

Original article

Physical play activities for young children's motor development: An action research study

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Abstract:

This action research study examines the design and organization of physical play activities for junior kindergarten children (aged 3–4 years) in a Chinese kindergarten context. Grounded in constructivist learning theory, dynamic systems theory, ecological perception theory, and differentiated instruction theory, the study identifies six interrelated design principles for play materials: (1) visual appeal integrated with safety features; (2) material texture aligned with children's psychological need for emotional security; (3) playfulness and dynamic interaction that generate multi-modal feedback; (4) variability and combinational functions enabling diverse movement possibilities; (5) hierarchical design accommodating individual differences in motor competence; and (6) structural properties supporting proprioceptive and spatial perception development. The findings further outline three organizational strategies for structuring physical play activities: a dual-structure arrangement balancing collective games with individual free-play stations, scientific regulation of exercise intensity, and progressive skill development scaffolded through graded material configurations. The study contributes an integrated material-environment-organization framework that extends prior research by embedding differentiation into material structure and positioning responsive materials as autonomous learning agents. Practical implications include the use of low-cost recycled resources, simple material variations for hierarchical difficulty, and the prioritization of dynamic feedback over static equipment.

1. Introduction

Kindergarten education in China is guided by the principle of integrating care and education, with a holistic focus on children's physical, cognitive, moral, and aesthetic development (Li & Chen, 2016). Physical development is explicitly identified as a primary goal, encompassing motor skill coordination, physical fitness, healthy habits, and sustained interest in physical activities (Li & Chen, 2016). Physical activities constitute an important component of kindergarten curricula, and because play reflects children's cognitive characteristics, interests, developmental needs, and behavioral patterns, "taking play as the basic activity" is regarded as a fundamental principle of early childhood education (Gibson et al., 2017; Li

& Chen, 2016). The Guidelines for Learning and Development of Children Aged 3–6 further emphasize that educators should respect children's developmental characteristics, learning patterns, and individual differences (Hu et al., 2016). Therefore, teachers need to scientifically guide children and effectively support their development based on careful observation and understanding of children's age characteristics and developmental needs.

Junior kindergarten children (typically ages 3–4 in the Chinese three-year kindergarten system) demonstrate several distinctive developmental characteristics. First, their thinking is highly concrete and image-based. They prefer play materials that are vivid, intuitive, concrete, and visually attractive. Sec-

ond, their attention is primarily characterized by involuntary attention, meaning bright colors, sudden sounds, and vivid images are more likely to attract their attention and interest (Ruff & Rothbart, 1996). Third, significant individual differences exist in children's physical movement development and motor coordination. Based on these characteristics, physical play activities in junior kindergarten should emphasize playfulness in both activity organization and material design to effectively stimulate children's interest and participation.

Play materials that meet the developmental needs and age characteristics of junior kindergarten children are not only important media for organizing physical play activities, but also serve as critical entry points for improving the quality of kindergarten physical education. In practice, however, many kindergarten teachers rely on generic, commercially available equipment or improvised handmade materials without systematic design guidance. The quality and appropriateness of these materials directly constrain children's opportunities for motor exploration and physical engagement. From a research perspective, existing literature predominantly focuses on material provision rather than systematic design principles tailored to specific age groups, particularly for children aged 3–4 years (Fraser et al., 2022; Huo, 2022). Furthermore, there is limited integration between theoretical frameworks and practical material design in kindergarten physical education contexts. Grounded in long-term action research at a Chinese kindergarten, the present study examines how play materials can be purposefully designed and organized to support the motor development and active engagement of junior kindergarten children.

2. Literature review

2.1 Play materials in early childhood physical education

Play materials serve as essential mediators between educational objectives and children's learning experiences in early childhood physical education (Gibson et al., 2017). In Chinese kindergarten contexts, the Kindergarten Work Regulations explicitly emphasize that play constitutes the fundamental activity through which young children learn and develop (Li & Chen, 2016). Physical play materials, including balls, hoops, balance beams, and teacher-designed equipment, provide tangible interfaces that enable children to explore movement possibilities, develop motor skills, and construct physical knowledge through direct interaction (Hulteen et al., 2018). Research indicates that the quality and design of play materials significantly influence children's engagement levels and the effectiveness of physical education programs (Pellegrini & Smith, 1998). However, existing literature predominantly focuses on material provision rather than systematic design principles tailored to specific age groups, particularly junior kindergarten children aged 3–4 years (Fraser et al., 2022; Huo, 2022).

