

The Design of Environment Elements Influencing Leisurely Physical Activity in 4 Types of Urban Open Spaces

Cuina Zhang*, Yusha Wei, Jiaxin Cao, Yatong Wang
College of Engineering, Shantou University, Shantou, China
**Corresponding Author*

Abstract: Environmental elements affecting leisurely physical activity (LPA) in urban open spaces are vital for sustainable healthy cities, yet research on spatial variations remains limited. This study surveyed four space types (Courtyards, Neighborhood Squares (NS), Parks, Campus) via questionnaire, employing Simultaneous Analysis of Several Groups (SASG). Results show: 1) Environmental elements significantly influence LPA across all spaces; 2) Impacts vary spatially: Physical Environment (PE) most affects Courtyards, Facilities most affect NS, Amenities only affect Parks, and Facilities uniquely affect both LPA duration and frequency in Campus; 3) Key design elements and tailored strategies are identified for each space type, demonstrated through four case examples.

Keywords: Environment Elements; Leisurely Physical Activity; Influence; Urban Open Space; Design

1. Introduction

Physical activity is beneficial to people's health and effectively help lower the risks of getting such diseases as heart attacks, strokes and Type-II diabetes [1]. Urban open space is important for leisurely physical activity (LPA) and the environment elements such as sports facilities, amenities, aesthetic feeling of landscapes and so on in spaces play significant roles in promoting LPA. The previous researches indicate that sports facilities including walking, riding facilities and court have positive influence on LPA [2]; Amy's[3] researches find that accessibility can promote LPA; researches by Cutt et al[4] show that physical environment such as noise and air have impact on LPA; Loo and Zhang also found that factors such as aesthetics and maintenance and security can influence people's perceptions and behaviors related to LPA[5]; the research of Ying Taoyuan

[6] in China shows that haze and exhaust in the open space have a negative effect on LPA. The achievement in China is far less than other countries and the empirical research of impact of environment elements in China is urgently needed.

The influence of elements on LPA in different demographic groups are also be studied. In aspect of ages: Veitch[7] find that climbed tree, bushes for hide and seek, attractive garden can promote the children activities; Kaczynski's[8] research shows that walking paths, equipment are related to LPA of 18~38 years old youth; basketball court, diving pool, swimming pool, baseball field promote activities of 40~59 years old adults. Wang Huan [9] concludes that environmental elements including sports facilities, greenery and the connection of street can influence the LPA of the senior citizens. Different genders lead to discrepancy in the perception of elements and LPA in male and female groups. Many studies have shown that environment elements have different effects on LPA in different gender groups: Rita et al.[10] find that there is a significant relationship between LPA and elements in boys group, but not in girls'; Research by Ajau Danis et al. [11] shows that girls pay more attention to social security of space. Those research shows that there are discrepancies of influence in different age and gender groups, but the types of space is not considered.

Because element allocation and user requirements are not uniform among types of urban open space, the resulting influences on LPA likewise differ. Either the discrepancies of effect or the design of elements which can promote LPA should be paid more attention to because those are benefit to develop the sustainable urban open space. The purpose of this study is to research the influence and discrepancies of environment elements in different types of spaces, determine the key elements and design countermeasures of these

spaces. Using Harbin as an example, this paper researches 4 types of urban open spaces, namely, Curtilage(no squares, only small spaces for LPA surrounding the house), neighborhood square(NS, there are large squares with some fitness facilities for LPA in neighborhood), Parks(there are more fitness equipment, aesthetics and amenities in it) and Campus(providing standard sports facilities with free access), analyzes the different influence of the elements in 4 types of spaces on LPA, discusses the key elements in designing of the 4 types of spaces and propose corresponding design strategies through 4 specific examples. The results of this research are expected to be helpful to guide the development of policies, management and design in urban open spaces.

2. Methods

2.1 Questionnaire

A questionnaire was administered to a randomly selected sample of respondents, from whom three types of data were obtained: evaluations of element quality, self-reported LPA (weekly frequency and per-session duration), and socioeconomic characteristics. The detailed demographic characteristics of participants are presented in Table 1. The evaluation of elements is measured by five-points Likert scale, which are divided into 5 grades: very poor, poor, average, good and very good. Elements included 6 domains {Facilities, Accessibility, Physical Environment (PE), Amenities, Aesthetics and maintenance & safety (MS)} and 42 items involved in the questionnaire were derived from the previous studies [12]. Random distribution of 400 questionnaires was conducted in eight urban open spaces in Harbin across four typologies (Curtilage, NS, Parks, Campus). The survey recovers 322 valid questionnaires with a recovery rate of 80.5%. The questionnaire proved to be suitable for further analysis because of the good reliability with Cronbach's α coefficients (0.809~0.957) and terrific validity (KMO=0.928, Sig=0.000) analyzed by exploratory factor analysis.

Table 1. Characteristics of Participants

Variable	Characteristics	N	%
Gender	Male	151	46.9%
	Female	171	53.1%
Age	13-18	52	16.1%
	19-35	142	44.1%

	36-50	67	20.8%
	51-65	42	13%
	66+	19	6%
Income (¥)	<2000	101	31%
	2000-5000	177	55%
	5000-8000	35	11%
	≥8000	9	3%
Health	Good	176	54.7%
	General	127	39.4%
	Not Very Good	19	5.9%
Space Types	Curtilage	78	24.2%
	NS	80	24.8%
	Parks	83	25.8%
	Campus	81	25.2%

2.2 Structure Equation Model (SEM)

Structure Equation Model (SEM) which is an important statistical method in the field of behavioral and social sciences [13] is adopted to analyse the relationship between elements and LPA. Simultaneous analysis of several groups (SASG) is often used for analyzing whether the theoretical model proposed by the researchers is the same or different in different groups, also can test the discrepancies of related paths in the same group. This study uses SASG to examine how the associations between elements and LPA differ across the 4 types of open spaces.

