以人群健康为导向的
小型公共绿地建成环境要素分析
——以江苏省南京市老城区为例

ANALYSES OF THE IMPACT OF BUILT ENVIRONMENT FACTORS OF SMALL PUBLIC GREEN SPACES ON PUBLIC HEALTH
—A CASE STUDY ON THE OLD CITY CENTER OF NANJING, JIANGSU PROVINCE

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1 Introduction

The speedup in people's pace of living and working in modern cities have exacerbated their sedentary and mentally-stressed status. Internet-based services such as food delivery, online shopping, and telecommuting, as well as the lack of green spaces due to the high-density urban construction, have also reduced residents' opportunities to access public green spaces and do outdoor activities. Recent studies proved that green spaces are highly correlated with public health level\[1\], and the natural resources within the green spaces can improve people's recovery\[2\][3], relieve stress\[4\], and recover attention\[5\].

Michiel van den Berg et al. surveyed 4 European cities and found that the increase in the time of accessing green spaces can effectively promote people's mental health and vitality\[8\]. A study by Abdullah Akpinar in Turkey shows that the distance and quality of the closest urban green space to people would impact the frequency of their sports activities: the higher the frequency and the longer the duration of sports activities, the better the mental and physical health of people will be\[9\]. Jolanda Maas et al. conducted a study in the Netherlands by recording residents' social connections and health status and verified the positive correlation between the size of green spaces in daily environment and the benign social relations and that social relations can affect public health level\[7\]. These studies all prove that public-health activities in green spaces, including exposure to nature, fitness exercise, and social and recreational activities, are important to increasing people's physical, mental, and social health level\[3\].

Encouraging residents to use public green spaces and to participate in physical, social, and recreational outdoor activities that help improve people's physical and mental health (“healthy activities” hereafter) has become an important part of China’s Healthy City Construction. To improve the nation's green space system, in 2017, the Ministry of Housing and Urban-Rural Development put forward that “the distribution of urban parks and green spaces should be optimized following the requirements of residents can see green spaces within a walking distance of 300 meters and can access parks or gardens within a walking distance of 500 meters.”\[10\] However, it is impracticable to create large-scale parks in built-up urban areas where land resources are limited. So far, China’s urbanization has shifted from incremental development towards inventory regeneration\[11\], and small public green spaces such as community gardens and pocket parks can be used to improve urban public green space systems and to meet citizens' demand for daily activities.
In-depth studies have been carried out on the impact of green spaces on public health at home and abroad. Currently, research on the characteristics of built environment mainly studies accessibility\(^{12-14}\), green space coverage\(^{15}\), and population density\(^{16}\) on a macro-scale; and also investigates greening\(^{17-19}\), facilities\(^{20,21}\), environmental quality\(^{22,23}\), spatial characteristics\(^{24}\), etc. on a site scale; research related to urban residents’ health level covers topics of physical health\(^{25,26}\), mental health\(^{27}\), and social health\(^{28}\). Such works of literature offer sufficient evidence for the exploration of the single-dimension impact of the built environment on public health.

Most of the existing studies on small public green spaces focus on the environmental characteristics within, and the related impact on users’ mental health. The research by Karin K. Peschardt et al. on 9 small public green spaces in Copenhagen, Denmark revealed that the reasons for...
现有针对小型公共绿地的研究大多采用访谈和调查问卷等形式，侧重于研究绿地品质对使用者主观感受和满意度的影响。本文则聚焦于探究在规划设计阶段建成环境的可操作要素对人群健康活动的影响作用。研究以小型公共绿地内的区位要素和功能空间要素为内在影响因子（自变量），以健康活动频次密度为外在表征因子（因变量），尝试通过建立岭回归模型量化分析两者间的相关性（图1），并提出以健康活动为导向的优化策略。

