

# A Systematic Review on the Associations Between Playground Features and Children's Physical Activity Levels

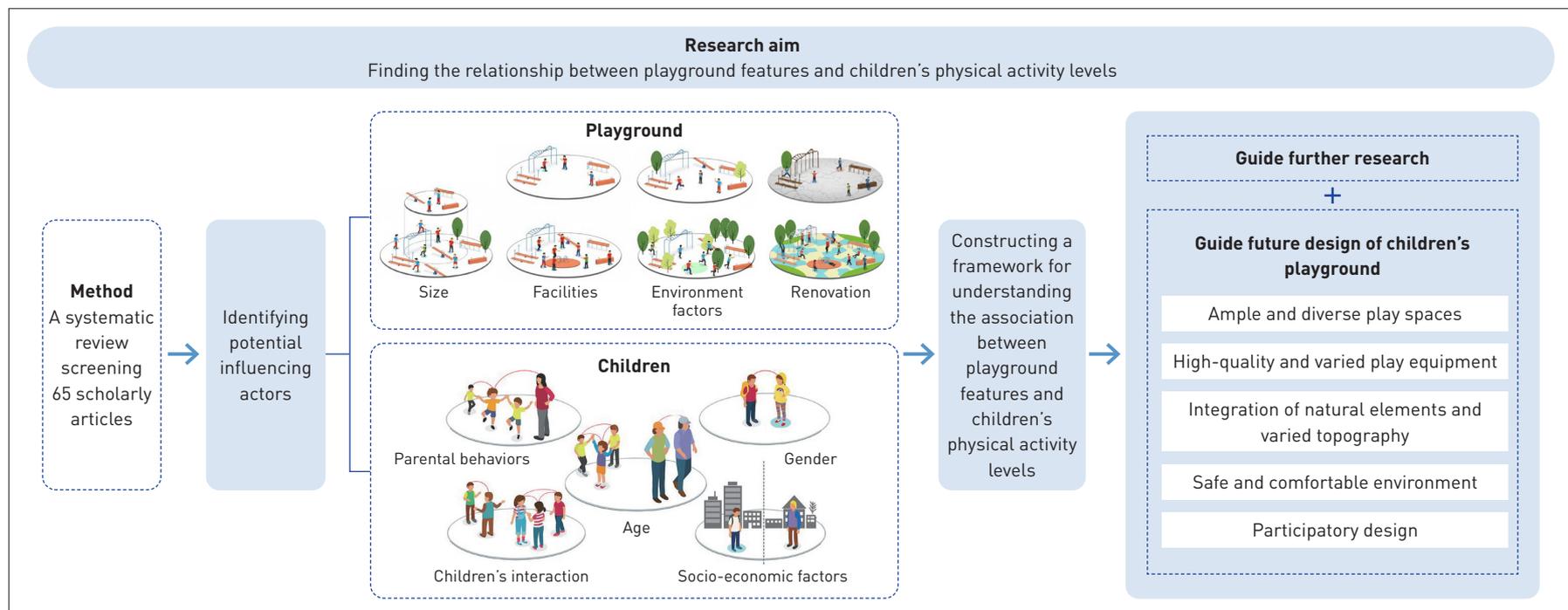
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## GRAPHICAL ABSTRACT



## ABSTRACT

Physical activity (PA) is essential for children's healthy development; however, many of them fail to achieve the suggested levels of activity due to an increase in sedentary behaviors. Playgrounds are pivotal for promoting PA among children. Nevertheless, the relationship between playground features and children's PA levels remains intricate and not fully elucidated. This review comprehensively analyzed 65 research articles exploring the multifaceted factors influencing children's engagement in PA within playgrounds. These factors include independent variables such as playground size, facilities, environment factors, and renovation, alongside moderating variables like age, gender, children's

interactions, parental behaviors, and socio-economic factors. Despite extensive research efforts in this domain, existing findings remain fragmented and at times contradictory. For instance, studies disagree on whether larger playgrounds and natural elements consistently enhance children's PA, and how facility preferences differ between boys and girls. This review proposes a comprehensive framework delineating the key variables influencing children's PA levels in playgrounds with different features. The aim is to advance understanding of how playground characteristics affect PA levels and to provide evidence to inform future playground design and planning for public health.

## KEYWORDS

Children; Physical Activity; Physical Activity Level; Playground; Playground Features

## HIGHLIGHTS

- Synthesizes research on how playground features influence children's physical activities levels
- Identifies and classifies eight influencing factors as independent or moderating variables of children's physical activity level
- Proposes a framework explaining the associations between playground features and children's physical activity levels
- Provides guidance for the design and construction of children's playgrounds

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## 1 Introduction

Physical activity (PA) plays an important role in promoting children's physical and mental health<sup>[1]</sup>. Many studies have shown that an adolescent who engages in PA during childhood is more likely to maintain a higher level of PA<sup>[2]</sup>. Therefore, guiding children to engage in regular and sufficient PA will help them maintain a sustainable healthy lifestyle. However, the PA time and levels of children are insufficient and declining in many countries/regions<sup>[3]</sup>, including America<sup>[4]</sup>, Australia<sup>[5]</sup>, Germany<sup>[6]</sup>, the United Kingdom<sup>[7-8]</sup>, Denmark<sup>[9-10]</sup>, Canada<sup>[11-12]</sup>, and China<sup>[13-14]</sup>. This decline

is attributable to several factors, including reduced incidental PA from convenient transportation, increased use of smart tools for chores, and greater sedentary time due to after-school use of electronic devices<sup>[3,5]</sup>. Studies indicate that many children do not meet the health-related PA guidelines proposed by the World Health Organization (WHO)<sup>[1]</sup>, the American government<sup>[15]</sup>, and the Australian government<sup>[16]</sup>, which recommend that school-aged children and adolescents (typically 5–17 years old) should accumulate at least 60 min of moderate-to-vigorous physical activity (MVPA) daily<sup>[1,15-16]</sup>.

Given the continuing decline in PA among children, the construction of playgrounds is regarded as a crucial strategy to promote children's engagement in PA. Offering a wide variety of play facilities, playgrounds support children's physical, cognitive, and social development<sup>[17]</sup>. Distinct characteristics of playgrounds exert differential influences on the PA levels. For instance, some playgrounds include hard-surfaced areas intended for competitive activities such as jump rope and basketball, whereas others incorporate natural elements like grassy fields or sand pits to promote unstructured play and sensory exploration. Such differences result in diverse impacts on the quality and effectiveness of PA. This can be also explained by the Affordance Theory and Behavior-Setting Theory. Proposed by James Jerome Gibson, the Affordance Theory posits that the environment offers "affordances," the possibilities for action, to an individual<sup>[18]</sup>. It explains how specific environmental features can elicit particular behaviors. For instance, a flat surface "affords" walking, while a slope "affords" climbing or sliding. Various environmental features of playgrounds present a diverse range of perceived opportunities for PA<sup>[19]</sup>. Behavior-Setting Theory provides a lens for understanding "place-specific" behaviors<sup>[20]</sup>. It holds that in specific settings like a playground, the physical environment and the socially accepted standing patterns of behavior are inextricably linked and mutually shaping<sup>[20]</sup>. A playground can thus be conceptualized as a "behavior setting," which comes with its own "program" that guides or even "coerces" children entering it to conform to the setting's expected behaviors. This helps explain why distinct types of PA consistently occur in specific playground zones.

