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Analysis of The Location Suitability of Sports Facilities in Seoul

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Abstract

Purpose: The main goal is to analyze the spatial distribution of public sports facilities in Seoul and evaluate accessibility disparities across different regions and facility types. This analysis seeks to identify areas with significant imbalances in accessibility, providing insights for policy and infrastructure development to address these inequalities. **Research design, data, and methodology:** The study uses the gravity potential model and Z-score analysis to assess the accessibility of public sports facilities in Seoul. The gravity potential model examines how a facility's location and capacity influence its accessibility, while Z-score analysis identifies variations in accessibility across different regions and facility types. **Results:** The results show significant regional imbalances in the accessibility of public sports facilities in Seoul, with high accessibility in the downtown area and low accessibility in the southwest and southeast. While disparities across facility types are generally minimal, specific regional inequalities exist, such as poor accessibility for baseball fields in downtown and northeast areas, and for gate-ball fields in the southwest and southeast. **Conclusions:** The following policy implications are suggested: (1) public sports facilities should be made more accessible; (2) local school sports facilities must be utilized; and (3) public sports facilities must be upgraded.

Keywords: Public Sports Facilities, Location Suitability, Accessibility Inequality, Gravity Potential Model, Z-score Analysis

JEL Classification Code: A14, A19, R11, R15, R41

1. Introduction

According to the World Bank survey, Korea's nominal gross domestic product per capita in 2020 was $31,631, ranking 10th in the world (Cho, 2022). Koreans are increasingly interested in health due to rapid economic development and improvement in the national income level (GBD 2019 South Korea Bod Collaborators, 2023). In Korea, economic growth has raised people's demands for quality of life, and with the implementation of a five-day work week, people want to improve their health through exercise during their leisure time. Health and exercise are highly correlated, with a chronic disease status index of 0.27 for those who exercised, 0.28 for those who exercised vigorously, 0.32 for those who exercised moderately, and 0.32 for those who did walking, while those who did not exercise was lower at 0.36 (Jeon et al., 2015). As people recognize the importance of exercise, the demand for sports facilities also increases.

The government is making efforts to expand public sports facilities in response to people's needs. These facilities contribute to citizens' sports activities by providing sports infrastructure that anyone can use conveniently as a sports welfare facility (Valeri, 2019). Public sports facilities are facilities owned or managed by the state or local governments. These include specialized, living, and

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workplace sports facilities. Specialized sports facilities include playgrounds and gymnasiums necessary for hosting domestic and international competitions and training athletes. Living sports facilities are those that citizens can easily use and are located near their residences. Workplace sports facilities are those that office workers can use for physical activities.

Sallis et al. (2012) explore the impact of built environments, including sports facilities, on physical activity levels, obesity, and cardiovascular disease, finding that environments designed with accessible physical activity resources significantly increase the likelihood of regular exercise among the population. This study highlights the direct correlation between the provision of sports facilities and increased physical activity, emphasizing the importance of expanding these amenities to foster a more active and healthier society. The evidence supports the argument that enhancing access to sports facilities is a vital public health intervention that can lead to more individuals engaging in regular exercise, thereby reducing the prevalence of obesity and cardiovascular diseases.

Raza et al. (2022) revealed that closer proximity to sports facilities is associated with higher exercise frequency and lower obesity rates, providing evidence that increasing the number of sports facilities could lead to more regular physical activity among the population.

This study focuses on public sports facilities, which are closely related to exercise for the health of citizens in Seoul, where 20% of the Korean population live among public sports facilities. With a population of 17,219 people/km2, Seoul has the highest population density among cities in OECD countries, eight times that of New York and three times that of Tokyo (Cho, 2022).

Seoul's high population density causes spatial restrictions on exercise and rest for citizens. As the health of citizens may be threatened by such restrictions, Seoul plans to gradually expand public sports facilities and provide them to citizens. In the short term, by 2023, the city of Seoul plans to build 85 indoor sports facilities, 35 in-door multi-purpose gyms, and 50 "My Neighborhood Small Gymnasiums" that will be used as living sports spaces.

The Seoul Metropolitan Government plans to expand 36 facilities as a public cooperation project to create sports and convenience facilities for residents along with sports facilities in parks and rivers, including 52 outdoor sports facilities for each sport in a small site. If a total of 460 sports facilities are successfully established in Seoul by 2023, it is expected that Seoul citizens will have short access to sports facilities on foot to less than 5 minutes (GBD 2019 South Korea Bod Collaborators, 2023). Therefore, in this study, the spatial accessibility of Seoul's public sports facilities was calculated using the current gravity potential model, and accessibility was evaluated by dividing accessibility by region into four grades through the jet score. Accordingly, we suggest ways to attain efficient spatial accessibility for public sports facilities in Seoul in the future.

