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Synergistic Strategies for Urban Linear Physical Activities Spaces: Insights From a Quantitative Review

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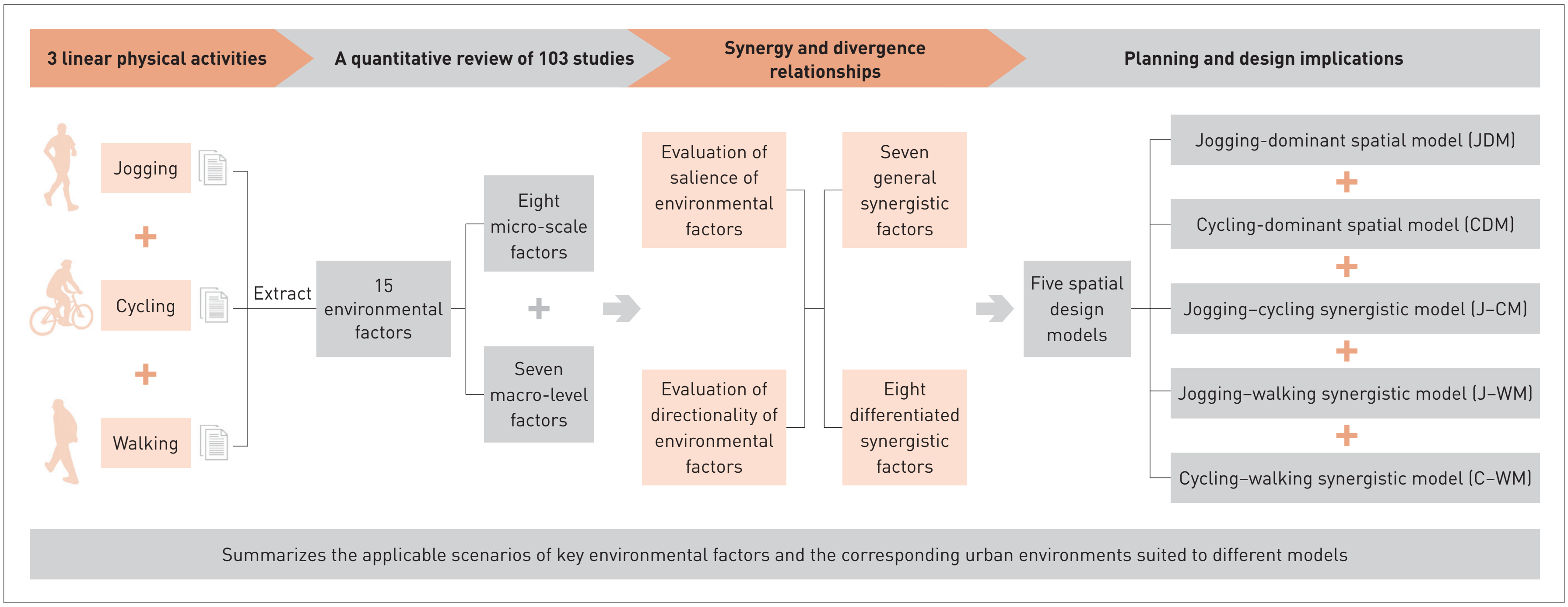
GRAPHICAL ABSTRACT



ABSTRACT

In high-density cities that lack public outdoor fitness facilities, engaging in physical activities such as jogging, walking, and cycling in linear spaces like streets has increasingly become a significant option for individuals. In recent years, a substantial body of research has emerged globally examining the associations between the built environment and physical activity behaviors, yet there is a lack of research that systematically compares preferences for environmental factors to different linear physical activity spaces and explores collaborative design approaches within cities. This study, based on a quantitative review of 103 articles, examines the mechanism between 15 environmental factors and three types of activities—jogging, walking, and cycling—at both macro and micro scales. It quantitatively assesses the synergy and divergence in the directionality of environmental factors on different activities through K-means cluster analysis. Based on the collaborative or differentiated manifestations of various environmental factors across different linear physical activities, this study identifies seven general synergistic factors and eight differentiated synergistic factors, and proposes five spatial design models. It summarizes key differentiated factors and their applicability to urban environments, providing theoretical support and practical application evidence for constructing urban health-supportive environments.

KEYWORDS

Landscape Design and Planning; Urban Residents’ Health; Health-Supportive Environment; Physical Activity; Cluster Analysis

HIGHLIGHTS

- Conducts a quantitative review comparing the preferences for factors to jogging, walking, and cycling spaces
- Identifies seven general and eight differentiated synergistic environmental factors to linear physical activities
- Proposes five spatial design models to guide urban planning and design practice

RESEARCH FUND

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1 Introduction

Against the backdrop of high-quality development, the creation of health supportive environments, which are urban settings designed to promote physical activity, mental well-being, and healthy lifestyles, has become a critical demand in the sustainable urban regeneration[1–2]. Internationally, the concept of health supportive environments has become a core component of sustainable urban agendas, as reflected in frameworks such as the WHO Healthy Cities initiative and the UN 2030 Sustainable Development Goals (SDGs)[3–4]. China has explicitly advocated for integrating health-oriented principles into territorial spatial planning and urban construction[5]. Based on recent sports activity reports in China, linear physical activities (PAs) such as cycling, jogging, and walking have also emerged as one of the most popular forms of exercise among the general public[6]. By effectively utilizing urban linear spaces such as streets and green corridors to support linear PAs, public health can be significantly improved[7]. However, in high-density urban areas, the lack of dedicated linear PA spaces is a significant challenge[8].

Environmental factors are widely recognized as critical determinants influencing residents’ engagement in linear PAs[9]. Due to the similar spatial requirements and functional characteristics shared by different types of linear PAs, such linear venues are typically designed through integrated or composite approaches—such as greenways, slow-traffic systems, and fitness trails—rather than being treated as single-function spaces[10]. Based on previous research[11], users’ preferences for certain environmental factors may exhibit consistency across different types of linear PAs, which are identified in this study as general synergistic factors. Due to movement speed, transportation modes, and exercise objectives, different linear PA types also exhibit a notable disparity in environmental preferences and spatial compatibility[12]. In this study, such factors are defined as differentiated synergistic factors. Reasonably combining the spatial carriers of different types of linear PAs to avoid conflicts and promote synergistic enhancement is of great significance in planning and design.

Early studies on the relationship between linear PAs and the urban environment primarily relied on conventional methods such as field survey[13], observational interviews[14–15], and questionnaire-based investigations[16–17]. With the advancement of urban digitalization, the widespread application of geographic information systems (GIS)[18], mobile applications[19], and other forms of big data has opened new avenues for research, leading to a growing body of quantitative studies in this field. Nevertheless, existing research has largely focused on the relationship between single PA types and specific environmental factors[20–23], with a notable lack of integrated comparative analysis across multiple PA types. Furthermore, current findings remain fragmented, and the synergistic potential among different linear PAs remains insufficiently explored. Given the surge of studies focusing on individual environmental factors or single types of linear PAs, a quantitative review that systematically integrates existing evidence and translates it into applicable design strategies offers insights for landscape planning and design practice.