2.2 Developmental characteristics of junior kindergarten children

Junior kindergarten children exhibit distinctive developmental characteristics that fundamentally shape their interaction with play materials. Cognitively, these children demonstrate concrete and image-based thinking patterns, preferring vivid, intuitive, and visually attractive stimuli (Darling-Hammond et al., 2019). Their attention is primarily involuntary, meaning they are naturally drawn to bright colors, sudden sounds, and dynamic movements rather than deliberately focusing on structured tasks (Ruff & Rothbart, 1996). Additionally, significant individual differences exist in physical development and motor coordination, necessitating differentiated approaches to material design and activity organization (Vygotsky, 1978; Suprayogi et al., 2017). The Guidelines for Learning and Development of Children Aged 3–6 underscore the importance of respecting these developmental characteristics and individual differences in educational practice (Hu et al., 2016).

2.3 Play-based learning and physical activity

A substantial body of empirical research has demonstrated the developmental benefits of play-based physical activity for young children. Pellegrini and Smith's (1998) meta-analysis of physical activity play research established that such play contributes uniquely to children's physical fitness, social competence, and cognitive flexibility—benefits that cannot be replicated through structured exercise alone. Subsequent studies have further shown that play-oriented physical education programs promote greater motor skill acquisition and sustained participation than didactic or drill-based approaches (Hulteen et al., 2018).

The characteristics of play materials have been identified as a critical factor influencing children's physical engagement and movement exploration. Research on early childhood play environments indicates that materials offering varied, open-ended action possibilities—such as loose parts and adaptable equipment—encourage longer periods of active play and more diverse motor behaviors than fixed, single-purpose apparatus (Brussoni et al., 2012; Sandseter, 2009). Children interacting with materials that provide immediate sensory feedback, such as sounds or motion responses, demonstrate increased repetition of movement and self-directed exploration. Pan et al. (2010) found that the quality and variety of play materials in kindergarten settings significantly predict children's physical activity levels and gross motor performance.

Despite this evidence, few empirical studies have systematically examined the design of physical play materials tailored to specific age groups, particularly for children aged 3–4 years. Existing research has predominantly investigated outdoor play environments or general physical activity provision, without isolating how material properties—such as texture, dynamic feedback, and hierarchical difficulty—interact with the developmental characteristics of this specific age group (Fraser et al., 2022; Huo, 2022). The present study addresses this gap by examining how purposefully designed play materials influence children's engagement and motor development in a junior

kindergarten context.

2.4 Material design principles in physical play

Existing research on material design in early childhood education highlights several key principles. Safety and age-appropriateness constitute foundational requirements (Brunsoli et al., 2012). Beyond safety, effective materials should offer multiple affordances—action possibilities that match children’s developmental capabilities while providing appropriate challenge (Gibson, 1979). Hierarchical design, allowing children to select difficulty levels according to their abilities, supports differentiated instruction and promotes autonomous learning (Suprayogi et al., 2017). Furthermore, materials that incorporate dynamic elements—sounds, movements, or responsive feedback—enhance children’s engagement by aligning with their preference for immediate, sensory-rich experiences (Thelen & Smith, 1994). Despite these general principles, limited research has specifically addressed the systematic design of physical play materials for junior kindergarten contexts, representing a gap that this study aims to fill.