2 研究区域和样本选择

本文选取南京市老城区（即以外秦淮河、护城河对岸及玄武湖东北岸为界，明城墙范围内的全部区域，总面积约43 km²（图2））作为研究范围。老城区既是南京现存的历史文化资源集中地，也是现代城市功能的汇聚中心，集中了大量人口和高层建筑。考虑到国内外对口袋公园和小游园的规模限定，本文将小型公共绿地的面积界定在0.04~1hm²之间。为了保证调研样本在区位分布和功能空间特征上的典型性和多元性，本研究在南京老城各行政区分别选取滨水绿地、社区活动广场、历史文化遗址、临街休闲广场等类型的小型公共绿地进行调研（图2），最终共选取了35个样本，其中鼓楼区9个、玄武区8个、秦淮区18个，均为市民可以进入、停留及活动的小型公共绿地（表1）。
### Table 1: Basic information of the surveyed samples in the research

| Sample No. | Sample Name | Type          | Area (hm$^2$) |
|------------|-------------|---------------|---------------|
| 1          | 铁路北街北广场 | 滨水 | 0.46 |
| 2          | 铁路北街南广场 | 滨水 | 0.23 |
| 3          | 三牌楼大街与模范马路交汇处广场 | 街区休闲 | 0.12 |
| 4          | 三牌楼大街沿路广场 | 社区活动 | 0.05 |
| 5          | 三牌楼大街与模范马路交汇处广场 | 街区休闲 | 0.10 |
| 6          | 三牌楼大街与模范马路交汇处广场 | 街区休闲 | 0.09 |
| 7          | 铁路南街新模范马路交汇处绿地 | 街区休闲 | 0.07 |
| 8          | 铁路南街新模范马路交汇处绿地 | 街区休闲 | 0.07 |
| 9          | 梅庵游园 | 街区休闲 | 0.05 |
| 10         | 和平公园西侧公园 | 滨水 | 0.57 |
| 11         | 梅庵游园 | 街区休闲 | 0.24 |
| 12         | 洋桥地铁站1号出口绿地 | 滨水 | 0.31 |
| 13         | 洋桥地铁站2号出口绿地 | 滨水 | 0.36 |
| 14         | 太平北街珠江交汇处公园 | 滨水 | 0.15 |
| 15         | 520站前活动纪念广场 | 历史文化 | 0.34 |
| 16         | 中山路与洪武北路交汇处广场 | 街区休闲 | 0.23 |
| 17         | 江南停车场西侧绿地 | 街区休闲 | 0.17 |
| 18         | 逸仙桥龙蟠中路交汇处公园 | 滨水 | 0.11 |
| 19         | 西门门遗址广场 | 历史文化 | 0.75 |
| 20         | 东华门遗址广场 | 历史文化 | 0.61 |
| 21         | 明瓦楞公园 | 街区休闲 | 0.32 |
| 22         | 东华门遗址广场 | 社区活动 | 0.13 |
| 23         | 新华门遗址广场 | 滨水 | 0.14 |
| 24         | 东华门遗址广场 | 滨水 | 0.27 |
| 25         | 东华门遗址广场 | 滨水 | 0.15 |
| 26         | 东华门遗址广场 | 滨水 | 0.19 |
| 27         | 颐和路亭子路交汇处公园 | 社区活动 | 0.39 |
| 28         | 颐和路亭子路交汇处公园 | 社区活动 | 0.19 |
| 29         | 颐和路亭子路交汇处公园 | 社区活动 | 0.55 |
| 30         | 水西门遗址公园 | 滨水 | 0.48 |
| 31         | 水西门遗址公园 | 滨水 | 0.13 |
| 32         | 水西门遗址公园 | 社区活动 | 0.08 |
| 33         | 水西门遗址公园 | 社区活动 | 0.56 |
| 34         | 水西门遗址公园 | 滨水 | 0.28 |
| 35         | 水西门遗址公园 | 滨水 | 0.04 |
3 数据获取与研究方法

研究分两阶段进行：第一阶段结合理论研究和实地调研确定各项指标及量化方法，并采用扫描式拍摄记录、勘察测绘、ArcGIS分析等方法完成数据收集；第二阶段以小型公共绿地建成环境要素数据为自变量，以场内健康活动数据为因变量，借助SPSS统计软件建立岭回归模型并分析结果。