Inequality in access to these facilities across different regions of the city. This involves identifying and quantifying disparities in how various populations can utilize public sports facilities based on their location.

Second, the study seeks to examine how accessibility to different types of public sports facilities varies by region. By focusing on specific facility types, such as gymnasiums, swimming pools, and soccer fields, the research aims to uncover whether certain facilities are more or less accessible depending on their location, and how this affects residents' ability to engage in physical activities.

Finally, based on these analyses, the study aims to propose an efficient supply plan for the distribution of public sports facilities in Seoul. The goal is to provide recommendations that can guide policymakers and urban planners in addressing the identified inequalities, ensuring that all residents have fair access to the facilities they need for active and healthy living.

2. Theoretical Background

2.1. The Necessity of Public Life Sports Facilities

People who live in cities have fewer natural spaces than in the countryside. Hence, city dwellers use sports facilities to exercise. However, some people are unable to exercise regularly due to the cost burden of private sports facilities; the gap between the rich and the poor leads to a gap in the amount of exercise and eventually leads to health disparities (Lee et al., 2016; Burillo et al., 2011). Accordingly, the necessity of public sports facilities is raised.

In Korea, the rate of regular participation in physical activity, defined as engaging in exercise for 30 minutes or more at least once a week over the past year, saw a significant increase of 11.8% over the past five years, rising from 54.8% in 2014 to 66.6% in 2019 (Data.seoul.go.kr). During this same period, the number of public sports facilities experienced an extraordinary growth of 141%, expanding from 21,317 facilities in 2014 to 30,185 in 2019 (Data.seoul.go.kr). Thus, the expansion of public sports facilities clearly contributes to increased citizen participation in sports activities, which positively impacts their health (Marston & Van Hoof, 2019).

2.2. A Study on Urban Public Sports Facilities

Studies on urban public sports facilities include research on construction funds, the impact on the local community, spatial management and utilization, and the services offered

in these facilities. Existing research can be divided into research on efficiency improvement and spatial accessibility of public sports facilities.

First, research on the construction funds for public sports facilities involves studies on the problem of inputting public funds (Coates & Humphreys, 2003; Murray, 2009), studies on subsidies (Humphreys 2019; Dugalić & Krsteska, 2013), and the issue of the legitimacy of injecting public funds into public sports facilities (Parlow, 2002).

Studies on the effects of public sports facilities on the local community include one on their positive effect on the quality of life of citizens (Wang, 2022) and on the accumulation of community capital. There are studies that show that it has a positive effect on academic achievement (Biernat et al., 2020) and that public life sports facilities have a positive effect on academic achievement (Wali et al., 2021).

A study on the spatial management and utilization of public sports facilities for public life (Karami, 2022), on the facilities for living (Li & Zhang, 2021; Sun, 2013; Taylor & Godfrey, 2003), and on spatial management of public sports facilities (Amaral et al., 2021).

Studies on the efficiency improvement of public sports facilities for public life (Benito et al., 2012; Niu & Zhang, 2021), on the efficiency evaluation of public sports facilities services (Chen, 2019), and on the effect of the efficiency of public life sports facilities services on their use (Wang & Makubuya, 2018).

Spatial accessibility of public sports facilities is an important issue in a city with limited space. Related studies analysed spatial accessibility based on the demand for sports facilities (Kim & Kim, 2017), spatial inequality of public sports facilities using a regression analysis method (Shen et al., 2020), and entropy indices (Chen et al., 2021).

Urban public sports facilities should be accessible to citizens in terms of their location. The accessibility of sports facilities directly influences the physical activity levels among city residents, impacting their overall health and well-being. Ensuring these facilities are accessible to all is essential for fostering a healthier, more active community. Accessible sports facilities encourage regular participation in physical activity by reducing travel times and making it easier for individuals to incorporate exercise into their daily lives.

This can ultimately lead to a reduction in lifestyle diseases and strengthen social cohesion within the community by providing a common space for participation. Accessible sports facilities promote health equity by offering everyone, regardless of socio-economic status, the chance to engage in physical activity. This inclusivity helps to reduce health disparities and fosters a community spirit of inclusion and well-being.

Therefore, this study aimed to assess the location efficiency of Seoul's public sports facilities using the gravity potential model, which takes into account both supply and demand aspects to provide a comprehensive evaluation of accessibility.

2.3. Seoul's Urban Living Area

The urban life area of Seoul consists of 5 districts and 25 autonomous districts (urban.seoul.go.kr), as shown in Figure 1.

