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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摘要

城市公共绿地对人群健康水平有着密切影响，有益于身心健康的体力、社交与休憩活动在两者间起到重要的中介作用。本文以南京市老城区35个小型公共绿地为样本，通过ArcGIS分析、实地调研、勘察测绘等研究方法获取各样本的建成环境要素数据和健康活动数据；随后以区位要素和功能空间要素数据为内在影响因子，以小型公共绿地内的健康活动频次密度为外在表征因子建立岭回归模型，研究规划布局和设计阶段的建成环境要素对人群健康活动的引导作用。结果表明：绿地区位布局对健康活动频次密度的影响相对较低，邻近高密度住区的绿地对健康活动频次密度的促进作用远大于功能密集区域内的绿地；功能设施是影响健康活动频次密度的主导因素，其中休憩座椅密度的正向效用最为显著；合理的空间配置、开敞的环境界面能够显著促进健康活动的发生，绿地率或步道密度过高反而会对健康活动频次密度产生负面影响。最后，基于研究结论，本文对小型公共绿地规划设计提出了相关建议。

关键词

小型公共绿地；人群健康；建成环境；区位要素；功能空间要素；南京市

ABSTRACT

Urban public green spaces significantly impact public health level, where physical, social, and recreational outdoor activities play an important role in improving people’s physical and mental health. In this paper, a total of 35 samples of small public green spaces were selected, and the data of built environment factors and healthy activities of each sample were collected through ArcGIS analysis, field survey, and mapping. This paper then analyzes the impact of built environment factors on public healthy activities from a planning and design perspective by establishing a ridge regression model, which adopts location factors and functional / spatial factors in small public green spaces as independent variables, and the frequency density of healthy activities as dependent variables. The research reveals that: 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; To functional / spatial factors, facilities are the dominant factor that positively impacts users’ healthy activities, particularly the seating density; Reasonably designed small public green spaces or the ones with more open interfaces can effectively encourage people’s healthy activities, while which would be significantly decreased when the green space rate or the path density is excessively high. Finally, the paper proposes suggestions on the planning and design of small public green spaces.

KEYWORDS

Small Public Green Spaces; Public Health; Built Environment; Location Factors; Spatial Elements; Nanjing City

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1 引言

现代生活节奏的加快和工作强度的增大，导致城市居民普遍处于久坐少动、精神紧张的生活状态。而外卖、网购、居家办公等互联网时代生活方式的出现和高密度城市建设对公共绿地的压缩，进一步减少了居民接触绿地、进行户外活动的机会。近年来，越来越多的研究表明，绿地与人群健康程度高度相关^[1]，其内部的自然资源对人们具有康复效用^{[2][3]}，并有助于舒缓压力^[4]和恢复注意力^[5]；同时，绿地也能对人们的体育活动^[6]和社交活动^[7]产生积极影响。米契尔·范·登·伯格等人针对4个欧洲城市的调研结果显示，绿地访问时间的增加能够有效改善人们心理健康状况、提升活力^[8]。阿普杜拉·阿卡皮那在土耳其的研究表明，人们与最邻近的绿地的距离及绿地品质与他们开展体育活动的频率相关，且体育活动的频率越高、时长越长，人们的身体和心理健康状况越好^[9]。乔兰达·马斯等人则在荷兰的一项研究中通过监测居民的社交联系和健康状况，验证了人们生活环境中绿地的面积与良性社会关系之间存在正相关，以及社会关系能够影响健康^[7]。由此可见，人们在绿地中进行亲近自然、健身运动和社交娱乐等有益于健康的活动，是促进人群生理、心理和社会健康水平提升的重要途径^[3]。

鼓励居民使用公共绿地、引导人们在户外展开有益于身心健康的体力、社交与休憩活动（以下简称“健康活动”），已成为中国健康城市建设的重要内容。2017年，住房和城乡建设部指出应完善绿地系统，“按照居民出行‘300米见绿、500米入园’的要求，优化城市绿地布局，均衡布局公园绿地”^[10]。然而，在土地资源紧缺的城市建成区域规划建设大规模城市公园是不切实际的。当前，中国城市建设已从增量发展转向存量优化阶段^[11]，通过小游园、口袋公园等小型公共绿地“见缝插绿”地提升城市公共绿地系统的服务功能、满足城市居民日常活动需求更具可实施性。

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]; the built-up environment can also encourage people's sports^[6] and social activities^[7]. 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.