3. Theoretical framework

3.1 Constructivism and dynamic systems theory

Constructivist theory provides the foundational framework for understanding how young children learn through physical play. Darling-Hammond et al. (2019) emphasized that children actively construct knowledge through direct interaction with their environment, while Vygotsky (1978) highlighted the social and cultural dimensions of learning, proposing that children develop new abilities within the zone of proximal development when supported by more knowledgeable others or appropriately designed tools. Dynamic systems theory, as articulated by Thelen and Smith (1994), further conceptualizes motor development as a self-organizing phenomenon in which new movement patterns emerge from the interaction of the child’s physical capabilities, task characteristics, and environmental constraints. Together, these theories suggest that play materials should be designed not as static equipment but as interactive, dynamic tools that invite exploration, manipulation, and problem-solving, with adjustable constraints that allow children to discover new movement solutions at their own developmental pace.

3.2 Ecological approach to perception and action

Gibson’s (1979) ecological approach to perception introduces the concept of affordances—the action possibilities offered by the environment relative to the perceiver’s capabilities. For junior kindergarten children, the affordances of play materials are critical determinants of engagement and learning. A balance beam affords walking for a novice but affords running or jumping for a more advanced child; a hanging bell affords hitting and produces sound feedback. Effective material design involves creating objects with rich, layered affordances that invite children to perceive and act upon them in increasingly complex ways. Suprayogi et al.’s (2017) differentiated instruction theory further provides the pedagogical

rationale for hierarchical material design, asserting that effective teaching requires responsive adjustments to content, process, and product based on learners’ readiness, interests, and learning profiles. In physical play, differentiation manifests through materials that present multiple levels of challenge within the same activity type, allowing children to self-select challenges appropriate to their individual developmental levels.

3.3 Integration of theoretical frameworks in material design

The three theoretical perspectives—constructivism, dynamic systems theory, ecological perception, and differentiated instruction—converge on a common design principle: play materials should function as dynamic, responsive, and developmentally adjustable learning environments. When children engage with thoughtfully designed materials, they construct embodied knowledge about movement, force, balance, and spatial relationships. The dynamic interaction between the child and the material becomes the engine of motor learning, while the hierarchical design ensures that children at different developmental levels can find appropriate challenges. The materials described in this study—such as decorated throwing nets, colorful hoop-crawling activities, and hanging bell targets—were designed specifically to maximize these integrated theoretical principles, matching the capabilities and interests of 3–4-year-old children.

4. Methodology

4.1 Research context

This study was conducted at a university-affiliated kindergarten in Beijing, China, serving a mixed population of children from academic and professional families, with a strong emphasis on developmental appropriateness and child-centered education. The junior kindergarten classes included in this study comprised children aged 3–4 years, with approximately 25–30 children per class. The research was conducted over multiple academic years, allowing for longitudinal observation and iterative refinement of materials and activities.

4.2 Research design

An action research methodology was employed, involving iterative cycles of planning, acting, observing, and reflecting (Fraser et al., 2022). The lead author, a senior kindergarten teacher with extensive experience in physical education, designed and implemented play materials, observed children’s interactions with these materials, documented outcomes through field notes and video recordings, and then modified the materials based on observed effectiveness. This cyclical process allowed for continuous refinement of both material design and teaching strategies. The study also incorporated qualitative analysis of observational data, with children’s behaviors and responses to materials coded and categorized to identify emergent patterns and principles.

4.3 Data collection

Data were collected through multiple sources: (1) detailed field observations during daily physical play activities, focusing on children's engagement levels, movement choices, and problem-solving behaviors; (2) video recordings of selected activities, enabling repeated analysis of children's interactions with materials; (3) teacher reflective journals documenting the design rationale, anticipated outcomes, and actual observed effects of each material; and (4) photographic documentation of the materials and their various configurations. Figures referenced in this study represent authentic examples of the materials and activities as implemented in the kindergarten setting.

4.4 Data analysis

Observational data were analyzed through qualitative content analysis. Children's behaviors were coded into categories related to material engagement (e.g., sustained attention, repeated attempts, modification requests), motor skill deployment (e.g., crawling style, balance strategy, throwing technique), and social interaction (e.g., solo play, parallel play, collaborative play). These codes were then organized into higher-order themes corresponding to the design principles presented in the findings. The analysis was conducted collaboratively by the researchers, with regular discussions to establish inter-rater reliability and to ensure that emergent themes were grounded in observed data rather than preconceived assumptions.