Both above theories underscore the critical role of the environment in shaping children's PA and highlight the need for further exploration of the relationship between playground features and children's PA levels. While numerous studies have examined the associations between the two, most have focused on only one or two factors. Consequently, it remains unclear how different types of playgrounds influence children's PA or which features exert the

greatest effect. Existing studies have examined the impact of various playground-related factors on children's PA levels—such as the size and facilities<sup>[9,17,21]</sup>, the environment factors of playground<sup>[11,22]</sup>, and the playground renovation<sup>[10]</sup>—which revealed mixed and sometimes contradictory findings. For example, some studies suggested that a larger space can promote children's PA<sup>[7,23–24]</sup>, while some studies caution against generalizing the positive effects of size of playground. Findings indicate that the influence of size may produce contrary results, depending on factors such as facility density<sup>[25]</sup> and gender<sup>[9,26]</sup>. However, a comprehensive conceptual framework that encompasses the major playground factors affecting children's PA is still lacking.

To address this gap, this paper presents a systematic review of research on the associations between children's PA levels and playgrounds features. The independent, moderating, and dependent variables are summarized to construct a theoretical framework and the influential roles of these factors are discussed. This study aims to provide a comprehensive understanding of the subjects, methods, and findings among existing research, and to propose future research insights and practical implications.

## 2 Methods

The systematic review was conducted in accordance with the PRISMA (*Preferred Reporting Items for Systematic Reviews and Meta-Analyses*) guidelines, encompassing four key stages: identification, screening, eligibility, and inclusion<sup>[27]</sup>. The initial identification stage involved a systematic search of multiple academic databases using a predefined search string to locate relevant articles. This was followed by the screening stage, where duplicate records were removed and the remaining articles were assessed based on their titles and abstracts to exclude those that were clearly irrelevant. Subsequently, the eligibility of the remaining articles was determined through a full-text review, where each paper was meticulously checked against the specific inclusion and exclusion criteria. The final inclusion stage comprised the set of studies that met all eligibility criteria and were carried forward for data extraction and qualitative synthesis<sup>[27]</sup>.

A preliminary search was performed in April 2024, with the application of Boolean logic (“children” or “teen” or “youth”) OR (“school” or “schoolyard” or “primary school” or “elementary school”) AND (“playground” or “outdoor” or “physical environment”) AND (“activity” or “physical activity”). The literature search was conducted in the Web of Science, Scopus, and ScienceDirect databases, with a focus on papers published from

January 2010 to July 2024. The search yielded 6,800 results in Environmental Science, 167 in Environmental Studies, and 2,505 in Urban Studies. Then 2,304 duplicate articles were removed. To ensure methodological quality, the entire literature selection criteria guided by the key principles of *The Strengthening the Reporting of Observational Studies in Epidemiology* (STROBE)<sup>[28]</sup> checklist were applied, and only peer-reviewed journal articles with full-text access were included. The STROBE statement provides essential guidelines for the transparent and rigorous reporting of observational studies. As research in this field predominantly utilizes observational designs, these principles offer a suitable benchmark for assessing the methodological quality of articles included in this review.

Following an initial screening, all potentially eligible articles were required to meet the following criteria for inclusion in this review.

1) Study objective and design: The study must have a clearly stated objective to investigate the associations between the environment features of playgrounds and children's PA, as recommended by STROBE. The key characteristics of the study participants, such as age range and gender distribution, must be explicitly defined.

2) Rigor of variable measurement: The study must employ clear, objective, and replicable methods for measuring key variables. Playground environmental features must be quantitatively assessed, including site area as well as the type and number of facilities. PA levels must be measured objectively using validated tools, with outcome metrics clearly defined.

3) Consideration of confounding factors: The study must have considered and measured non-physical environmental factors that could influence PA. These factors may include social interactions, parental supervision, or children's subjective perspectives. The manuscript should also describe how these variables were addressed in the analysis.

4) Reporting transparency and bias control: The study's methodology must be described with sufficient clarity to ensure transparency and replicability. Furthermore, the study must describe its efforts to address potential sources of bias, such as selection bias or information bias.

Finally, a snowball search method was employed to identify additional relevant articles and 7 additional articles were identified for the inclusion. Ultimately, 65 papers were included in this review<sup>[2–14,17,19,21–26,29–72]</sup> (Fig. 1). The 60 studies categorized by region are shown in Fig. 2, while an additional 5 studies not included in the figure were either non-regional ( $N = 4$ ) or global ( $N = 1$ ).

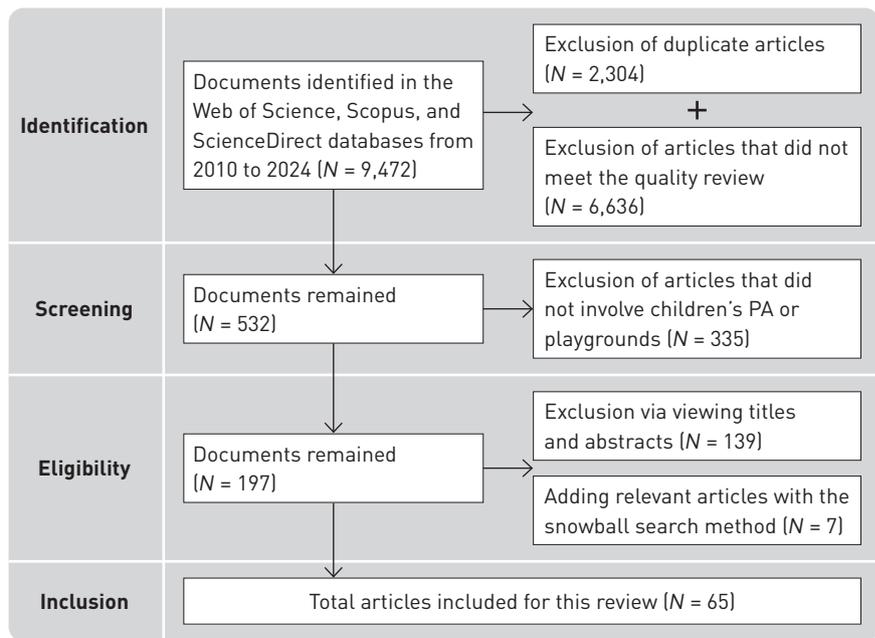


Fig. 1 Process of literature retrieval.

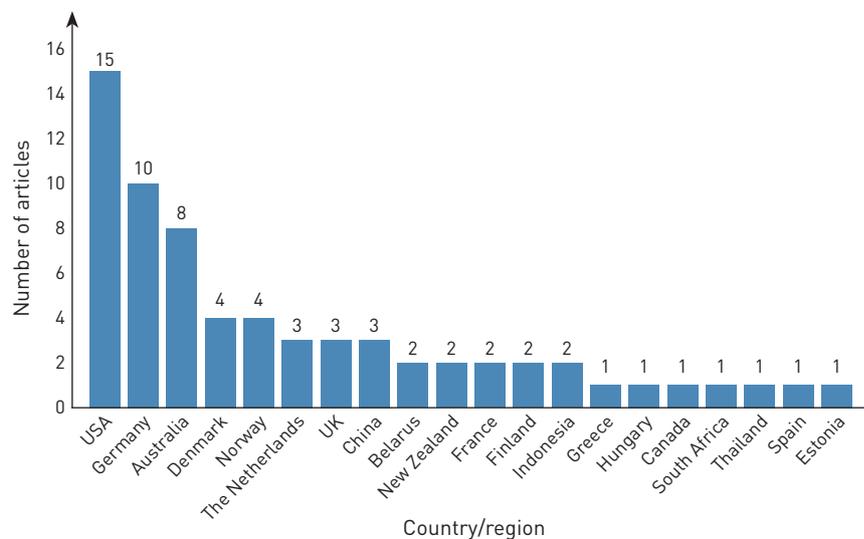


Fig. 2 Distribution of the reviewed articles by the studied country/region. Of the 65 studies, 60 focused on specific countries or regions, 1 adopted a global perspective, and 4 studies were conducted across multiple countries.