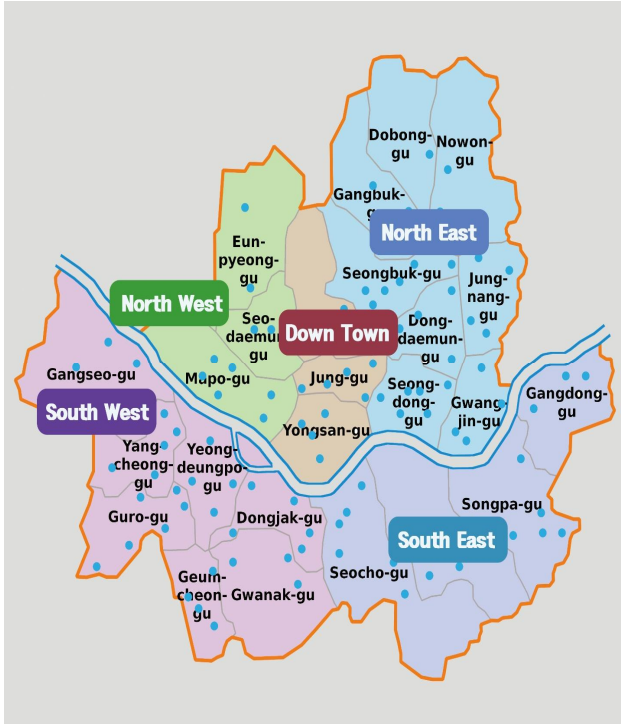

Illustration by the author

Figure 1: The urban life area of Seoul

Seoul is divided into five regions: the downtown area, the northeast area, the northwest area, the southwest area, and the southeast area. The downtown area comprises Jongno-gu, Jung-gu, and Yongsan-gu, with an area of 56 km^2 and a population of 580,000. The northeast region comprises Seongdong-gu, Gwangjin-gu, Dongdaemun-gu, Jungnang-gu, Seongbuk-gu, Gangbuk-gu, Dobong-gu, and Nowon-gu, with an area of 171 km^2 and a population of 3.26 million. The northwestern region comprises Eunpyeong-gu, Seodaemun-gu, and Mapo-gu, with an area of 71 km^2 and a population of 1.22 million. The southwest region comprises Yangcheon-gu, Gangseo-gu, Guro-gu, Geumcheon-gu, Yeongdeungpo-gu, Dongjak-gu, and Gwanak-gu with an area of 163 km^2 and a population of 3.17 million. The southeast region comprises Seocho-gu, Gangnam-gu,

Songpa-gu, and Gangdong-gu, with an area of 146 km^2 and a population of 2.18 million. In terms of area, the largest is the northeast (171 km^2), followed by the southwest (163 km^2), southeast (146 km^2), northwest (71 km^2), and downtown (56 km^2), In terms of population, the largest is the northeast area (3.26 million), followed by the southwest area (3.17 million), the southeast area (218,000 people), the northwest area (1.22 million people), and the downtown area (580,000 people). In terms of autonomous districts, the largest number is the southwest area (10), then the northeast area (8), the southeast area (4), the northwest area (3), and the downtown area (3). In the east, the northeast area (36)> southwest area (33)> southeast area (22)> northwest area (14) and downtown area (12) are in order.

3. Data and Research Methods

3.1. Data

Public sports facilities in Seoul are classified into 22 facilities. Of these, seven facilities are not in Seoul: a wrestling field, a shooting range, an archery field, an equestrian field, a rowing canoe field, a yacht field, and a snow sports field. Among these facilities, public sports facilities, the subject of this study, are not clearly classified. Therefore, based on previous studies (Benito et al., 2012; Sun, 2013; García-Unanue et al., 2015), residents selected the sports facilities that can be used for daily living. The facilities selected included soccer field, baseball field, tennis field, gate-ball field, swimming pool, national archery field, golf driving range, ball game gymnasium, and daily life gymnasium. In Korea, along with economic growth and the spread of coronavirus disease 2019, the number of people who mainly enjoy golf outdoors has increased, and it has become a daily sport (Kang et al., 2022).

Table 1 presents data from 2023 on public sports facilities in Seoul. Gymnasiums constitute the largest share of public sports facilities in Seoul at 22%, closely followed by swimming pools at 21%, indicating a strong public inclination towards these activities. Comparatively, specialized facilities such as national archery fields are much less common, comprising only 2% of the total. Gate-ball fields and golf driving ranges also occupy a smaller portion of the sports infrastructure, with 5% and 7% respectively. This distribution highlights a clear disparity in the availability of different types of sports facilities, suggesting varying levels of public interest and municipal investment. The data underscores the need for a more balanced approach to developing sports facilities to cater to a broader range of interests. In terms of the area of the facility, soccer fields (26%) were the largest, followed by gymnasiums (25%). Gate-ball fields and national archery fields were the smallest, each at 1%. Golf driving ranges, comprising 5% of the total area, and baseball fields, making up 7%, represented smaller portions of the allocated space. These facilities, though occupying lesser extents, contribute significantly to the diversity and recreational offerings of the area, providing specialized venues for enthusiasts and athletes of their respective sports.