3. Analysis and Results

3.1 Establishing SEM and SASG Analysis

According to the results of previous research results, and to examine the relationships between elements and LPA, the hypotheses are proposed that Facilities (I₁), Accessibility (I₂), PE (I₃), Amenities (I₄), Aesthetics (I₅) and MS(I₆) have influence on LPA of the Frequency(F) and Duration(D), the influence among elements are also considered. The initial influencing model on the basis of those hypotheses is established as shown in Figure 1.

All the sample date is introduced into the initial SEM, non-significant routes are removed after several modifying and fitting, the final influencing model is obtained as shown in Figure 2. All the fitting indexes in the final model are shown in Table 2: all parameters meet the fit standards except the three simple indicators including PGFI, PNFI and PCFI with a slight gap which may be due to the complexity of the model. Generally speaking, the final model fit well and meets the requirements. The

final model yielded estimates of how elements affect LPA across the full dataset, which are provided in Table 3.

SASG is conducted using space types as moderator variables, based on the final influencing model outlined above. Relationships between elements and LPA were evaluated for each group, and the outcomes appear in Table 4. Path coefficients and their statistical significance

within each group are further provided in Table 5. From Table 4 and Table 5, the influencing relationships are revealed in 4 types of spaces which will be elaborated later. To identify the significance of influencing discrepancies, the coefficient critical ratio of relevant paths are examined by SASG including some paths within groups and between groups (Table 6, Table 7).

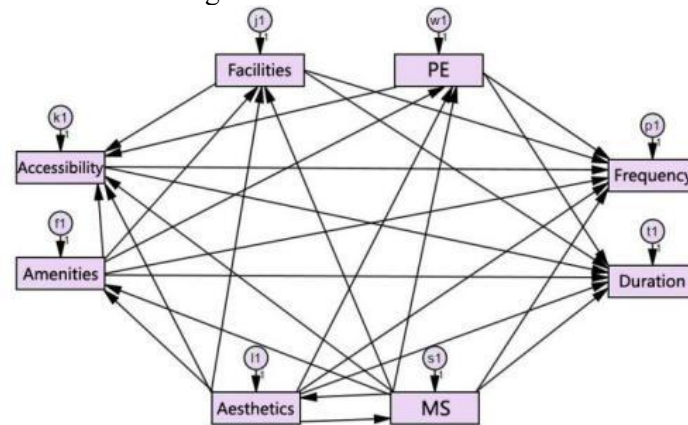


Figure 1. Initial Influencing Model

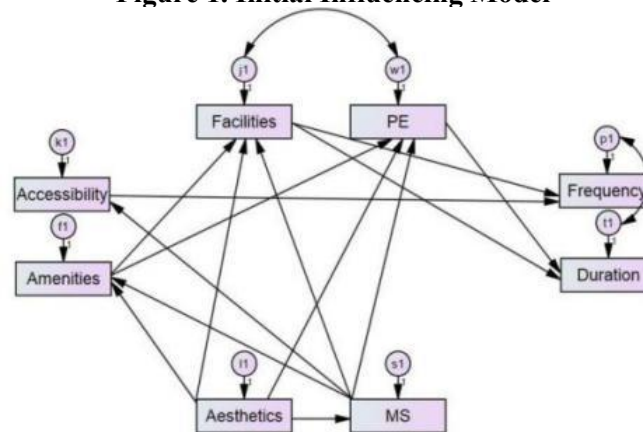


Figure 2. Final Influencing Model

Table 2. Overall Adaptation Degree of Final Influencing Model

parameters	χ^2	RMR	RMSEA	GFI	AGFI	NFI	RFI	IFI
standards	$P > 0.5$	$< .05$	$< .08$	$> .90$	$> .90$	$> .90$	$> .90$	$> .90$
result	$p = .938$	.038	.000	.996	.988	.996	.989	1.006
parameters	TLI	CFI	PGFI	PNFI	PCFI	CN	χ^2/df	
standards	$> .90$	$> .90$	$> .50$	$> .50$	$> .50$	> 200	< 2.00	
result	1.014	1.000	.393	.391	.393	1302	.441	

Table 3. The Effect of Elements on the LPA of all Samples

Elements	Direct Effect		Indirect Effect		Total Effect	
	D	F	D	F	D	F
Facilities	.236*	.214*	.000	.000	.236*	.214*
Accessibility	.000	.185*	.000	.000	.000	.185*
PE	.191*	.000	.000	.000	.191*	.000
Amenities	.000	.000	.020	.072*	.020	.072*
Aesthetics	.000	.000	.046*	.208*	.046*	.208*
MS	.000	.000	.031	.156*	.031	.156*