This study conducts a quantitative literature review to systematically examine the relationships between environmental factors and the three major types of linear PAs: jogging, walking, and cycling①. The aim is to: 1) identify differences in the influence

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① It is important to clarify that the jogging, cycling, and walking examined in this study represent fitness-oriented physical activities rather than commuting-related behaviors.

of environmental factors across linear PA types; 2) explore differences in preference for environmental factors among linear PAs; and 3) propose collaborative design models for diverse linear PA spaces. These efforts are intended to guide landscape design strategies that promote health and sustainability.

2 Methods

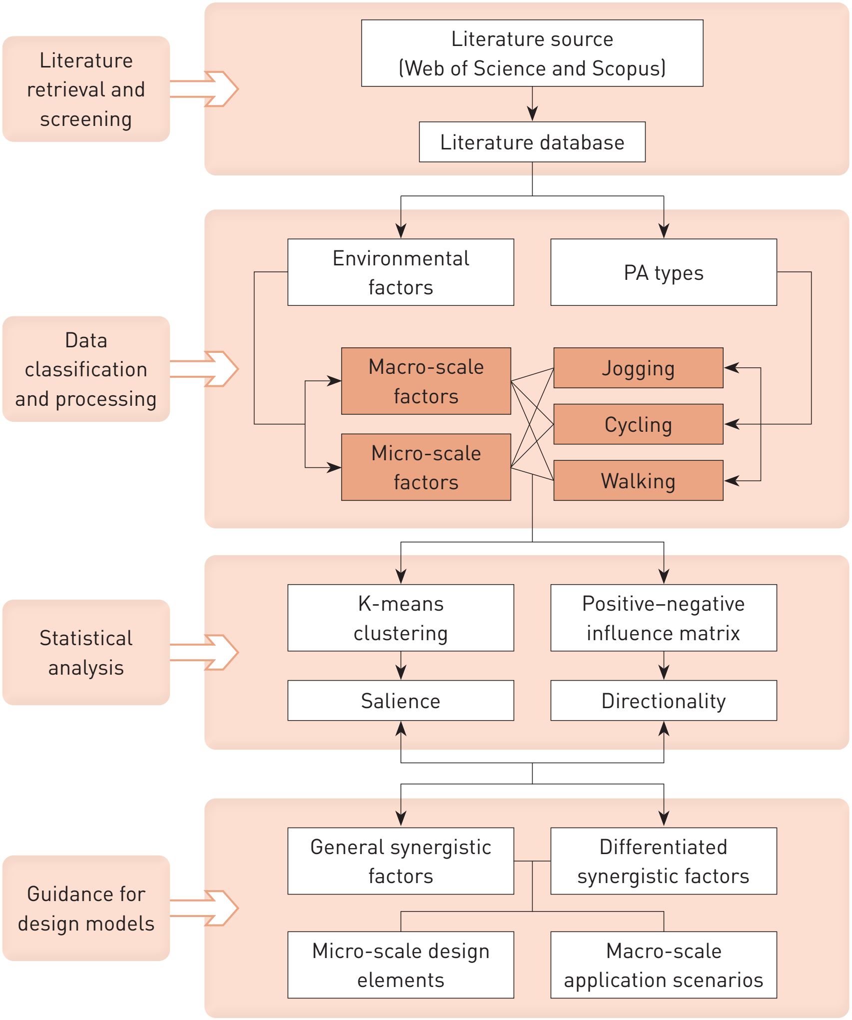
2.1 Research Framework

Based on a systematic review and screening process, this study established a literature database where environmental factors associated with jogging, walking, and cycling were extracted from empirical findings and a classification framework of 15 environmental variables was developed across both macro-scale and micro-scale dimensions[11]. The relationships between each activity type and environmental factor were evaluated by two dimensions: salience and directionality. K-means clustering and a positive–negative influence matrix were then employed to identify the collaborative patterns and divergences in how different activities respond to these environmental factors. Finally, the study discussed collaborative spatial strategies for linear urban fitness environments from both macro- and micro-scale perspectives, offering insights for urban spatial planning and design (Fig. 1).

2.2 Literature Search and Screening

This study sourced data primarily from the Web of Science—focusing on journals indexed in the Science Citation Index (SCI), Social Sciences Citation Index (SSCI), and Arts & Humanities Citation Index (A&HCI)—and Scopus databases. Using the search query TS = ("built environment" AND "urban design" AND "physical activities" AND (jogging* OR running* OR biking* OR cycling* OR walking* OR strolling*)), the study retrieved publications spanning Landscape Architecture, Urban Studies, Environmental Science, Public Health, and related disciplinary fields, from 2004 to 2024. The retrieved literature was analyzed using CiteSpace to obtain annual trends in research output. The retrieved articles were screened based on the following selection criteria: 1) examining the relationship between environmental factors and users' preferences for cycling, jogging, or walking and excluding studies focusing primarily on commuting; 2) limiting study settings to urban built environment and excluding rural or peri-urban contexts; and 3) requiring to present empirical findings—either quantitative or qualitative—demonstrating the associations between linear PAs and environmental factors.

After applying these criteria, a total of 103 articles[17,23–124] were included for the analysis (Fig. 2).



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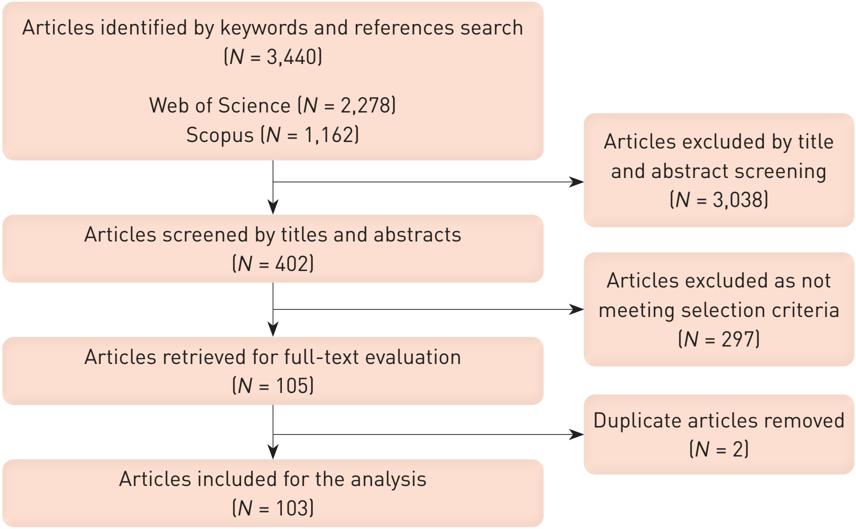

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Fig. 1 Research framework.
Fig. 2 Literature screening process.

