

From Space to Place: A Review of Landscape Design and Children's Health Research

从空间到场所：景观设计与儿童健康研究综述

Xili Han

A list of authors

A list of authors and their affiliations appears

Corresponding author's name:
Xili Han

Specific affiliation:
School of Urban Planning and Design, Peking University
Shenzhen Graduate School
School of Architecture and Landscape Architecture,
Peking University

E-mail address:
hanxl@pkusz.edu.cn

Abstract

Against the backdrop of rapid urbanization and the “indoor, sedentary” lifestyle of children, the role of the built environment in promoting children’s health has garnered increasing attention. This review systematically synthesizes research advances in the field of landscape design and children’s health, aiming to provide an academic reference for child-friendly city initiatives and evidence-based design. The article elucidates core theories such as environmental behavior, environmental affordance, place attachment, and play classification, establishing the foundation for understanding the chain mechanisms of “physical environment → psychological perception → behavioral response → health outcomes.” At the scales of public open spaces, playgrounds, neighborhoods, and school routes, the review synthesizes the multidimensional impacts of landscape spaces on children’s physical activity, cognitive development, and socio-emotional well-being. Methodologically, the review explores the converging trend of diverse techniques, including objective measurements (accelerometers, GPS, computer vision), systematic behavioral observations (SOPARC, behavioral mapping), subjective perception and participatory methods (perceptual mapping, photovoice, walking interviews), and spatial analysis. Current research remains limited, with a stronger emphasis on physiological indicators over psychological development, a predominance of cross-sectional designs, the lack of focus on children’s own perspectives, and insufficient exploration of the underlying mechanisms within China’s high-density urban contexts. Future research should develop interdisciplinary performance evaluation frameworks, extend to higher-order benefits such as cognition, emotion, and environmental ethics, promote participatory action research paradigms, and bridge the gap between policy and design through longitudinal studies and indigenous theoretical innovation, thereby translating “child-friendliness” into high-quality spatial realities.

摘要：在快速城市化与儿童生活方式“室内化、静态化”背景下，建成环境对儿童健康的促进作用日益受到关注。本综述系统梳理景观设计与儿童健康领域的研究进展，为儿童友好城市建设与循证设计提供学术参考。文章阐释了环境行为、环境可供性、地方依恋及游戏分类等核心理论，奠定理解“物理环境—心理感知—行为响应—健康结果”链式机制的基础。从公共开放空间、游戏场地、社区邻里及通学路径等空间类型，整合分析了景观空间对儿童体力活动、认知发展、社交情感的多维影响。方法论上，综述了从客观测量（加速度计、GPS、计算机视觉）、系统行为观察（SOPARC、行为笔记）到主体感知参与（感知地图、相片发声法、步行访谈）及空间分析的多元技术融合趋势。当前研究仍存在重生理指标轻心理发展、横断面设计主导、儿童主体性缺失，以及针对中国高密度城市语境的深层机理探索不足。未来需构建跨学科效能评估框架，拓展至认知、情感与环境伦理等高阶效益，推广参与式行动研究范式，并通过纵向追踪与本土理论创新，填补制度与设计之间的断层，将“儿童友好”转化为高质量的空间现实。

Keywords: landscape design; children's health; environmental affordance; physical activity; place attachment; playground; child-friendly city; high-density city

关键词: 景观设计; 儿童健康; 环境可供性; 体力活动; 地方依恋; 游戏场地; 儿童友好城市; 高密度城市

1. Introduction

Against the backdrop of rapid global urbanization in the 21st century, children's health and development are facing serious challenges. Urban spatial restructuring, the expansion of motorized transportation, and lifestyle changes have led to a pronounced trend toward "indoor, sedentary, and screen-based" daily lives among children. As a result, children's independent mobility and opportunities for outdoor activities have greatly decreased (Kytta, 2004; Whitzman, 2008; Deng et al., 2024; Bozkurt, 2021). The consequent issues of physical inactivity, obesity, and mental health problems have become global public health concerns (WHO, 2020; NCD-RisC, 2023). The built environment, particularly outdoor public spaces, is the primary carrier of children's daily activities, has received increasing attention for its role in promoting children's health. A large body of research indicates that high-quality neighborhood spaces, parks, playgrounds, and school routes can effectively encourage children's physical activity and social play, thereby fostering their physical, mental, and socio-emotional development (Ottawa Charter for Health Promotion, 1986; Wang, 2008; Li, 2009; Zhang, 1980; Bao, 2021). From the Convention on the Rights of the Child to the Child-Friendly Cities Initiative, and further to China's "Healthy China 2030" planning outline, policies have consistently emphasized the importance of creating supportive environments for children.

Over the past two decades, relevant research has made significant progress. The research focus has deepened from "whether there is an impact" to "how specific environmental elements work," and research methods have evolved from qualitative descriptions to a diversified technical system integrating objective measurements, behavioral observations, participatory perception, and spatial analysis (Davison

and Lawson, 2006; Rainham et al., 2012; Scheller et al., 2024). Domestic research started relatively late, and there is a notable scarcity of in-depth studies on the underlying mechanisms specific to China's high-density urban contexts (Wang & Han, 2012; Lin et al., 2018). More fundamentally, existing research rarely addresses the institutional roots of spatial production—the current Code for Urban Residential Area Planning and Design provides overly vague requirements for children's play spaces, resulting in construction quality depending on individual developers' decisions and hindering the implementation of high-quality designs (Han & Cui, 2013).

Therefore, this review aims to systematically synthesize research progress in landscape design and children's health spaces, clarify the theoretical foundations, core themes, and methodological evolution, integrate and analyze evidence of the multidimensional impacts of landscape spaces at different scales on children's health, and specifically explore the mediating roles of psychological constructs such as environmental perception and place attachment. Ultimately, we seek to construct an interdisciplinary understanding framework, identify research gaps and future directions, and provide an academic reference for advancing "evidence-based, child-centered" healthy landscape design and the development of child-friendly cities.

2. Theoretical Foundations and Conceptual Framework

Research on the relationship between children's health and the built environment is rooted in the intersection and integration of multiple disciplines. This chapter aims to outline the core theoretical foundations that support research in this field, providing a theoretical basis for understanding how landscape spaces affect children's health.

2.1 Children's Health and Environmental Behavior

Theory

Children's health, particularly physical activity levels, has been widely demonstrated to be closely related to the everyday built environment. Early environmental behavior research established the basic paradigm of "environment–behavior" interaction, indicating that the physical environment is not a passive container but an important factor actively influencing individual behavior, health, and well-being (Moore, 1987). For children, due to their limited range of activity and autonomy, outdoor environments at the neighborhood and community scale become key places affecting their daily physical activity, play, and social interaction (Ottawa Charter for Health Promotion, 1986; Zhang, 1980).

Research within this theoretical lineage reveals that the negative effects of urbanization (e.g., motor vehicle dominance, reduced public space, diminished natural elements) are significantly associated with decreased physical activity levels, reduced independent mobility, and increased obesity rates among children (Kytä, 2004; Van der Ploeg et al., 2008). Conversely, supportive environmental features—such as safe walking paths, accessible parks and green spaces, and diverse play facilities—can effectively promote moderate-to-vigorous physical activity (MVPA) and active play in children (Davison & Lawson, 2006; Crawford et al., 2007). This provides a fundamental rationale for landscape design interventions: by deliberately shaping the physical environment, it is possible to guide and encourage healthier behavioral patterns, thereby improving children's health outcomes.

2.2 Environmental Affordance Theory

The theory of environmental affordance was proposed by psychologist J. J. Gibson (1979). It transcends the traditional objective descriptions of the physical properties of the environment, emphasizing the "possibilities for action" that an environment offers to a specific actor, such as a child. The "affordance" of an environmental element (e.g., a stone, a slope) depends on the relationship between its physical characteristics and the actor's capabilities. For example, the same tree may afford "shelter" for a young child but "climbing" for a schoolaged child.