Table 1: Status of Public Life Sports Facilities in Seoul.

Facility Items	Place	Ratio (%)	Area (m^2)	Ratio (%)
Soccer Field	73	15	1,154,917	26
Baseball Stadium	19	4	299,994	7
Tennis Court	65	14	392,013	9
Gateball Court	23	5	24,418	1
Swimming Pool	97	21	728,535	16
National Archery Field	8	2	38,874	1
Golf Driving Range	33	7	245,117	5
Ball Gym	50	11	511,815	11
Life Gym	105	22	1,110,699	25
Total	473	100	4,506,382	100

Source: Seoul Metropolitan Government, 2024

3.2. Research Hypothesis

The hypothesis of this study is as follows.

H1: The accessibility of public sports facilities differs across the urban life area of Seoul.

H2: Within the same urban life area of Seoul, accessibility varies according to the type of sports facility.

The theoretical background for hypotheses concerning the differences in accessibility of public sports facilities across and within urban life areas in Seoul encompasses a selection of theories, concepts, and results from previous studies. Here are key theoretical frameworks that can be used to explain these hypotheses:

3.2.1. Urban Planning and Design Theory

Urban planning and design theory explains how the use, layout, and development of space influence the accessibility of public facilities. In mega-cities like Seoul, urban planning plays a crucial role in determining the location, size, and type of sports facilities. Policies and decisions regarding the allocation of space are primary factors shaping the accessibility of sports facilities in certain areas (Pineo, 2022).

3.2.2. Socio-Economic Inequality Theory

Socio-economic inequality theory explores how the distribution of economic and social resources affects the opportunities and accessibility for certain groups or areas. The differences in accessibility of sports facilities across

various areas in Seoul, and even within the same area, may be attributed to the unequal distribution of economic resources and social support systems (Schröder & Neumayr, 2023).

3.2.3. Environmental Justice Theory

Environmental justice theory argues that all members of society should have equal rights to a healthy and sustainable environment. This theory posits that the accessibility of public sports facilities is not merely a matter of recreation but is intimately connected to broader social and environmental justice issues, providing an important perspective in explaining the background of the research hypotheses (Mohai & Saha, 2015).

3.2.4. Public Policy and Resource Allocation Theory

Public policy and resource allocation theory describe how decisions by governments and public institutions distribute resources and, thereby, shape accessibility to various services and facilities within communities. In the study of sports facility accessibility in Seoul, this theory can be utilized to analyze how investment and placement decisions for specific sports facilities impact different parts of the city (Andrews & Cingano, 2014).

These theoretical backgrounds support the hypotheses regarding the accessibility of public sports facilities in Seoul, providing a foundation and framework necessary for research design and analysis. The outcomes of the study can be further explored based on these theoretical underpinnings, offering insights into urban planning, social policy, and public health.

3.3. Analysis Methods

In this study, Guagliardo's Gravity potential model was used to analyse the location adequacy of public sports facilities.

Guagliardo's model complements the shortcomings of Talen and Anselin, and Joseph and Bantock's models, as discussed in the following subsections.

3.3.1. Talen and Anselin's Gravity potential model

Talen and Anselin's (1998) gravity potential model focus solely on the supply aspect of the facility without accounting for the demand side. This model aims to predict spatial accessibility based on facility supply; disregarding factors related to demand for the service. The equation of Talen and Anselin's model incorporates variables such as facility locations, their capacities, and distance decay effects to estimate accessibility within a given geographic area.

$$A_i = \sum_j \frac{S_j}{d_{ij}^{\beta}}$$

where:
A_i = Accessibility of area i,
$S_{j=}$ the size of the facility j,
d_{ij} = Distance between demand area i and sports facility j
β = distance friction coefficient

3.3.2. Joseph and Bantock's Model

Joseph and Bantock's (1982) model is designed to measure the potential demand group size (V_i). The formula for this model is:

$$V_i = \sum_i \frac{P_i}{d_{ij}^{\beta}}$$

where:
V_j = Potential user group size for facility j
d_{ij} = Distance between demand area i and sports facility j
P_i = Total population of demand area i
β = distance friction coefficient

3.3.3. Guagliardo's Gravity potential model

Guagliardo's (2004) model, which is used in this study, measures accessibility of sports facilities considering both supply and demand. The formula for this model is:

$$A_i = \sum_j \frac{S_j}{d_{ij}^{\beta} V_j}$$

Where:
A_i = Accessibility of demand area i
d_{ij} = distance between demand area i and sports facility j
V_j = size of the potential demand group sports facility j
S_j = size of sports facility j
β = distance friction coefficient

3.3.4. Measurements

The distance (d_{ij}) between the demand area and public sports facilities was obtained by measuring the straight-line distance between the facilities and dongs on Google Maps. For the potential group size (V_j) of public sports facilities, we used the population for each dong, obtained from the city's population census.