### 3 Associations Between Children Playground and Children's Behaviors

#### 3.1 The Standards of PA Levels

##### 3.1.1 PA Guidelines for Children

Accurately assessing children's PA levels requires its precise quantification. International standards for PA levels are generally based on energy expended per minute or heart rate. There are

three common PA levels, as recommended by the WHO and the U.S. Centers for Disease Control and Prevention (CDC)<sup>[1,15]</sup>.

1) Light physical activity (LPA): LPA does not significantly increase the heart rate or breathing rate. Examples include slow walking, stretching exercises, and light household chores<sup>[1]</sup>.

2) Moderate physical activity (MPA): MPA increases the heart rate and breathing rate, but one can still carry on a conversation. Examples include brisk walking, slow cycling, swimming, and Tai Chi<sup>[1]</sup>.

3) Vigorous physical activity (VPA): VPA significantly increases the heart rate and breathing rate, making it difficult to carry on a conversation. Examples include running, fast cycling, lap swimming, and aerobic dancing<sup>[1]</sup>.

Based on the categorization of PA levels, existing research used different guidelines to measure whether children who use the playground met a healthy standard of daily PA. The main consideration was whether the child spent enough time physically active to meet a specific PA level. Among the 65 articles reviewed, 28 introduced clear standards for PA<sup>[2-7,10,17,21-22,24-26,29-43]</sup>.

The most common standard was the WHO guidelines for children and adolescents, which was adopted in 16 papers. The guideline recommends that children and adolescents aged 5-17 years engage in a minimum of 60-minute daily MVPA<sup>[1]</sup>. Another common standard was the CDC guidelines, which was used in 8 papers. It also recommends that children and adolescents aged 6-17 years should engage in at least 60 min of MVPA each day<sup>[15]</sup>. Compared with the WHO guidelines, the CDC guidelines concentrates more on children's aerobic activity. Specifically, the daily PA should consist of 60 min of aerobic MVPA at least three days of per week<sup>[15]</sup>. The third standard, adopted in 3 papers, was the 24-Hour Movement Guidelines released by the Australian government, which recommends that children and young people aged 5-17 years should engage in 60 min of MVPA daily<sup>[16]</sup>. Additionally, it recommends limiting sedentary time and screen time, with a maximum limit of 2 h for daily recreational screen use<sup>[16]</sup>. The final standard<sup>[6]</sup>, adopted by 3 papers, was developed by the German government and indicates the equal time for adolescents to engage in MVPA. Overall, most guidelines call for 60 min of MVPA per day.

In addition, children's PA needs to include different intensity levels to ensure their physical and mental development. The WHO guidelines categorizes children's PA based on various contexts and recommends that children should engage in adequate PA to promote their physical and mental development through leisure, sports, transportation, and household activities<sup>[1]</sup>. The CDC guidelines includes three key components (i.e., cardiovascular fitness,

muscular development, and skeletal health) and recommends that children participate in specific aerobic, resistance, and bone-strengthening exercises<sup>[15]</sup>. The recommendations from the German government align closely with these principles. Finally, the Australian government's guidelines further implements restrictions on sedentary behavior and screen time<sup>[16]</sup>.

### 3.1.2 Tools for Quantifying PA

Children's PA levels are difficult to measure, since the number of children in the recreational environment and their PA levels change frequently<sup>[73]</sup>. Therefore, tools to quantify PA are essential for studying children's PA. Out of the 65 papers included in this study, 34 utilized relatively systematic scientific measurement techniques, while the others primarily relied on more subjective methods, including questionnaires<sup>[29-30,65]</sup>, interviews<sup>[65]</sup> or focus groups<sup>[9]</sup> to assess children's PA levels.

The most common quantitative methods used to measure PA levels were accelerometers and GPS devices, which provide objective recordings of a child's movement trajectory and acceleration levels within specific parameters<sup>[31-32]</sup>. Among the reviewed articles, 15 used such methods. For example, Dirk Dessing et al.<sup>[31]</sup> used a uniaxial accelerometer to measure children's PA levels and had the children carry a GPS receiver to record their geographical location changes. While the use of accelerometers and GPS allows for detailed analysis of children's PA, several limitations should be noted. First, they usually require cooperation from both the child and their parents to adhere to the usage instructions over an extended period to ensure accurate data collection; second, they may not adequately capture activities like climbing or descending slides at varying heights.

There were 15 papers utilizing the System for Observing Play and Leisure Activity in Youth (SOPLAY), established by Thomas Louis McKenzie, to obtain children's PA levels data during play and leisure time within a specified activity area through observation<sup>[73]</sup>. The method systematically and periodically scans and records the behaviors, personal characteristics of children, and environmental factors in the target area through instant observations conducted by trained observers. The PA of each child is coded as Sedentary (e.g., lying down, sitting, standing), Walking or Very Active in the scan<sup>[73]</sup>.

Other 5 papers adopted the System for Observing Children's Activity and Relationships during Play (SOCARP) method. It uses a 10-second observation period to record each target child who was randomly selected to represent the study population for 30 intervals in 10 consecutive minutes, and then moves on to the next child. Additionally, the availability of devices and the number of

adult supervision during rest time are recorded, and these data will be collected at the end of each observation period for target children<sup>[74]</sup>.

SOPLAY and SOCARP both classify children's PA levels through observation, and ultimately produce relatively objective statistical data. SOPLAY focuses on observing and recording the PA of individual child, determining PA levels by categorizing different PA types. SOCARP further records social group size, activity type, and social interaction, and the collected data allow for a more comprehensive assessment of factors influencing children's PA levels.

## 3.2 Independent Variables

### 3.2.1 Size of Playground

While playground size is a commonly cited variable influencing children's PA, research indicates that its impact is not straightforward. Among the 65 articles, 10 investigated the influence of size of playground.

Among them, 3 articles suggest that a larger space positively influences PA levels by reducing perceived crowding and activity conflict or facilitating long-distance movement<sup>[7,9,26]</sup>. For example, Nicola D. Ridgers et al. found that a larger play space per child was positively associated with VPA and negatively with sedentary time<sup>[7]</sup>. This is reinforced by qualitative findings from Charlotte S. Pawlowski et al., where both boys and girls identified "lack of space" and feeling "crowded" as significant barriers to recess PA, often leading to conflicts between different play activities<sup>[9]</sup>. These findings suggest that sufficient space is crucial for enabling simultaneous, unhindered play.

Some studies also found that the effect of size is contingent on the density and arrangement of play facilities, which in turn affects children's PA. The arrangement of equipment determines how a large space is utilized. For instance, Marsha Dowda et al. found that children in preschools with more fixed playground equipment (e.g., slide, jungle gym) were less active than those with less fixed equipment. One reason for increased sedentary behavior with fixed playground equipment may be that children often congregate on and around fixed playground equipment<sup>[26]</sup>.