Kytä (2002, 2004) developed and applied this theory to research on children's environments, proposing a hierarchical model of "perceived affordances," "used affordances," and "shaped affordances." This framework has greatly deepened the understanding of the quality of child–environment interaction. Accordingly, the goal of landscape design shifts from providing isolated "facilities" to creating a rich, multilayered, and responsive "network of affordances." Encouraging natural elements (e.g., variable terrain, water, sand), multifunctional equipment, and flexible spatial layouts essentially increases the "actualized affordances" of the environment, thereby supporting children in autonomously initiating a wider variety of exploratory, constructive, and creative activities, and promoting their integrated physical, cognitive, and social development (Fjørtoft & Sageie, 2000; Brussoni et al., 2017). Ding and Han (2019) found that multifunctional zones, owing to their rich environmental affordances, significantly stimulated children's functional and constructive play. Research by Wang and Han (2012) corroborated this theory from the perspective of children's perception: when children could connect dispersed activity places through pathways into an explorable network, both their perceived activity opportunities and actual activity levels increased.

2.3 Place Attachment Theory and Spatial Emotional Connection

Place attachment theory focuses on the emotional bonds, sense of belonging, and identity that individuals develop with specific places (Low & Altman, 1992). The tripartite framework of "person–process–place" proposed by Scannell and Gifford (2010) deconstructs attachment into personal dimensions (emotion, memory), psychological process dimensions (cognition, affect, behavior), and place dimensions (physical features, social meanings).

Introducing place attachment into children's health and landscape research is of great significance. A child becomes attached to a playground or a community park not only because of its physical functions but also due to the happy memories, social interactions, and sense of autonomy accumulated there (Shabak et al., 2015). Such emotional connection can significantly

increase children's willingness to revisit and sustain activity, serving as a key psychological mechanism for maintaining longterm health behaviors (Koohsari et al., 2023). Research indicates that the naturalness, aesthetic quality, social atmosphere of a space, and opportunities for children to participate in design and activities all strengthen place attachment (Scheller et al., 2024). Therefore, while optimizing physical attributes, landscape design should also strive to create places that evoke children's emotional engagement and serve as anchors for memories.

2.4 Theories of Children's Play Behavior Classification

Understanding children's diverse play behaviors is fundamental to evaluating and designing healthy spaces. Jean Piaget (1969), from a cognitive-developmental perspective, classified play into sensorimotor play, symbolic play, constructive play, and games with rules, revealing a developmental sequence of play with age. Sara Smilansky (1968), building on Piaget's work, proposed a four-category classification that has been widely adopted in practice: functional play (repetitive muscle movements, e.g., running, jumping, primarily promoting physical development); constructive play (manipulating materials to build objects, e.g., playing with sand, building blocks, fostering creativity and problem-solving skills); dramatic/symbolic play (roleplaying and imaginary situations, promoting language, social, and emotional development); and game with rules (play with established rules, e.g., ball games, cultivating cooperation and a sense of competition).

In addition, Parten (1932) proposed a classification based on the degree of social participation (unoccupied behavior, onlooker behavior, solitary play, parallel play, associative play, cooperative play), providing an important perspective for observing social interaction. Together, these theories indicate that a healthy space supporting children's holistic development should simultaneously accommodate and stimulate various types of play, ranging from physical exertion to social collaboration, and from sensory exploration to complex cognition. Landscape design should avoid a tendency toward single-function, equipment-dominated spaces; instead, by providing diverse physical environmental

cues and opportunities for social interaction, it should support the natural evolution and cooccurrence of play behaviors.

2.5 Child-Friendly City and Healthy City Concepts

The "Child-Friendly City" is a global initiative officially proposed by the United Nations Children's Fund (UNICEF) in 1996. Its core objective is to ensure that urban policies and construction effectively guarantee children's rights to survival, development, protection, and participation, thereby creating safe, inclusive, and opportunity-rich environments. This concept aligns closely with the "Healthy City" movement, which emphasizes promoting population health through improved urban planning, environmental conditions, and socioeconomic factors.

In China, these concepts have been elevated to national strategies. The "Healthy China 2030" Planning Outline explicitly calls for attention to the health of key population groups. Subsequently, 23 government departments, including the National Development and Reform Commission, jointly issued the Guidelines on Promoting the Construction of Child-Friendly Cities, marking the entry of the child-friendly concept into the substantive stage of urban development. These policies and concepts assign a clear social responsibility and action framework to the discipline of landscape design: that is, to transcend traditional beautification functions and actively engage in the field of public health. However, the advancement of these concepts does not automatically translate into widespread practice. Han (2015), in a study of the decision-making mechanism for residential area development in Beijing, indicated that although China has signed the Convention on the Rights of the Child at the national level, the Code for Urban Residential Area Planning and Design, which serves as the core technical basis for implementation, has long lacked specific provisions for children's play spaces. This disconnection between high-level concepts and grassroots regulations often reduces child-friendly city construction at the micro level to a "marketing gimmick" for developers or a matter of "conscientious configuration," rather than a "standard provision" guaranteed by institutional mechanisms. To achieve the construction from "healthy cells" to a "healthy

organism," this institutional gap must first be repaired.

3. Research Progress Review

3.1 Public Open Space and Children's Physical Activity

Public open space (POS), including parks, plazas, greenways, and roadside green spaces, serves as a core carrier for urban children's outdoor physical activity and social interaction (Timperio et al., 2008; Bao, 2021). Numerous studies have shown that the physical and social environmental characteristics of POS influence children's usage behavior and physical activity levels through complex mechanisms.

Regarding physical environmental characteristics, facility provision is a fundamental element affecting the intensity of children's activity. Dedicated sports facilities (e.g., basketball courts) are significantly positively associated with children's moderate-to-vigorous physical activity (MVPA) (Floyd et al., 2011; Pintos-Toledo et al., 2024), while large, challenging play equipment is key to attracting children's visits (Veitch et al., 2021; Rivera et al., 2021). The maintenance condition of facilities and the availability of amenities (toilets, drinking fountains) also indirectly influence willingness to use and length of stay (Huang et al., 2020; Reuben et al., 2020). The incorporation of natural elements significantly enhances the attractiveness and activity diversity of POS. Vegetation, water bodies, sand, and varied terrain provide children with opportunities for unstructured play such as climbing and exploration, promoting creativity and physical coordination (Fjørtoft & Sageie, 2000; Brussoni et al., 2017; Zhang et al., 2023). In terms of spatial layout, moderate clustering of related activity facilities can create social hotspots; open and transparent sightlines and connected path systems encourage free exploration (Podolska, 2014), while appropriately enclosed small spaces provide a sense of security (Frost et al., 2001).

Accessibility is a prerequisite for POS use. A large body of research confirms that POS proximity is positively associated with frequency of use (Huang et al., 2020; Dunton et al., 2014; He et al., 2017). The average comfortable walking distance for children is approximately 1.5 kilometers (Timperio, 2004; Sallis,

1993), and the quality of the route environment to the POS is equally critical (Giles-Corti et al., 2011). Notably, significant socioeconomic disparities exist in accessibility: low-income communities may face "spatial deprivation," where despite short physical distances, the POS are of poor quality and the routes are unsafe, resulting in low actual usage rates (Chen et al., 2019; Huang et al., 2020).

Social support and environmental perception play mediating roles. Parents' and children's perceptions of POS safety (crime, traffic, facilities) and attractiveness are key variables; if perceived as unsafe or uninteresting, activity levels may be suppressed even when the physical environment is superior (Shokoohi et al., 2012; Carver et al., 2008b). The presence of peers is one of the strongest predictors of children's activity in POS (Floyd et al., 2011). Parental accompaniment can increase activity opportunities (Ge et al., 2024). However, observations by Han et al. (2013) of high-rise communities in Beijing revealed that while adult supervision ensures safety, it may also inhibit children's free exploration – activities under supervision tend to be "planned, short-duration, and fixed-location," whereas activities when alone or with peers exhibit "unplanned, long-duration, and circuitous route" characteristics.

There are significant within-group differences in children's use of POS. Boys are more inclined to use sports facilities for competitive activities (Van Hecke et al., 2018; Duan, 2022), whereas girls prefer social facilities and natural landscapes (Zhang et al., 2023). Lin et al. (2018) found that building density has markedly different effects on activity levels of boys and girls. In terms of age differences, younger children require safe, appropriately scaled play nooks; school-aged children need complex facilities and semi-natural areas; adolescents need social gathering spaces (Marquet et al., 2019; Pintos-Toledo et al., 2024). Regarding socioeconomic differences, Zhang et al. (2023) found that children from urban villages exhibited significantly higher diversity of after-school outdoor MVPA compared to children from planned communities, attributable to higher land-use mix and vitality of ground-floor commercial activities.