* $p < 0.05$

Table 4. The Effect of Elements on the LPA in Different Groups

Elements	PA	Groups				Elements	PA	Groups			
		Curtilage	NS	Parks	Campus			Curtilage	NS	Parks	Campus
I ₁	D _d	0.25	0.133	0.204	0.338*	I ₄	D _d	0	0	0	0
	F _d	0.134	0.425*	0.205*	0.237*		F _d	0	0	0	0
	D _i	0	0	0	0		D _i	0.097	0.079	0.009	0.098
	F _i	0	0	0	0		F _i	0.052	0.062	.072*	0.089
	D _t	0.25	0.133	0.204	0.338*		D _t	0.097	0.079	0.009	0.098
	F _t	0.134	0.425*	0.205*	0.237*		F _t	0.052	0.062	.072*	0.089
I ₂	D _d	0	0	0	0	I ₅	D _d	0	0	0	0
	F _d	0.011	0.254*	0.170*	0.196		F _d	0	0	0	0
	D _i	0	0	0	0		D _i	0.019	0.069	0.065	0.178
	F _i	0	0	0	0		F _i	0.078	0.252*	0.199*	0.209*
	D _t	0	0	0	0		D _t	0.019	0.069	0.065	0.178
	F _t	0.011	0.254*	0.170*	0.196		F _t	0.078	0.252*	0.199*	0.209*
I ₃	D _d	0.367*	0.257*	0.340*	0.318*	I ₆	D _d	0	0	0	0
	F _d	0	0	0	0		F _d	0	0	0	0
	D _i	0	0	0	0		D _i	0.042	0.074	0.049	0.11
	F _i	0	0	0	0		F _i	0.034	0.228*	0.151*	0.161*
	D _t	0.367*	0.257*	0.340*	0.318*		D _t	0.042	0.074	0.049	0.11
	F _t	0	0	0	0		F _t	0.034	0.228*	0.151*	0.161*

*p<0.05; subscript 'd' is for direct effect; subscript 'i' is for indirect effect; subscript 't' is for total effect

Table 5. The Path Coefficient and Significance of the Relationship among the Elements in Different Groups

Paths	Curtilage		NS		Parks		Campus	
	β	P	β	P	β	P	β	P
Accessibility←MS	.122	.434	.509	***	.264	*	.321	*
PE←Amenities	.155	.289	.452	***	.496	***	.208	.101
PE←Aesthetics	.066	.660	.156	.154	.109	.241	.498	***
PE←MS	.540	***	.225	.093	.172	*	.120	.320
Facilities←Amenities	.405	**	.280	*	.298	***	.320	*
Facilities←Aesthetics	.277	.050	.322	**	.257	***	.300	*
Facilities←MS	.164	.235	.262	*	.368	***	.223	.067
Amenities←MS	.274	.077	.647	***	.224	.007	.414	***
Amenities←Aesthetics	.378	*	.230	*	.519	***	.385	***
MS←Aesthetics	.648	***	.726	***	.655	***	.570	***

*p<0.05; **p<0.01; ***p<0.001

Table 6. Coefficient Critical Ratio of Paths in the Groups

Paths	Coefficient Critical Ratio			
	Curtilage	NS	Parks	Campus
D←I ₃ 、I ₁	2.137*	1.696	1.555	1.979*
F←I ₁ 、I ₂	.222	-1.964*	-1.968*	-1.017
I ₃ ←I ₄ 、I ₅	-1.809	-1.115	-2.455*	1.908
I ₃ ←I ₄ 、I ₆	-2.457*	-1.286	-3.377***	-0.741
I ₃ ←I ₅ 、I ₆	0.081	-0.138	0.020	-2.986**
I ₁ ←I ₄ 、I ₅	-0.326	0.702	-0.252	0.339
I ₁ ←I ₄ 、I ₆	-1.781	-0.353	-0.538	-0.992
I ₁ ←I ₅ 、I ₆	-1.004	-1.090	-0.161	-1.295
I ₄ ←I ₆ 、I ₅	1.065	-1.130	2.990**	1.227

*p<0.05; **p<0.01; ***p<0.001

Table 7. Coefficient Critical Ratio of Paths between Groups

Paths	Coefficient Critical Ratio					
	Curtilage & NS	Curtilage & Parks	Curtilage & Campus	NS & Parks	NS & Campus	Parks & Campus
D←I ₃	0.778	1.024	1.344	0.320	0.792	0.525
F←I ₁	-0.648	-0.614	-0.642	1.991*	-0.042	-0.128
D←I ₁	-0.391	0.040	0.469	0.478	0.874	0.483
F←I ₂	-1.591	-1.144	-1.104	0.672	0.403	-0.165
I ₂ ←I ₆	1.383	0.598	0.844	-1.066	-0.525	0.390
I ₃ ←I ₄	-0.678	-0.507	-1.864	0.298	-1.267	-1.778
I ₃ ←I ₅	0.514	0.137	2.419*	-0.539	2.216*	3.029**
I ₃ ←I ₆	0.508	0.099	-0.182	-0.518	-0.723	-0.346
I ₁ ←I ₄	-1.519	-1.194	-0.640	0.627	0.821	0.422
I ₁ ←I ₅	-0.283	-0.633	0.197	-0.541	0.563	0.972
I ₁ ←I ₆	0.273	1.028	0.273	0.887	0.013	-0.805
I ₄ ←I ₆	2.818**	-0.186	0.799	-3.950***	-2.370*	1.282
I ₄ ←I ₅	-0.625	0.455	0.304	1.534	1.076	-0.114
I ₆ ←I ₅	-0.006	-0.930	-0.140	-1.310	-0.160	0.713