3.1 影响因子筛选及量化方法

3.1.1 区位要素

在区位要素设定层面，研究主要探究小型公共绿地服务范围内的居住人口、功能分布，以及周边公共绿地布局对小型公共绿地中健康活动的影响。本研究以各样本的500米可达范围覆盖面积作为其服务范围（图3），借助ArcGIS在南京现状路网的基础上构建网络分析模型。模型以服务范围内居住建筑总面积（L1）作为居住人口的表征因子，以服务范围内的公共兴趣点（POI）密度（L2）作为功能分布情况的表征因子，周边公共绿地影响度（L3）则借助如下公式进行量化[31][32]：

\[ L_3 = \sum_{k=1}^{k} \frac{S_k A_k}{D_{nk}} \]

其中k为周边公共绿地数量，n为被测算的周边公共绿地的代号，S_k为该周边公共绿地面积，A_k为该周边公共绿地服务范围半径，D_{nk}为该周边公共绿地到达样本的最短路径距离，L_3的计算结果（影响度指数）即为样本受到周边公共绿地影响的数值总和。

3.1.2 功能空间要素

在空间配置层面，研究选取每个样本的面积（S1）、绿地率（S2）、步道密度（S3）和空间类型丰富度（S4）4项指标。其中，绿地率（S2）与硬质铺地率呈反比，所以，可借助S2反映场地的硬质铺地情况。
on users’ healthy activities. Due to the hard pavement ratio is usually negatively correlated with green space rate, it can be evaluated by S2 as well. Path density (S3) refers to the ratio of the total length of the paths of a given sample to its total area. Concerning the last indicator, a sample was divided into several functional / spatial zones (hard pavement square, tree-side open space, waterfront, trails, fitness facilities, and shaded recreational facilities), and the spatial use diversity (S4) of a sample means the density of such functional / spatial zones. Given that the small public green spaces in Nanjing are often located in streets or adjacent to buildings and rivers, and the entrance are often connected with streets, in this research 3 indicators of the interface were analyzed, including waterfront ratio (E1), street-front ratio (E2), and openness (E3). Specifically, the indicator of openness (E3) refers to the ratio of the length of the open interface of a given sample to its total interface length.
In terms of that almost all the samples are equipped with trash bins and barrier-free entrances, this research only studied the impact of the distribution of recreational, fitness, and lighting facilities on users’ healthy activities. Selected indicators include opening seating density (F1a), shaded seating density (F1b), fitness facilities (F2), and lighting facility density (F3).

3.2 Quantitative Methods to Analyze Health Activities

In this research, users’ multiple instantaneous frequency of healthy activities during peak hours in the samples were studied. This method examined both the duration and frequency of healthy activities, that is, the longer the duration and the higher the frequency of healthy activities are, the higher the probability of the healthy activities and the stronger the impact on public health will be. The data of frequency density of healthy activities (the ratio of the frequency of healthy activities observed on the site to the total area of the site, hereafter referred to as FDoHA) in the samples were used as the dependent variables avoiding the interference of the site scale. Finally, this research examined the corresponding impact pattern of each built environment element on users’ healthy activities in type, period, and user group. To be specific, the types of healthy activities included fitness exercises (dancing, Tai Chi, fitness with equipment, running, walking, race walking, dog walking, etc.), social and recreational activities (chess and card playing, singing, musical instruments, etc.), and relaxing and leisure activities (resting, fishing, bird watching, etc.). The investigated periods included morning hours (7:00 ~ 10:00), afternoon hours (14:00 ~ 17:00), and evening hours (18:00 ~ 21:00). The user groups were surveyed by gender (female users and male users) and by age (children, young and middle-aged, and elderly). The study analyzed FDoHA on weekends, weekdays, and daily average (the average of both) to disclose the impact patterns of built environment elements on users’ healthy activities.