5. Findings

5.1 Content selection and progressive development of physical play activities

5.1.1 Alignment between play content and developmental goals

The content design of physical play activities for junior kindergarten children was derived from the developmental goals and content requirements in the health domain for junior kindergarten children as outlined in the Kindergarten Education Guidelines (Huo, 2022), the Guidelines for Learning and Development of Children Aged 3–6 (Hu et al., 2016), and the Beijing Implementation Guidelines (Pan et al., 2010) for the Kindergarten Education Guidelines.

5.1.2 Progressive development of play content and goals

The principle of progressive development in play content and goals means that the design of physical play activities and developmental goals must follow children's developmental characteristics, gradually deepening and advancing step by step. In other words, play content and goal design enabled children to improve on the basis of their existing abilities, with difficulty gradually increasing during the activity process and play content corresponding to progressively higher goal levels. For example, two-foot jumping was a relatively achievable developmental goal for junior kindergarten children. On the basis of two-foot jumping, teachers designed "single-foot standing balance" games, which allowed children to practice

both bodily coordination and balance while also exercising the movement of standing on one foot. On this basis, teachers then guided children to practice "single-foot jumping." This process reflected a continuous step-by-step progression with increasing difficulty, in which the play content and movement goal design of each subsequent stage were generated and completed on the foundation of the previous stage. Taking the "balance walking" activity as an example, the progressive development of activity stages and content difficulty can be illustrated as follows: (1) Teachers first guided children to "walk continuously on wide balance boards." Because wide balance boards were broad and relatively stable, children quickly mastered them. At the same time, walking on wide balance boards helped reduce junior kindergarten children's fear and nervousness, allowing them to become familiar with the characteristics of the balance board as quickly as possible. (2) On the basis of "walking continuously on wide balance boards," teachers then guided children to "walk continuously on narrow paths," leading children to experience the feeling of walking on a narrow path or board and helping them gain initial attempts and sensory movement experiences. (3) After walking on narrow paths or boards, teachers then guided junior kindergarten children to walk on "S-shaped paths," and from there transitioned to "walking continuously on narrow elevated balance boards," and finally to "walking alternately across stepping blocks." Furthermore, the stepping blocks also had differentiated levels of difficulty in terms of height and spacing. In addition to the different arrangements of "paths" of various shapes, widths, and heights, which presented different levels of difficulty, teachers also introduced various obstacles for balance walking practice. Children walked on paths of different heights, while others engaged in weighted balance walking. All of these reflected the different levels of difficulty within balance walking activities. At the same time, these various balance walking activities were new levels of difficulty and new games that continuously emerged from the original practice foundation. Through these activities, children not only developed walking coordination and balance, but also gained multifaceted development in vestibular balance, body control, and bodily perception through movement experiences on surfaces of different heights, angles, and textures.

5.1.3 Integration of physical fitness and motor skills

The design of physical play activities reflected careful analysis of activity goals, integrating children's physical fitness development with motor skill training. During the process of designing activities, teachers broke down and analyzed activity objectives so that physical fitness development goals could correspond effectively to the cultivation of movement skills. For example, "chasing games" were commonly used forms of running activities in junior kindergarten physical play. Teachers first analyzed the developmental goals that could be achieved through chasing activities. These goals included the development of physical fitness, improvement of cardiovascular endurance, enhancement of running speed, strengthening of movement coordination, and the development of avoidance abilities during movement. Based on these different developmental goals, teachers organized and implemented

different types of chasing games. For example, the “Hit the Mouse” game combined chasing movements, target throwing, and throwing at moving objects within the same activity. In this game, children ran while chasing and throwing paper balls at a moving cardboard “mouse.” This integrated activity not only corresponded to junior kindergarten children’s preference for situational, collective, and imitative play, but also effectively supported the simultaneous development of chasing and target-throwing skills. Another example was the “crawling under the net” activity. In this activity, the height of the suspended net determined children’s crawling methods. When the net was relatively high, children freely chose different crawling styles, such as hand-and-foot crawling or hand-and-knee crawling. As the height of the net decreased, children gradually needed to adopt lower crawling positions. When the net was lowered further, children used prone crawling movements in order to pass underneath the net successfully. The changing height of the net therefore determined children’s selection of crawling methods. In this process of movement selection and crawling adjustment, children developed the strength and coordination of different body parts, while their physical fitness and movement abilities were simultaneously strengthened and improved.