3.2 Playground Design and Children's Holistic

Development

The design quality of playgrounds directly affects children's holistic development in physical, cognitive, social, and emotional domains. According to design philosophies, playgrounds can be broadly classified into traditional, adventure, and contemporary natural types. Traditional playgrounds center on standardized equipment, primarily supporting "functional play" with relatively monotonous play patterns (Frost & Klein, 1979; Barbour, 1999). Adventure playgrounds provide loose parts that allow children to build freely, highly supporting "constructive" and "dramatic" play (Hayward, 1974), but they require high levels of supervision. Contemporary natural playgrounds combine the durability of traditional equipment with the richness of natural elements, creating multisensory exploration environments through varied topography, natural materials, and customized facilities, supporting the full spectrum of play from functional to rulebased play (Moore & Goltsman, 1997; Luchs & Fikus, 2013).

Regarding spatial layout, the connectivity between facilities is crucial. Interconnected equipment clusters encourage continuous sequential play and prolong activity duration (Bruya, 1985; Podolska, 2014). Han et al. (2013) proposed the concept of "preplay areas," finding that the surrounding loop paths also stimulate physical activity. Nicholson's (1973) "theory of loose parts" emphasizes that providing movable components empowers children to modify their environment, greatly stimulating constructive play (Maxwell & Evans, 2008; Ding & Han, 2019).

Natural elements have unique restorative values. Natural topography offers variable challenges for running and jumping, comprehensively exercising strength and coordination (Fjørtoft & Sageie, 2000). Natural elements provide a foundation for symbolic thinking (Wang et al., 2018). Han and Sun (2025) found that aquatic organisms in water features can stimulate observation and social interaction. Exposure to nature reduces stress and improves attention (Brussoni et al., 2017). Han et al. (2013) revealed the synergistic effect of natural and artificial elements. Design details are equally important: warm wood is more inviting than cold metal; natural soft colors are more conducive to

focusing on play itself; undulating terrain creates a sense of exploration and surprise (Han & Sun, 2025).

3.3 Children's Environmental Perception and Place Attachment

Understanding how children perceive the environment and develop emotional bonds is key to designing spaces that truly appeal to them. Research methods have undergone a paradigm shift from "research on children" to "research with children." Early studies relied heavily on questionnaires, which suffered from generational bias (Creswell, 2003). Drawing mental maps and thematic painting provide children with channels for free expression. Wang and Han (2012) were among the early researchers to use perceptual maps, asking children from urban villages to draw their activity ranges and identifying three types of perceived structural patterns. Current cuttingedge approaches emphasize children's agency: the photovoice method allows children to photograph "places important to me" (Wang & Burris, 1997; Scheller et al., 2024); the walking interview captures realtime perceptions in authentic settings (Scheller et al., 2024); GPS combined with accelerometers records spatiotemporal trajectories of activity (Rainham et al., 2012; Quan et al., 2017).

Children's perceptions differ systematically from adults'. Rather than macroscale morphology, children focus more on microscale, tangible elements and immediate sensory experiences – the value of a space lies first in "what it can be used for," i.e., environmental affordances (Gibson, 1979; Kytä, 2002). Wang and Han (2012) found that children's depictions prominently highlighted microelements such as "the doorstep" and "trees, water features." Place attachment is typically based on autonomous exploration and a sense of mastery, accumulation of positive emotions, and the space as a vehicle for social relationships (Scannell & Gifford, 2010). Ding and Han (2019) found that children's playgrounds in Shenzhen parks were predominantly used by children aged 1–6 years, with only 4.57% usage by children aged 7–12, indicating that designs fail to meet the preferences of schoolaged children.

Place attachment serves as a dynamic psychological resource driving sustained health behaviors: it acts as an intrinsic motivator, prompting children to visit

spontaneously (Koohsari et al., 2023); it also acts as a buffer for behavioral persistence, enhancing a sense of security (Shabak et al., 2015). Research indicates that place attachment mediates the relationship between the built environment and physical activity (Mohammad et al., 2023). Translating perception and attachment into design strategies requires creating multilevel exploration sequences, providing modifiable elements (Nicholson, 1973), stimulating sensory experiences, and supporting social narratives. Participatory design is the most fundamental pathway for this translation, involving children directly in the design process to ensure that the design aligns with their authentic perceptions (Pawlowski et al., 2019; Fatahi et al., 2025).

3.4 Health Support from Community and Neighborhood Spaces

Community and neighborhood spaces constitute the “first scene” supporting children’s daily physical activity, independent mobility, and social play. Their healthsupporting effects are more evident in highfrequency, fragmented activities (Jones et al., 2009; Perry et al., 2016). Community outdoor spaces can be divided into formally designed playgrounds and informal spaces that are not designed but are spontaneously used by children. Traditional standardized equipment playgrounds primarily support “functional play” and offer limited promotion of higherorder cognitive abilities (Hayward, 1974; Barbour, 1999). Spaces that integrate nature, loose parts, and compound challenges can stimulate “constructive” and “dramatic” play (Nicholson, 1973; Luchs & Fikus, 2013). Podolska (2014) emphasizes the importance of spatial connectivity. Brussoni et al. (2020) found that perceived safety, the presence of playmates, and opportunities for challenging play are core influencing factors.

Informal activity spaces have received increasing attention in recent years. Due to the longstanding lack of mandatory indicators in the Code for Urban Residential Area Planning and Design, a large number of children rely on such spaces. Wang and Han (2012) found that the “doorstep” accounted for 18% of the elements in children’s perceptual maps. Xiao and Han (2019) found that children in Pingshan Village, Shenzhen, primarily used informal areas such as ancestral hall entrances

and shop doorsteps. Zacharias et al. (2017) found a significant positive correlation between the total amount of play space within 400 m around schools and children’s traveling in groups. Han and Sun (2025) found that dry ponds can be transformed into informal activity grounds. Han et al. (2013) found that loop paths and greenspace edges supported a large amount of spontaneous play.

Streets are important venues for children’s daily physical activity and social learning (Guo et al., 2023). Children’s independent mobility is declining globally (McDonald, 2007; Van der Ploeg et al., 2008). Lin et al. (2018) found that residential floor level was significantly negatively correlated with activity time, especially for girls. At the macro level, the effects of landuse mix and intersection density exhibit regional heterogeneity (Broberg et al., 2013). At the micro level, the quality of the route environment has a more direct effect. Meng et al. (2018) found that intersection density was positively associated with active commuting, but wider sidewalks were unexpectedly positively associated with motorized travel. Zacharias et al. (2017) found that pedestrian streets were positively associated with children walking alone. Melia’s (2012) concept of “filtered permeability” provides a new perspective for understanding childfriendly streets.

The health potential of school routes has been underestimated. The MVPA contributed by walking or cycling to school can reach onethird of the daily recommended amount (Elissa et al., 2012). Meng et al. (2018) were the first to systematically explore “afterschool detouring,” finding that 57% of active commuters detoured; wider sidewalks, more open spaces, and more play opportunities were positively correlated with detour distance, indicating that children are attracted by play opportunities along the route. Objective distance is a strong predictor (Timperio et al., 2004; Sun et al., 2018); perceived safety plays a decisive role (Catherine & Susan, 2012). Sun et al. (2018) found that walking with parents actually reduced the likelihood of active commuting. The “Safe Routes to School” program in the United States has achieved a 5%–75% increase in walking and cycling rates (Boarnet et al., 2005; McDonald et al., 2013).

The community social environment plays a

moderating role. Parents' perceptions of neighborhood safety are stronger predictors of children's outdoor activity than objective crime data (Weir et al., 2006). Families with higher perceived social cohesion are more likely to allow independent activity (McDonald, 2007). Xiao and Han (2019) noted that groundfloor commercial uses increase street vitality and informal surveillance. Zacharias et al. (2017) found that housing prices were positively correlated with parental accompaniment and negatively correlated with group travel; gated communities were positively correlated with accompaniment. Wang and Han (2012) found that poor sanitation and increased car traffic were negative factors in urban villages. Ge et al. (2024) found that parental exercise accompaniment was positively associated with children's activity levels. Regarding environmental equity, lowincome communities often suffer from poor facility maintenance, leading to low usage rates (Huang et al., 2020; Chen et al., 2019). Wang and Han (2012) and Xiao and Han (2019) filled research gaps on lowincome residential areas in China.