3.3 Data Collection

The survey was carried out from mid-September to mid-November, 2019 on weekdays and weekends with soothing weather (not raining or hazy) and comfort temperature (15 ~ 25°C). The observation was conducted in open-view places in each sample during the morning, afternoon, and evening hours of a weekday and a weekend, and the scanning shooting records were carried out once an hour. So that 18 sets of data were collected for each sample, and totally 630 sets of FDoHA data were acquired. The research then mapped the built environment elements and calculated the value of each indicator.
4 研究结果与分析

4.1 建立岭回归模型

研究对14个自变量和因变量数据进行标准化处理，构建建成环境要素与日均健康活动频次密度的综合模型。首先，应用多元线性回归模型检查变量间的共线状况，其中部分变量的方差膨胀因子（VIF）大于4[34]，存在中等程度的多重共线性，因而选择岭回归的方式进行拟合以获得更加稳定的回归模型。加入全部变量生成岭迹图，剔除岭迹图上标准化岭回归系数较稳定且绝对值很小的自变量，以及岭回归系数不稳定且震动趋于零的自变量[35]。每次删除变量后对岭迹进行重新判定和选择。最终，服务范围内居住建筑总面积（L1）、服务范围内POI密度（L2）、周边绿地影响度（L3）、绿地率（S2）、空间类型丰富度（S4）、界面开放性（E2）、界面开放性（E3）、户外休憩座椅密度（F1a）和遮阳休憩座椅密度（F1b）这9个变量得到保留，获得清晰的岭迹图（图6）；图中显示，当K值大约达到0.3时各变量岭迹开始趋
表2: 各因变量回归模型结果（Beta系数、指标与参数）
Table 2: Regression model results on each dependent variable (Beta coefficients, model indices, and parameter)

| 变量 | 日均模型 | 类型特征模型 | 时段特征模型 | 人群特征模型 |
|------|----------|--------------|-------------|--------------|
|      | Daily average | Types | Time periods | User groups |
| L1   | 0.144* | 0.092 | 0.132 | 0.103 | 0.183** | 0.095 | 0.124 | 0.219** | 0.139** | 0.154* |
| L2   | -0.134* | -0.129** | -0.116 | -0.162* | -0.095 | -0.082 | -0.183** | -0.141** | -0.092 | -0.143* |
| L3   | -0.105 | -0.095 | -0.113 | -0.115 | -0.121 | -0.108 | -0.111 | -0.098 | -0.127 | -0.092 |
| S2   | -0.208*** | -0.148* | -0.150 | -0.168** | -0.156* | -0.246*** | -0.187*** | -0.128 | -0.239*** | -0.170*** | -0.203*** | -0.208** |
| S3   | -0.106 | -0.106 | -0.123* | -0.104 | -0.256*** |       |       |       |       |       |       |
| S4   | 0.108 | 0.199*** | 0.196** | 0.165* | 0.125* | 0.145* | 0.282*** | 0.103 | 0.103 | 0.109 |
| E1   | 0.113 | 0.116 | 0.116 | 0.119** |       |       |       |       |       |       |       |
| E2   | 0.147* | 0.103 | 0.183** | 0.123 | 0.121 | 0.144** | 0.145* | 0.122 | 0.139** | 0.2** | 0.122 |
| E3   | 0.198** | 0.218*** | 0.195* | 0.168** | 0.295*** | 0.137 | 0.252*** | 0.234*** | 0.159* | 0.138** | 0.168** | 0.209** |
| F1a  | 0.247*** | 0.291*** | 0.326*** | 0.180** | 0.243*** | 0.286*** | 0.299*** | 0.291*** | 0.256*** | 0.18** | 0.263*** | 0.262*** |
| F1b  | 0.232*** | 0.153** | 0.199* | 0.340*** | 0.170** | 0.281*** | 0.163** | 0.198** | 0.275*** | 0.205*** | 0.198** | 0.231*** |
| F2   | 0.180** |       |       |       | 0.107 |       |       |       |       |       |       |       |
| F3   |       |       |       |       | 0.173** |       |       | 0.124** |       |       |       |       |
| N    | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 |
| R²   | 0.755 | 0.825 | 0.454 | 0.764 | 0.484 | 0.699 | 0.864 | 0.737 | 0.681 | 0.870 | 0.744 | 0.717 |
| adj. R² | 0.667 | 0.729 | 0.359 | 0.494 | 0.570 | 0.607 | 0.748 | 0.442 | 0.583 | 0.807 | 0.652 | 0.615 |
| F    | 8.560 | 8.620 | 4.817 | 10.642 | 5.999 | 7.565 | 8.759 | 7.765 | 6.947 | 13.959 | 8.085 | 7.026 |
| p    | 0.000 | 0.000 | 0.003 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| K    | 0.30 | 0.32 | 0.28 | 0.29 | 0.33 | 0.25 | 0.33 | 0.34 | 0.29 | 0.28 | 0.30 | 0.33 |