*p<0.05; **p<0.01; ***p<0.001

3.2 The Influence of Elements on LPA

3.2.1. The Influence of All Samples

The hypotheses that six domain elements including Facilities (I₁), Accessibility (I₂), PE (I₃), Amenities (I₄), Aesthetics (I₅) and MS(I₆) all affect LPA have been confirmed. Table 3 shows the results analyzed using the data of all samples: Facilities, PE have direct effect on the Duration of LPA and Aesthetics have indirect effect on it; Facilities, Accessibility have direct effect on the Frequency of LPA and Aesthetics, Amenities, MS have indirect effect on it. The elements which have indirect impact affect the LPA through other elements. There are indirect effects because the elements depend on each other in space, for example, the maintenance of fitness Facilities has an impact on the use of Facilities, while MS affects LPA by affecting Facilities. In terms of the degree of effect, five factors that positively impact Frequency are identified in descending order of total effect: Facilities(.214), Aesthetics(.208), Accessibility(.185), MS(.156), Amenities(.072); three factors that positively impact Duration from greatest to least: Facilities(.236), PE(.191), Aesthetics(.046). The influence of Facilities on Duration and Frequency all presents the maximum coefficient, while the coefficient of PE and Aesthetics are also larger, which are the key points of spatial design.

3.2.2. The Influence in the 4 Groups

The influence of elements in the 4 groups was also examined and the results are shown at Table 4: Only PE has significant impact on Duration in Curtilage group, while other factors had no

effect on LPA. That's possibly because the Facilities and other elements are insufficient or not-configuration in the Curtilage space which are usually located in old neighborhoods. The Facilities, Accessibility, PE, Aesthetics and MS of NS all have notable influence; Facilities, Accessibility, PE, Amenities, Aesthetics and MS are all significantly affected LPA in Parks. These two groups belong to the spaces in which various elements are more completely configured, the significant impact of most factors reflects the public's attention to those elements. In the Campus group, Facilities, PE, Aesthetics, and MS have a significant impact, with Facilities exerting a notable influence on both Frequency and Duration. The elements configuration varies with the changing of function and size in different types of space, that's the reason of significance of influence in the 4 groups differing from the results of all samples. PE has a significant influence in all 4 groups, which reflects the users' special attention to PE elements including the items of air, noise, thermal comfort, etc.

3.2.3. The Discrepancies of Influence in Groups

The significant variations in the relevant paths within the groups are analyzed using SASG, for example, by comparing the coefficient of path "D(Duration)←I₃(PE)" and path "D(Duration)←I₁(Facility)" and testing the significance of critical ratio in a particular group, the element (PE or Facility) which has greater influence on Duration are confirmed. The results are shown at Table 6, combined with Table 4 and Table 5:

In the Curtilage group, Facilities and PE have a

markedly different impact on LPA, with only the latter having a significant effect. MS and Amenities show a substantial difference in their influence on PE, with only the latter exerting a strong impact. In Curtilage, Amenities such as bins and toilet is closely related to fresh air which is an important part of PE, it follows that Amenities and PE are vital elements in Curtilage group. In the NS group, Facilities and Accessibility exert significantly different effects on Frequency, with the effect of Facilities being much stronger than that of Accessibility. The Facilities such as fitness equipment and the Accessibility element such as proximity all affect LPA in the NS group, Facilities have a greater effect because of proximity is less important in this space where the neighborhood square is near to the respondents' house. In Parks group, the influence of Facilities and Accessibility on Frequency differs greatly, with Facilities exerting a notable effect and Accessibility having an insignificant impact. The impact of Accessibility is not significant in this group and that need to further research, the greater effect of Facilities shows that providing abundant equipment and places for LPA is vital in planing of Parks. In Campus group, the Facilities and PE have differing impacts on Duration, with Facilities exerting a notable influence, while PE has an insignificant effect. The Campus space provides Facilities such as football fields and standard runways which is rarely provided in other types of space, but traditionally it pays less attention to the public LPA, so compared with factors such as PE, the respondents focus more on the Facilities suitable for their LPA. MS and Aesthetics exert vastly different influences on the PE in Campus group, with MS having an insignificant effect and Aesthetics showing a notable impact. The impact of Aesthetics on PE is because the Aesthetics elements such as greenery and water is benefit to purifying air and reducing noise which belong to the PE domain.

3.2.4. The Discrepancies of Influence among Groups

Comparing the coefficient of relevant paths between different groups, such as the coefficient of path "F(Frequency) $\leftarrow$ I₁(Facility)" between NS group and Parks group, then testing the significance of critical ratio, the discrepancy of Facility affecting Frequency in those two groups is identified. The results can be seen from table 7, combined with Table 4 and Table 5:

Within the Curtilage group, PE exhibits the strongest effect on Duration among the four groups. In addition to the incomplete configuration of this space analyzed above, the poor sanitary maintenance, poor landscape resulted from the limited funds of this type of space also affect the PE, which made the public pay more attention to the PE. Meanwhile, Amenities have significant influence on the PE compared with other groups, that further confirms the importance of Amenities and PE in Curtilage space. In both the NS and Parks groups, Facilities have a significant impact on Frequency, with the influence being stronger in the former group than in the latter. Compared with Parks group, the NS space has less elements of Amenities, Aesthetics and MS domains, so the respondents in NS space pay more attention to Facility than in Parks space. Aesthetics exhibits a pronounced effect on PE within Campus, whereas its influence is negligible across the other three groups. That demonstrates that the design of Aesthetics elements such as trees, water and other natural landscape should be enhanced to improve the quality of PE. The impact of MS in NS and the other three groups on Amenities varies significantly, with NS showing a stronger influence than Campus, while the effects in the remaining two groups are negligible. The MS elements including sanitation maintenance and Amenities care closely related to Amenities, it should to focus on the sanitation maintenance and Amenities in NS space and Campus space. Moreover, the effects of Amenities are evident only within the Parks group. In comparison with other groups, Parks can offer a variety of services with it's adequate allocation and large area. Complete Amenities can attract more people to participate in activities in the Parks, and further promote LPA. In Campus group, the Facility affects both Duration and Frequency, which is unique in all the 4 groups. That fully reflects the high demand for Facilities in Campus space.