国内外围绕绿地健康效用的研究已较为深入。聚焦于建成环境特征的研究主要包括宏观层面的可达性^{[12]-[14]}、绿地覆盖范围^[15]、人口密度^[16]，也包括中微观层面的绿化植被^{[17]-[19]}、功能设施^{[20][21]}、环境品质^{[22][23]}、空间特征^{[20][24]}等；聚焦于城市居民健康的研究主要包括生理健康^{[25][26]}、心理健康^{[9][27]}和社会健康^{[7][28]}等维度的研究，研究成果中围绕单一维度的健康效用与相关建成环境要素之间关系的探索已较为深入，具备一定的借鉴意义。

针对小型公共绿地的研究多聚焦于内部建成环境特征，且主要关注其对使用者心理健康的影响。凯琳·K·帕斯嘉特等人对丹麦哥本哈根的9个小型公共绿地的研究表明，人们使用这些绿地的原因与日常生活中对社会互动和精神恢复的需求有直接联系，且使用频率与访问距离成反比^[14]。谭少华等人的研究发现，在公园缓解精神压力效果的评价中，自然景观的色彩、种类和数量具有非常显著的影响^[19]。张晓等人则通过使用后评价的方法对武汉市街旁绿地进行分析，发现绿地率、绿化覆盖率、休憩设施和景观设施的设计对使用者满意度的影

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 greenery^{[17]-[19]}, facilities^{[20][21]}, environmental quality^{[22][23]}, spatial characteristics^{[20][24]}, etc. on a site scale; research related to urban residents' health level covers topics of physical health^{[25][26]}, mental health^{[9][27]}, and social health^{[7][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

1. 城市小型公共绿地建成环境特征与健康活动相关性分析的探究框架
1. The research framework of the correlation analysis between built environment characteristics and healthy activities in urban small public green spaces

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2. 调研样本本区图

2. Location map of the samples in the study area

响较大^[21]。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为研究范围，即以秦外秦淮河、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43km²（图2）。老城区既是南京现存的历史文化资源集中地，也是各种现代城市功能的汇聚中心，集中了大量人口和高层建筑^[29]。

综合考虑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^[30]。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内分别选取滨水绿地、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）。

people’s usage are directly related to their needs for daily social interaction and refreshment, and that their visit frequency is negatively related to the walking distance^[14]. The research by Tan Shaohua et al. proved that the color, type, and mass of natural landscapes of a given park would greatly impact users’ stress relief^[19]. Zhang Xiao et al. analyzed the green spaces on the streets of Wuhan City with post-occupancy evaluation methods and found out that the urban green rate, urban green coverage rate, and the design of recreational and landscape features would largely impact user satisfaction^[21]. Existing studies on small public green spaces mostly adopted investigation forms of interviews and questionnaires, with more attention paid to the impact of the quality of small public green spaces on people’s feelings and satisfaction. For associated planning and design practice, this paper analyzes the impact of manipulable elements of built environments on public healthy activities by establishing a ridge regression model, which adopts location factors and functional / spatial factors in small public green spaces as independent variables, and the frequency density of healthy activities as dependent variables, to quantify the correlations (Fig. 1) and then proposes improvement strategies to promote healthy activities.

2 Study Area and Sample Selection

This research studies the old city center of Nanjing, Jiangsu Province. The study area is defined by the Ming Dynasty City Wall, the outer Qinhuai River, the moat, and the Xuanwu Lake, covering a total area of nearly 43 km² (Fig. 2). The study area is not only a place of rich regional historical and cultural resources but also a place of mixed land uses, homing a large population and gathering a lot of high-rise buildings^[29].

According to the common size of pocket parks and community gardens, the area of the small public green spaces selected in this research ranges from 0.04 hm² to 1 hm²^[30]. To ensure that the samples are representative and diverse in location and functional / spatial characteristics, sites such as waterfront green spaces, community squares, historical or cultural heritages, and street gardens in each administrative district of the study area were selected (Fig. 2). Finally, a total of 35 samples were selected, 9 in Gulou District, 8 in Xuanwu District, and 18 in Qinhuai District, all of which are small public green spaces where citizens can access, stay, and play around (Table 1).