注
*代表p<0.1；**代表p<0.05；***代表p<0.01。

NOTE
* means p < 0.1, ** means p < 0.05, *** means p < 0.01.

由于平稳，故研究K取值0.3建立日均健康活动频次密度回归方程。

通过回归分析，模型在具体活动类型的时段、人群的健康活动频次密度建模过程中各模型保留下来的变量有所差异。分析显示（表2），模型结果具有统计学意义，方程的拟合优度R²越高，表示该方程内各变量对因变量的总解释力越强；变量的Beta系数越高，表示其对因变量的影响作用越强；变量的p值越低，表示其在方程中的显著性越高。表2中未列出的变量，即为该模型在岭迹图阶段时剔除的变量。

the ridge trace of each variable begins to stabilize, so the value K = 0.3 was used to establish the regression equation to analyze the daily average FDoHA.

Through the regression analysis, the models on specific characteristics between the variables and different activity types, periods, and user groups were established, and the retained variables in each model were varied. The modeling results (Table 2) were statistically significant. The higher the R² value is, the stronger the total explanation effectiveness of independent variables on the dependent variable; the higher the Beta coefficient of the variable is, the stronger its influence on the dependent variable will be; the lower the p-value of the variable is, the higher its significance will be. The variables which are not displayed in Table 2 are the ones eliminated based on ridge trace plots.
4.2 Model Analysis

The fit of the comprehensive model is good, and the total explanatory effectiveness of each variable reaches 75.5%. Showing in Figure 7, the factors that have a positive impact on the daily average FDoHA are, by the importance (Beta coefficient), F1a (0.267), F2a (0.232), E3 (0.198), E2 (0.147), L1 (0.144), and S4 (0.108). The factors showing a negative impact are S2 (-0.208), L2 (-0.134), and L3 (-0.105). Although factors of S1, S3, E1, F2, and F3 did not show their significance in the comprehensive model, their impact on FDoHA can be studied with other specific models.

Among the models on specific characteristics employed in this research, both positive and negative correlations of each variable were consistent with that in the comprehensive model, which verified the reliability of the model. The significance and influence degree of several variables varied in multiple specific models, suggesting that there was a disparity in the dependence and sensitivity of different characteristics on the built environment elements of small public green spaces.

4.2.1 Analyses of Location Indicators

1) L1 had a positive impact on FDoHA in all models,
indicating that more healthy activities would occur in the sites neighbouring dense residential areas. This was especially obvious in the afternoon hours (0.183) when social and recreational activities (0.132) were mostly observed. Male users (0.219), as main players in chess and card games, were the users who most require playing venues neighbouring residential areas.

2) L2 presented a negative impact on FDoHA in all models. The users of the mixed land use areas (e.g. office, catering, commercial, recreation, and entertainment) are mainly office workers, students, and tourists, who less visit small public green spaces in frequency and duration. This was most significant on weekdays (-0.14), in the afternoon hours (-0.162), and for the fitness exercise activities (-0.129).

3) L3 showed a slight negative impact on FDoHA in every model. The reason might be that though surrounding green space clusters would attract more visitors, periods and weather conditions would impact people's choice of on-site visit and the type of activity. This finding also suggests that densely distributed small public green spaces also show competition with each other.

