between total length and caloric consumption (Table 3).

We used the t-test to statistically validate the difference by the respondents' demographic and social characteristics (Table 4). Regarding the respondents' average ranking score in the teenager, the group was 2.43, which was higher than that of those aged 20 or older. Even if we look at the calorie requirement based on the inclination, this difference in rank is statistically significant at 90% confidence level. Teenagers take less care of the advantage of the shortest distance in convenience store choice than those 20s or older. The calorie consumption based on physical fitness during walking is also considered less important than the minimum calorie consumption. The differences between Type 1 and Type 2 in the average rank scores for both minimum distance and caloric consumption strategies are not statistically significant. In terms of gender, female respondents' selection of convenience stores was not as energy efficient as men. The preference of minimum energy requirement for convenience store selection was relatively less important for women than for men.

For the reasons for choosing the convenience store, respondents who considered the diversity of goods offered at convenience stores were less likely to consider the shortest distance and minimum calories, compared to those who did not. However, 2-in-1 commodity offers, cashback, convenience store presence near the vicinity, and slope factors were not statistically significant (Table 4).

Table 2. Consumer behavioral characteristics

Variable	Freq.	%	Min	Mean	Max
Origin					
Home	46	42.2			
Work	6	5.5			
School	55	50.5			
Other	2	1.8			
Destination					
Home	50	45.9			
Work	7	6.4			
School	41	37.6			
Other	11	10.1			
Visits previous week	109	100.0	0.0	3.8	21.0
Visiting time					
06:00-09:00	4	3.8			
09:00-12:00	5	4.8			
12:00-15:00	10	9.5			
15:00-18:00	42	40.0			
18:00-21:00	32	30.5			
21:00-00:00	8	7.6			
00:00-03:00	3	2.9			
03:00-06:00	1	1.0			
Reason to visit*					
Promotional items	30	28.0			
Cashback	7	6.5			
Variety of items	39	36.4			
No stores nearby	23	21.5			
Short distance	69	64.5			
Mild slope	11	10.3			
Safety	4	3.7			
Expense (KRW)	107	98.2	0.0	2,571	10,000
Trip type					
Type 1	56	50.5			
Type 2	53	49.5			
Traveled meters	109	64.9			
Calories burned	109	64.9			

*Multiple answers allowed

Table 3. Rank scores by participant group

	Freq.	Length-based			Calorie-based		
		mean	t	p	mean	t	p
Group 1	50	1.00	-13.45	0.000	1.18	-9.29	0.000
Group 2	59	3.31			3.29		

Group 1: Participants whose rank score based on trip length is 1
Group 2: Participants whose rank score based on trip length is greater than 1

Table 4. Rank scores by demographic and socioeconomic status and consumers' behaviors

	Freq.	Length-based			Calorie-based		
		mean	t	p	mean	t	p
Age Group							
<20 yrs	74	2.43	1.994	0.050	2.49	1.679	0.097
≥20 yrs	35	1.86			1.97		
Trip Type							
Type 1	56	2.09	-1.1131	0.260	2.09	-1.516	0.133
Type 2	53	2.42			2.57		
Gender							
Female	56	2.46	1.564	0.121	2.63	2.036	0.045
Male	53	2.02			2.00		
Reason to visit–Promotional items							
Yes	30	2.07	-0.809	0.422	2.17	-0.619	0.539
No	79	2.32			2.39		
Reason to visit–Cashback							
Yes	7	1.71	-1.472	0.178	1.57	-2.365	0.051
No	102	2.29			2.38		
Reason to visit–Variety of items							
Yes	39	2.64	2.031	0.046	2.74	1.943	0.056
No	70	2.03			2.09		
Reason to visit–No stores nearby							
Yes	23	2.00	-0.988	0.379	2.04	-0.985	0.331
No	86	2.32			2.40		
Reason to visit – Short distance							
Yes	69	2.22	-0.300	0.766	2.29	-0.286	0.776
No	40	2.32			2.39		
Reason to visit–Mild slope							
Yes	11	2.00	-0.682	0.507	2.09	-0.540	0.598
No	98	2.28			2.35		
Reason to visit–Safety							
Yes	4	1.50	-2.304	0.217	1.50	-1.633	0.184
No	105	2.28			2.36		