表 1：研究调研的小型公共绿地样本基本信息
Table 1: Basic information of the surveyed samples in the research

样本编号 Sample No.	名称 Sample Name	类型 Type	面积 Area (hm ²)
1	铁路北街北广场 North Square in Railway North Street	滨水 Waterfront	0.46
2	铁路北街南广场 South Square in Railway North Street	滨水 Waterfront	0.23
3	三牌楼大街与福建路交汇处广场 Square at the intersection of Sanpailou Street and Fujian Road	临街休闲 Street garden	0.12
4	三牌楼大街沿路广场 Roadside Square in Sanpailou Street	社区活动 Community square	0.05
5	三牌楼大街模范马路交汇处广场 Square at the intersection of Sanpailou Street and Mofan Road	滨水 Waterfront	0.10
6	铁路南街新模范马路交汇处绿地 Green space at the intersection of Railway South Street and New Mofan Road	临街休闲 Street garden	0.09
7	颐和路牯岭路交汇处北侧公园 The park north to the intersection of Yihe Road and Guling Road	临街休闲 Street garden	0.07
8	颐和路琅琊路交汇处绿地 Green space at the intersection of Yihe Road and Langya Road	社区活动 Community square	0.07
9	扬州路二号院绿地 Green space in the No.2 Compound of Yangzhou Road	临街休闲 Street garden	0.05
10	和平公园西侧公园 Park to the west of Peace Park	滨水 Waterfront	0.57
11	梅庵游园 Mei An Garden	临街休闲 Street garden	0.24
12	浮桥地铁站1号口绿地 Green space at the No.1 exit of Fuqiao Metro Station	滨水 Waterfront	0.31
13	浮桥地铁站2号口绿地 Green space at the No.2 exit of Fuqiao Metro Station	滨水 Waterfront	0.36
14	太平北路珠江路交汇处公园 Park at the intersection of Taiping North Road and Zhujiang Road	滨水 Waterfront	0.15
15	520学生运动纪念广场 May 20 Movement Memorial Square	历史文化 Historical / cultural heritage	0.36
16	中山东路与洪武北路交汇处广场 Square at the intersection of Zhongshan East Road and Hongwu North Road	临街休闲 Street garden	0.23
17	江南织造局西南侧广场 Square to the southwest of Jiangnan Weaving Bureau	临街休闲 Street garden	0.17

样本编号 Sample No.	名称 Sample Name	类型 Type	面积 Area (hm ²)
18	逸仙桥龙蟠中路交汇处公园 Park at the intersection of Yixianqiao and Longpan Middle Road	滨水 Waterfront	0.11
19	西华门遗址广场 Xihua City Gate Relic Square	历史文化 / 滨水 Historical / cultural heritage; waterfront	0.75
20	东华门遗址广场 Donghua City Gate Relic Square	历史文化 / 滨水 Historical / cultural heritage; waterfront	0.61
21	明瓦廊公园 Mingwalang Park	临街休闲 Street garden	0.32
22	白下社区公园 Baixia Community Park	社区活动 Community square	0.13
23	解放南路明御河路交汇处公园 Park at the intersection of Jiefang South Road and Mingyuhe Road	滨水 Waterfront	0.14
24	建邺路滨河游园广场 Square of Riverside Park on Jianye Road	滨水 Waterfront	0.27
25	建邺路滨河游园西侧游园 Park to the west of Riverside Park on Jianye Road	滨水 Waterfront	0.15
26	建邺路滨河游园 Riverside Park on Jianye Road	滨水 Waterfront	0.19
27	朝天宫文化社区广场 Square of Chaotiangong Cultural Community	社区活动 Community square	0.39
28	水西门北侧广场 Square to the north of Shuiximen	临街休闲 Street garden	0.19
29	水西门西侧广场 Square to the west of Shuiximen	滨水 Waterfront	0.55
30	来凤街文化广场 Cultural Square on Laifeng Street	滨水 Waterfront	0.48
31	仙鹤桥广场 Xianheqiao Square	滨水 Waterfront	0.13
32	双塘太平苑社区广场 Square of Shuangtang Taipingyuan Community	社区活动 Community square	0.08
33	集庆门游园 Jiqingmen Park	历史文化 Historical / cultural heritage	0.56
34	大油坊巷北侧绿地 Green space to the north of Dayoufang Alley	滨水 Waterfront	0.28
35	大油坊巷南侧绿地 Green space to the south of Dayoufang Alley	滨水 Waterfront	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、以场地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500m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]}：

$$L3_n = \sum_{k=1}^k \frac{\sqrt{S_k A_k}}{D_{nk}}$$

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， $L3_n$ 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

3 Data Acquisition and Research Methods

The research consists of two parts: the first part is to determine the indicators and the quantitative methods to be employed based on literature review and field investigation, and to collect data through scanning shooting records, mapping, and ArcGIS analysis; and the second part is to establish a ridge regression model with IBM SPSS statistics, which adopts the data of built environment elements in small public green spaces as independent variables and the data of healthy activities observed in the sites as dependent variables, and then to analyze the results.