4.2.2 Analyses of Functional / Spatial Indicators

1) S2 showed a negative impact on FDoHA in multiple models. Although vegetation helps improve micro-climates that benefit to the site’s environmental quality[36], a higher ratio of green space might lead to a reduction of the ratio of hard pavement area, resulting in the lack of places for people's activities and a decrease of FDoHA in the site. The research found that in some samples the activity places and seating areas are combined with small tree pools, which not only increases the vegetation coverage on the site but also ensures the size of activity spaces and helps improve the comfort level, encouraging the occurrence of healthy activities.

2) S4 has no obvious impact on the daily average FDoHA in the comprehensive model, but it has a significant positive impact on fitness exercise activities (0.199) and relaxing and leisure ones (0.196). The sites with a higher spatial use diversity would have a greater promotion on health activities in the morning (0.165) and evening (0.125) hours and attract more children (0.282) and female users (0.145).

3) S3 had a significant negative impact on FDoHA of children users (-0.254). The reason might be that the path system within the samples would not continually attract children users, who are more likely to be attracted by open playgrounds or other playful elements such as fitness facilities. S3 showed little significance in the comprehensive model because that continuity of the paths in most samples are poor and only used for passing through. However, in some waterfront samples, the path systems within are also an important part of the city’s waterfront trail system, which...
城市滨水步道系统中的重要组成部分，具有较强的连续性和功能导向性，能够促进散步、跑步、遛狗等活动的发生。

4）S1在所有模型中均未对健康活动频次密度起到显著影响，说明不同规模的小型公共绿地都可以通过合理的布局设计促进健康活动的提升。以中国香港为例，香港居民人均公共空间面积仅为1.5m²，但市政尽可能提供服务设施健全、环境品质优良、空间类型丰富、具备趣味性和吸引人的自然休憩空间，因此走在香港街头并不会感到公共空间匮乏[37]。

4.2.3 环界面要素的影响

1）在综合模型的各个环界面要素中，E3对日均健康活动频次密度的影响最为显著并呈正相关，说明较为开放的场地对人们的吸引力更高，同时也具备更高的安全性。界面开阔的场地有益于健身运动型活动（0.218）的发生，便于吸纳更多使用人群加入其中。以广场舞为代表的集群性健身运动型活动为主的上午活跃时段（0.295）和夜间活跃时段（0.252），以及女性使用者的（0.234）中，这一要素的影响最为明显。

2）E2与日均健康活动频次密度也存在一定的正相关性，并对舒缓休憩型活动（0.183）和夜间活跃时段（0.144）的影响较显著。界面临街率较高的样本多处于道路交叉口，可达性好，面向城市的展示界面较大，易吸引路过行人进入小憩。界面临街率高的小型公共绿地的夜间安全性也较高。

3）E1在综合模型中未发现显著作用，但对上午活跃时段（0.116）、夜间活跃时段（0.119）和健身运动型活动（0.113）呈促进作用，说明人们倾向于在滨水景观良好的场地进行活动。但在实地调研中发现，部分样本并未有效利用河畔景观布置活动场地，或存在下沉式滨水步道与场地高差较大、滨水平台规模过小等问题，导致场地利用率较低。

4.2.4 功能设施要素的影响

1）F1在综合模型及各个特征模型中对健康活动频次密度都呈现出非常显著的促进作用，其中舒缓休憩型活动与F1b的关联程度更高（0.340），健身运动型活动受F1a的影响更大（0.291），而社交娱乐型

4.2.3 Analyses of Interface Indicators

1) Among all the interface indicators, E3 had the most significant positive impact on the daily average FDoHA, indicating that open sites are more attractive and safer to users. Samples with open interfaces have a higher occurrence of fitness exercise (0.218) and invite more people to visit and use the site, which is especially obvious in the morning hours (0.295) and evening hours (0.252) when gathering fitness exercise activities (e.g. square dance) were mostly observed, and also for female users (0.234).