2.3 Classification Framework of Environmental Factors

The study further extracted and organized empirical findings from the included literature, consolidating different expressions of the same or similar environmental factors into unified categories. In consideration of planning and design practices, a classification framework of environmental factors was developed[125–128] (Table 1).

All environmental factors were divided into two primary categories: micro-scale and macro-scale. Micro-scale factors primarily inform site-level design, such as cross-sectional spatial configuration and material selection, while macro-scale factors are more relevant to the layout design and applicable land use types.

2.4 Evaluation of Salience of Environmental Factors

The same environmental factor may exert varying degrees of influence across different types of linear PAs. To evaluate these differences, this study first conducted a quantitative assessment of the salience of environmental factors based on 103 studies by the Frequency Effect Size (*FES*) indicator[129] to quantify the frequency of each factor mentioned in the literature, thereby reflecting the degree to which environmental factors influence different types of activity.

In this method, the occurrence of each environmental factor across the three activity types—jogging, cycling, and walking—was first identified based on the results of the preliminary literature review. To ensure statistical independence, studies derived from the same dataset were merged and counted once per factor. The

Table 1: Classification framework of environmental factors

Primary category	Secondary category	Tertiary category	Source
Micro-scale factor	Road width	Road/street width	Refs. [24–27]
	Road surface material	Asphalt road, bark tracks, paved surface, surface type, quality of the surface	Refs. [17,24,28–32]
	Slope	Terrain features, road gradient, road slope	Refs. [27,33–40]
	Road facility	Running facilities, speed bumps, signage, traffic lights, light facilities	Refs. [17,26,32,35–36,41–51]
	Greening	Streetscape greenery, vegetation, shady trees, garden beds, street trees	Refs. [17,26,46,49,52–56]
	Traffic separation	Segregated roadways, separation from motorized traffic and pedestrians, buffers	Refs. [17,23,32,54,57–64]
	Safety	Road hazards, hinderance, traffic condition, spatial openness	Refs. [24,30,47,54,65–74]
	Microclimate	Air quality, local temperature, humidity, air pollution	Refs. [24,54,75–82]
Macro-scale factor	Mixed land use	Park area, industrial/commercial area, residential density	Refs. [43,50,83–92]
	Street network structure	Street connectivity, street density, road infrastructure continuity	Refs. [47,49,87–88,93–97]
	Point of interest (POI) density	Number of points, information points, public service node density	Refs. [25,28,40,49,56,99–103]
	Service facility	Public service access points, route accessibility	Refs. [32,87–88,104–108]
	Population density	Community pedestrian density, neighborhood population size, low pedestrian activity and quiet streets	Refs. [24,34,73,75,109–111]
	Regional traffic pressure	Traffic density, speed limit, vehicle/pedestrian flow density	Refs. [17,50,58,112–113]
	Blue–green space	Green/blue space density, landscape resource richness, landscape maintenance	Refs. [28,34,47–49,54,89,114–124]

NOTE

In this study, the term "microclimate" is operationally defined as the immediate, small-scale atmospheric conditions perceived by moving individuals along the routes (Refs. [125–126]).

number of studies mentioning each factor for each activity type (denoted as $C_{i,a}$) was tallied, and the total number of included studies (N = 103) served as the denominator for calculating the *FES* as follows:

$$FES_{i,a} = \frac{C_{i,a}}{N}, \tag{1}$$

where $FES_{i,a}$ represents the proportion of studies that mentioned factor i in association with activity type a, reflecting the prevalence and relative importance of that factor in existing research. In this study, values are presented in percentage form.

By calculating and comparing the *FES* values, it becomes possible to identify factors which are consistently emphasized across multiple activity types and which are predominantly associated with specific activities. Furthermore, to reveal the synergistic mechanism of environmental factors among different activity types, the *FES* values of linear PAs were subjected to cluster analysis.

Then, the study employed K-means clustering analysis to explore the degree of synergy among jogging, walking, and cycling. K-means is a widely used unsupervised learning algorithm that aims to partition a dataset into several distinct clusters, such that intra-cluster similarity is maximized while inter-cluster differences are minimized[130].

2.5 Evaluation of Directionality of Environmental Factors

In addition to salience, the relationships between environmental factors and different PAs may vary. For instance, joggers may prefer less crowded environments[47], while walkers may favor livelier areas with more people[50]. In order to systematically compare and quantitatively analyze the directional influence of environmental factors across different activity types, this study introduced a scoring mechanism on the directionality upon the existing association matrix approach[131–132]. The qualitative descriptions of environmental factor influence directions (positive/negative/non-significant) were converted into comparable quantitative values (Table 2). The directionality scores were assigned according to the strength of the preferences described in the literature. Positive influence was assigned scores ranging from 1 to 5, with higher scores indicating stronger positive associations; while negative influence was assigned scores from −1 to −5, with lower scores reflecting stronger negative associations; non-significant directions assigned a value of zero. The values were derived directly from the descriptions provided in the studies. To make the magnitude and direction of effects comparable across factors, we standardized all the directly obtained scores to a symmetric range from −1 (strong negative effect) to +1 (strong positive effect)[133], with 0 indicating no significant effect.

The directionality of each environmental factor was calculated as the average value across all studies addressing that specific factor. After determining the directionality of environmental factors for each activity type, a positive–negative influence matrix was constructed to quantitatively compare intergroup differences and potential synergies in environmental preferences across activities.

3 Results

3.1 Research Trends

Figure 3 illustrates the historical research trends on jogging, cycling, and walking. It is evident that studies in this area have grown rapidly in recent years, particularly since 2018, and have stabilized over the past three years. This surge may be attributed

Table 2: Scoring of directionality for environmental factors

Positive influence description	Score	Negative influence description	Score
Minimal positive preference	1	Minimal negative preference	−1
Slight positive preference, or possibly preferred	2	Slight negative preference, or possibly not preferred	−2
Moderate positive preference, or somewhat preferred	3	Moderate negative preference, or somewhat avoided	−3
Strong positive preference, or important factor for behavior	4	Strong negative preference, or important factor for behavior	−4
Key positive preference factor, or decisive positive factor	5	Key negative preference factor, or decisive negative factor	−5

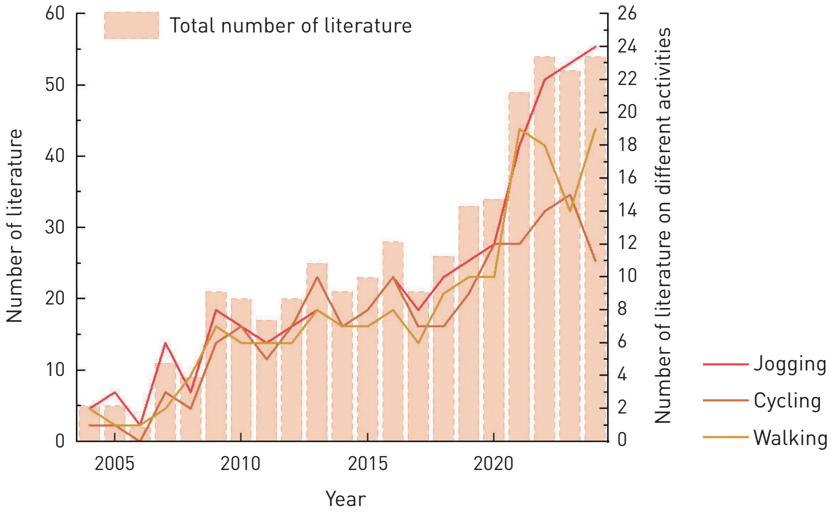


Fig. 3 Numbers of annual publications.

to the emergence of new data environments brought about by the widespread use of big data and linear activity tracking Apps[134–136]. The recent plateau in publication volume may reflect a gradual saturation, with many related scientific questions having been extensively addressed. This highlights the value of systematically reviewing and synthesizing existing research[137].