For the scale of public life sports facilities (S_j), the facility area provided by the Ministry of Culture, Sports, and Tourism in 2020 was used. Referring to the values used in previous studies (Kim & Kim, 2017; Guagliardo, 2004), the distance friction coefficient (β) of living gyms with a low service distance was 1, and less than 1 otherwise. The distance friction coefficient was differentially applied to the value. The β of the gate-ball field was 0.8 silver, the β of the golf driving range was 0.7 silver, the β of the soccer field,

swimming pool, and tennis court was 0.6, the β of the baseball field and the ball game gym was 0.5 silver, and the β value of the national archery field was 0.3.

4. Results and Discussion

4.1. Basic analysis

Table 2 presents the findings from an analysis of access to public sports facilities in Seoul for the year 2022. This analysis utilized the Guagliardo's gravity potential model to evaluate the accessibility levels of these facilities. The model's findings reveal varying degrees of accessibility across different regions of Seoul. Specifically, the downtown area exhibited an average accessibility score of 0.1910, indicating a relatively high level of accessibility compared to other areas.

The northeast area's accessibility was measured at 0.1262, and the northwest area had an accessibility score of 0.1494, both of which are above the city-wide average and suggest moderately high accessibility. However, a notable decrease in accessibility is observed in the northeast (a second reference, possibly a typographical error, should likely refer to another area) with a score of 0.0905, and the southeast area, which recorded the lowest accessibility score of 0.0816. When these figures are compared to the overall average accessibility score for Seoul's public sports facilities, which stands at 0.118, it becomes clear that the downtown, northeast (assuming the first mention), and northwest areas enjoy better access to sports facilities.

The observed disparities in accessibility to public sports facilities across different areas of Seoul suggest a complex interplay of factors, including urban development patterns, historical allocation of resources, and possibly even socio-economic considerations that have led to uneven infrastructure development. This uneven distribution not only impacts the immediate accessibility of sports facilities for physical activities but also has broader implications for public health, social inequality, and community well-being.

Addressing this imbalance requires a multifaceted approach that goes beyond simple acknowledgment of the disparities. It necessitates a commitment from city planners, policymakers, and community stakeholders to engage in holistic urban planning efforts that prioritize equitable access to recreational and sporting facilities. Such efforts could include the strategic placement of new sports facilities in underserved areas, the renovation and upgrading of existing facilities to improve their attractiveness and utility, and the implementation of targeted programs designed to increase engagement and participation in physical activities across all segments of the population.

Furthermore, this situation calls for a proactive dialogue between government entities, local communities, and the private sector to explore innovative solutions and partnerships that can facilitate the development of accessible and inclusive sports facilities. For instance, leveraging public-private partnerships to fund the construction of new facilities or the adoption of technology-driven solutions to enhance the efficiency of existing spaces can play a pivotal role in addressing the accessibility gap.

Table 2: Descriptive statistics of sports facilities in Seoul

Division	Area (m^2)			
	Min.	Max.	Mean	S.D.
Soccer Field	4,232	216,712	25,432	45,165
Baseball Stadium	1,680	364,420	34,921	77,947
Tennis Court	1,043	56,000	6,294	10,108
Gate-ball Court	231	4,666	1,126	1,071
Swimming Pool	830	92,494	8,407	12,404
National Archery Field	359	16,500	5,391	5,653
Golf Driving Range	300	41,328	7,769	9,528
Ball Gym	341	54,146	9,774	13,525
Life Gym	397	261,303	10,728	29,407
Division	**Distance (km)**			
	Min.	**Max.**	**Mean**	**S.D.**
Soccer Field	0.50	20.00	4.24	4.06
Baseball Stadium	1.50	23.00	5.74	5.14
Tennis Court	1.00	15.00	4.07	2.70
Gate-ball Court	1.40	5.80	3.03	1.21
Swimming Pool	0.60	11.00	3.79	2.11
National Archery Field	2.00	12.00	4.63	3.54
Golf Driving Range	1.30	8.60	3.61	1.95
Ball Gym	1.00	9.00	3.67	1.83
Life Gym	0.11	21.00	4.16	2.96

The author created the table

In parallel, there is a need for ongoing research and data collection to better understand the dynamics of sports facility usage, preferences, and barriers to access among different demographic groups. Such data can inform more targeted interventions and ensure that efforts to improve accessibility are grounded in the real needs and preferences of the community.

Ultimately, achieving equitable access to sports facilities in Seoul requires a concerted effort that encompasses policy reform, community engagement, and innovative urban planning.