4. Discussion and Suggestions

Through the analysis of the influence discrepancies of elements above, the characteristics of morphology, users, suitable LPA, key elements and design countermeasures in 4 types of spaces are discussed in the following aspects.

4.1 Curtilage

The morphology of Curtilage is no large squares and open space in the neighborhood, there are only small areas for LPA surrounding the house. The present situation is shortage of land and fund, lack of Facilities and most of the elements especially PE are poorly allocated because the Curtilage space is mainly existing in the old and poor neighborhood. The users are the residents in the neighborhood, adults of whom mostly are migrant workers and have no time for LPA because of heavy work, so the majority of users are elderly and children. The slight LPA for the elderly and simple LPA which need little

investment on land and fund are suitable for Curtilage, such as walking, sitting, playing cards, shadowboxing and small equipment activities. PE and Amenities have significant influence on LPA in this group according to the analysis above, therefore, PE, Amenities and space-saving Facilities are the key elements in this space. The most pressing priority for Curtilage at present is to enhance the PE and Amenities, while providing essential Facilities to fulfill the basic needs of residents for engaging in LPA. The detailed design countermeasures are shown in Table 8.

Table 8. Key Elements and Design Countermeasures of 4 Types of Spaces

Types	Key Elements	Countermeasures
Curtilage	Facilities; PE; Amenities;	Facilities and PE; Setting up roadside parking, overpass and zebra crossing to build pedestrian branch system separately from cars in order to offer more space undisturbed by vehicle and increase the pedestrians' space (path for walking), meanwhile, Vehicle noise will be reduced and PE will be improved; Afford Facilities: fitness equipment for elders' slight LPA; play equipment for children; seats for resting and chatting; small open space for excise, shadowboxing; large open space for dancing and other activities. Amenities and PE; Consummating Amenities such as providing sufficient bins; maintaining sanitation to ensure the quality of the air. Planting trees for shade and building Windshield Construction, and all of this can improve PE. Others: well-maintained lighting in night
NS	Facilities; PE; Aesthetics; MS	Facilities: Consummating Facilities to meet the requirement of residents of all ages, especially the elders, children and teenagers. Providing with play-equipment, fitness-equipment, Three-peoples basketball court(with lighting in night), ping-pong table, table and chair for chess, square for dancing, path for walking, seats for resting and so on; Setting up billboard to encouraging LPA. Aesthetics and PE: Offer fountain, flowers, greenery; increase categories of evergreen plants to attract people; afford trees for shading, outdoor covered-corridor and architectural sunshade for a comfortable thermal environment. MS: install monitoring and to ensure public security; setting light in the night; regular maintenance of equipment and other facilities; cleaning the snow in time in winter, etc.
Park	Facilities; Accessibility; PE; Amenities; Aesthetics; MS, especially the Facilities and Amenities.	Facilities: In addition to the basic functions of parks, LPA Facilities lacking in NS and Curtilage should be increased : court, climbing rock, skateboard place, skating and skiing site, etc. for youth and adults; sandpit, rope net, climbing equipment, playground, seesaw and so on for children(Safe measures of Facilities for children should be considered); strengthen-foot path, dancing square, chess-table, etc. for elders. Amenities: setting up tables, bins, drinking water, retail stores, toilet, park service department, etc. Accessibility: multiple entrances for different direction, map of function distribution, overpass or zebra crossing to park. PE: surrounding trees for decreasing noise, Windshield Construction, trees or buildings for shading. Aesthetics: Offer landscape such as greenery, water, Ice and snow sculptures in winter.

		MS: warning sign, obstacle-free caring facilities, monitoring for security; lights in the night; regular maintenance of equipment and other facilities; cleaning the snow in time in winter
Campus	Facilities; PE; Aesthetics; MS	Facilities: Providing free courts and tracks; increasing fitness equipment and for citizens lived near the Campus; offering children's play equipment and venues if possible; Seats and tables for resting. PE and Aesthetics: Offer landscape such as greenery, water, Ice and snow sculptures in winter; setting trees for shielding noise; using greenery and water bodies to adjusting fresh air; outdoor covered-corridor and architectural sunshade are used to provide a comfortable thermal environment from sun and rain MS: regular maintenance of equipment and other facilities; cleaning the snow in time in winter; separating space of citizens' LPA from students' activities; installing monitoring and to ensure public security.