3.2 Synergy and Divergence in the Salience of Environmental Factors

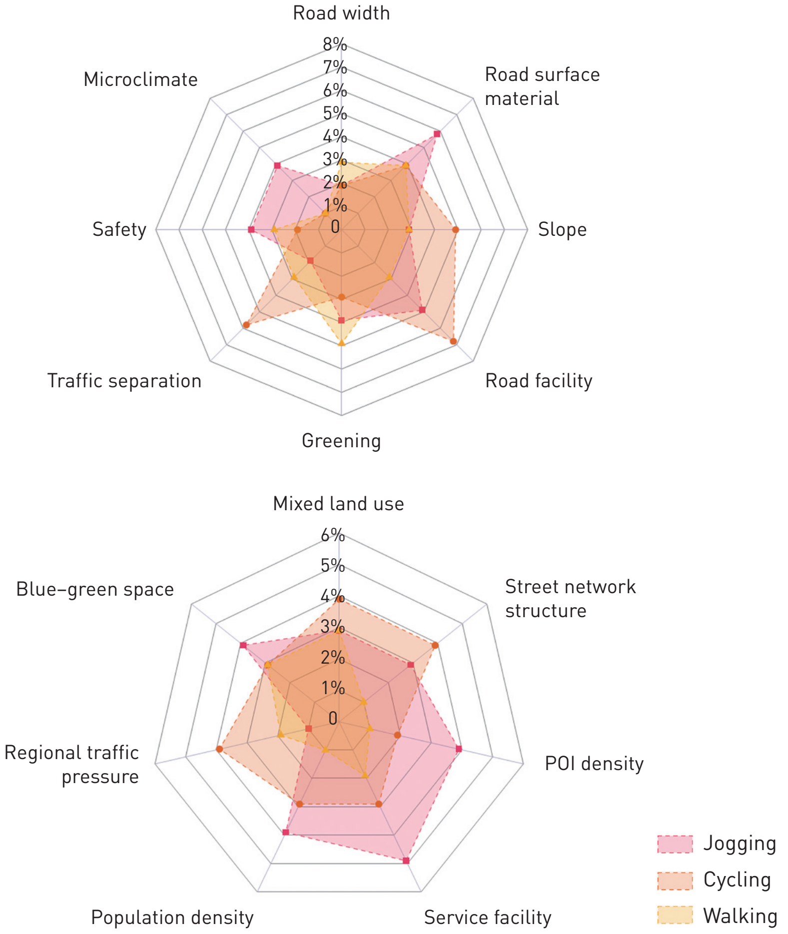
Figure 4 presents radar charts representing the *FES* values of environmental factor influence across different types of PAs.

As shown in Fig. 5, the K-means clustering results classified the environmental factors into three distinct clusters with significant differences.

1) Cluster C1 is characterized by a higher influence percentage for jogging (α = 0.700) compared with the other two PA types. This cluster includes microclimate, POI density, service facility, and population density, which can be considered high-impact factors for jogging.

2) Cluster C2 shows a substantially stronger influence on cycling (α = 0.945), and includes slope, traffic separation, and regional traffic pressure, which are identified as high-impact factors for cycling.

3) Cluster C3 reflects a relatively balanced level of influence across all three PA types. It comprises road width, road surface material, road facility, greening, safety, mixed land use, street network structure, and blue–green space. These factors are considered equally important for supporting jogging, cycling, and walking in urban linear PA environments.



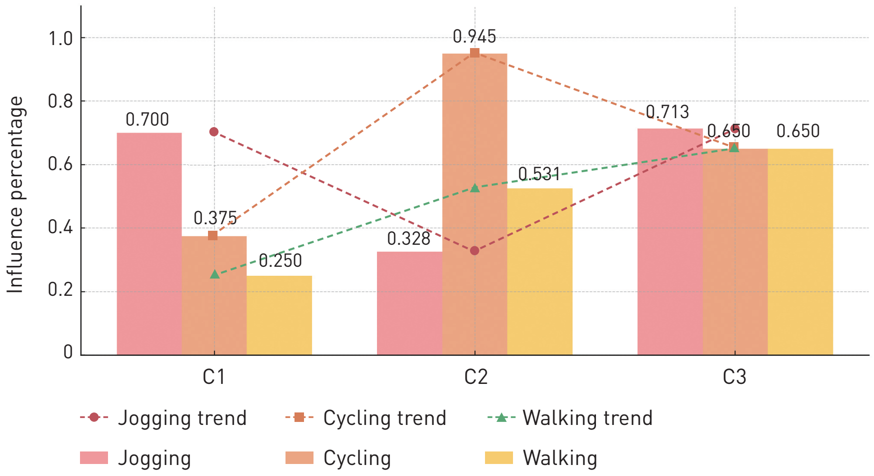
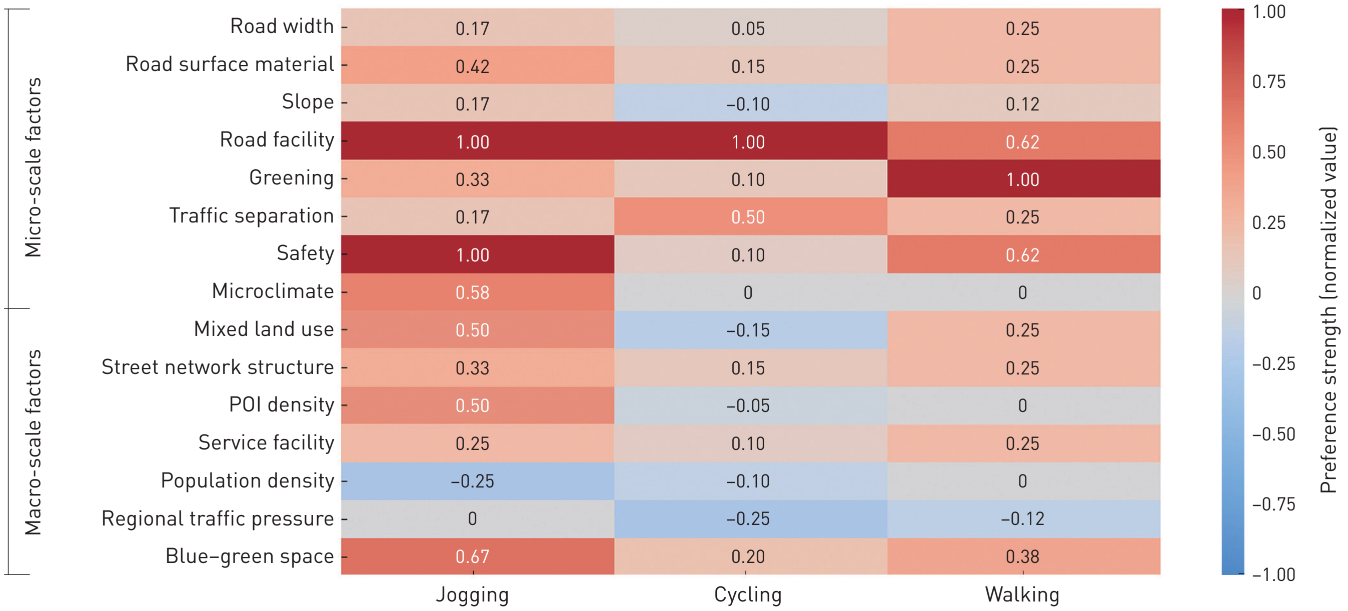