4. Advances in Research Methods and Technological Applications

Over the past two decades, research methods in the field of landscape design and children's health have undergone a significant paradigm shift. Early studies relied heavily on crosssectional questionnaire surveys and empirical observations. Although these approaches could reveal surfacelevel associations between environment and behavior, they struggled to precisely analyze how spatial characteristics instantaneously trigger or inhibit children's activities (Hume et al., 2005; Creswell, 2003). Currently, the field has developed a comprehensive technical system integrating objective measurements, behavioral observations, subjective perception, and spatial analysis.

4.1 Objective Measurement Techniques for Physical Activity and Spatiotemporal Behavior

Accurate quantification of children's physical activity is a prerequisite for exploring the relationship between environmental exposure and health outcomes. Accelerometers are currently the most widely used objective measurement tool, converting raw counts

into activity intensity levels by sensing changes in acceleration (Freedson et al., 2005). The ActiGraph series has been wellvalidated for reliability and validity in child populations and can continuously record children's physical activity rhythms for one week or longer (Troiano et al., 2008), but it cannot identify the specific locations where activities occur.

The introduction of the Global Positioning System (GPS) effectively compensates for this limitation. Wearing GPS devices simultaneously with accelerometers allows researchers to precisely answer the core questions of "where, at what intensity, and for how long do children engage in activity" (Rainham et al., 2012; Cooper et al., 2010). Using this combined technology, Dunton et al. (2014) found that children's MVPA time in parks was significantly higher than in other settings. Similarly, Quan et al. (2017), in a study of children in Shanghai, confirmed that community parks and sports grounds are the main spaces contributing to children's MVPA. A bottleneck of this technical approach is the loss of GPS signals in areas with dense highrise buildings. In recent years, computer vision technology has begun to emerge. No et al. (2024) used trajectory data from urban public surveillance systems to automatically identify children's typical behavioral patterns on streets, overcoming the labor cost limitations of traditional observation methods, but facing privacy and ethical controversies.

4.2 Observation and Behavioral Mapping Techniques

When research interests shift from "total activity volume" to "activity patterns" and "details of environmental interaction," systematic behavioral observation methods become an irreplaceable tool. Behavioral mapping is a classic method in environmentbehavior studies, in which observers systematically record the locations, ages, activity types, and social interaction status of people within a specific area during predetermined time windows (Ittelson et al., 1970). CzalczyńskaPodolska (2014) used behavioral mapping to reveal a significant association between facility connectivity and children's play duration. Ding and Han (2019) employed behavioral mapping to observe

the play behaviors of 2,604 children in park playgrounds in Shenzhen, revealing the mechanisms linking spatial characteristics to children's behavior. Xiao and Han (2019) divided Pingshan Village in Shenzhen into 23 grids and recorded the distribution of outdoor activities of 1,754 children in time blocks, accurately identifying activity hotspots.

The introduction of the SOPARC system has promoted the standardization of observation methods. SOPARC (System for Observing Play and Recreation in Communities) was developed by McKenzie et al. (2006). It uses momentary time sampling to systematically record the activity intensity, type, gender, age, and social grouping of individuals in a target area. Its reliability has been validated in multiple countries (Evenson et al., 2016). Its advantages include high comparability and reproducibility; however, momentary sampling may miss low-frequency but important behavioral events. Some studies have adopted tracking observation methods to gain a deeper understanding of dynamic interaction processes. For example, Han and Sun (2025) continuously tracked 224 children for 10 minutes each, recording sequences of activity type transitions in detail, revealing "behavior chains" that are difficult to capture through scan sampling. Han et al. (2013) conducted both fixed-point and tracking observations in a high-rise community in Beijing, capturing seasonal differences in children's activities and evolving patterns with age. Video recording for subsequent behavioral coding is also an important technique. When studying the afterschool behaviors of elementary school students in Shenzhen, Zacharias et al. (2017) set up cameras at all main exits to record continuously, precisely identifying each child's travel mode, providing a reliable pathway for large-scale, high-precision behavioral research.

4.3 Research Methods for Children's Subjective Perspectives on Perception and Experience

Children are active experiencers and meaningmakers of space. Over the past decade, participatory, visual, and narrative methods have developed rapidly, aiming to "let children's voices be heard." Mental mapping and drawing are low-threshold tools for accessing children's inner worlds. By drawing "the place where I live" or "the place where I play,"

children project their selective attention and emotional evaluation of spatial elements. Wang and Han (2012) analyzed 38 perceptual maps drawn by children, extracted 41 types of environmental perception elements, and identified three patterns of children's perception of neighborhood space.

The introduction of photovoice represents an important breakthrough in participatory research. This method was pioneered by Wang and Burris (1997) and later systematically applied to children's environmental perception research by Scheller et al. (2024). It encourages children to photograph "places important to me" and then explain the meanings behind the images through semistructured interviews. Using this method, Veitch et al. (2021) found that Australian children highly valued interactive facilities and natural elements. Fatahi et al. (2025), in a study in Iran, revealed children's strong preference for "modifiable environments." The walking interview moves the interview context from a meeting room to the real environment, eliciting immediate perceptions and memories during real-time environmental exposure (Carpiano, 2009; Scheller et al., 2024). It can evoke narratives that are difficult to access through retrospective interviews. Children's participatory design workshops allow children to express spatial preferences directly through activities such as building blocks and model making (Pawlowski et al., 2019). The analytical tools for these qualitative methods have evolved in parallel. Software such as MAXQDA and NVivo supports systematic coding and thematic extraction from multimodal data, including interview transcripts, photographs, and videos (Kuckartz & Rädiker, 2019). Quantitative research using structured scales to measure children's environmental perception is also relatively mature. Sun et al. (2018), in a study of schoolaged children in Shenzhen, adapted and validated the "Neighborhood Environment Walkability Scale for Youth" for the local context.

4.4 Spatial Analysis and Statistical Modeling Techniques

For validating associations between environmental characteristics and health behaviors, Geographic Information Systems (GIS) and multivariate statistical models constitute the core methodological

pillars. GIS spatial analysis enables the quantification of environmental characteristics from “subjective perception” to “objective measurement.” Buffer analysis is used to delineate children’s activity ranges and calculate indicators such as green space ratio and facility density (Frank et al., 2004; He et al., 2015, 2017). Network analysis calculates walking accessibility based on actual road networks, which better reflects children’s actual walking experiences than Euclidean distance (Reyes et al., 2014). Kernel density estimation can be used to identify spatial hotspots of children’s physical activity (Zhang et al., 2023). To accurately capture the environmental influences at the route level, some studies have adopted segmentbased route environment audits. For example, Meng et al. (2018), when studying middle school students’ afterschool route choices, asked students to draw their daily homeward routes and then coded each road segment for microscale environmental features such as sidewalk width, intersection density, and number of open spaces. This approach provides strong support for revealing the realtime “environment–behavior” interaction mechanisms at the route scale. However, GIS analysis faces the “modifiable areal unit problem,” where the choice of buffer radius directly affects the analysis results.

In terms of statistical modeling, early studies mostly used multiple linear regression or logistic regression to test the correlation between single environmental factors and activity levels (Davison & Lawson, 2006). Multilevel modeling effectively addresses the challenge of nested data by placing neighborhoodlevel and individuallevel variables within a unified analytical framework (Franzini et al., 2009). Structural equation modeling further allows the testing of mediating pathways and moderating effects, providing a powerful tool for revealing the chain mechanism of “physical environment → psychological perception → behavioral response” (Koohsari et al., 2023). Association rule analysis has been used in recent years to uncover nonlinear associations between combinations of environmental elements and specific play behaviors (Zhang et al., 2023).