Ⅴ. CONCLUSION

For the past 20 years, convenience stores have replaced the traditional corner stores and small grocery stores, and become one of the major retailers. Unlike the car-dependent North American cities, cities in Korea are more likely to be in the compact city-style with mixed-use and have a higher share of public transit riders and pedestrians. For this reason, the service radius of convenience stores in South Korea almost coincides with the walking distance. They are even located within 100 meters or 50 meters of one another, causing overheated, and even destructive, competition. To protect small business owners from destructive competiveness, governmental agencies and legislature have recently introduced measures to ban the opening of convenience stores with the same brand within 200 meters, but the effect is questionable. In this situation, most customers of convenience stores in South Korea are pedestrian, and the distance threshold of utilitarian walking trips is considered as a metric to estimate the service area of a store. However, most physical layouts of Korean cities were built on the steep landscape, and therefore land slope should be considered another critical factor affecting walking behavior.

Under the premise that human beings make their trips in a way to minimize the travel cost, we investigated whether a convenience store visited by a person guaranteed that the person would travel a shorter distance compared to other stores nearby in a neighborhood. If the minimum distance strategy was applicable, we tested whether the store visited by the person ensured the person would spend less caloric energy than for other stores.

We found that half of the respondents visited convenience stores without superiority in minimizing the traveling distance to other stores. Unlike our expectation that participants with longer trips compensate for minimizing energy expenditure, the more extended traveling group also expended more energy. We did not find any evidence to suggest that people make their trip longer to minimize energy consumption while walking (Table 3). The result is not comparable to previous studies. The studies are based on active-transportation related trips with cycling whose riders tend to travel longer distances than pedestrians. Unlike the related research, this study focuses more on the micro-environment in which pedestrian travelers pursuit their errands in relatively shorter distances. Human subjects need to be more specified in future research, based on sensitivity to the natural environment.

Considering the demographic and socioeconomic characteristics of respondents who did not comply with the minimum distance strategy, we found that the length of walking trips differed by age, sex, and sale products. Teenagers were not sensitive to the minimum distance and the minimum energy consumption strategies on walking trips than other age groups. The younger age group tended to take less care of energy expenditure. Unlike our expectations, we found that female pedestrian customers walked farther and consumed more energy than male pedestrian customers. The consumption behavior showed the most dramatic difference from the shortest distance strategy and the least energy strategy. We found that the minimum distance strategy was not always applicable to decision making in-store and route choice, given a set of convenience stores nearby. Also, the land slope does not explain why people do not visit a convenience store with the shortest travel distance compared with the others. In the future study, samples with various demographic characteristics, especially for age, would provide meaningful findings on the impact of slope on travel behavior.

This study investigates the service area of convenience stores that sell everyday goods among the neighborhood level's retail services. In addition to the travel distance, this study assumes that shopping trips will be planned considering walking convenience. The minimum energy strategy for inclination and pedestrian physical condition is based on the effectiveness of the location of public services provided at other neighborhood levels, such as community centers, schools, transit stops, welfare centers, and convenience stores. It can be useful for empirical analysis.

This study has three limitations. First, the demographic and socioeconomic background of the respondents was not varied. Although primary and secondary schools are located in the study area, the proportion of teenagers in the surveys is too high to understand older generations' behavior. In comparison with teenagers, we found that the older age group respondents were relatively sensitive to distance or energy consumption. However, it was challenging to identify the elderly population's travel behavior in detail because of the limited number of participants. Because this study focuses more on environmental settings, such as hilly neighborhoods, the limitation of the demographic profile's representativeness exists. Second, there was a methodological limit. In this study, only the pedestrian customers' location data, the convenience store, and the final destination after shopping at the specific convenience store were used. Through the network analysis to find the shortest path, we identified the shortest path between the three points, but there is no guarantee that the pedestrian customer took the path. Future studies will be possible to elaborate on how pedestrians are moving and compare the shortest route based on the actual route and the calculated shortest route and energy demand on the network. Lastly, a limited number of external factors are considered to explain the variability of the average rank scores. Given its methodological features as a case study, this research faces difficulty to have a sample size good enough to conduct multi-variate analysis, including multiple regression analysis, rather than the two-group comparison analysis. Future research needs to address the problem by either limiting the target group for study or ensuring to have sample size bigger.

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