Fig. 4 Radar charts of salience for micro- and macro-scale environmental factors.
Fig. 5 K-means clustering results.

3.3 Synergy and Divergence in the Directionality of Environmental Factors

The processed data were visualized using a heat map (Fig. 6) to compare and analyze the synergy and divergence in the directionality



	Jogging	Cycling	Walking
Road width	0.17	0.05	0.25
Road surface material	0.42	0.15	0.25
Slope	0.17	−0.10	0.12
Road facility	1.00	1.00	0.62
Greening	0.33	0.10	1.00
Traffic separation	0.17	0.50	0.25
Safety	1.00	0.10	0.62
Microclimate	0.58	0	0
Mixed land use	0.50	−0.15	0.25
Street network structure	0.33	0.15	0.25
POI density	0.50	−0.05	0
Service facility	0.25	0.10	0.25
Population density	−0.25	−0.10	0
Regional traffic pressure	0	−0.25	−0.12
Blue–green space	0.67	0.20	0.38

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Fig. 6 Heat map of directionality for environmental factors.

of environmental factors to different activity types.

Overall, road width, road surface material, road facility, greening, traffic separation, safety, street network structure, service facility, and blue–green space all exhibited positive influence across the three PA types, indicating strong synergistic relationships. In contrast, the influence of the remaining factors showed opposite directions, suggesting weaker synergistic relationships compared with the other factors.

For jogging, nearly all environmental factors showed positive preference directionality, with the only notable negative factor being population density. Microclimate, POI density, and regional traffic pressure showed neutral or opposite preference directionality with the other two activities.

For cycling, most environmental factors showed negative preference directionality. Slope and mixed land use showed opposite preference directionality with the other two activities.

For walking, population density and POI density showed neutral or opposite preference directionality with the other two activities.

3.4 Synergistic Factor Classification and Spatial Design Models

From the combined perspective of salience and directionality, environmental factors can be categorized into two types: general synergistic factors and differentiated synergistic factors. In this study, road width, road surface material, road facility, greening, safety, street network structure, and blue–green space are classified as general synergistic factors, which demonstrated relatively consistent patterns in both salience and directionality for all PA types. The remaining eight factors are classified as differentiated synergistic factors, which display varying effects across activities and require attention to specific key factors depending on the targeted spatial context.

Based on these findings, the study proposes five spatial models for supporting multiple types of linear PAs: 1) jogging-dominant spatial model (JDM), 2) cycling-dominant spatial model (CDM), 3) jogging–cycling synergistic model (J–CM), 4) jogging–walking synergistic model (J–WM), and 5) cycling–walking synergistic model (C–WM). The relationships between the research findings and the five spatial models are illustrated in Fig. 7. In the left section of the diagram, solid lines represent the environmental factors that are uniquely included in each synergistic model, whereas dashed lines indicate the factors shared among different models.

Among these models, JDM and CDM models are derived from the C1 cluster and C2 cluster identified through K-means analysis. J–CM, J–WM, and C–WM represent synergistic spatial models formed by pairing two of the three linear PAs. It should be noted that, since the K-means clustering did not identify a walking-dominant cluster, no dedicated model was developed for walking alone. Following the establishment of these models, we discuss the planning and design implications of key environmental factors at both macro and micro scales.

3.5 Micro-scale Application Implications of Key Research Findings

Considering the applicability of key research findings across different spatial design scales, section diagrams and axonometric illustrations were adopted to assist in summarizing and visualizing