5. Research Gaps and Future Directions

After nearly three decades of interdisciplinary

accumulation, research on the relationship between landscape design and children’s health has developed from empirical observation into a specialized field with theoretical awareness and methodological consciousness. However, a systematic review reveals that the field still faces several structural challenges that urgently require future breakthroughs.

5.1 Research Gaps

Although multiple disciplines have accumulated rich literature around common issues, a shared conceptual system and theoretical framework have yet to emerge. The divergent discourses of different disciplines make it difficult to effectively translate and cumulate research findings (Hume et al., 2005; Koohsari et al., 2023). More critically, existing studies generally lack an integrated examination of the full chain of “physical environment → psychological perception → behavioral response → health outcomes.” Most studies stop at testing statistical associations between single environmental factors and single health indicators, while mediating mechanisms and moderating conditions are often simplified into a “black box.” In terms of the focus of environmental characteristics, research still emphasizes quantifiable indicators such as number of facilities and park area, while paying insufficient attention to qualitative features such as spatial form, material texture, and modifiability (Podolska, 2014; Guo et al., 2023). Regarding health outcomes, research has focused more on physiological indicators than on psychological development, and more on physical activity than on social interaction. The vast majority of studies use moderate to vigorous physical activity as the core outcome variable, while higher order developmental benefits such as imagination stimulation, creativity cultivation, and risk coping skills acquisition remain marginal (Brussoni et al., 2017; Wang et al., 2018). Ding and Han (2019) pointed out that in Shenzhen’s playgrounds, constructive play accounted for only 25.7% and imaginative play for only 0.42%, reflecting the very limited support of design for children’s creativity.

At the methodological level, crosssectional designs have long dominated, while longitudinal followup studies are extremely scarce (Davison & Lawson, 2006; Wang et al., 2020). The accuracy of environmental exposure

measurement is insufficient. Most studies define fixed buffers centered on home addresses, which deviate significantly from children's actual activity geographies (BooneHeinonen et al., 2010). Although the combined use of GPS and accelerometers has become common in international frontier research, it remains rare in China. Participatory research and mixedmethod designs are particularly lacking (Wang et al., 2020; Jiang et al., 2023). It is worth noting that although research methods are showing a trend toward pluralistic integration – with objective measurements contributing precision, behavioral observations contributing contextual richness, participatory methods contributing depth of meaning, and spatial modeling contributing possibilities for causal inference – each individual method has inherent limitations. Although the mixedmethods research paradigm has become mainstream at the international frontier – for example, Scheller et al. (2024) combined GPS tracking with photovoice to achieve a fullchain analysis of “where children are active – how they are active – why they are active there” – such integrated research is still absent in China. Moreover, methods focus on the terminal “environment–behavior” association, with little attention to the deeper institutional mechanisms that explain “why the space is presented as it is.” Han (2013), through interviews, revealed the black box of developer decisionmaking, providing an institutional perspective for understanding the inadequate supply of children's activity spaces in China.

From the perspective of research approach, although “child participation” has become a highfrequency term in policies, children are still mostly positioned as passive data providers rather than coproducers of knowledge in research. A large number of studies follow a oneway path of “adults design the questionnaire – children check the answers – adults analyze the data.” Empowerment methods such as photovoice and walking interviews have accumulated over a decade of international experience (Wang & Burris, 1997; Scheller et al., 2024), but remain in sporadic trial stages in China. Wang and Han (2012) used perceptual maps to make children active participants in research, providing a local example for reflecting on adultcentrism.

Indigenous research lags behind. Chinese urban

children face unique contexts including highdensity living conditions, intense academic pressure, and the prevalence of grandparentled care (Deng et al., 2024; Sun et al., 2024). Although some studies have revealed the activity patterns of children in urban villages (Wang & Han, 2012; Xiao & Han, 2019) and the complex influences of factors such as cram schools and urban villages (Meng et al., 2018; Zhang et al., 2023), domestic research still largely directly imports Western theoretical frameworks without critical questioning of their contextual applicability.

5.2 Future Directions

Future research should strive to construct a shared interdisciplinary conceptual system. Key priorities include: deepening the “hierarchy of affordances” to elucidate the psychological mechanism through which “perceived affordances” are transformed into “used affordances” (Kytta, 2002, 2004); developing a “developmental model of children's place attachment” to clarify how spatial characteristics and social interactions shape emotional bonds (Scannell & Gifford, 2010; Scheller et al., 2024); and constructing an “evaluation framework for childfriendly space effectiveness” that integrates multidimensional benefits including physical, psychological, and social development into a unified measurement.

At the level of methodological innovation, measurement techniques should advance the integration of wearable sensors with ecological momentary assessment (EMA), and introduce physiological sensing technologies such as galvanic skin response to achieve synchronized recording of environmental exposure, physiological arousal, and emotional experience. Research designs should increase the proportion of longitudinal followup studies and quasiexperimental designs, and leverage urban intervention practices to conduct natural experiments. Data analysis should explore machine learning and complex network analysis to identify key environmental predictors among highdimensional covariates. Looking ahead, methodological development in this field will exhibit three major trends: first, the integration of wearable sensors with EMA will enable dynamic capture of children's environmental perception and realtime

emotions; second, the deep involvement of computer vision and big data will push behavioral monitoring from “sampling” toward “fullsample” analysis; third, the refinement of causal inference methods – such as regression discontinuity design and instrumental variable analysis – will strengthen the evidencebased support capacity of research for policy interventions and design renovations.

Regarding the deepening of research topics, the field must move beyond a singular focus on “moderatetovigorous physical activity” and expand to dimensions such as cognitive development, social development, emotional development, and environmental ethics. This includes: the effects of spatial form on attention restoration and executive function (Brussoni et al., 2017); the promotion of emotional regulation and riskcoping abilities through naturebased play environments (Fjørtoft & Sageie, 2000); and how spatial layout supports the acquisition of social skills such as cooperative play and conflict resolution. Han and Sun (2025) found that aquatic animals in residential water features can stimulate children’s daily caring behaviors, serving as an “incipient classroom” for cultivating ecological responsibility.

In terms of perspective shift, children should be repositioned from “research subjects” to “research partners.” Participatory action research paradigms should be promoted, allowing children to be deeply involved in the entire process of research question formulation, tool design, and result interpretation. Specific pathways include: developing childfriendly research tools (e.g., emoji scales); establishing child research advisory committees; and exploring childled community environmental audits, in which children act as “junior researchers” to evaluate their living environments.

At the level of indigenous research, Chinese studies urgently need to move beyond the role of “Western theory importers” and toward local theoretical innovation. Pressing issues include: environment–health threshold studies in highdensity contexts (Liang et al., 2025); intergenerational shared space design to address the spatial competitioncooperation between “the young and the old” (Sun et al., 2024); research on the effectiveness

of microinterventions in the context of urban renewal; and evidencebased evaluation of childfriendly city policies, achieving coevolution of policy practice and knowledge production through baseline surveys, process tracking, and outcome evaluation. During the current policy window in which China is vigorously promoting the construction of childfriendly cities, there is an urgent need to establish a research paradigm that is locally grounded, methodologically diverse, and rigorously evidencebased, thereby providing methodological support for evidencebased design in highdensity urban contexts.

6. Conclusion

This review systematically synthesizes the theoretical foundations, core themes, and methodological evolution in the field of landscape design and children’s health, aiming to construct an interdisciplinary understanding framework and provide an academic reference for evidencebased design. Through integrated analysis, the following core conclusions are drawn.

The built environment exerts multidimensional healthpromoting effects on children. From community neighborhoods to playgrounds, landscape spaces profoundly influence children’s physical activity levels, cognitive development, social skills, and emotional health by providing opportunities for physical activity, stimulating diverse play behaviors, and shaping social interaction scenarios. Highquality public open spaces, well designed playgrounds, and informal spaces spontaneously used by children have all been shown to effectively encourage moderatetovigorous physical activity and autonomous exploration (Timperio et al., 2008; Floyd et al., 2011; Brussoni et al., 2017). However, spatial effects depend on environmental quality – the incorporation of natural elements, the affordances of facilities, and the connectivity and safety of spaces, rather than sheer quantity (Fjørtoft & Sageie, 2000; Podolska, 2014; Zhang et al., 2023).