By embracing a comprehensive and inclusive approach, Seoul can move towards a future where every resident has equal opportunity to engage in sporting and recreational activities, thereby enhancing the overall quality of life and fostering a stronger, healthier, and more connected

community.

4.2. Accessibility Analysis Result of Sports Facilities

Table 3 shows the results of analysing accessibility to public sports facilities in Seoul as of 2022. Guagliardo's gravity potential model was used to analyse the accessibility of the facilities. The average accessibility of public sports facilities was 0.1910 in the downtown area, 0.1262 in the northeast area, 0.1494 in the northwest area, 0.0905 in the northeast area, and 0.0816 in the southeast area. Compared to the average accessibility of Seoul's public sports facilities (0.118), the downtown, northeast, and northwest areas had high accessibility, and the northeast and southeast areas had low accessibility. In the table below, "S.F." stands for Soccer Field, "B.S." represents Baseball Stadium, "T.C." indicates Tennis Court, "G.C." denotes Gate ball Court, "S.P." means Swimming Pool, "N.F." refers to National Archery Field, "G.R." signifies Golf Driving Range, "B.G." stands for Ball Gym, and "L.G." represents Life Gym.

Table 3: Accessibility Analysis Result of Public Sports Facilities

Zone		S.F.	B.S.	T.C.	G.C.	S. P.	N.F.	G.R.	B.G.	L.G.	Total
Downtown Area	Jongno	0.021	0.016	0.024	0.002	0.030	0.087	0.016	0.014	0.014	0.223
	Jung	0.064	0.037	0.058	0.002	0.028	0.006	0.020	0.027	0.027	0.268
	Yongsan	0.018	0.012	0.009	0.002	0.003	0.017	0.009	0.006	0.006	0.081
Northeast Area	Seongdong	0.019	0.014	0.004	0.002	0.011	0.007	0.016	0.012	0.012	0.096
	Gwangjin	0.014	0.024	0.004	0.003	0.010	0.003	0.027	0.003	0.003	0.091
	Dongdaemun	0.016	0.014	0.001	0.001	0.005	0.003	0.015	0.011	0.011	0.077
	Jungnang	0.012	0.009	0.004	0.001	0.007	0.003	0.010	0.037	0.037	0.120
	Seongbuk	0.012	0.010	0.003	0.000	0.005	0.003	0.022	0.002	0.002	0.058
	Gangbuk	0.077	0.015	0.003	0.001	0.016	0.004	0.005	0.004	0.004	0.129
	Dobong	0.015	0.017	0.084	0.005	0.071	0.004	0.014	0.049	0.049	0.309
	Nowon	0.012	0.005	0.020	0.001	0.007	0.001	0.011	0.021	0.021	0.100
Northwest Area	Eunpyeong	0.008	0.023	0.008	0.001	0.010	0.009	0.009	0.009	0.009	0.087
	Seodaemun	0.009	0.035	0.004	0.001	0.018	0.014	0.008	0.002	0.002	0.092
	Mapo	0.180	0.026	0.002	0.001	0.015	0.021	0.008	0.008	0.008	0.269
Southwest Area	Yangcheon	0.051	0.027	0.025	0.001	0.004	0.006	0.004	0.006	0.006	0.130
	Gangseo	0.006	0.021	0.010	0.000	0.001	0.008	0.015	0.004	0.004	0.069
	Guro	0.015	0.057	0.002	0.001	0.016	0.003	0.007	0.019	0.019	0.138
	Geumcheon	0.010	0.044	0.010	0.000	0.012	0.006	0.016	0.003	0.003	0.104
	Yongdengpo	0.009	0.008	0.007	0.001	0.008	0.003	0.014	0.006	0.006	0.061
	Dongjak	0.009	0.026	0.005	0.001	0.004	0.003	0.007	0.008	0.008	0.070
	Gwanak	0.010	0.016	0.002	0.000	0.005	0.000	0.009	0.009	0.009	0.061
Southeast Area	Seocho	0.028	0.017	0.015	0.001	0.015	0.003	0.014	0.020	0.020	0.134
	Gangnam	0.007	0.017	0.001	0.000	0.003	0.002	0.014	0.012	0.012	0.069
	Songpa	0.006	0.020	0.003	0.000	0.012	0.001	0.002	0.016	0.016	0.076
	Gangdong	0.009	0.012	0.003	0.001	0.005	0.002	0.006	0.005	0.005	0.048
Seoul Mean		0.025	0.021	0.012	0.009	0.001	0.013	0.009	0.012	0.013	0.013

The author created the table

4.3. Z-score Analysis Result of Public Sports Facilities

The results of the accessibility analysis of public sports facilities are shown in Table 4. This study's analysis showed clearer differences by dividing it into 4 grades using Z-score. The Z-score equation is:

$$Z = \frac{x - \mu}{\sigma}$$

Where:
x= value of data
μ = mean of data
σ = standard deviation of the data

A positive Z-score means that the measured value is higher than average, and a negative Z-score means that the measured value is lower than average.