3.1 Impact Factors Selection and Quantitative Methods

3.1.1 Location Factors

This research mainly explored the impact of residential population, functional / spatial distribution, and surrounding green space layout within the service radius of the small public green spaces on users' healthy activities. This research determined the distance of 500 meters as the service radius of each sample (Fig. 3), and a road network analysis model of the City of Nanjing was constructed with the aid of ArcGIS. The factor of the total residential building area (L1) within the service radius of each sample was used to characterize the residential population. The density of Point of Interest (POI) within the service radius (L2) was used to characterize the functional / spatial distribution. The overall impact of the surrounding green spaces (L3) was quantified with the calculation formula^{[31][32]} as follows:

$$L3_n = \sum_{k=1}^k \frac{\sqrt{S_k A_k}}{D_{nk}}$$

where k is the total number of surrounding public green spaces, n is the serial number of a given surrounding green space, S_k is the size of a given surrounding public green space, A_k is the service coverage of the surrounding public green space, D_{nk} is the shortest walking distance from the surrounding public green space to the sample, and $L3_n$ is the sum of the values of all the surrounding public green spaces' impact on the sample.

3.1.2 Functional / Spatial Factors

This research selected 4 indicators of spatial characteristics, including the area of a small public green space (S1), green rate (S2), path density (S3), and spatial use diversity (S4), to study the impact of functional / spatial factors of the samples

3. 各样本500m服务范围示意图

3. The service radius of 500 meters of each sample

装面积；步道密度（S3）为场地内的步道总长度与场地总面积之比；空间类型丰富度（S4）则依据功能空间特征（硬质广场、树旁空地、滨水空间、健身步道、器材区域和遮阳休憩设施空间）将场地划分为若干子空间^[24]，以空间类型的分布密度为指标。

在环境界面层面，鉴于南京小型公共绿地所邻接的周边环境界面通常为河流、街道、建筑物等，且入口多设置在临街界面上，故在环境界面层面本研究选取界面滨水率（E1）、界面临街率（E2）和界面开放性（E3）三个指标，其中界面开放性为入口界面长度与公园边界总长度的占比。

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)^[24], 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 entranced 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.

① 本研究调研样本中的健身器材均未超过一组，且不受样本场地面积影响，故采用数量作为研究指标。

① Among the surveyed samples, no more than one set of fitness facilities was observed on the site, no matter how large the site's size is, so the number of fitness facilities was analyzed in this research.

实地调研发现，样本普遍设置有完善的垃圾回收设施和无障碍入口，因此在功能设施层面本研究仅探讨休憩设施、健身设施和照明设施的布置对小型公共绿地中健康活动的影响。选取的研究指标包括开放休憩座椅密度（F1a）、遮阳休憩座椅密度（F1b）、健身设施数量^①（F2）和照明设施密度（F3）。

3.2 健康活动量化方法

本研究以小型公共绿地活跃时段内的多个瞬时健康活动频次^{[24][33]}表示场地内的健康活动状况。该方法对健康活动的持续时间和发生频率进行综合考量，即持续时间越长、发生频率越高的健康活动被统计的概率越高，对人群健康的影响效用越强。同时，选取健康活动频次密度（即样本内健康活动频次与样本总面积之比）作为因变量数据，以平衡场地规模对结果的干扰。本研究对不同类型、不同活跃时段及不同使用人群的健康活动对建成环境各要素的依赖程度进行了逐项分析，以其为因变量展开了针对性研究。其中，健康活动类型根据其主导的健康效用分为健身运动型（舞蹈、练剑、器材健身、跑步、散步、竞走、遛狗等）、社交娱乐型（棋牌、唱歌、乐器等）和舒缓休憩型（休憩、钓鱼、观鸟等）；研究时段分为上午（7:00~10:00）、下午（14:00~17:00）及夜间人群活动活跃时段（18:00~21:00）；人群特征根据性别划分为女性使用者和男性使用者，根据年龄层划分为儿童、中青年和老年人；研究以周末、工作日及日均（两者均值）健康活动频次密度作为主要指标，以分析建成环境对健康活动的综合影响。