Conversely, some studies suggested that a large space concentrated with high-quality, engaging equipment encourages vigorous play. For example, Thomas A. Farley et al. observed that children in grades 2-8 were more active in high-density areas<sup>[25]</sup>. The disparity in these results may stem from variations of the facilities at different research sites. High-quality equipment can encourage active play, while the availability of non-fixed items, such

as balls and scooters, also promotes PA.

The influence of a playground's size is also dependent on the children using it. Perceived adequacy of size is moderated by user demographics, particularly gender. There were 2 articles that examined gender differences in spatial size preferences, which revealed notable distinctions<sup>[9,26]</sup>. Boys may dominate larger, open areas for sports and expansive games, whereas girls often prefer smaller and more secluded areas that better support social interactions<sup>[26]</sup>. These divergent preferences may explain why some studies found no significant overall association between playground size and PA levels<sup>[17,50]</sup>, as different subgroups utilize the space in varied, sometimes contradictory, ways. Furthermore, 3 additional studies suggested that the size of playground has no relation to children's PA levels.

In summary, the influence of playground size is complex. Size alone is insufficient to predict children's PA levels; instead, its effect is critically moderated by contextual factors such as facility density and user age and gender.

### 3.2.2 Playground Facilities

Playground facilities are a critical element influencing the number, age, and gender of the children users and playing a role in guiding different behaviors and interactions. At present, the research on the impact of facilities mainly focuses on their quantity and type. Altogether, 18 articles investigated the influence of equipment, indicating a consensus among researchers regarding its importance<sup>[7,9-10,17,21,23,25,29-30,32,34,38-39,44,50,55-57]</sup>.

There are 8 studies supporting the notion that the number<sup>[9,17,25,29-31,34]</sup> and size<sup>[57]</sup> of play facilities on playground is positively associated with children's PA levels. They indicated that while the number of play facilities varies across playgrounds, the main barrier to children's PA is lack of facilities, including buildings, courts, and equipment<sup>[9,17]</sup>. Consequentially, increasing the number and variety of permanent play facilities benefits the promotion of children's PA levels<sup>[34]</sup>. In the study by Pawlowski et al., both boys and girls frequently reported a lack of play facilities as the most common barrier to recess PA<sup>[9]</sup>. Similarly, Farley et al. observed that children were more active in areas with fixed play equipment, such as installed play structures, compared with open spaces, a trend that was particularly noticeable for girls<sup>[25]</sup>. Glen Nielsen et al. found that for every additional facility added to the school playgrounds, the MVPA increased by 3.4%<sup>[34]</sup>. This study also found that increasing the number of play facilities on school playgrounds leads to higher children's PA levels both during school time and outside of school. Each additional 10 facilities was associated with a 3.8% increase

in overall activity counts, a 7.5% increase in daily MVPA, and a 3.2% increase in activity counts and 8.3% increase in MVPA during recess<sup>[29]</sup>. Research also indicates that the quantity of facilities influenced PA differently for boys and girls. Ellen Haug et al. found that boys at secondary schools have 2.69 times higher odds of engaging in PA when they have a larger number of outdoor facilities compared with other schools with fewer facilities, and girls have 2.90 times higher odds<sup>[30]</sup>.

However, another study found the opposite result. Jessie Adams et al. found that children in a traditional playground spent more time engaged in MVPA compared with those in an adventure playground<sup>[44]</sup>. This may be attributed to the fact that the traditional playground offers a narrower range of equipment, leading children to frequently engage in higher levels of PA such as running games for entertainment.

The influence of facility type on children's PA is also varied and influenced by both the characteristics of the children and the site. Several studies have examined children's preferences by focusing on observational elements and site-specific factors<sup>[9,17,21,23,30,34,49,58]</sup>. The findings consistently indicate that children have distinct preferences for certain types of facilities, and their preferences may differ by gender, a topic that has been explored by 13 articles. Marcella A. Raney et al. found that when the gaming area design incorporates facilities that promote the development of motor skills, such as balance, agility, and coordination, there is an increased number of physically active children who engage in MVPA<sup>[58]</sup>. Children are more active on traditional playgrounds than on modern and adventure playgrounds, underscoring the enduring importance and popularity of traditional equipment<sup>[44]</sup>. A comparative analysis of various facilities demonstrated that both boys and girls prefer for playgrounds that provide balanced equipment, trampolines, skipping ropes, sand, and hilly terrains, which can lead to higher levels of PA among children<sup>[55]</sup>. Conversely, playgrounds with gravel terrain and seesaws were linked to lower PA levels, irrespective of gender. Saskia A. M. Boonzajer Flaes et al. indicated that playgrounds with lendable equipment and organized events attract more children than those without such features<sup>[56]</sup>. A study targeting young children found that for those aged 2-3 years, riding toys and a small playing area lead to lower PA levels<sup>[57]</sup>. From a gender perspective, girls exhibit a preference for innovative playground facilities such as trampolines, obstacle race tracks, dance studios, and gymnastics equipment over traditional sports amenities, whereas boys show no clear preference for new facilities<sup>[49]</sup>.

Generally, children demonstrate individual preferences for

certain types of playgrounds, and they are more likely to engage in MVPA in their preferred areas<sup>[10,21,23,31-32]</sup>. This suggests that a playground located within or outside of certain types of playgrounds can have an impact on children's behaviors and levels of PA<sup>[23]</sup>.

### 3.2.3 Environment Factors of Playground

Environmental factors that encompass both natural elements and ambient thermal conditions play a significant role in shaping children's play behaviors and PA levels. This suggests that the quality and design of playground features are more important than the mere presence of the features. However, the included literature showed conflicting results regarding the impact of these factors.

A consistent finding across 8 of the reviewed studies was the positive association between natural elements and children's PA<sup>[8,11,30,39,51,58,64,70]</sup>. For instance, a repeated measures study by Dean A. Dudley et al. found that grassed areas were more than twice as conducive to VPA than hard surfaces like concrete or asphalt<sup>[22]</sup>. Janet E. Dymont et al. also showed that green spaces encouraged the highest percentage of children to engage in MPA. The benefits of such green spaces extend beyond mere PA, fostering social interaction and creative play<sup>[11]</sup>.

Evidence from 5 of the reviewed articles indicate that green space exposure is associated with improvements in social and emotional well-being, including reduced aggression and enhanced prosocial behavior. However, the impact of nature is not uniform. The discrepancies in the literature can be largely explained by the distinction between integrated, affordance-rich nature and tokenistic or poorly designed green elements. At least 6 studies highlighted this distinction. Affordance-rich nature, which provides diverse opportunities for play, consistently produces positive outcomes. For example, Ingegerd Fjørtoft et al. found that forest-like environments in Norwegian village schools were particularly effective for increasing PA levels in girls<sup>[24]</sup>. Natural environments that offer challenging features—such as climbable trees, logs for balancing, and varied topography—promote functional play and motor skills<sup>[64]</sup>. This aligns with findings from the study by Jenny Veitch et al., where children expressed a preference for parks with these features<sup>[45]</sup>. As Frances Harris noted in the context of a forest school, deep interactions with nature also fosters a sense of care and environmental stewardship<sup>[8]</sup>.