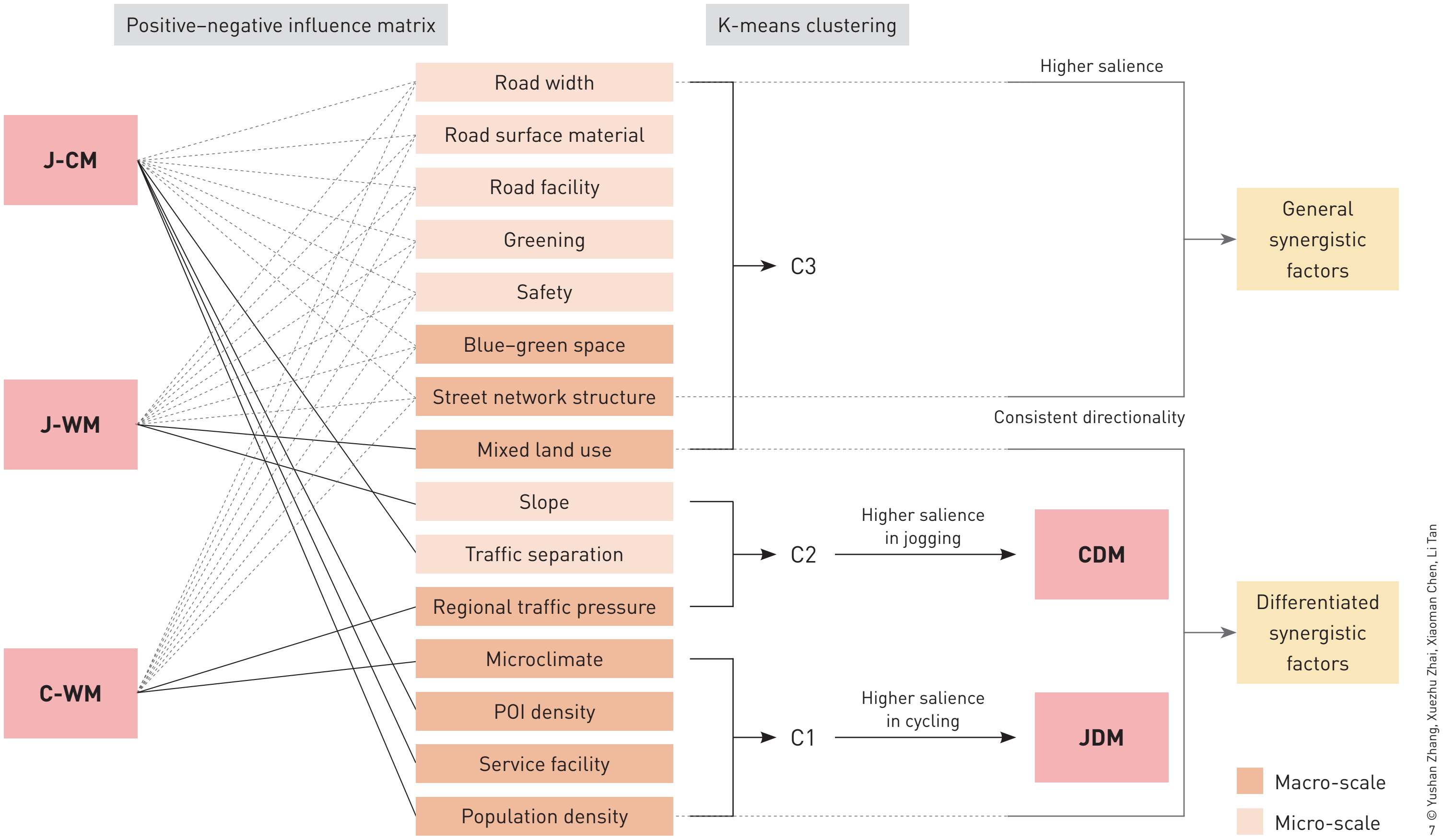
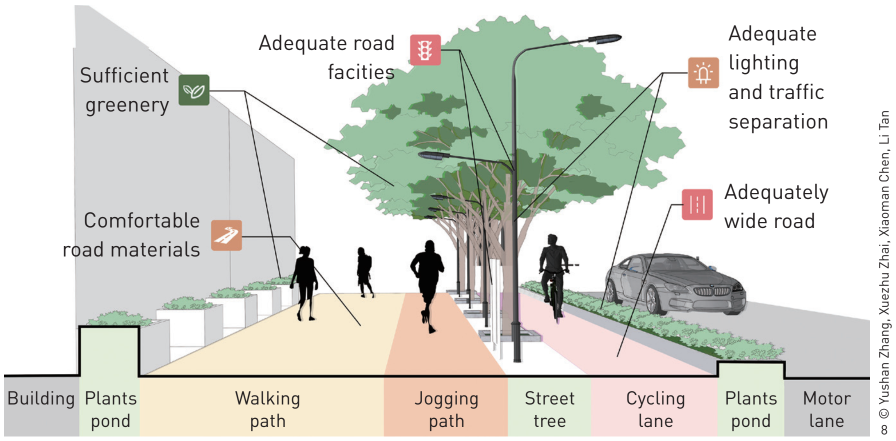


Fig. 7 Relationships between research findings and five spatial models.
Fig. 8 Micro-scale design model guided by general synergistic factors.

how these environmental factors influence linear PAs. At the micro-scale, a typical model designed around general synergistic factors was conceptualized as Fig. 8.

Figure 9 illustrates the typical cross-sectional diagrams of the five spatial models at the micro-scale, highlighting considerations of differentiated synergistic factors.

1) JDM: Creating favorable microclimates is essential for supporting joggers. Ideal conditions include ample tree shade, increased green coverage, and enhanced ventilation.



2) CDM: Cyclists often prefer routes with some degree of slope, reflecting a positive preference for physical challenge (e.g., areas with moderate elevation changes). In addition, cyclists favor road environments with a high degree of traffic separation. It is recommended that green buffer zones be incorporated to separate cyclists from both pedestrians and motor vehicles. Since such green buffers require additional spaces, this model is best suited to road corridors with relatively wide right-of-way.

3) J–CM: Since jogging and cycling show opposite preference directionalities for slope, this model is not suitable for environments where these factors are present in extreme forms (either excessively high or low).

4) J–WM: Both joggers and pedestrians prefer routes with gentle slopes and relatively flat terrains.

5) C–WM: Both cyclists and pedestrians exhibit relatively low sensitivity to microclimatic conditions, making this model suitable for areas with limited green coverage.

3.6 Macro-scale Application Implications of Key Research Findings

At the macro-scale, urban areas characterized by high street network density and abundant blue–green spaces are similarly