3.3 调研数据获取

调研于2019年9月中旬至11月中旬、温度15~25℃、非阴雨 / 雾霾天气的工作日和周末展开；以各样本内空间视野开阔的位置为调研点，分别在上午、下午和夜间人群活动活跃时段内对样本每一个小时进行一次扫描式拍摄记录^[33]，每个样本都选取一个工作日和周末进行共18次的数据记录，最终收集到630组瞬时健康活动数据。研究以此为基础计算各样本内的健康活动频次密度，同时对建成环境要素进行勘察与测绘，计算各指标数值。

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), number of fitness facilities^① (F2), and lighting facility density (F3).

3.2 Quantitative Methods to Analyze Health Activities

In this research, users' multiple instantaneous frequency of healthy activities^{[25][33]} 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℃). 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^[33] 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.

② 岭回归参数K值是岭回归为了减少共线性对回归方程的影响，在最小二乘的目标函数基础上加上的惩罚项。随着K取值的增大，共线性的影响逐渐减小，但方程的偏差也会变大，因此需酌情选择合适的K值建立方程。本文采用岭迹图法，选取在岭迹图上各回归系数的岭估计变化趋势基本趋于稳定的临界点数值作为K值。

② The ridge regression parameter K is a penalty term added on the ordinary least squares function in order to reduce the influence of collinearity on the regression equation. As the value of K increases, the influence of collinearity will gradually decrease, but the deviation of the equation will also become larger, so it is necessary to choose an appropriate value of K to establish the equation. In this paper, the ridge trace plots are used to select the critical point value at which the ridge estimation change trend of each regression coefficient on the ridge trace plot basically stabilizes as the K value.

4. 各样本内工作日、周末及日均健康活动频次密度分析

5-1. 各样本内不同时段健康活动频次密度分析

5-2. 各样本内不同类型健康活动频次密度分析

5-3. 各样本内女性使用者及男性使用者健康活动频次密度分析

5-4. 各样本内不同年龄段使用者健康活动频次密度分析

6. 建成环境要素与日均健康活动频次密度回归模型岭迹图
4. FDoHA analysis on weekday, weekend, and the daily average of each sample

5-1. FDoHA analysis of morning, afternoon, and evening hours in each sample

5-2. FDoHA analysis of different activity types in each sample

5-3. FDoHA analysis of female users and male users in each sample

5-4. FDoHA analysis of children, young and middle-aged, and elderly in each sample

6. Ridge trace plot of the built environment factors and the daily average FDoHA

4 研究结果与分析

根据健康活动频次密度的研究结果可知，各样本内工作日与周末健康活动的差异较小（图4）。根据实地调研观察，样本内的使用者群体以非就业人群（如中老年人和儿童）为主，他们日常使用小型公共绿地的频率和时段相对稳定。研究发现，各样本之间不同时段、不同活动类型和不同使用人群的健康活动数据差异较大（图5），具有比对研究价值。

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^②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）、界面临街率（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

4 Research Results and Analyses

According to the research results of FDoHA, the difference between weekdays and weekend in each sample was not significant (Fig. 4). The reason is that the users of small public green spaces are mainly retired or unemployed people (including children). The frequency and periods of their daily usage of small public green spaces are relatively fixed. The research results evidenced the significant differences in activity periods, types, and user groups in each sample, so further comparative analysis was conducted (Fig. 5).