The mechanisms linking children’s health and landscape are complex and require moving beyond a binary “environment–behavior” perspective. Environmental affordance theory reveals the dynamic matching between environmental characteristics and

children's capabilities, emphasizing that design should create a rich "network of affordances" rather than isolated facilities (Gibson, 1979; Kytta, 2004). Place attachment theory indicates that children's sustained use of spaces is deeply rooted in emotional bonds and a sense of belonging (Scannell & Gifford, 2010; Koohsari et al., 2023). Children's environmental perception differs systematically from adults'; they focus more on microscale, tangible, and modifiable elements (Wang & Han, 2012; Scheller et al., 2024). Understanding the fullchain mechanism of "physical environment → psychological perception → behavioral response → health outcomes" is key to designing spaces that truly attract children.

Methodological evolution provides robust support for deepening research. From early questionnaires and empirical observations, the field has developed a diversified technical system integrating objective measurements (accelerometers, GPS, computer vision), systematic behavioral observations (SOPARC, behavioral mapping), subjective perception and participatory methods (perceptual mapping, photovoice, walking interviews), and spatial analysis (GIS, network analysis) (Rainham et al., 2012; Scheller et al., 2024; No et al., 2024). Mixedmethods research, by combining quantitative data with qualitative narratives, enables a fullchain analysis of "where children are active – how they are active – why they are active there," significantly enhancing the capacity for evidencebased design support.

Current research still has structural shortcomings. Interdisciplinary findings are fragmented, lacking an integrated theoretical framework. The research orientation emphasizes physiological indicators (e.g., MVPA) over psychological and social development. Methodologically, crosssectional designs dominate while longitudinal studies are scarce, and the accuracy of environmental exposure measurement is insufficient (Davison & Lawson, 2006; BooneHeinonen et al., 2010). "Child participation" often remains at the policy discourse level; in research, children are still mostly treated as passive data providers (Hart, 1992; Morrow, 2001). Domestic research still lacks indepth investigation of the specific contexts of highdensity cities, intense

academic pressure, and grandparentled care, and indigenous theoretical innovation is urgently needed (Wang & Han, 2012; Deng et al., 2024; Sun et al., 2024).

Looking ahead, the field needs breakthroughs in the following directions: constructing a shared interdisciplinary conceptual system and effectiveness evaluation framework that incorporates multidimensional developmental benefits into a unified measurement; advancing methodological innovation by integrating wearable sensors, ecological momentary assessment, and longitudinal designs; deepening research topics to expand to higherorder benefits such as cognitive development, emotional development, and environmental ethics cultivation; shifting perspectives by promoting participatory action research paradigms that reposition children from "research subjects" to "research partners"; and grounding research locally by conducting threshold studies in highdensity contexts, designing intergenerational shared spaces, and performing evidencebased evaluations of childfriendly city policies. Only in this way can the institutional gap be filled, transforming "childfriendliness" from a conceptual consensus into a highquality spatial reality.

References

- (1) Bao, Y., Gao, M., Luo, D., & Zhou, X. (2021). Effects of children's outdoor physical activity in the urban neighborhood activity space environment. *Frontiers in Public Health*, 9, 631492.
- (2) Barbour, A. C. (1999). The impact of playground design on the play behaviors of children with differing levels of physical competence. *Early Childhood Research Quarterly*, 14(1), 75–98.
- (3) Boarnet, M., Day, K., Anderson, C., McMillan, T., & Alfonzo, M. (2005). California's safe routes to school program: Impacts on walking, bicycling and pedestrian safety. *Journal of the American Planning Association*, 71(3), 301–317.
- (4) Boone-Heinonen, J., Popkin, B. M., Song, Y., & Gordon-Larsen, P. (2010). What neighborhood area captures built environment features related to adolescent physical activity? *Health & Place*, 16(6), 1280–1286.
- (5) Bozkurt, M. (2021). Metropolitan children's physical fitness: The relationship between overweight and obesity prevalence, socioeconomic status, urban green space access, and physical activity. *Urban Forestry & Urban Greening*, 64, 127272.
- (6) Broberg, A., Salminen, S., & Kytta, M. (2013). Physical environmental characteristics promoting independent and active transport to children's meaningful places. *Applied Geography*, 38(3), 43–52.
- (7) Brussoni, M., Ishikawa, T., Brunelle, S., & Herrington, S. (2017). Landscapes for play: Effects of an intervention to promote nature-based risky play in early childhood centres. *Journal of Environmental Psychology*, 54, 139–150.
- (8) Bruya, L. C. (1985). The effect of play structure format differences on the play behavior of preschool children. In J. Frost & S.

Sunderlin (Eds.), When children play (pp. 115–120). Association for Childhood Education International.

(9)Whitzman, C. (2008). Policies and practices that promote children's independent mobility. *Urban Planning International*, 23(5), 56–61.

(10)Carpiano, R. M. (2009). Come take a walk with me: The “Go-Along” interview as a novel method for studying the implications of place for health and well-being. *Health & Place*, 15(1), 263–272.

(11)Carver, A., Timperio, A., & Crawford, D. (2008b). Neighbourhood road environments and physical activity among youth: The CLAN Study. *Journal of Urban Health*, 85(4), 532–544.

(12)Emond, C. R., & Handy, S. L. (2012). Factors associated with bicycling to high school: Insights from Davis, CA. *Journal of Transport Geography*, 20(1), 71–79.

(13)Chen, S., Christensen, K. M., & Li, S. (2019). A comparison of park access with park need for children: A case study in Cache County, Utah. *Landscape and Urban Planning*, 187, 119–128.

(14)Cooper, A. R., Andersen, L. B., Wedderkopp, N., Page, A. S., & Froberg, K. (2005). Physical activity levels of children who walk, cycle, or are driven to school. *American Journal of Preventive Medicine*, 29(3), 179–184.

(15)Creswell, J. W. (2003). *Research design: Qualitative, quantitative, and mixed methods approaches* (2nd ed.). Sage Publications.

(16)Crawford, D., Timperio, A., Salmon, J., Giles-Corti, B., Adrianopoulos, N., Roberts, R., & Ball, K. (2007). Which features of public open space are associated with children's physical activity? *Journal of Science and Medicine in Sport*, 10(1), 27.

(17)Czalczyńska-Podolska, M. (2014). The impact of playground spatial features on children's play and activity forms: An evaluation of contemporary playgrounds' play and social value. *Journal of Environmental Psychology*, 38(6), 132–142.

(18)Davison, K. K., & Lawson, C. T. (2006). Do attributes of the physical environment influence children's physical activity? A review of the literature. *International Journal of Behavioral Nutrition and Physical Activity*, 3, 19.

(19)Deng, J., Liu, T., & Long, Z. (2024). Factors affecting outdoor physical activity (OPA) in children and adolescents: A systematic review and meta-analysis. *Heliyon*, 10(21), e38859.

(20)Duan, Y., & Yin, J. (2022). A study on the impact of park built environment on physical activity of children in urban villages: A case study of Shenzhen's urban village children. *Agriculture and Technology*, 42(1), 129–131.

(21)Dunton, G. F., Almanza, E., & Jerrett, M. (2014). Neighborhood park use by children: Use of accelerometry and global positioning systems. *American Journal of Preventive Medicine*, 46(2), 136–142.

(22)Ding, K., & Han, X. (2019). The impact of contemporary outdoor playground spatial features on children's play and development, Shenzhen. *Planners*, 35 (15), 87–92.

(23)Southward, E. F., & Page, A. S. (2012). Contribution of the school journey to daily physical activity in children aged 11–12 years. *American Journal of Preventive Medicine*, 43(2), 201–204.

(24)Evenson, K. R., Jones, S. L., Holliday, K. M., Cohen, D. A., & McKenzie, T. L. (2016). The System for Observing Play and Recreation in Communities (SOPARC): A review and synthesis of studies. *Journal of Physical Activity and Health*, 13(8), 869–877.

(25)Fatahi, N., Bahrami, B., & Aminpour, F. (2025). From the perspective of children and parents: What makes communal open spaces in multi-story residential neighborhoods child-friendly? *Cities*, 158, 105605.

(26)Fjortoft, I., & Sageie, J. (2000). The natural environment as a playground for children: Landscape description and analyses of a natural

playscape. *Landscape and Urban Planning*, 48(1–2), 83–97.