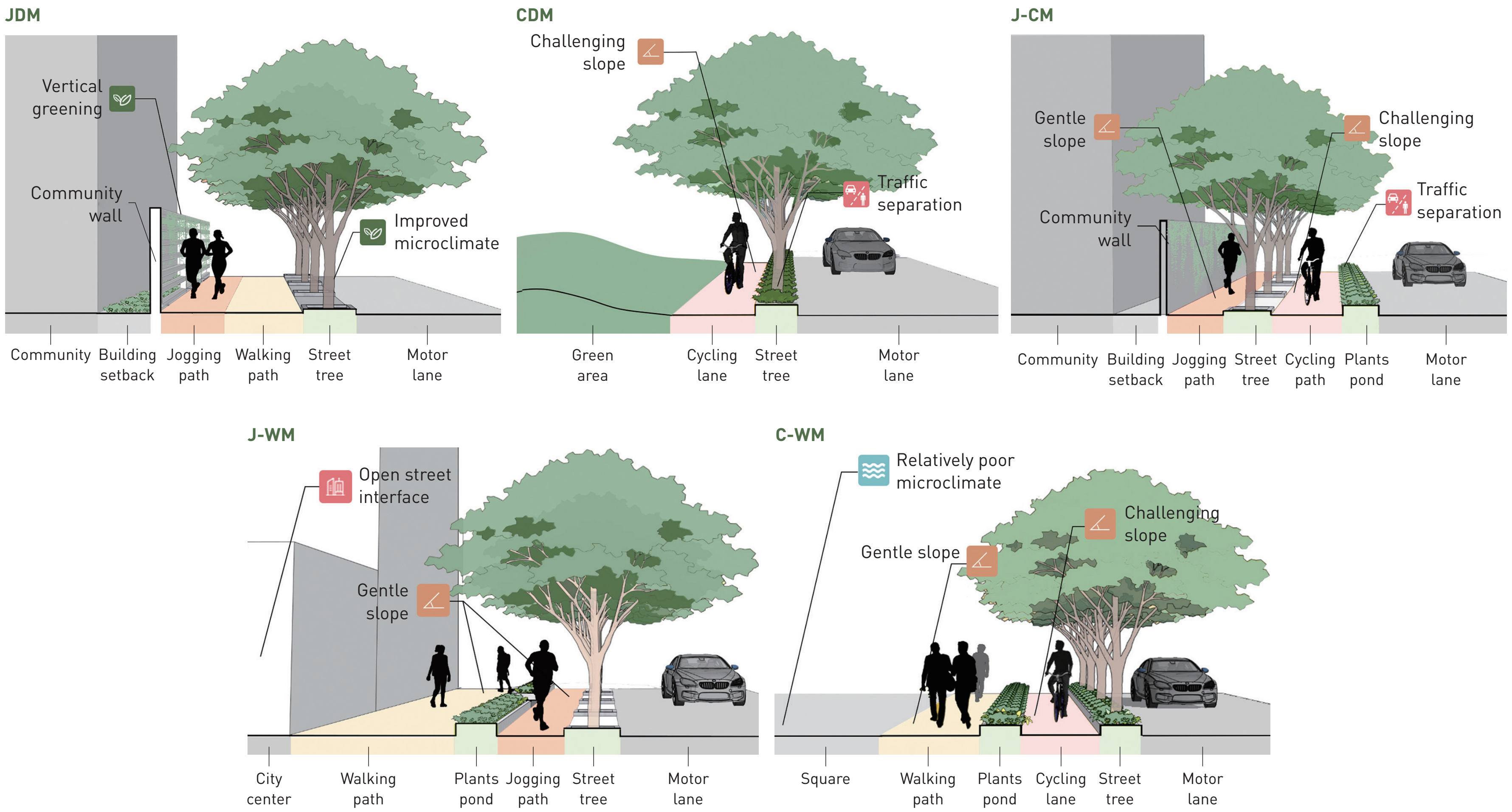


Fig. 9 Cross-sectional diagrams illustrating micro-scale differentiated factors of the five spatial models.

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favorable for all three activities, which has also been confirmed in previous studies[27,138–140]. Such areas should be prioritized in shaping fitness-friendly linear spaces within urban settings.

Figure 10 illustrates the typical urban spatial layouts suitable for the five proposed models at the macro-scale. It also highlights key environmental factors considered in each model.

1) JDM: Joggers tend to avoid areas with high population density and prefer urban spaces that offer a diverse range of functions (high POI density) and convenient access to service facilities. Less crowded residential streets—particularly those located outside of dense commercial zones—may be best suited for this model. In neighborhoods with extensive boundary walls, enhancing the functionality and vitality of the external street spaces could help address issues of underutilization and support the creation of vibrant, jogger-friendly environments.

2) CDM: This model is appropriate for areas with lower regional traffic pressure, such as zones near suburban edges or residential neighborhoods with moderate building or population density. Urban centers or commercial districts with heavy traffic are generally not appropriate for such applications[141].

3) J–CM: Since jogging and cycling show opposite preference directionalities for mixed land use, POI density and slope, which has been reflected in several empirical studies[140,142–143]. This model is not suitable for environments where these factors are present in extreme forms (either excessively high or low). In newly developed urban areas with strong planning control, land use tends to be more clearly structured with relatively simple functional mixing, making them more suitable for this type of synergistic model. In contrast, this model is not recommended for older districts or high-density central areas with overly complex land use patterns.

4) J–WM: Both joggers and walkers prefer environments with relatively mixed land uses and gentle slopes, which may provide a more engaging and enjoyable exercise experience[50,142]. Overall, this model is well-suited for implementation in urban areas with diverse and complex land use patterns.

5) C–WM: This model is better suited to areas with low regional

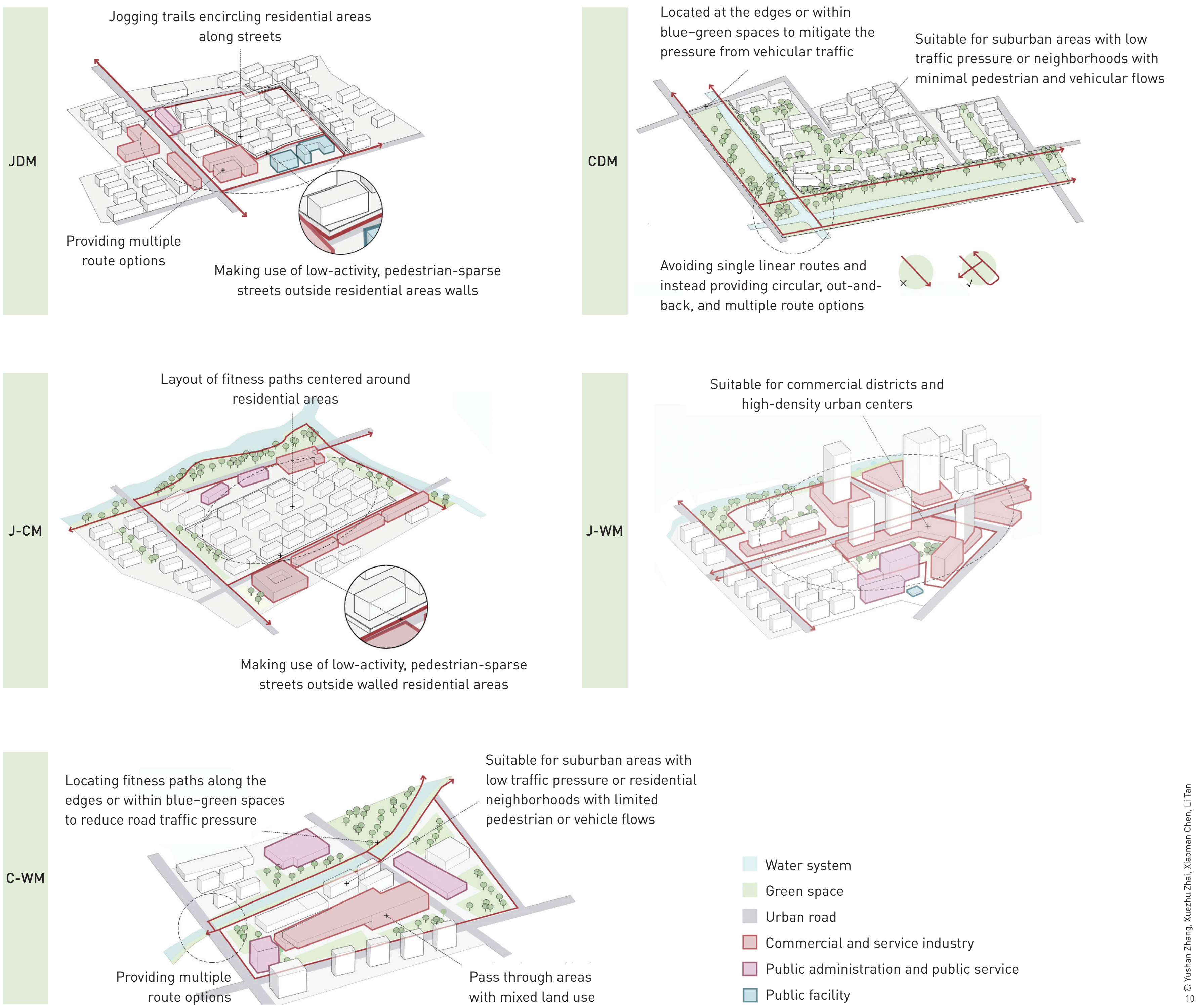

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Fig. 10 Urban spatial layouts of the five spatial models and the considered macro-scale differentiated synergistic factors.

traffic pressure. Additionally, the differing preferences regarding mixed land use should be considered—areas with overly complex land use in dense city centers should be avoided, while overly monotonous environments are also inappropriate, as they may reduce walkers' interest.