4.1 Ridge Regression Model Building

The data of 14 independent variables and dependent variables were standardized to establish a comprehensive model of built environment elements and daily average FDoHA. First, the multiple linear regression model was used to verify the collinearity between the variables. The values of variance inflation factors (VIF) of several variables were higher than 4^[34], showing a moderate degree of multi-collinearity. The research then adopted a ridge regression model^② to generate ridge trace plots on all the variables and eliminated the independent variables whose standardized ridge regression coefficient was relatively stable and whose absolute value was small, and the independent variables whose ridge regression coefficient was unstable and whose inflation approaches to zero^[35]. The ridge trace was re-analyzed after each time of the variables being eliminated. Finally, L1, L2, L3, S2, S4, E2, E3, F1a, and F1b were retained in the model, and a clear ridge trace plot was obtained. Showing in Figure 6, when the K value reaches about 0.3,

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 Variables	日均模型 Daily average	类型特征模型 Types			时段特征模型 Time periods			人群特征模型 User groups				
		健身运动 Fitness	社交娱乐 Social and recreational	舒缓休憩 Relaxing and leisure	上午 Morning	下午 Afternoon	夜间 Evening	女性 Female	男性 Male	儿童 Children	中青年 Young and middle-aged	老年人 Elderly
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**	-0.149*	-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*	-0.260***	-0.187***	-0.128	-0.239***	-0.170***	-0.203**	-0.208**
S3		-0.106					-0.123*	-0.104		-0.254***		
S4	0.108	0.199***		0.196**	0.165*		0.125*	0.145*		0.282***	0.103	0.09
E1		0.113			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**	0.169**	0.209**
F1a	0.267***	0.291***	0.326***	0.180**	0.243***	0.286***	0.299***	0.291***	0.254***	0.18***	0.283***	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			0.162**		
F3							0.173**			0.124*		
N	35	35	35	35	35	35	35	35	35	35	35	35
R ²	0.755	0.825	0.454	0.766	0.684	0.699	0.844	0.737	0.681	0.870	0.744	0.717
adj.R ²	0.667	0.729	0.359	0.694	0.570	0.607	0.748	0.642	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.

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。

将自变量与不同活动类型、时段、使用人群的健康活动频次密度进行回归拟合构建特征模型，拟合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.

7. 综合模型中Beta系数分布图

7. Distribution of Beta coefficients in the comprehensive model

7 © 樊凡, 徐小东, 徐宁, 王伟

4.2 模型解析

综合模型的拟合情况较为理想，各变量的解释力总计75.5%。如图7所示，变量中对日均健康活动频次密度呈正向影响的要素按照重要程度（Beta系数）依次为F1a（0.267）、F2a（0.232）、E3（0.198）、E2（0.147）、L1（0.144）和S4（0.108）；呈现负面效用的要素为S2（-0.208）、L2（-0.134）和L3（-0.105）；S1、S3、E1、F2和F3在综合模型中并未展现出显著作用，其效用有待通过特征模型进一步细究。

在特征模型中，变量的正负影响关系仍与综合模型一致，验证了模型的稳定性。其中，部分变量在多个特征模型中展现出的显著性和影响程度有所差异，可见不同特征的健康活动对各要素的依赖程度和敏感度也不尽相同。

4.2.1 区位要素的影响

1) L1在多个模型中均与健康活动频次密度呈现正相关，说明可达

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,

服务范围内居住建筑面积越大的小型公共绿地内产生健康活动的可能性更高；该特征在社交娱乐型健康活动（0.132）为主的下午活跃时段（0.183）尤为明显，其中男性使用者（0.219）作为棋牌活动的主要参与群体，对邻近居住区的场地依赖程度最高。

2）L2在多个模型中与健康活动频次密度呈现负相关性。以办公、餐饮、商业、休闲娱乐为主的功能密集区域的使用群体多为上班族、学生和游客，对小型公共绿地的使用频率低、使用时间短，这一点在工作日（-0.14）和下午活跃时段（-0.162），以及健身运动型活动模型（-0.129）中最为显著。

3）L3与健康活动频次密度在多个模型中存在负向影响，但并不显著。其原因在于，多个紧邻的公共绿地对于使用者而言具备一定吸引力，但人们会在不同时段和天气状况下选择不同的场地和活动类型，使密集分布的小型公共绿地之间又表现出一定的竞争关系，使L3呈现出不显著的负相关性。

4.2.2 空间配置要素的影响

1）S2在多个模型中与健康活动频次密度呈现负相关。植被可以有效改善场地微气候，对提升场地环境品质有着重要作用^[36]，但植被面积占比过大也会导致硬质铺装面积占比减少，可供人们开展各项活动的场地相应减少，从而导致健康活动频次密度的降低。研究发现，部分样本中采用与活动场地和座椅结合良好的小型树池，并种植树冠高大的树木，以提高场地的植被覆盖率。该方式既保证了一定规模的活动场地，又能提供舒适的活动场所，更利于促进健康活动的发生。