Conversely, 4 studies reported either negative or null relationship between natural elements and children's PA<sup>[7,17,46,58]</sup>. Anne K. Reimers found that playground "naturalness" was inversely associated with usage and the PA of children<sup>[17]</sup>. Tanja Poulain et al.

reported that associations between green spaces in the immediate home environment and children's outdoor PA varied by distance and season, with a significant positive association observed in winter within 50 m of home<sup>[51]</sup>. Veitch et al. found that children rated an image of a "natural play area with sticks, stones, and other natural items" as one of the least encouraging features for park visitation or activity<sup>[46]</sup>. As argued by Raney et al., the current study demonstrates that green space alone is not sufficient to attract or promote student engagement in MVPA<sup>[58]</sup>. These findings suggest that tokenistic greening may fail to stimulate significant PA engagement.

The thermal environment is another critical factor for outdoor play. There were 6 reviewed articles discussing the impact of thermal conditions on playground use. Research by Tongye Guo et al. showed that air temperature and mean radiant temperature are the main meteorological factors affecting children's thermal sensations in summer<sup>[13]</sup>. Extreme heat not only pose health risks but also significantly deters outdoor PA. Nadja Kabisch observed a marked decline in park users when temperatures rise above 30°C<sup>[52]</sup>. In this context, shade emerges as a crucial design element. Providing shade, especially from trees, is among the most effective strategies to mitigate heat stress and enhance outdoor thermal comfort in summer<sup>[13]</sup>. Studies have shown that children and their caregivers actively seek out and adapt their locations as temperatures rise based on the availability of shade, moving from open, sun-exposed venues to shaded areas, so the presence of shade is positively associated with higher playground utilization<sup>[21,45,58]</sup>. For instance, according to Guo et al., children expressed a clear preference for large trees that provide substantial canopy coverage<sup>[13]</sup>. Natalie Colabianchi et al. found that shade coverage for resting features was significantly associated with greater utilization by boys and adults<sup>[21]</sup>. Therefore, the strategic design of playgrounds should include a mix of sunlit and shaded areas to ensure comfort and usability across varying thermal conditions.

### 3.2.4 Playground Renovation

Playground renovation is a common strategy to increase PA, but its effectiveness is inconsistent<sup>[10,21,39,56]</sup>. This suggests the nature and quality of the renovation are more critical than the act of renovation itself. Successful renovations often increase the quantity and functionality of play opportunities, which was supported by 3 of the reviewed studies<sup>[10,21,39]</sup>. For example, Colabianchi et al.<sup>[21]</sup> found that at renovated schoolyards, a greater number of play features was significantly associated with higher utilization by girls and adults. The study by Lois A. Brink et al.<sup>[39]</sup> clearly indicated that after

the playground renovation, the number of children participating in MVP and VPA significantly increased.

However, a renovation's success is contingent on it aligning with children's needs and preferences. This point is illustrated by at least 2 reviewed studies. As Henriette Bondo Andersen et al. demonstrated, a renovation can fail if the new features do not support desired activities. In their study, a renovated area at one school saw a decrease in PA because the new hills were not suitable for scooters, an activity the students had requested<sup>[10]</sup>. The complexity of renovation outcomes is evident in the literature: it found that while two schools saw an increase in time and activity in the renovated area, a third school experienced a decrease<sup>[10]</sup>. A systematic review by Jean C. Bikomeye et al. also highlighted this variability, noting that MVPA decreased after a renovation that added natural materials<sup>[70]</sup>. The evidence indicates that renovation is not a guaranteed solution, highlighting the necessity of involving children in the design process. Effective renovations must be thoughtfully designed to provide a variety of functional and appealing features that cater to the diverse needs of the children using the space.

### 3.3 Moderator Variables

#### 3.3.1 Age

There is considerable variation in children's behaviors, needs, interests, and activities across different age groups, which leads to the disparities in research findings caused by variations in subject age. Age is recognized as a core intrapersonal factor within the socio-ecological model<sup>[75]</sup>. This model emphasizes that an individual's biological and psychological developmental stage directly shapes their interactions with the environment. Significant variations in physical abilities, cognitive levels, and social needs exist across different age groups, leading to distinct ways in which they perceive and use playground environments.

Findings from 12 out of 65 studies suggested that age influences the intensity and variety of children's PA. Jessica S. Gubbels et al. found that 3-year-olds were more active than 2-year-olds<sup>[57]</sup>. In contrast, older children tend to benefit more from structured early childhood education in terms of engaging in high-intensity PA<sup>[36]</sup>. From the perspective of Affordance Theory, the same playground environment provides entirely different affordances to children of different ages, dependent on the actor's body scale and capabilities. A half-meter-high platform might afford PA like climbing and jumping off for a 3-year-old, thereby promoting VPA. For a 10-year-old, however, the same platform may only afford sitting or placing belongings, suggesting a much lower PA levels.

#### 3.3.2 Gender

Gender is another crucial intrapersonal factor within the socio-ecological model that profoundly influences children's preferences and levels of PA in playgrounds<sup>[75]</sup>, as highlighted by 28 of the 65 reviewed articles. Gender differences arise not only from physiological variations—which can naturally lead to different capacities for activities like running or climbing—but are also heavily shaped by interpersonal factors, such as socio-cultural norms and expectations from peers and family<sup>[59,63,71]</sup>. As a result, boys and girls often exhibit distinct behaviors on the playground. Among them, 8 papers indicated the significant disparities in PA levels between children of different genders on the same playground<sup>[22,30–31,54,59–60,63,68]</sup>. For instance, Dudley et al. reported a gender gap in PA, with girls spending half as much time in VPA as boys in 2014, and only one-third as much time in 2015. Additionally, there exists a gender disparity in PA during the brief class breaks in school hours, where girls spend 52.5% of their time on sitting, while boys only spend 40.7%<sup>[22]</sup>. This trend is further supported by studies from Dessing et al. and Reimers et al., which indicated that in nearly all domains of PA, girls are generally less active than boys<sup>[31,54]</sup>. Haug et al. found that these differences in PA were linked to gender role patterns<sup>[30]</sup>. It appears that girls are more prone to undertake social activities during their break time rather than get involved in more intensive PA, whereas boys are more likely to prefer the latter<sup>[60,68]</sup>.

A total of 14 studies identified significant gender differences related to PA types<sup>[9,17–18,22,30,32,42,45,47,49,54,63–64,68]</sup>, though these differences did not translate into variations in MVPA levels. Girls seem to prefer smaller-sized spaces<sup>[9,49]</sup>, and boys tend to dominate the larger areas of the schoolyard<sup>[9]</sup>. This may be attributed to girls' heightened need for quiet<sup>[49]</sup> and secluded<sup>[9]</sup> spaces for social interactions. In terms of the types of facilities, Pawlowski et al. found boys exhibit a preference for sports-oriented amenities, such as obstacle race tracks, climbing frames, skate parks, and parkour facilities<sup>[9]</sup>. In contrast, girls were found to be more active in playgrounds without multi-purpose areas<sup>[17]</sup>, and they tend to gravitate towards compact social environments with limited occupancy, such as swings, climbing frames, and small cabins. Dudley et al. also found that girls exhibit a greater inclination towards participating in activities involving chasing or aerobic exercises/dance, whereas boys display less interest in such pursuits<sup>[22]</sup>. Based on findings regarding different gender needs, Haug et al. suggested that it is important for playgrounds to offer more equal opportunities and a greater variety of PA options, such as dancing and gymnastics, to help address the differences

between boys and girls<sup>[30]</sup>. Boys and girls may perceive different affordances from the same playground features and consequently act differently<sup>[18]</sup>. This perceptual divergence leads to observable spatial segregation within playgrounds.