5.1.4 Integration of hierarchical materials and differentiated guidance

Play materials were designed hierarchically according to different motor skill development goals and the individual differences among children. At the same time, teachers grouped children according to their developmental levels and provided differentiated guidance in the use of play materials. In addition to reflecting different levels of difficulty in the design of play materials, teachers also implemented hierarchical guidance during children’s participation in activities. Specifically, based on observations of children’s motor development, teachers classified children according to movement types and skill levels. For children at different or similar developmental levels, teachers provided corresponding guidance regarding the use of play materials. Taking throwing activities as an example, teachers created a large number of vivid, visually attractive, and easy-to-operate throwing materials that effectively stimulated children’s interest in throwing games. At the same time, teachers used supportive materials to divide throwing activities into different levels of throwing games in order to specifically develop the throwing abilities of children at different skill levels. For example, teachers transformed cardboard boxes into vivid animal images and divided them into three different height levels. Children could “feed” these animal figures by throwing tennis balls or paper balls into the openings. The animals positioned at lower levels could be reached through simple rolling-ball or underhand tossing actions, while the animals positioned at higher levels required children to throw with greater distance, height, and angle control in order to successfully complete the game. At the same time, teachers also adjusted throwing distances according to children’s developmental levels by grouping children based on their throwing abilities. For children with weaker throwing skills, teachers drew throwing lines closer to the target objects so that children could first experience success

and gradually increase their confidence before progressively extending the throwing distance. In contrast, for children with stronger throwing abilities, teachers appropriately moved the throwing lines farther back, thereby continuously improving children’s throwing skills based on their existing developmental levels. Through this gradual and progressive process, teachers recognized that each activity contained different levels of difficulty and corresponding developmental goals. As long as teachers deeply analyzed and understood the motor skill objectives associated with play materials and carefully observed and assessed the actual motor development levels of junior kindergarten children, they could design play activities with different levels and different materials that effectively supported children’s physical fitness and motor development.

5.2 Design and presentation of physical play materials

5.2.1 Visual appeal and safety

The vivid and colorful characteristics of play materials reflect the integration of young children’s involuntary attention patterns and psychological preferences. Brightly colored and vividly designed play materials are more likely to attract junior kindergarten children’s attention and stimulate their motivation and interest in participating in physical activities. This corresponds closely to the developmental characteristic that junior kindergarten children are mainly influenced by involuntary attention. For example, a throwing-height net was designed by teachers to regulate children’s throwing height and prevent incorrect throwing movements caused by excessively low throwing trajectories. The net was decorated with brightly colored flowers and elastic bands, making it visually vivid and attractive to children from the very beginning. Similarly, a hoop-crawling activity was designed to help junior kindergarten children practice crawling movements using different body postures. Teachers decorated the hoops with colorful chenille stems, giving the hoops brighter colors and a thicker, richer tactile texture, which effectively stimulated children’s interest in participating in the game and attempting challenges. Various cardboard play materials were also transformed through colorful painting and vivid decorative designs, effectively attracting children to participate in various throwing, crawling, and climbing games. Safety was also a core consideration in material design. All materials were constructed with rounded edges, non-toxic surfaces, and stable bases to prevent injuries during high-intensity physical activities. The size, weight, and height of materials were carefully calibrated to match the physical capabilities of 3–4-year-old children, ensuring that they could manipulate and transport materials independently without risk of strain or falling. Additionally, visual elements such as bright colors and clear boundaries served dual purposes: they attracted children’s attention while simultaneously marking safe zones and pathways within the play space.

Examples of these materials and activities are shown in Fig. 1–4.