Using the XuanXi neighborhood as a case study, the following presents the design countermeasures. The neighborhood is in poor condition, with most elements being of low quality. The Facilities are inadequate, such as no play and fitness equipment, no path for walking, even no small square for dancing and other LPA. The Amenities, maintenance is very poor. The qualities of air, smell, acoustic environment included in PE are in bad condition. The LPA was seriously disturbed by vehicles. But Accessibility are better because the "Curtilage" is adjacent to residential houses. The users are the neighborhood residents, most are old people and children. The design object is providing

space-saving Facilities and improving PE and Amenities. The emphases of design is establishing the human-vehicle branch system, setting roadside parking along the XuanLi street to prohibit the entry of vehicles. The specific implements showed in Figure 3. The plan includes establishing a human-vehicle separation system, installing roadside parking and zebra crossings to restrict vehicle access, and providing elements such as expansive open spaces for dancing, areas for shadowboxing, walking and jogging paths, play equipment like swings for children, fitness stations for adults, resting facilities for sitting or chess, and sufficient lighting for night safety.

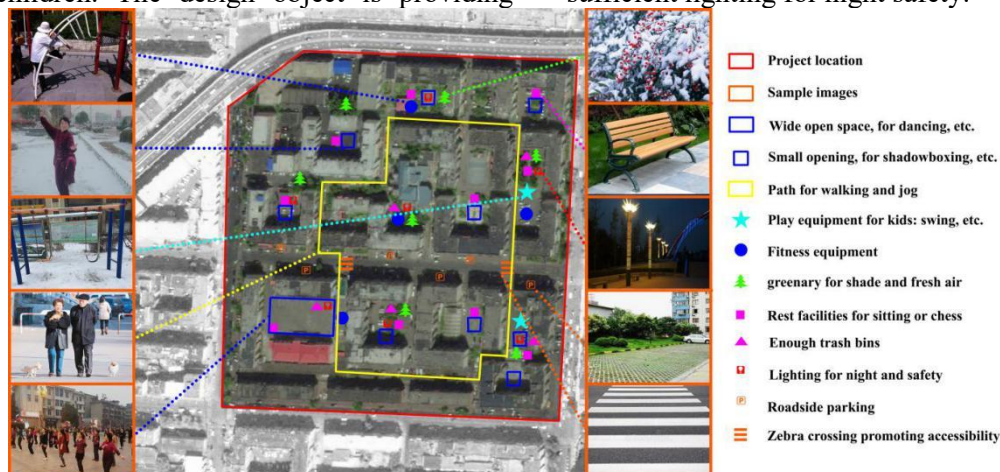


Figure 3. The Design Countermeasures of Curtilage in Xuan Xi neighborhood

4.2 NS

The NS space is represented by the central square in which there are some of fitness equipment, landscape, tables and seats, etc. in the new neighborhood. NS space is the most widely distributed and abundant in the city and it plays an very important role for citizens' daily LPA. NS has much more Facilities, Aesthetics elements than Curtilage space and is also better

in terms of PE, MS than Curtilage. All elements need to be focus on in design duo to the significant influence on LPA except for Amenities. Facilities should be highly valued followed by PE, Accessibility, Aesthetics and MS because the influence effect of these elements is from greatest to least. Facilities, Aesthetics and MS are the key elements, the PE in the NS space are in a better condition duo to good maintenance and management, the seem as

Accessibility because the NS space is almost nearby the residents' house. The residents of all ages excluding most adults who have to work daily are all the users of NS space. The suitable LPA is Square Dancing, table tennis, children's equipment game, Five-peoples basketball, walking, sitting, shadowboxing, etc. The design objective of this space is to enrich the elements to meet multiple levels of needs and to allow residents to participate in the LPA every day. See Table 7 for specific design methods.

Rui Cheng is a new neighborhood with a large open square on which there are fitness equipment, trees, pool, landscape, etc. The Accessibility and the MS elements are better. But the Facilities such as ball field, path for

walking and Aesthetics elements such as perennial green plant is lacked. The main users are the elderly people, children and teenagers of residents. The design object is enhancing the current facilities to cater to the needs of users across various age groups, meanwhile, consummating Aesthetic design and setting up security apparatus. Specific design countermeasures showed in Figure 4. Add and Plan the following items of elements: expansive open spaces for dancing, areas for shadowboxing, walking and jogging paths, fitness equipment, courts for teenagers; resting facilities such as seats, pavilions, etc; billboards advertising fitness, etc. lighting for court and evergreen plants are also provided.



Figure 4. The Design Countermeasures of NS in Rui Cheng Neighborhood

4.3 Parks

The characteristics of Parks is adequate of land and service facilities, there are equipment and squares for activity, landscape for enjoying, apartment of managing park, etc. The elements in park is configured more complete than the other 3 tapes of spaces. All the elements should be attached importance to because that each of them has significant influence on LPA in Parks group. Amenities, in particular, should be particular concerned in Parks design due to the unique significance in the 4 groups. Facilities should also be focus on because of the greatest coefficient in effect relation. Parks provide LPA space for the citizens at all ages of surrounding communities. In addition to the elderly and children, adults and young people also visit the park on weekends. So the park should meet the needs of a variety of people and offer the space for LPA including: walking, sitting, playing cards and other activities for the elderly; Square Dancing, running, equipment exercise, ball

games for adults; courts, ball games, extreme sports such as climbing rock for young people; equipment game for children. As primary settings for LPA, Urban Parks should be designed to accommodate people of diverse ages and backgrounds, emphasizing the provision of comprehensive fitness Facilities and the enhancement of Amenities such as "toilets," "tables," and "retail stores. Aesthetics and MS should be enhanced in parallel, with detailed design strategies presented in Table 7.