2) E2 reflected a positive impact on the daily average FDoHA, being significant on relaxing and leisure activities (0.183) and in evening hours (0.144). Samples with a higher street-front interface ratio are mostly located at road intersections and have good accessibility, and such interfaces would invite passers-by for relaxation. At night, small public green spaces with a higher street-front interface ratio are often much safer.

3) E1 showed little sign of the impact on FDoHA in the comprehensive model, but it had promotion to fitness exercise activities (0.113) in the morning (0.116) and evening (0.119) hours, suggesting people have a higher preference to exercise in venues with good waterfront landscapes. However, during the field survey, some problems were found in some samples such like the riverfront landscapes were not well used as activity places, the sunken waterfront trails are designed in a large elevation difference with its activity spaces, or the viewing platforms are too small, resulting in low utilization of waterfront sites.

4.2.4 The Impact of Facility Indicators

1) F1 had a very significant positive impact on FDoHA in the comprehensive model and each specific model. Relaxing and leisure activities were observed a stronger correlation with F1b (0.340); fitness exercise activities were found more being
活动则受F1a (0.326) 和F1b (0.199) 的影响均较大。在阳光强烈的下
午活跃时段，F1b的重要性显著提升 (0.281)。
2) F2对日均健康活动频次密度未见显著影响，但对健身运动型活
动 (0.180) 呈显著正相关，且备受儿童 (0.162) 青睐。研究实地调研
中发现，各样本中人们对健身设施的利用率普遍较高。
3) F3对夜间活跃时段的健康活动频次密度 (0.173) 呈显著促进作
用，且与儿童健康活动频次密度 (0.124) 存在正相关。说明适当密度
的照明设施能够提升场地活动的舒适度，并提高夜间安全性，也便于
家长对儿童的看护。

5 结论、讨论和建议
5.1 结论与讨论
1) 小型公共绿地的合理布局和设计能够有效提升其对居民健身运
动、舒缓休憩、社交娱乐等健康活动的引导作用，从而促进居民的生
理、心理和社会健康。
2) 在区位层面，布点可达服务范围内居住建筑密度越大的小型公
共绿地对健康活动的促进作用远大于选址在功能密集区域的小型公共
绿地，而集群布置的公共绿地虽能够为居民提供更多样的选择，但集
群内单个绿地对健康活动存在竞争性。
3) 在功能空间层面，功能设施是影响健康活动的主导因素，其中
开放休憩座椅和遮阳休憩座椅设施密度的增加对健康活动具有较高的
促进作用，而健身设施的设置对健身运动和儿童健康活动存在显著的
促进效用。合理的空间配置则有助于提高夜间健康活动频次密度。同
时，合理的空间配置也能够作为显著地促进健康活动的发生。其中，
当场地的绿地率过高时，健康活动频次密度将显著降低；步道密度过
高对儿童的健康活动存在负面影响；空间类型丰富度对健身运动型和
娱乐休憩型活动呈显著促进作用，且与儿童健康活动存在显著正相关。
同时，合理的空间配置也能够作为显著地促进健康活动的发生。其中，
当场地的绿地率过高时，健康活动频次密度将显著降低；步道密度过
高对儿童的健康活动存在负面影响；空间类型丰富度对健身运动型和
娱乐休憩型活动呈显著促进作用，且与儿童健康活动存在显著正相关。

subject to F1a (0.291); social and recreational activities were
found being largely subject to both F1a (0.326) and F1b (0.199);
and particularly, in the afternoon hours, F1b (0.281) significantly
defined people's activities.
2) F2 did not have a significant impact on the daily average
FDoHA, but it had a significant positive correlation with fitness
exercise activities (0.180) and was often widely used by children
(0.162). Fitness facilities found in the surveyed samples were
frequently used.
3) F3 significantly promoted FDoHA in evening hours (0.173)
and had a positive impact on FDoHA of children users (0.124).
The layout of lighting facilities in an appropriate density can
sufficiently improve the comfort and safety for users' activities at
night, especially for children and their parents.