Table 4: Z-score Analysis Result of Public Sports Facilities

Zone		S.F.	B.S.	T.C.	G.C.	S. P.	N.F.	G.R.	B.G.	L.G.	Mean
Downtown Area	Jongno	3	3	1	2	1	1	1	2	2	1.8
	Jung	1	1	1	1	1	3	1	1	1	1.2
	Yongsan	3	4	3	1	4	2	4	4	4	3.2
	Mean	2.3	2.7	1.7	1.3	2.0	2.0	2.0	2.3	2.3	2.1
Northeast Area	Seongdong	3	4	3	1	3	3	1	3	3	2.7
	Gwangjin	3	2	3	1	3	3	1	4	4	2.7
	Dongdaemun	3	4	4	2	4	3	2	3	3	3.1
	Jungnang	3	4	3	3	3	3	3	1	1	2.7
	Seongbuk	3	4	4	4	4	3	1	4	4	3.4
	Gangbuk	1	4	3	3	2	3	4	4	4	3.1
	Dobong	3	3	1	1	1	3	2	1	1	1.8
	Nowon	3	4	2	3	3	3	3	1	1	2.6
	Mean	2.8	3.6	2.9	2.3	2.9	3.0	2.1	2.6	2.6	2.8
Northwest Area	Eunpyeong	3	2	3	3	3	2	3	3	3	2.8
	Seodaemun	3	1	3	3	2	2	4	4	4	2.9
	Mapo	1	2	4	3	2	1	4	3	3	2.6
	Mean	2.3	1.7	3.3	3.0	2.3	1.7	3.7	3.3	3.3	2.7
Southwest Area	Yangcheon	1	2	1	3	4	3	4	4	4	2.9
	Gangseo	4	2	3	4	4	3	1	4	4	3.2
	Guro	3	1	4	3	2	3	4	1	1	2.4
	Geumcheon	3	1	3	4	3	3	1	4	4	2.9
	Yongdengpo	3	4	3	4	3	3	2	4	4	3.3
	Dongjak	3	2	3	3	4	3	4	3	3	3.1
	Gwanak	3	3	4	4	4	3	3	3	3	3.3
	Mean	2.9	2.1	3.0	3.6	3.4	3.0	2.7	3.3	3.3	3.0
Southeast Area	Seocho	2	3	2	4	2	3	2	1	1	2.2
	Gangnam	4	3	4	4	4	3	2	3	3	3.3
	Songpa	4	3	3	4	3	3	4	2	2	3.1
	Gangdong	3	4	4	3	4	3	4	4	4	3.7
	Mean	3.3	3.3	3.3	3.8	3.3	3.0	3.0	2.5	2.5	3.1
Seoul Mean		2.8	2.8	2.9	2.8	2.9	2.7	2.6	2.8	2.8	2.8

The author created the table

In the table, "S.F." stands for Soccer Field, "B.S." represents Baseball Stadium, "T.C." indicates Tennis Court, "G.C." denotes Gate-ball Court, "S.P." means Swimming Pool, "N.F." refers to National Archery Field, "G.R." signifies Golf Driving Range, "B.G." stands for Ball Gym, and "L.G." represents Life Gym.

A positive Z-score close to 0 means that the measurements are close to the mean. In this study, the degree of inequality in access to facilities by category and the degree of inequality in accessibility by region in Seoul were divided into four grades. Grade 1 was defined as having a Z-score of 0.5 or more; grade 2 was defined as 0 or more and less than 0.5; grade 3 was defined as -0.5 or more and less than 0; and grade 4 was defined as less than -0.5. Table 4 shows the results of analysing the degree of inequality in access to facilities by sport in Seoul's public sports facilities.

The downtown area was ranked at 2.1, the northeast at 2.8, the northwest at 2.7, the southwest at 3.0, and the southeast at 3.1. Regional disparities in accessibility have emerged. Accessibility was low in the southwest and southeast areas, and accessibility in the downtown area was excellent. This is interpreted as a result of the fact that the downtown area has a population of 580,000, which is significantly smaller than other areas, and the total area is 56 km^2, which is smaller than other areas, so the distance from the facilities is less.