Yellow River Park is as an example to elaborate design measures: The Facilities for elders, some Amenities, Aesthetics and MS elements are better in this Park. But the Facilities for youth and children, Accessibility and Amenities such as "toilet" are also markedly insufficient. The background of users is complex and various which belong to each age group and came from surrounding residential area including the high-, medium- and low-income community. The design objectives should address the needs of individuals of all ages, including both healthy

and disabled persons. Nearly all elements need to be considered and specific design countermeasures are showed in Figure 5. The following facilities should be added or enhanced: retail store; overpass to improve accessibility; play equipment or ground for kids ; security for kids such as soft ground, etc; park services

department; warning sign; toilet; sculpture made from snow or ice; wider variety of evergreen plants; resting facilities such as seats, pavilions, gazebos, etc; large trees shielding the wind; chess tables; zebra crossing; pedestrian entrance; top-view map of park; Parking; obstacle-free caring design.



Figure 5. The Design Countermeasures of Yellow River Parks

4.4 Campus

The Campus space is the supplementary space for public LPA and there are standard sports field and track which is scarce in other types of spaces. Excellent landscaping and maintenance management are another features of the Campus and that can attract citizens to go to Campus for LPA. Facilities, Aesthetics and MS are the key elements in the design of Campus because of the significant impact of those three elements in the Campus group. The influence of Aesthetics on PE is particularly prominent. Therefore, attention should be paid to the adjustment of air quality by landscape such as greenery and water bodies, regulating of noise by trees and architectural landscapes, designing of Shelter by architectural landscape and so on. Residents lived near the Campus are its main users, usually including all ages of peoples. The design of this space should consider the needs of all ages of residents near the Campus, but also depending on the demographic composition of neighborhood nearby. The LPA that can be carried out in the Campus space is walking, sitting, shadowboxing and other activities for the elderly; football, basketball, tennis and running for adults and young peoples, equipment games for children if possible. The main objective of design is to provide free standard ball field and track though adjusting policy: the citizens and students use the court at different times, for

example. The Aesthetics and MS also should be reinforced as shown in Table 7.

Campus of HIT is as an example : Due to primarily serve the university students, this Campus is lack of fitness Facilities, children's play equipment, and additional amenities serving nearby residents. The user base is diverse, comprising university faculty, their families, and residents of nearby communities, with ages spanning children, teenagers, youth, middle-aged and old people. The design objectives is supplying fitness equipment and free ball fields, and enhancing Aesthetics and MS to encourage broader participation in LPA. Specific design countermeasures are showed in Figure 6. Add or perfect the following elements: free courts or playgrounds and runway; paved small area for shadowboxing; walking and jogging paths; play equipment or designated play areas for children; fitness equipment for adults; table for placing objects; seating for rest; fitness advertising billboards; lighting for court; pedestrian; entrances; toilets.

5. Conclusions

1) In Curtilage space: the PE elements exerts greatest significant influence on LPA in the 4 groups and Amenities have a considerable impact on the PE in this group. The key elements of Curtilage space is PE, Amenities and space-saving Facilities, the chief task of Curtilage design is to enhance PE and Amenities

while providing basic space-saving Facilities to support residents' participation in LPA.

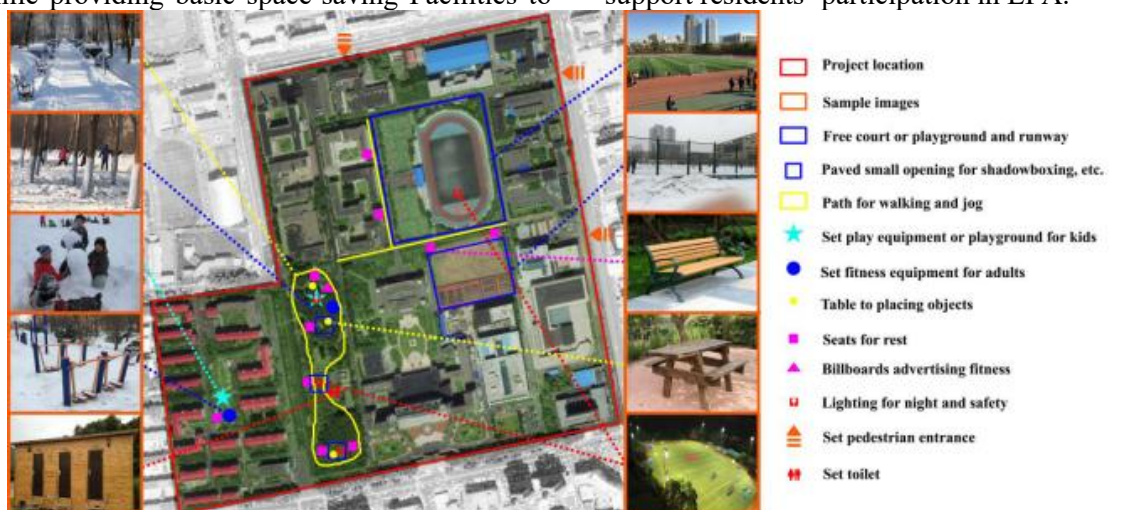


Figure 6. The Design Countermeasures of Campus of HIT

2) In NS space: the Facilities, Accessibility, PE, Aesthetics and MS all have significant influence in this group; The Facilities element has greater influence on Frequency of LPA compared with Accessibility within the group and compared with Park group. Facilities should be pay more attention to followed by PE, Accessibility, Aesthetics and MS, all of which are the key elements of NS space. The design objective of this space is to enrich the elements to meet multiple levels of needs and to allow residents to participate in the LPA every day.