(27)Floyd, M. F., Bocarro, J. N., Smith, W. R., Baran, P. K., Moore, R. C., Cosco, N. G., Edwards, M. B., Suau, L. J., & Fang, K. (2011). Park-based physical activity among children and adolescents. *American Journal of Preventive Medicine*, 41(3), 258–265.

(28)Frank, L. D., Andresen, M. A., & Schmid, T. L. (2004). Obesity relationships with community design, physical activity, and time spent in cars. *American Journal of Preventive Medicine*, 27(2), 87–96.

(29)Freedson, P. S. (1991). Electronic motion sensors and heart rate as measures of physical activity in children. *Journal of School Health*, 61, 220–223.

(30)Frost, J. L., & Klein, B. L. (1979). *Children's play and playgrounds*. Allyn & Bacon.

(31)Frost, J. L., Wortham, S. C., & Reifel, S. (2001). *Play and child development*. Prentice-Hall.

(32)Ge, X., Zhang, E., Liu, Y., Li, H., Hu, F., Chen, J., Wang, Y., Cai, Y., & Xiang, M. (2024). Factors associated with out-of-school physical activity among Chinese children and adolescents: A stratified cross-sectional study. *Preventive Medicine*, 184, Article 107985.

(33)Gibson, J. J. (1979). *The ecological approach to visual perception*. Houghton Mifflin.

(34)Giles-Corti, B., & Wood, G. (2011). School site and the potential to walk to school: The impact of street connectivity and traffic exposure in school neighborhoods. *Health & Place*, 17(2), 545–550.

(35)Guo, D., Shi, Y., & Chen, R. (2023). Environmental affordances and children's needs: Insights from child-friendly community streets in China. *Frontiers of Architectural Research*, 12(3), 411–422.

(36) Han, X., Chen, Y., & Burton, O. R. (2013). Providing possibilities for children's physical activities in a neighborhood high-rise building community in Beijing. In *Fourth International Conference on Education and Sports Education (ESE 2013)* (Vol. 12, pp. 3–10).

(37)Han, X., & Cui, R. (2013). Decision-making mechanism of the construction of children's outdoor playground in Chinese urban community. *Community Design*, (5), 35–39.

(38)Han, X., & Sun, Z. (2025). An empirical study on waterscape design in child-friendly residential areas: Based on behavioral observation and preference analysis. *Science Discovery*, 13(5), 78–85.

(39)Hayward, D. G. (1974). Children's play and urban playground environments: A comparison of traditional, contemporary, and adventure playground types. *Environment & Behavior*, 6(2), 131–168.

(40)Van Hecke, L., Ghekiere, A., Veitch, J., Van Dyck, D., Van Cauwenberg, J., Clarys, P., & Deforche, B. (2018). Public open space characteristics influencing adolescents' use and physical activity: A systematic literature review of qualitative and quantitative studies. *Health & Place*, 51, 158–173.

(41)He, X., Zhuang, J., Zhu, Z., Wang, C., & Chen, P. (2017). Built environment factors influencing moderate-to-vigorous physical activity among children and adolescents: A study based on objective GIS measurements. *Sport & Science*, 38(1), 101–110, 51.

(42)He, X., & Duan, C. (2015). Analyzing appropriate buffer distances for GIS-based quantitative measurement of the built environment. *Chinese Journal of Sports Medicine*, 34(11), 1115–1120.

(43) Ittelson, W. H., Proshansky, H. M., Rivlin, L. G., & Winkel, G. H. (1970). The environmental psychology of the psychiatric ward. In H. M. Proshansky, W. H. Ittelson, & L. G. Rivlin (Eds.), *Environmental psychology: Man and his physical setting* (pp. 419–439). Holt, Rinehart and Winston.

(44)Huang, J. H., Hipp, J. A., Marquet, O., Alberico, C., Fry, D., Mazak, E., Lovasi, G. S., Robinson, W. R., & Floyd, M. F. (2020). Neighborhood characteristics associated with park use and park-based

physical activity among children in low-income diverse neighborhoods in New York City. *Preventive Medicine*, 131, Article 105948.

- (45) Hume, C., Salmon, J., & Ball, K. (2005). Children's perceptions of their home and neighborhood environments, and their association with objectively measured physical activity: A qualitative and quantitative study. *Health Education Research*, 20(1), 1–13.
- (46) Jiang, M., Wang, Z., & Ma, M. (2023). Research progress in the impact of community built environment on physical activity of children and adolescents. *Journal of Chinese Urban Forestry*, 21(1), 149–155.
- (47) Jones, A. P., Coombes, E. G., Griffin, S. J., & van Sluijs, E. M. F. (2009). Environmental supportiveness for physical activity in English schoolchildren: A study using Global Positioning Systems. *International Journal of Behavioral Nutrition and Physical Activity*, 6(1), Article 42.
- (48) Koohsari, M. J., Yasunaga, A., Oka, K., Nakaya, T., Nagai, Y., & McCormack, G. R. (2023). Place attachment and walking behavior: Mediation by perceived neighborhood walkability. *Landscape and Urban Planning*, 235, Article 104767.
- (49) Kuckartz, U., & Rädiker, S. (2019). Analyzing qualitative data with MAXQDA: Text, audio, and video. Springer.
- (50) Kytä, M. (2002). Affordances of children's environments in the context of cities, small towns, suburbs and rural villages in Finland and Belarus. *Journal of Environmental Psychology*, 22(1–2), 109–123.
- (51) Kytä, M. (2004). The extent of children's independent mobility and the number of actualized affordances as criteria for child-friendly environments. *Journal of Environmental Psychology*, 24(2), 179–198.
- (52) Liang, J., Huang, S., Bao, W., Pu, Y., Liu, M., Yang, X., Wu, Z., Chen, J., Dong, G., & Chen, Y. (2025). Longitudinal relationship between built environment and physical fitness in Chinese children and adolescents: Findings from the COHERENCE study. *Building and Environment*, 267, Article 112216.
- (53) Li, L.H. (2009). Built environment and children's academic performance—A Hong Kong perspective. *Habitat International*, 33(1), 45–51.
- (54) Lin, C., Han, X., & Fan, J. (2018). Impact of land development intensity on children's outdoor physical activity: A case study of Shenzhen. *City Planning Review*, 42(11), 97–102.
- (55) Low, S. M., & Altman, I. (1992). Place attachment. In I. Altman & S. M. Low (Eds.), *Place attachment* (pp. 1–12). Plenum Press.
- (56) Luchs, A., & Fikus, M. (2013). A comparative study of active play on differently designed playgrounds. *Journal of Adventure Education and Outdoor Learning*, 13(3), 206–222.
- (57) Marquet, O., Hipp, J. A., Alberico, C., Huang, J. H., Mazak, E., Fry, D., Lovasi, G. S., & Floyd, M. F. (2019a). How does park use and physical activity differ between childhood and adolescence? A focus on gender and race-ethnicity. *Journal of Urban Health*, 96(5), 692–702.
- (58) Marquet, O., Hipp, J. A., Alberico, C., Huang, J. H., Fry, D., Mazak, E., Lovasi, G. S., & Floyd, M. F. (2019b). Park use preferences and physical activity among ethnic minority children in low-income neighborhoods in New York City. *Urban Forestry & Urban Greening*, 38, 346–353.
- (59) Maxwell, L. E., & Evans, G. W. (2008). Effects of play equipment and loose parts on preschool children's outdoor play behavior: An observational study and design intervention. *Children, Youth and Environments*, 18(2), 36–63.
- (60) McDonald, N. C. (2007). Travel and the social environment: Evidence from Alameda County, California. *Transportation Research Part D: Transport and Environment*, 12(1), 53–63.
- (61) McKenzie, T. L., Cohen, D. A., Sehgal, A., Williamson, S., & Golinelli, D. (2006). System for Observing Play and Recreation in Communities (SOPARC): Reliability and feasibility measures. *Journal of Physical Activity and Health*, 3(Suppl. 1), S208–S222.
- (62) Melia, S. (2012). Filtered and unfiltered permeability: The European and Anglo-Saxon approaches. *Project*, 4, 6–9.
- (63) Meng, S., Zacharias, J., & Han, X. (2018). Longer afterschool active commutes and the travel environment of middle schools in Shenzhen, China. *Preventive Medicine Reports*, 12, 170–175.
- (64) Moore, G. T. (1987). The physical environment and cognitive development in child care centers. In C. S. Weinstein & T. G. David (Eds.), *Spaces for children: The built environment and child development*. Plenum Press.
- (65) Moore, R. C., Goltsman, S. M., & Iacofano, D. S. (Eds.). (1997). *Play for all guidelines: Planning, design and management of outdoor play settings for all children* (2nd ed.). MIG Communications.
- (66) NCD Risk Factor Collaboration (NCD-RisC). (2023). Diminishing benefits of urban living for children and adolescents' growth and development. *Nature*, 615(7954), 874–883.
- (67) Nicholson, S. (1973). The theory of loose parts. *Man/Society/Technology*, 32(4), 172–175.
- (68) No, W., Choi, J., & Kim, Y. (2024). How do children move and behave on streets? Vision-based movement behavior analysis using children's trajectories in urban surveillance systems. *Applied Geography*, 162, Article 103170.
- (69) World Health Organization. (1986). *Ottawa Charter for Health Promotion* [Conference document]. First International Conference on Health Promotion, Ottawa, ON, Canada.
- (70) Pan, A. H. O. (1986). *Ottawa Charter for Health Promotion*. In *Proceedings of the First International Conference on Health Promotion* (p. 405). Health and Welfare Canada & Canadian Public Health Association.
- (71) Parten, M. B. (1932). Social participation among preschool children. *Journal of Abnormal and Social Psychology*, 27(3), 243–269.
- (72) Pawlowski, C. S., Schmidt, T., Nielsen, J. V., Troelsen, J., & Schipperijn, J. (2019). Will the children use it?—A RE-AIM evaluation of a local public open space intervention involving children from a deprived neighborhood. *Evaluation and Program Planning*, 77, Article 101706.
- (73) Perry, C. K., Ackert, E., Sallis, J. F., Glanz, K., & Saelens, B. E. (2016). Places where children are active: A longitudinal examination of children's physical activity. *Preventive Medicine*, 93, 88–95.
- (74) Pintos-Toledo, E., Fernandez-Gimenez, S., Hino, A. A. F., Olivares, P. R., & Brazo-Sayavera, J. (2024). Analysis of the use of public open spaces and physical activity levels in children and adolescents from Rivera (Uruguay). *Health & Place*, 88, Article 103278.
- (75) Rainham, D. G., Bates, C. J., Blanchard, C. M., Dummer, T. J., Kirk, S. F., & Shearer, C. L. (2012). Spatial classification of youth physical activity patterns. *American Journal of Preventive Medicine*, 42(5), e87–e96.
- (76) Reuben, A., Rutherford, G. W., James, J., & Razani, N. (2020). Association of neighborhood parks with child health in the United States. *Preventive Medicine*, 141, Article 106265.
- (77) Reyes, M., Páez, A., & Morency, C. (2014). Walking accessibility to urban parks by children: A case study of Montreal. *Landscape and Urban Planning*, 125, 38–47.
- (78) Rivera, E., Timperio, A., Loh, V. H., Deforche, B., & Veitch, J. (2021). Important park features for encouraging park visitation, physical activity and social interaction among adolescents: A conjoint analysis. *Health & Place*, 70, Article 102617.
- (79) Sallis, J. F. (1993). Epidemiology of physical activity and fitness in children and adolescents. *Critical Reviews in Food Science and Nutrition*, 33(4–5), 403–408.
- (80) Scannell, L., & Gifford, R. (2010). Defining place attachment:

A tripartite organizing framework. *Journal of Environmental Psychology*, 30(1), 1–10.

(81)Scheller, D. A., Sterr, K., Humpe, A., Mess, F., & Bachner, J. (2024). Physical activity through place attachment: Understanding perceptions of children and adolescents on urban places by using photovoice and walking interviews. *Health & Place*, 90, Article 103361.

(82)Shabak, M., Norouzi, N., Abdullah, A. M., & Khan, T. H. (2015). Children's sense of attachment to the residential common open space. *Procedia - Social and Behavioral Sciences*, 201, 39–48.

(83)Shokoohi, R., Hanif, N. R., & Dali, M. M. (2012). Children walking to and from school in Tehran: Associations with neighbourhood safety, parental concerns and children's perceptions. *Procedia - Social and Behavioral Sciences*, 38, 315–323.

(84)Smilansky, S. (1968). The effects of sociodramatic play on disadvantaged preschool children. John Wiley & Sons.

(85)Sun, G., Han, X., Sun, S., & Oreskovic, N. (2018). Living in school catchment neighborhoods: Perceived built environments and active commuting behaviors of children in China. *Journal of Transport & Health*, 8, 251–261.

(86)Sun, Y., Chen, J., Yuan, Y., & Liu, S. (2024). A study on environmental elements of residential open spaces for grandparent-child rearing based on a field survey in Tianjin, China. *Journal of Urban Management*. Advance online publication.

(87)Timperio, A., Giles-Corti, B., Crawford, D., Andrianopoulos, N., Ball, K., & Salmon, J. (2008). Features of public open spaces and physical activity among children: Findings from the CLAN study. *Preventive Medicine*, 47(5), 514–518.

(88)Timperio, A., Crawford, D., Telford, A., & Salmon, J. (2004). Perceptions about the local neighborhood and walking and cycling among children. *Preventive Medicine*, 38(1), 39–47.

(89)Troiano, R. P., Berrigan, D., Dodd, K. W., Mâsse, L. C., Tilert, T., & McDowell, M. (2008). Physical activity in the United States measured by accelerometer. *Medicine and Science in Sports and Exercise*, 40(1), 181–188.

(90) Van der Ploeg, H. P., Merom, D., Corpuz, G., & Bauman, A. E. (2008). Trends in Australian children traveling to school 1971–2003: Burning petrol or carbohydrates? *Preventive Medicine*, 46(1), 60–62.

(91)Veitch, J., Ball, K., Flower, E., Deforche, B., & Timperio, A. (2021). Children's ratings of park features that encourage park visitation, physical activity and social interaction. *Urban Forestry & Urban Greening*, 58, Article 126963.

(92)Wang, C., & Burris, M. A. (1997). Photovoice: Concept, methodology, and use for participatory needs assessment. *Health Education & Behavior*, 24(3), 369–387.

(93)Wang, L. (2005). Exploration on the adaptability design of children's activity place in residential district. *Chinese & Overseas Architecture*, (6), 40–42.

(94)Wang, X., He, G., & Zhang, S. (2020). Research hotspots and evolution of physical activity among children and adolescents and built environment. *Chinese Journal of Sports Medicine*, 39(1), 72–78.

(95)World Health Organization. (2020). WHO guidelines on physical activity and sedentary behaviour. Geneva: World Health Organization. <https://www.who.int/publications/i/item/9789240015128>

(96)Wang, X., Woolley, H., Tang, Y., Liu, H., & Luo, Y. (2018). Young children's and adults' perceptions of natural play spaces: A case study of Chengdu, southwestern China. *Cities*, 72(Part A), 173–180.

(97)Xiao, X., & Han, X. (2019). Spatial characteristics and environmental influencing factors of children's outdoor physical activity in urban villages: A case study of Pingshan Village in Shenzhen. *Modern Urban Research*, (1), 8–14.

(98)Zacharias, J., Bai, Z., Han, X., & Huang, Y. (2017). Local environment and social factors in primary school children's afterschool commute in China. *Preventive Medicine Reports*, 103(7), 206–210.

(99)Zhang, D. (1980). Spatial arrangement and daylighting of residential communities. *Urban Planning Research*, (4), 42–48.

(100)Zhang, J., Xiang, Q., Hu, G., Ma, X., & Lu, S. (2023). A study on children's space preference for outdoor activities based on association rules: A case study of three community parks in Hangzhou. *Chinese Landscape Architecture*, 39(5), 69–74.

(101)Zhang, X., Han, X., Sun, G., & Zhang, Y. (2023). Influencing factors of children's after-school outdoor activity site preference and moderate-to-vigorous physical activity. *Modern Urban Research*, (5), 14–21.