Fig. 1. Throwing height net.



Fig. 2. Cardboard game materials.



Fig. 3. Cardboard game materials.



Fig. 4. Cardboard game materials.

5.2.2 Material texture and children's psychological needs

The findings indicate that combining material texture with children's tactile experiences and psychological feelings enhances their engagement from an internal emotional perspective. The design of play materials moved beyond merely attracting children through external colors and visual stimulation and further provided children with feelings of comfort, warmth, and psychological security during play activities. For example, materials designed for vertical jumping and touching activities included hanging objects such as bananas, apples, and radishes made of soft cotton filling and brightly colored velvet fabric in red and green. Their vivid appearance and soft texture effectively attracted children's interest in touching and jumping activities. Traditional play materials, including "riding bamboo horses," "land boats," and "small carts," were created using recycled newspapers and cardboard boxes. These brightly colored and vividly designed play materials were highly favored by children. Because they were entirely made from paper materials, the toys were no longer hard in texture but instead appeared soft, warm, and safe both visually and tactually, thereby ensuring children's safety during play activities.

5.2.3 Playfulness and dynamic features

Examples of these materials and activities are shown in Fig. 5–6.

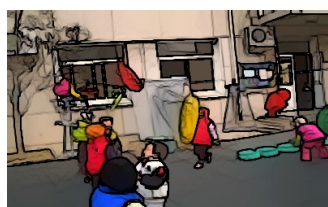


Fig. 5. Vertical jumping.



Fig. 6. Land boat.

The design of play materials in this study effectively combined playfulness with children's sense of satisfaction, intuitive understanding, and psychological expectations. Materials designed for vertical jumping and touching activities illustrate several important principles in the design and provision of physical play materials. First, when children jump and hit the hanging objects, the sounds produced by the objects and their swinging movements can easily attract the attention of other children, thereby encouraging more children to participate in the jumping and touching activity. Second, after jumping upward, children can directly reach and touch the hanging objects above them. Because the hanging objects contain bells, they produce sounds immediately after being hit. This sound becomes an intuitive result of the game and serves as direct feedback for children's movements. The intuitive nature of junior kindergarten children's thinking and psychological experiences is reflected in the immediate connection they establish between their actions and the results produced during play. Such positive feedback further reinforces children's movements and behaviors. Third, after children hit the target objects, the materials not only produce sounds but also swing in the opposite direction. During this process, children gradually establish cognitive connections between their own movements and the reactions of the materials, such as "When I hit it, it moves forward," or "When I hit it, it makes a sound." However, after swinging to a certain extent, the target object swings back toward its original position. At this moment, children begin to discover that "one action can produce two results," and that these two results are causally connected. Because of these changing interactions between children's actions and the reactions of the materials, children repeatedly hit the hanging objects in order to observe these two dynamic results. Although the activity may appear repetitive, it actually contains multiple layers of cognitive experience, allowing children to remain highly engaged in the game.

Examples of these materials and activities are shown in Fig. 7–11.



Fig. 7. Gymnastics hoop (S-shape).



Fig. 8. Gymnastics hoop (straight line).



Fig. 9. Gymnastics hoop (straddle jump).



Fig. 10. Throwing box (single).



Fig. 11. Throwing box (combined).

5.2.4 Variability and combinational functions

Examples of these materials and activities are shown in Fig. 12–13.



Fig. 12. Crawling mat.



Fig. 13. Crawling mat.