Children's PA in the playground is also influenced by the presence of children of the opposite gender, with negative study result on girls<sup>[41,50,56,68]</sup>. This implies an inequality for girls in space utilization. Female students have been observed to adopt three strategies to cope with male dominance: utilizing separate playtimes, seeking out alternative playgrounds, and playing in groups<sup>[66]</sup>. In particular, research has discovered that the presence of boys has a notably negative influence on girls' participation in PA, but no such evidence exists for boys. These findings imply that girls' PA participation and levels might be restrained when boys are around<sup>[60]</sup>. Alternatively, girls may feel chased away by boys who often engage in more aggressive and competitive sports, making girls feel unwanted and incompetent<sup>[56]</sup>. While boys often engage in ball games<sup>[40]</sup>, girls may also participate in these activities; however, they might avoid games that involve physical collisions or where boys are overly dominant<sup>[68]</sup>. In the study of Pawlowski et al., when girls express an interest in playing soccer, they tend to seek alternative football facilities within the school playground due to a sense of exclusion caused by the predominant presence of boys on the football field<sup>[41]</sup>. Additionally, the gender difference of the PA level becomes evident during the transition to adolescence, especially in terms of overall PA and MPA<sup>[37-38,53]</sup>. Research suggests that girls' PA in the playground tends to decline before the age of 13, while boys' PA decreases after 13<sup>[54]</sup>.

### 3.3.3 Children's Interaction

Children's interactions, referring to the ways in which children engage and communicate with each other within a specific environment<sup>[77]</sup>, were discussed in 9 of 65 reviewed articles<sup>[42,44,46,50,54,61,63,68,74]</sup>. These interactions can take place in many forms, such as playing games together, collaborating on tasks, sharing toys or equipment, and communicating through both verbal and non-verbal means. Children's PA within a playground can be influenced by their peers, and this influence typically manifests as reciprocal promotion<sup>[50,54,61]</sup>. There were 5 articles mentioning that the existence of active children is a crucial variable that affects MVPA and contributes to raising children's PA levels in public playgrounds<sup>[50,68]</sup>. Sarah-Jeanne Salvy et al. found that children engaged in significantly more PA when with peers or friends than when alone, highlighting peers as a key motivator for active play<sup>[61]</sup>. In traditional playgrounds, children are inclined to play with their

peers instead of undertaking PA alone<sup>[44,76]</sup>. Regarding the influence and support of peers, boys are more prone to have physically active friends and encounter more peer support and influence<sup>[54]</sup>. Meanwhile, girls receive relatively less positive social influence in PA, as children tend to interact with same-gender peers and parents may limit girls' PA more than boys<sup>[76]</sup>. Additionally, findings from 5 articles<sup>[42,50,56,66,68]</sup> demonstrated the influence of gender interactions. For instance, many girls reported feeling chased away by boys, which reduced their time on the playground<sup>[66]</sup>. This suggests that boys, who often prefer vigorous and competitive activities, can negatively impact the PA of girls when sharing the same space.

### 3.3.4 Parental Behaviors

Results from 5 studies emphasized the importance of parental involvement in children's PA, particularly for younger children<sup>[12,48,54,71-72]</sup>. Karolina Boxberger et al. found that outdoor activities serve as a primary source of PA for children, and parental roles as supervisors and managers significantly influence children's PA levels<sup>[71]</sup>. It has been demonstrated that parents can motivate their children to play by creating an enjoyable atmosphere during the PA process<sup>[12]</sup>. Stephanie Schoeppe et al. suggested that the behavioral patterns of mothers may exert a greater influence on children than those of fathers and are more likely to guide children to engage in more PA<sup>[48]</sup>. However, Reimers et al. found that children's PA levels are impacted by their primary caregivers<sup>[54]</sup>.

### 3.3.5 Socio-economic Factors

Of the reviewed articles, 3 examined how different socio-economic factors influence children's PA<sup>[6,71-72]</sup>. The factors examined included parental income, social standing, racial identity, and perceived social cohesion. For example, Boxberger et al. found children of ethnic minority mothers spend less time playing outdoors compared with those of majority ethnicity mothers<sup>[71]</sup>, which might be attributed to the fact that ethnic minority women undertake less leisure-time PA than women of the majority ethnicity<sup>[78]</sup>. Furthermore, minority groups are more prone to reside in poverty-stricken areas, which might lead them to curtail their support for children's outdoor PA due to apprehensions regarding safety and economic reasons. Owing to the scarcity of safe places in impoverished communities, parents in these areas are typically more worried about their children's outdoor play compared with those in non-poverty areas<sup>[72]</sup>. Particularly, girls in poverty-stricken areas and ethnic minority groups are most vulnerable, exhibiting lower PA and health-related fitness, alongside reduced self-efficacy and limited access to healthy food options<sup>[62]</sup>.

## 4 Discussion

This systematic review synthesizes findings from 65 articles and builds a comprehensive framework to explain the complex relationship between playground features and children's PA. Since existing literature presents fragmented and sometimes contradictory results, an elaboration on the structure of the proposed framework, discussion on the interactions between its variables with evidence from the literature, and the framework's practical implications for design and policy are necessary.

### 4.1 The Integrated Framework

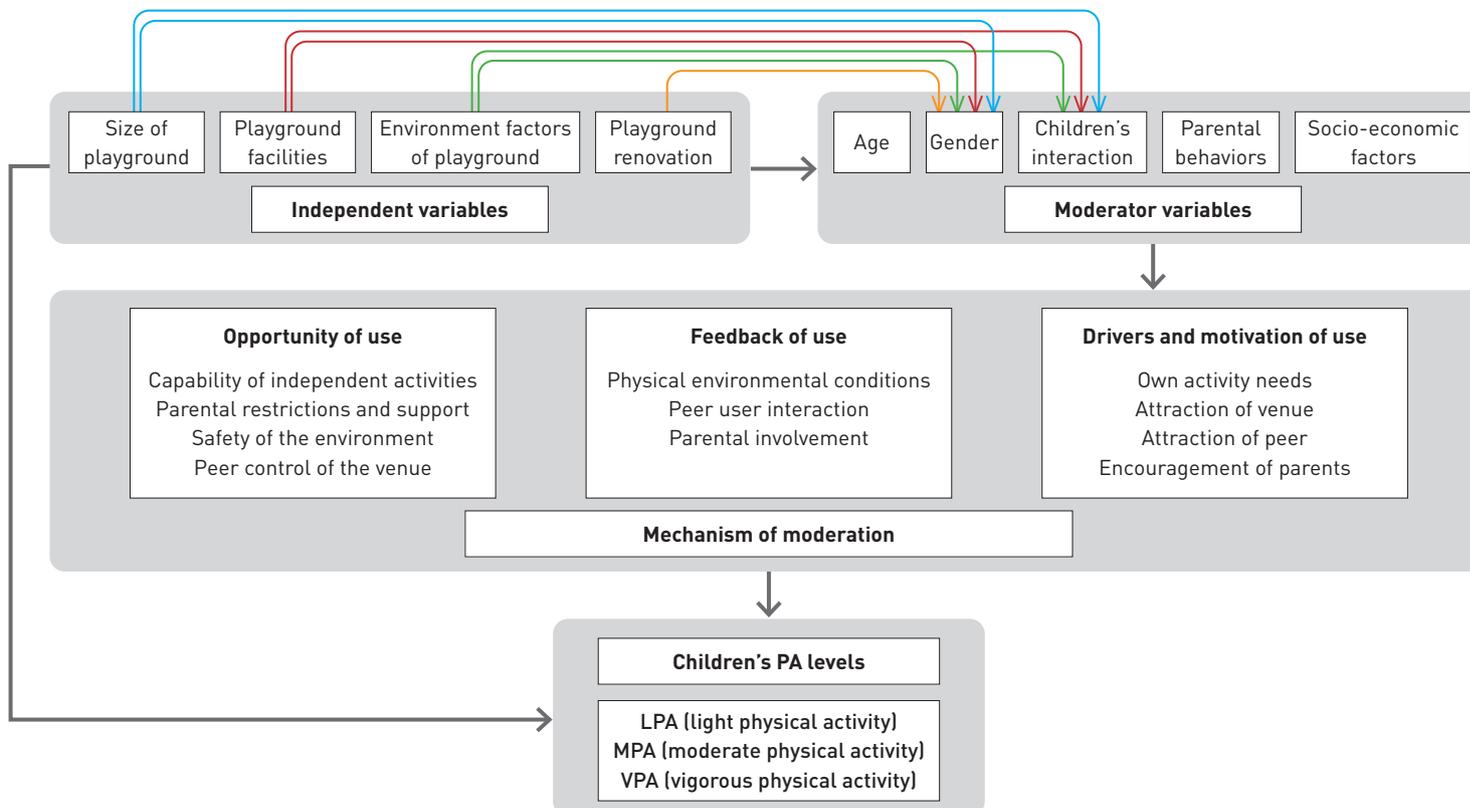
A primary contribution of this review is the development of a conceptual framework in Fig. 3 that moves beyond single-factor analyses and offers a systemic perspective. It posits that children's PA is a complex outcome of interacting variables, rather than a direct response to any single environmental feature.