4 Discussion

4.1 Performance of Micro- and Macro-scale Factors Across Different PAs

The results indicate that the majority of general synergistic factors (71%) fall under the category of micro-scale factors (Fig. 7), indicating that the environmental demands of jogging, walking, and cycling are largely aligned at the micro-scale, whereas more pronounced differences emerge at the macro-scale. This result may be attributed to the differences in speed, distance, and duration among jogging, walking, and cycling[144–145]. Consequently, participants perceive environmental attributes such as land-use diversity, path connectivity, and accessibility quite differently[50,56], making spatial relationships at the macro-scale more influential in shaping activity preferences. For instance, the relatively high speed of cycling means that an overly diverse mix of surrounding land uses may disrupt the continuity of movement, whereas joggers and walkers, moving at a slower pace, tend to appreciate the variety and richness of land-use environments, which can enhance their overall experience and engagement[49,146].

4.2 Comparison With Existing Studies

The findings of this study are generally consistent with previous research that simultaneously examined multiple types of linear PAs[12,132,147–148]. In those empirical studies, the analysis of environmental factors tended to be more narrowly focused; in contrast, this study establishes a systematic multi-scale framework of environmental factors, a structure that has previously appeared primarily in studies focusing on a single activity type[148–149]. The conclusions presented here can inform and guide more in-depth empirical research. Some empirical studies have also compared two types of activities, and certain environmental factors exhibited differences that were not fully consistent with the findings of this study[12,151–152], possibly due to the limitations of single-case regional studies. Moreover, existing review has mainly focused on broad categories of PA[148], without clearly revealing the detailed pathways through which specific activities respond to environmental factors. In this regard, the comparative analysis among different activity types and the practically oriented synergistic framework proposed in this study represent its most significant contribution.

From an urban landscape design perspective, the results of this study contribute to the inclusive space design within urban areas[152], facilitating the integrated and multifunctional use of urban spaces. As a thematic component within the broader inclusive design framework, this study provides landscape architects with a systematic design reference for shaping open, shared, and adaptive urban spaces[153].

Furthermore, future research could explore the synergies between linear PA spaces and other types of urban linear spaces, including those related to commuting, commerce, tourism, vehicular mobility, and autonomous driving. The needs of diverse user groups, especially vulnerable populations, should also be considered—for instance, how these spaces can be better integrated with school commuting routes or tactile paving systems for the visually impaired.

4.3 Limitations and Prospects

This study integrates a substantial body of literature through a systematic review and offers direct reference strategies for landscape planning and design. However, several limitations should be acknowledged. First, many of the reviewed studies are based on empirical data derived from fitness Apps, which may limit the reliability of the findings due to the characteristics of the data sources—particularly the underrepresentation of populations such as the elderly and children who tend to use such Apps less frequently (though it should be noted that these groups are generally not the primary participants of linear PAs[154]). Second, this study focused on linear PAs, particularly walking and cycling, which may lead to the neglect of health benefits associated with routine commuting behaviors. Therefore, the findings may be less applicable to active transport spaces primarily used for commuting[155]. Lastly, the study did not distinguish between different countries or regions; as such, the applicability of the proposed strategies should be carefully adapted to local socio-cultural and climatic contexts.

The study proposes several landscape design models that can serve as useful references; however, many of these models require support in terms of land ownership, particularly when developing non-motorized pathways of adequate width during urban redevelopment in built-up areas. Encouragingly, with the growing emphasis on inclusive design for linear urban spaces such as streets and the gradual adoption of technologies like autonomous driving, more urban street space is expected to be allocated to pedestrians in the future. The conclusions of this study offer valuable guidance for future urban scenarios, contributing to the promotion of healthy and sustainable urban development.

5 Conclusions

Based on a systematic review and quantitative analysis of global literature from 2004 to 2024, this study focuses on the synergies and divergences among jogging, cycling, and walking in relation to the urban linear spaces. The main findings are as follows.

1) In terms of salience, environmental factors clustered into three distinct groups: high-impact factors for jogging (including microclimate, POI density, service facility, and population density),

high-impact factors for cycling (including slope, traffic separation, and regional traffic pressure), and comprehensively high-impact factors (including road width, road surface material, road facilities, greening, safety, mixed land use, street network structure, and blue–green space).

2) In terms of directionality, environmental factors showed either consistent or divergent patterns across PA types, with some factors exhibiting entirely opposite preference directionalities.

3) Road width, road surface material, road facility, greening, safety, street network structure, and blue–green space demonstrated consistent influence and directionality across all three PA types and were identified as general synergistic factors. The study also identifies eight differentiated synergistic factors, summarizing their characteristics and potential applications with five spatial design models.

This study synthesizes key insights from prior research to reveal potential underlying patterns that emerge across multiple studies. It offers practical conclusions that can directly inform complex processes in urban planning and design practice, while also serving as a systematic reference for future academic work.

Competing interests | The authors declare that they have no competing interests.

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城市线性健身空间的协同路径：定量综述研究启示

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摘要

在缺乏公共户外健身场所的高密度城市中，在街道等线性空间开展跑步、散步和骑行等健身运动逐渐成为人们的重要选择。近几年，国内外已开展大量针对建成环境与运动行为关联的研究，但尚未有研究系统地比较不同线性运动空间的偏好差异，以及如何在城市中进行协同设计。本研究基于103篇文献开展定量综述，从宏观和微观两个层级梳理了15个环境因子与跑步、散步和骑行3种运动的关系，通过K-means聚类分析定量评估这些环境因子对不同运动方式的作用方向及其协同与分异特征。基于不同环境因子在不同运动中的协同或分异表现，本研究识别了7个综合性协同因子和8个分异性协同因子，并提出了5种空间设计模式，继而总结出关键环境因子的适用场景（微观）和不同协同模式所匹配的城市环境（宏观），为构建城市健康支持环境提供了理论支持与实践应用依据。

关键词

景观规划与设计；城市居民健康；健康支持性环境；体力活动；聚类分析

文章亮点

- 基于定量综述，比较了影响跑步、散步与骑行空间的环境因子偏好
- 识别出7个综合性协同性因子与8个分异性协同因子
- 提出了5种空间设计模型，指导规划与设计实践

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