Two key principles emerged regarding the combinational use of play materials. First, one type of play material can serve multiple functions. The same gymnastics hoops can be arranged in an S-shape for practicing alternating walking movements, or arranged in a straight line for two-foot jumping or single-foot jumping activities. By changing the arrangement of the hoops, teachers can also guide children to practice straddle-jumping movements. The same type of play material can be used independently or in combination with other materials. Different forms of use correspond to different activity content and developmental goals. For example, throwing cardboard boxes can be used individually to guide children in target-throwing practice, or combined together to form S-shaped obstacle courses for different types of activities, such as S-shaped running games or pushing-cart obstacle games. These materials can also serve as supportive equipment and standards for crawling and climbing activities. Second, multiple combinations of different materials and multiple skill combinations can be achieved. In outdoor physical play areas for junior kindergarten children, teachers can combine a variety of different play materials in order to maximize the comprehensive organizational functions of the materials and support the development of different movement skills. For example, hoop-walking activities can be combined with weighted balance-walking activities, while balance activities involving different heights and widths can also be combined together. Similarly, different forms of crawling and climbing activities can be combined with balance-walking and two-foot jumping activities. Through such combinations of materials, children can independently choose movement types and levels of difficulty according to their own abilities and interests. This fully reflects the interaction between teachers' intentional material design and children's autonomous choices during play activities.

Examples of these materials and activities are shown in Fig. 14–21.



Fig. 14. Hoop crawling (different sizes).



Fig. 15. Balance.



Fig. 16. Throwing box (different heights).



Fig. 17. Throwing box (different heights).



Fig. 18. Foam board obstacle.

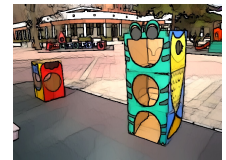


Fig. 19. Cardboard caterpillar.



Fig. 20. Throwing box.

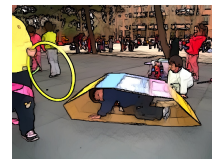


Fig. 21. Tunnel crawling.

5.2.5 Hierarchical design and individual differences

Because significant individual differences exist among junior kindergarten children, the design and provision of play materials must reflect scientific and child-centered approaches. When designing, producing, and providing play materials with different levels of difficulty, two principles emerged: (1) the same type of skill-related material should demonstrate different levels of difficulty in its design and production, and (2) children with different developmental levels should be guided to independently select and participate in activities of the same type but with different levels of difficulty. Teachers' designs represent only an initial framework for organizing activities. In order for play materials to truly correspond to the actual developmental levels of different children, teachers must also provide careful observation, guidance, and support during activities. During the guidance process, children were encouraged to select activities of the same type but with different difficulty levels according to their own abilities. For example, in weighted balance-walking activities, children with stronger physical abilities increased the amount of weight they carried. If children originally carried one water bottle on each side of a shoulder pole, children with higher ability levels carried two bottles on each side instead. Children were also encouraged to decide independently how many bottles they would like to carry. Similarly, in balance-walking activities, children with weaker abilities began by walking on low and wide balance beams and gradually progressed to narrower balance beams and balance posts with spaced intervals. Children with stronger abilities, however, directly began practicing on

narrow balance beams. In actual play situations, children also tended to independently select play materials and movement types according to their own developmental levels.

Examples of these materials and activities are shown in Fig. 22–24.



Fig. 22. Throwing game.



Fig. 23. Throwing game.



Fig. 24. Hit the mouse.

5.2.6 Proprioceptive and spatial perception development through play materials

Physical activities and physical play are not only intended to develop children's gross motor skills and physical fitness. Because physical activities involve bodily strength, balance, coordination, and posture adjustment, they also play an important role in promoting children's proprioception, spatial perception, and sensory development. Therefore, the design and provision of physical play materials should also consider these developmental goals. For example, the self-made "fabric tunnel crawling" activity allowed children to crawl inside soft fabric tunnels that were partially enclosed and dimly lit. During the crawling process, children could still see teachers and peers at both ends of the tunnel, which ensured emotional and psychological security. Through interaction with this play material, children not only developed bodily coordination abilities but also received stimulation that promoted the development of proprioception. Similarly, the "cardboard caterpillar-track" activity required children to alternately coordinate their hands and feet in order to keep the structure moving forward continuously. During this process, children needed to support the caterpillar track with their heads, extend their arms forward, and coordinate their arm and leg movements simultaneously. Through this seemingly difficult movement process, children continuously adjusted their body posture, thereby promoting the development of proprioception and spatial perception. Another example can be found in throwing games. Teachers covered a basket with a long fabric bag so that when children successfully threw paper balls into the basket, the balls would slowly roll out of the fabric bag and fall onto the ground after a short delay. In this game process, which resembled a "hide-and-seek" activity, children not only developed throwing strength and accuracy but also experienced interesting discoveries regarding the relationship between their own actions and the resulting outcomes.