The independent variables—playground size, facilities, environment, and renovation—represent the foundational physical attributes of the play space. This study confirms their direct influence; for example, multiple studies suggest that a greater quantity of facilities is positively associated with higher PA levels<sup>[7,9]</sup>. However, the included literature presents conflicting results that

these variables alone cannot explain, necessitating a deeper analysis of moderating influences.

The framework's additional explanatory power comes from integrating the moderator variables: age, gender, peer interaction, parental behavior, and living context. These factors are not peripheral; rather, they can alter the relationship between the physical environment and the child's PA. Gender is the most powerful moderator. Several reviews found that boys consistently engage in more MVPA than girls and their spatial preferences differ<sup>[22,31]</sup>. Boys tend to dominate large, open fields for competitive sports like soccer, making playground size a critical factor for their PA<sup>[9]</sup>. In contrast, girls may prefer specific types of facilities (e.g., swings, climbing frames) or innovative equipment like dance areas, and may favor smaller, more defined spaces that support social interaction<sup>[49]</sup>. Thus, a playground's effectiveness is directly moderated by how its physical design caters to these gender-specific preferences.

Age is another crucial moderator that shapes how children perceive and use a playground. The review shows that PA levels vary with age. For example, an environmental feature that provides a challenging climbing affordance for a young child may only afford sitting for a pre-teen, meaning the same facility has a different impact depending on the developmental stage of the user.



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**Fig. 3** A framework illustrating the associations between playground features and children's PA levels.

The social context—comprising peer interaction, parental behavior, and living context—forms the ecosystem of play. The presence of active peers can significantly amplify a child’s PA levels through modeling and encouragement<sup>[50,61]</sup>. Parental behavior, through direct supervision and creating a positive atmosphere, is particularly important for younger children’s outdoor PA<sup>[48,71]</sup>. The living context, including neighborhood safety and socio-economic status, acts as a primary gatekeeper. In high-poverty or unsafe neighborhoods, parental concerns—such as fear of crime—can severely limit children’s access to even well-equipped playgrounds. This dynamic is also documented by Rachel Tolbert Kimbro and Ariela Schachter<sup>[72]</sup>. For children from ethnic minorities, the deficit in outdoor interaction is often exacerbated by factors such as limited positive parental influence and residence in disadvantaged communities.

In Fig. 3, the lines connecting independent and moderator variables illustrate potential interactions among these factors. For instance, playground size may influence the gender of child users. Girls, who generally prefer low-intensity social activities such as conversation and small-group games, tend to favor smaller spaces<sup>[9,49,68]</sup>. Conversely, boys are more inclined towards high-intensity activities like chasing, thus finding larger areas more suitable<sup>[22,68]</sup>. In addition, the size of playgrounds can also directly influence children’s interaction. For example, research findings show that crowded spaces often lead to conflicts between different play activities, which creates a barrier to children’s PA<sup>[9]</sup>.

These interactions, in turn, serve as moderating mechanisms that eventually influence children’s PA levels. The influence of moderator variables on the relationship between playground features and children’s PA levels can be understood through three mechanisms: opportunity of use, feedback of use, and drivers and motivation of use. Opportunity of use refers to the extent to which playgrounds provide children with the chance to be active; playgrounds that feature a compact layout, a high quantity of diverse and functional facilities, and varied surfaces are known to promote MVPA<sup>[10,21,39]</sup>. Age also shapes these opportunities by affecting children’s ability for autonomous use, as PA levels within the preschool stage increase with age<sup>[36,57]</sup> and have more specific equipment requirements<sup>[68]</sup>. Specific parental behaviors, such as restricting outdoor play due to safety concerns (often prevalent in impoverished or minority communities) and negative peer influences, may reduce children’s PA levels<sup>[63,68,71–72]</sup>. Feedback of use refers to the experiential responses generated during play, with well-designed playgrounds provide positive feedback that encourages continued MVPA<sup>[18–19]</sup>. Children’s

interactions and parental behavior can either facilitate or hinder children’s engagement depending on the context<sup>[54,61,63,71–72]</sup>. Finally, drivers and motivation of use encompass children’s intrinsic and extrinsic impulses to engage in PA. This includes children’s own activity needs<sup>[18,64]</sup>, attractiveness of the site<sup>[20]</sup>, and social catalysts such as invitations from peers and encouragement from parents<sup>[12,39–41,54,60–61,66,68,71]</sup>. Together, these mechanisms offer a comprehensive framework for understanding how moderator variables influence children’s PA levels, addressing the notable research gap in the holistic consideration of all influencing factors and the potential interactions among them.

Additionally, there is a scarcity of rigorous quantitative research assessing the impact of each factor on PA levels. While existing research has investigated many influencing factors, the variability between regions and populations raises questions about the consistency of the experimental results when applied to different contexts. The effects of standardized influencing factors may vary, or even contradict, when comparing children in developed and developing regions. Therefore, by constructing this framework, we aim to offer a foundation for future research, encouraging comprehensive studies that consider children and their families across diverse countries, regions, income groups, and communities. Such research would enable comparative analyses and mutual references, ultimately enriching our understanding of how these variables interact to shape children’s PA across varied contexts.

Moreover, research related to playgrounds and PA levels is scattered across various research elements. There is a need for a comprehensive summary to establish a foundational understanding and guide future studies. While the framework proposed in this paper requires further validation and exploration through additional research, we believe that this framework is instrumental in summarizing existing research findings and bridging the gaps between different research focuses. Moreover, this framework allows for the identification of weak points within the existing research. Some aspects remain underexplored, such as the interaction between children of different age groups and the influence of parental presence on children’s behaviors. Recognizing these gaps enables us to pinpoint future research directions.