3) In Park space: the Facilities, Accessibility, PE, Amenities, Aesthetics and MS of Parks boast drastic influence on LPA. Facilities has significant impact on Frequency of LPA compared with Accessibility. The influence of Amenities is only significant in Parks instead of the other 3 groups. All the six elements are the key factors in designing especially the Facilities and Amenities. The current objective of Park is to meet the needs of individuals from various age groups and backgrounds, to focus on prioritizing comprehensive fitness Facilities, upgrading Amenities, and addressing additional elements in parallel.

4) In Campus space: The influence of Facilities on both the Frequency and Duration of LPA is significant and unique across all four groups. PE, Aesthetics and MS also have significant influence in this group and those three elements with Facilities should be considered as the key elements in the Campus space. The primary task of design is adjusting policy to provide free sports field to citizens and consummate PE, Aesthetics and MS elements considering the requirements of the residents nearby.

Author Contributions

conceptualization, Cuina Zhang; methodology, Cuina Zhang and Yusha WEI; formal analysis, Cuina Zhang and Jiaxin Cao; investigation Yusha Wei; writing—original draft preparation, Yusha Wei; writing—review and editing, Jiaxin Cao; project administration, Cuina Zhang and Jiaxin Cao.

6. Statements and Declarations

1) Ethical considerations

This study was approved by the Ethics Committee of Harbin University (Approval No.2023-001).

2) Consent to participate

Informed consent to participate was obtained verbally from all participants.

3) Consent for publication

Informed consent for publication was obtained verbally from the participants.

4) Declaration of conflicting interest

The authors declared no potential conflicts of interest with respect to the research, authorship, and publication of this article

Acknowledgment

This study was supported by the 2022 Teaching Quality and Reform Construction Project of Guangdong Province Undergraduate University (YUEJIAOGAohan 2023-04-580); 2025 Ministry of Education's Industry-University Collaborative Talent Cultivation Project, Research on practical teaching of virtual human living environment design driven by "AI + human factors"; Shantou University Scientific Research Startup Funding Project (ST22YB08);

Research and Reform Project of Online Open Course Alliance for Universities in the Greater Bay Area (WGKM2024015); Shantou University's 2025 "Artificial Intelligence+" Higher Education Teaching Reform Key Project(STUAI2025006).

References

- [1] Organization W H . Global recommendations on physical activity for health. 2010. DOI: /entity/dietphysicalactivity/factsheet_recom mendations/en/index.
- [2] Guerra J, Jhon J, Lanza K, et al. The availability between recreational facilities and physical activity of US adolescents. Preventive Medicine Reports, 2024, 38: 102592.
- [3] Amy V. Ries et al. A Quantitative Examination of Parks Characteristics Related to Parks Use and Physical Activity Among Urban Youth. Journal of Adolescent Health. 2009, 45:S64–S70.DOI:10.1016/j.jadohealth.2009. 04.020
- [4] Cutt, H, Giles-Corti, B, Wood, L, Knuiman, M, Burke, V, Barriers and motivators for owners walking their dog: results from qualitative research. Health Promotion Journal of Australia, 2008(19):118–124.DOI:10.1071/HE08118
- [5] Loo BP, Zhang F. Design of public open space: Site features, playing, and physical activity. Health & Place. 2024 Jan 1; 85: 103149.
- [6] Ying Taoyuan、Ying Jun. The impact of the urban Parks built environment on physical activity of the residents: A case study of Hangzhou. Journal of Shandong Forestry Science and Technology, 2016 ,223(2): 47-50.
- [7] Veitch J, Salmon J, Ball K. Children\'s Perceptions of the Use of Public Open Spaces for Active Free-play. Children\'s Geographies, 2007, 5(4):409-422.DOI: 10.1080/14733280701631874
- [8] Kaczynski A T, Potwarka L R, Saelens B E. Association of Park Size, Distance, and Features With Physical Activity in Neighborhood Parks. American Journal of Public Health, 2008, 98(8):1451-1456. DOI: 10.2105/ajph.2007.129064
- [9] Wang Huan, The Influence of Community Built Environment on Leisure Physical Activity of the Elderly from the Perspective of Social Ecology: A Case Study of Baibuting Community in Wuhan. Postgraduate Program of Central China Normal University, 2017.5.
- [10] Pereira R, Santos R, Susana Póvoas, et al. Environment perception and leisure-time physical activity in Portuguese high school students. Preventive Medicine Reports, 2018, 10: 224. DOI:10.1016/j.pmedr.2017.10.013
- [11] Danis A, Sidek S, Yusof S M. Environmental Characteristics Influences on Physical Activity among Overweight Adolescents: Urban Neighbourhood Parks. Procedia - Social and Behavioral Sciences, 2014, 153(10):407. DOI:10.1016/j.sbspro.2014.10.073
- [12] Zhang Cuina, Li Lingling. Construction and application of Evaluation system of daily outdoor leisure sport space. Journal of Harbin Institute of Technology, 2017(4). DOI: 10.11918/j.issn.0367-6234.201510083
- [13] Ellaway A, Macintyre S, Bonnefoy X. Graffiti, greenery, and obesity in adults: secondary analysis of European cross sectional survey. BMJ 2005; 331: 611–12. DOI: 10.1136/bmj.38575.664549.F7.