2）S4在综合模型中对日均健康活动频次密度的影响作用并不明显，但对健身运动型活动（0.199）和舒缓休憩型活动（0.196）存在非常显著的促进作用。其中，空间类型丰富的场地对上午活跃时段（0.165）和夜间活跃时段（0.125），以及儿童（0.282）和女性使用者（0.145）的健康活动更具吸引力。

3）S3与儿童健康活动频次密度呈显著负相关（-0.254），其原因在于，步道空间对儿童并不具备持续的吸引力，儿童更容易被可以自由玩耍的宽阔场地或趣味性的健身设施所吸引。该指标在综合模型中未起到显著效用，大部分小型公共绿地内的步道的连续性和系统性不强，仅起到通行作用。即便如此，小部分样本中的滨水景观步道属于

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

城市滨水健身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、具备趣味性和吸引力的自然休憩空间，因此走在香港街头并不会感到公共空间匮乏^[37]。

4.2.3 环境界面要素的影响

1) 在综合模型的各个环境界面要素中，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。在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(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，说明人们乐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

have better continuity and can encourage the occurrence of walking, running, dog walking, and other activities.

4) S1 did not show a significant impact on FDoHA in any model, suggesting that small public green spaces, no matter of their scales, can promote public-health activities through reasonable layout design. In Hong Kong, China, for example, although the per-capita area of public spaces of Hong Kong residents is only 1.5 m², the city provides them with recreational natural resources of sound service facilities, quality and attractive environmental elements, and diversified spatial types to increase the city's public green spaces^[37].

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面积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，适当的照明设施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较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舒缓休憩型活动呈显著促进效用；环境界面形式对健康活动也存在一定影响，界面开敞、临街率高的小型公共绿地更易吸引人们访问并参与健康活动，滨水界面率则与上午和夜间的健康运动频次密度呈正相关。

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 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.

本研究主要关注小型公共绿地建成环境要素对人群健康活动的影响，部分要素的分析结果与其他相关研究中该要素对人们主观感受的影响的分析结果差异较大。例如，本研究结果显示，小型公共绿地绿地率的增高对健康活动频次密度呈负面效用，界面开放性的增高呈正面效用；但其他相关量化研究显示，小型公共绿地的绿地率、空间私密性和安静氛围与人们的满意度^[21]和精神压力缓解程度^[19]呈正相关。这意味着部分要素对健康活动客观存在的“量”和人们主观评价的“质”的影响作用是相反的，在设计过程中应根据实际需求对两者进行均衡考虑，在公共绿地资源有限的区域以“量”为先，在公共绿地充足的区域以“质”为重。由于本研究仅对相关性展开探讨，对各项指标的合理数值区间的研究不足，有待在未来的研究中通过拓宽样本数量进行深入探索。

5.2 小型公共绿地规划设计建议

小型公共绿地的选址、规模、类型及布局应综合考虑潜在使用人群的可达性和活动需求；在密集居住区域增大活动场地的面积占比，在功能密集区域着重加强环境品质的优化；设计应与周边其他绿地形成互补，共同构建促进居民健康的绿地空间网络。与此同时，设计师还应关注以下层面：

1) 在进行空间布局时，应提供足够容量的活动场所和丰富的空间类型，以满足使用者的不同活动需求；在种植设计上建议采用高冠树木与休憩设施、活动空间紧密结合的形式，在适当增加植被覆盖率的同时避免布置大面积无法进入的绿地，步道的铺设要与周边步道系统建立良好联系，且密度不宜过高。

2) 在进行环境界面设计时，需保证场地具有良好的开放性，宜在人流量大的临街界面结合无障碍设施设置开敞入口空间；充分利用滨

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 questionnaired 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^[38]；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**

facilities, and guarantee the size of waterfront activity places to encourage users’ healthy activities.

3) To improve the facilities of small public green spaces, the sufficiency of outdoor seats should be prioritized, and wooden seats should be used to improve the users’ comfort^[38], a variety of recreational facilities should be provided as much as possible^[39]. For example, seats and shaded relaxing facilities can be organized in clusters in combination with flower beds and tree pools; fitness facilities should be installed in groups with trees and seats; lighting facilities should be designed in an appropriate density to ensure the illumination and increase the safety of the site at night. **LAF**

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