#### 4.2 Practical Implications and Recommendations

This study provides a structured methodology to understand existing contradictions in the literature. For example, the debate over whether natural elements enhance or impede PA is clarified: the impact is not from “nature” as a monolith, but is moderated by its design quality—the “feedback” it provides—and the age and

gender of the user who perceive its “opportunities” differently. In other words, a tokenistic patch of grass may offer few affordances, while a complex, interactive natural environment supports diverse play.

This proposed framework also provides actionable guidance for policymakers, urban planners, and landscape architects to optimize playground design. The findings demonstrate that creating an active playground requires integrated social and physical interventions, including parent engagement programs and strategies to address gendered space exclusion (Table 1). By understanding these complex interactions, stakeholders can make more targeted and effective investments to improve child health. Planners should focus on creating a variety of functional zones for both high-energy activities and quiet social interactions. This involves incorporating a balanced mix of traditional and innovative equipment. Beyond basic greening, meaningful natural elements should be integrated—such as dense plantings for hiding spaces and loose natural materials—to offer richer play affordances for children. Thermal comfort is also a significant factor affecting children’s use of playground. Most importantly, engaging children directly in the design process is essential to ensure that new or renovated playgrounds provide features that children will find appealing and use actively.

### 4.3 Limitations

This review has three main limitations that should be considered when interpreting its findings. First, the reviewed

literature exhibits a clear geographic and socio-economic bias. Statistically, the vast majority of the 65 included studies were conducted in urban areas of high-income European and North American countries. This research originates from contexts that often have higher standards for play facilities and a greater societal emphasis on child-centric planning compared to regions with little or no published research. Consequently, the challenges and influential factors identified in the existing literature may be fundamentally different from those faced in other parts of the world. Research from the African continent and from unique high-density contexts such as the slums of India is conspicuously absent. This lack of geographic and contextual diversity limits the universal applicability of the findings. Cultural norms around play and the constraints of the built environment can vary dramatically. Therefore, the framework proposed here requires specific place-based research and validation in these under-researched settings to establish its broader relevance.

Second, a significant methodological limitation exists in the objective measurement of PA. Several of the more technologically advanced studies utilized accelerometers and GPS. While these tools are excellent for capturing horizontal movement and location, they are largely unable to accurately measure vertical displacement. This is a critical omission, as climbing on play structures is a common and vigorous form of play. This measurement bias could skew conclusions about the relative values of different types of equipment. Future research should prioritize the use of multi-

**Table 1: Design strategies for children’s playground informed by the findings of this study**

Key finding	Practical recommendation
The influence of playground size is moderated by facility density and user demographics (e.g., gender)	Design large parks with distinct zones for various activities; avoid large, empty spaces; ensure zones and amenities appeal to both boys and girls (e.g., areas for dance and gymnastics)
The type and variety of facilities are as important as their quantity	Provide a diverse mix of fixed equipment (e.g., slides, swings), loose natural materials (e.g., woodchips, sand), and structures that support both traditional sports and creative, social play
The quality of natural elements determines their impact; tokenistic greening is ineffective	Incorporate natural features (e.g., diverse plantings, logs), topographic variations (e.g., hills, mounds), or innovative structures that challenge motor skills (e.g., climbing nets, obstacle courses) to offer rich play affordances
Thermal comfort, especially the availability of shade, significantly impacts playground use	Strategically plant large-canopy trees and install built shade structures to create thermally comfortable microclimates
Renovations can fail if they do not align with children’s actual needs and preferences	Use participatory design methods to involve children and parents in the planning and design process to ensure the new or renovated features are functional as desired

sensor methods or refined algorithms that can more accurately capture three-dimensional movement.

Third, this review is inherently constrained by the heterogeneity of the included studies. The research varies significantly in terms of participant demographics ranging from preschoolers to adolescents, measurement tools (e.g., SOPLAY, SOCARP, accelerometry), study duration, and the specific characteristics of the investigated sites. This high level of variation, while reflecting real-world complexity, makes direct quantitative comparison and meta-analysis challenging. Consequently, the conclusions in this study are based on a qualitative synthesis of the evidence. The observational nature of the study precludes the establishment of causality; therefore, the findings should be interpreted as correlational rather than causal. While this approach is effective for theory-building, future research using more standardized protocols would allow for more precise quantitative estimates of the effects of different variables. It is essential to further quantify the impact of specific elements to better inform the planning, construction, and renovation of children's activity sites in the future. This is particularly important for existing playgrounds, where an understanding of the primary reason for low utilization rates can help guide targeted renovation efforts. Identifying the key factors contributing to the popularity of highly utilized sites can offer valuable insights for the development of other similar sites.

## 5 Conclusions

This systematic review establishes a comprehensive conceptual framework that clarifies the complex associations between playground features and children's PA. It demonstrates that children's PA levels are not the result of simple, linear interactions with environmental features, but rather emerge from a dynamic interplay of the physical environment, key users and their socio-economic characteristics, and the underlying mechanisms of opportunity, feedback, and motivation. The central conclusion is that effective playground design requires a nuanced, holistic approach. Designers and planners must consider the quality, diversity, and specific affordances of features, and how these interact with contextual factors like thermal comfort and the demographic characteristics of the users.

By providing a systematic lens to understand these interactions, the framework serves as a valuable tool for guiding future studies with several key research directions. First, there is a clear need for longitudinal studies to track the long-term effects of playground renovations, moving beyond short-term observations to distinguish

sustained behavioral changes from novelty effects<sup>[43]</sup>. Second, future research should employ methodologies that allow for causal inference. While this framework proposes causal pathways, these hypotheses require empirical testing to confirm the cause-and-effect relationships between specific design interventions and observed activity outcomes<sup>[79]</sup>. Finally, to address the challenge of the heterogeneity across studies, the development of unified quantitative metrics for key playground elements is expected. Standardizing the assessment of factors like facility diversity, naturalness, and shade quality would enable more accurate, comparable results and facilitate powerful meta-analyses; it would also be possible to conduct weighted analysis to determine the relative importance of each factor.

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# 活动场地特征与儿童体力活动水平关联的系统综述

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## 摘要

体力活动对儿童的健康发展至关重要; 然而, 由于久坐行为的增加, 许多儿童未能达到建议的活动水平。活动场地对于促进儿童体力活动而言尤为关键。尽管如此, 活动场地特征与儿童体力活动之间的复杂关系尚未被完全阐明。本综述全面分析了65篇文献, 探讨了活动场地中影响儿童参与体力活动的多方面因素。这些因素包括活动场地大小、设施、环境因素及翻新改造等自变量, 以及年龄、性别、儿童互动、家长行为及社会经济因素等调节变量。尽管该领域已积累了广泛研究, 但研究结果仍较零散, 甚至在关于更大的活动场地和自然元素能否增强儿童的体力活动、男孩和女孩对设施的偏好差异等方面存在矛盾。本综述提出了一个包含一系列影响儿童体力活动水平的活动场地特征(即关键变量)的综合框架。此框架可增进对活动场地特征如何影响儿童活动水平的理解, 同时为未来在设计和公共卫生领域的规划设计提供科学支撑。

## 关键词

儿童; 体力活动; 体力活动水平; 活动场地; 活动场地特征

## 文章亮点

- 综合了关于活动场地特征如何影响儿童体力活动水平的研究
- 识别了8个影响因素, 并将之分类为儿童体力活动水平的自变量和调节变量
- 提出了一个解释环境与儿童体力活动水平之间联系的框架
- 为未来儿童活动场地的设计和建设提供实践指导

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