5 Conclusions, Discussion, and Suggestions
5.1 Conclusions and Discussion
1) Reasonably designed small public green spaces can effectively
encourage citizens' fitness exercise, relaxing and leisure activities,
and social and recreational activities, promoting people's physical,
mental, and social health.
2) To location factors, the small public green spaces located near
dense residential areas have a much greater impact on promoting
public health activities than the ones sitting in dense mixed land
use areas. Although the other clustered surrounding green spaces
can diversify citizens' activity opportunities, the competition exists
between individual green spaces in the occurrence of public-health
activities.
3) To functional / spatial factors, facilities are the dominant
factor that impacts users' healthy activities. The increase in
the density of open seats and shaded seats would promote the
frequency of healthy activities; the existence of fitness facilities can
greatly encourage the occurrence of fitness exercise and children's
healthy activities, appropriately distributed lighting facilities can
help increase FDoHA at nights. The layout and distribution can
also largely impact users' frequency of health activities: FDoHA
would be significantly decreased when the green space rate is
ever excessively high, so does the path density to children users; the
spatial use diversity of a small green space is in a significant positive
correlation with the frequency of fitness exercise and relaxing and
leisure activities. Interface factors would also considerably impact
public healthy activities: small public green spaces with more open
interfaces and a higher street-front ratio would better encourage
people to visit and do healthy activities, and the waterfront
interface ratio is positively correlated with FDoHA in the morning
and evening.
This study mainly focuses on the impact of built environment elements of small public green spaces on public-health activities. The research results on certain indicators are quite different from the existing research that studies the questionnaires performance with the same indicators. For example, this research evidence that FDoHA has a negative and positive correlation with the green space rate and the open interface ratio of small public green spaces, respectively; However, the results of other related quantitative studies prove that the green space rate, and the intimacy and tranquil level of small public green space are positively correlated with people's satisfaction
[21] and the degree of stress relief
[19]. This implies that some elements would promote people's actual occurrence of healthy activities, but oppositely affect the users' feelings and evaluation. In design practice, to the areas where public green spaces are in short supply, the creation of green spaces should be prioritized; to the areas of a relatively high green space rate, the improvement of the quality of the green space should be prioritized. Due to the focus of this research, as well as the insufficiency in determining value ranges of each indicator, efforts are expected to further explore on certain elements of small public green spaces by increasing the size of studied samples.

5.2 Suggestions on the Planning and Design of Small Public Green Spaces

The location, size, type, and layout of small public green space should give considerations of the accessibility and real activity demands of potential users. To dense residential areas, the size and quantity of activity venues should be guaranteed, and to mixed land use areas, the optimization of environmental quality should be emphasized. In addition, the design of small public green spaces should be complementary with the surrounding green spaces to improve the city's green space network and to leverage the promotion of the public health level. Furthermore, designers need to pay their attention to the following aspects:

1) In terms of spatial configuration, designers should ensure the sufficiency of activity spaces and the diversity of spatial uses to meet the various needs of different users. In planting design, tall trees can be planted in combination with relaxing facilities and activity spaces, the greenery coverage ratio should be appropriately increased while avoiding the creation of large inaccessible green spaces, and the path system should be designed in an appropriate density and well connected with the surrounding urban trail system.

2) To the interface design, it is necessary to ensure the openness of the site, and is advisable to set barrier-free accesses in the street with large pedestrian flows; designers also need to make full use of the waterfront landscape to arrange relaxing and fitness
水空间布置休憩设施或健身设施，或保证滨水活动场地规模以提高对健康活动的引导性。

3) 在完善功能设施时，应布置充足的户外座椅，多采用木质座椅以提高休憩舒适度[39]；尽可能提供多样化的休憩设施[39]，利用花坛边缘和树池四周布置集中座椅；布置座椅容量较大的遮阳休憩设施；结合树木或休憩座椅设置健身器材；铺设适宜密度的照明设施。保证夜间场地照度能够满足健康活动的需求。**LAF**

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