The accessibility of Yongsan-gu (3.2) is lower compared to Jongno-gu (1.8) and Jung-gu (1.2) in the downtown area. The high accessibility of Jongno-gu and Jung-gu contributed to an increase in the average accessibility of the downtown area. The most accessible region in the northeast region was Dobong-gu with a rating of 1.8, and the least accessible region is Seongbuk-gu with a rating of 3.4. In the northwest region, there was no significant difference in accessibility. The most accessible area was Mapo-gu with a rating of 2.6, and the least accessible was Seodaemun-gu with a rating of

2.9. The most accessible area in the southwest region was Guro-gu with a grade of 2.4, while Gwanak-gu and Yeongdeungpo-gu with a grade of 3.3 were the least accessible. The southeast region has a smaller population compared to the northeast and northeast regions, and the area is the third largest, so it is interpreted as having the least accessibility to public living facilities. In the southeast region, the most accessible area was Seocho-gu with a rating of 2.2, while Gangdong-gu with a rating of 3.7 was the least accessible. The lowest accessibility in Gangdong-gu lowered the average accessibility in the southeast region.

Areas with accessibility level 2 or lower were Jung-gu (1.2), Jongno-gu (1.8), and Dobong-gu (1.8). The lower five regions with low accessibility were Gangdong-gu (3.7), Seongbuk-gu (3.4), Gangnam-gu (3.3), Gwanak-gu (3.3), and Yeongdeungpo-gu (3.3).

Urban planning in areas like Gangnam has traditionally favored commercial and residential development over recreational spaces, leading to a scarcity of accessible sports facilities despite high demand in these densely populated regions. Addressing this gap requires innovative policy measures, such as incentives for integrating sports facilities into new developments, and further research into the economic and social factors influencing facility accessibility in affluent communities.

The average of each type of public sports facilities in Seoul was 2.6–2.9, showing no significant difference. The golf driving range had the highest accessibility grade at 2.6, and the lowest accessibility grade was the swimming pool and tennis court at 2.9.

Inequality in accessibility existed according to the type of facility by region. In the downtown area, the accessibility of the gate-ball court (1.3) and the tennis court (1.7) was excellent, and the baseball field had the lowest accessibility with a grade of 2.7. In the northeast region, the golf driving range was the most accessible with a grade of 2.1, and the baseball field was the least accessible with a grade of 3.6. In the northwest region, the baseball field had the best accessibility with a grade of 1.7, and the golf driving range had the lowest accessibility with a grade of 3.7. In the southwest region, the baseball field had the best accessibility with a grade of 2.1, and the gate-ball with a grade of 3.6 was the least accessible. In the southeast region, the ballpark and sports gym were the most accessible with a grade of 2.5, and the gate-ball field had the lowest accessibility with a grade of 3.8.

5. Conclusions

This study investigated and analysed the location accessibility of public sports facilities that contribute to the promotion of health among urban people in Seoul, which lacks a natural environment due to the concentration of business and residential facilities. Further, this study examined the inequality in accessibility of facilities by region and by sport.

Accessibility was analysed using the Gravity potential model, and Z-score analysis was performed on the results to clearly show the degree of disparity in accessibility by type of facility by region.

The results of the analysis first showed that there was an imbalance in accessibility of public sports facilities by region. The downtown area was ranked at 2.1, the northeast at 2.8, the northwest at 2.7, the southwest at 3.0, and the southeast at 3.1. Thus, it can be inferred that accessibility is low in the southwest and southeast areas, and accessibility in the downtown area is excellent.

The following shows that the disparity in accessibility by type of public sports facilities in Seoul did not show a significant difference in most areas in Seoul. The golf driving range showed the best accessibility (grade 2.6), and the swimming pool and tennis court showed the worst accessibility with a grade of 2.9. However, inequality in accessibility existed according to the type of facility by region. Facilities with excellent accessibility include a gate-ball court (1.3) and tennis courts (1.7) in the downtown area, a golf driving range (2.1) in the northeast area, a baseball field in the northwest area (1.7) and in the southwest area (2.1), and a ballpark (2.5) in the southeast area. Meanwhile, facilities with poor accessibility were found to be baseball fields (2.7) in the downtown area, baseball fields in the northeast area (3.6), golf driving ranges in the northwest area (3.7), gate-ball fields in the southwest area (3.6), and gate-ball fields in the southeast area (3.8).

Based on the results of the above analysis, policy implications for efficiently supplying public sports facilities in Seoul are presented as follows. First, public sports facilities should be provided to resolve inequalities in locational accessibility of sports facilities by region (district) and sports in Seoul. Second, during the period required for planning and implementation, it is necessary to utilize local accessible school sports facilities and to prepare a plan to expand the sports facilities in the park. Third, it is necessary to implement measures for upgrading and developing sports facilities that are not being used well.

To suggest a specific budget for public sports facilities, comprehensive decisions must be made based on various evaluation criteria. In this regard, the limitation of this study lies in the fact that it only analysed the locational accessibility aspect for residents. It is hoped that future research will be conducted on the criteria for determining the supply direction of public sports facilities by considering other comprehensive factors.

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