5.3 Organization and implementation of physical play activities

Examples of these materials and activities are shown in Fig. 25–26.



Fig. 25. Chase game.



Fig. 26. Net crawling.

5.3.1 Combination of collective and individual play

In junior kindergarten physical activities, teacher-organized collective games were combined with children's individual and freely chosen play activities. Outdoor physical play included not only purposeful and organized physical skill practice guided by teachers, but also provided opportunities for children to engage in autonomous and individualized play. Collective games helped teachers guide children toward specific developmental goals and motor skill training, while individual play allowed children to independently explore materials, select preferred activities, and participate according to their own interests and developmental levels. The combination of these two forms of activity better supported children's initiative, participation, and individualized development in physical play.

5.3.2 Scientific arrangement of exercise intensity

The organization of physical play activities reflected a scientific arrangement of children's exercise intensity. Physical activities provided sufficient movement opportunities to effectively promote physical fitness and motor development, while at the same time ensuring children's physical safety and preventing excessive fatigue. Teachers considered children's age characteristics, physical endurance, and activity levels when arranging movement intensity. Appropriate physical activity intensity helped children develop strength, coordination, balance, and cardiovascular function while maintaining positive emotional experiences during participation. Excessively intense activities, however, negatively affected children's physical comfort and participation interest. Therefore, the arrangement of exercise intensity in junior kindergarten physical activities balanced developmental effectiveness with children's physical and psychological well-being.

5.3.3 Balance and diversity in activity organization

The organization of physical play activities also demonstrated balance and diversity in terms of activity content, movement types, and time arrangement. Different types of activities were reasonably organized to achieve an alternation between dynamic and relatively quiet activities, while avoiding excessive repetition of the same movement patterns or overly intensive activity arrangements. In addition, the organization of activities avoided monotony in both game content and movement forms. Different physical skills and movement experiences were integrated into activity arrangements so that children's physical activity rhythms corresponded to scientifically appropriate patterns of movement and rest. Such balanced organization respected children's physical activity patterns

and helped maintain their motivation, interest, and sustained participation in physical play activities. Through scientifically organized and diversified physical play arrangements, teachers better supported children's comprehensive physical and psychological development while creating enjoyable and engaging play experiences.

6. Conclusion and discussion

6.1 Material responsiveness as a mechanism for self-directed learning

A central finding of this study is that materials producing immediate, multi-modal feedback—auditory, visual, and kinesthetic—serve as autonomous learning agents, reducing the need for continuous teacher intervention. When children struck the hanging bells in the vertical jumping activity, the resulting sound and swing motion provided intrinsic reinforcement that sustained repeated practice. This observation aligns with constructivist theory (Darling-Hammond et al., 2019) in that children did not merely execute a teacher-prescribed movement but actively constructed an embodied understanding of cause and effect. The finding extends Gibson's (1979) affordance theory by demonstrating that affordances in physical play materials are not static properties but dynamic events: the same bell offered a different action possibility on the return swing than it did on the initial impact, prompting children to discover that "one action produces two results." From a dynamic systems perspective (Thelen & Smith, 1994), this responsive feedback functioned as a continuously adjusting constraint, inviting children to self-organize progressively complex movement patterns without explicit instruction. The practical implication is that material designers should prioritize feedback loops—sound, motion, or delayed reveal—over static aesthetics alone.

The study also found that the combination of visual appeal and tactile softness was not merely additive but synergistic. Newspaper-constructed bamboo horses and soft-filled hanging fruit were preferred over their harder counterparts because the soft texture reduced fear of collision and encouraged closer, more sustained interaction. This finding suggests that safety and emotional comfort operate as preconditions for exploratory behavior: unless children feel physiologically secure, they will not fully exploit the motor affordances a material offers. Consequently, texture and safety should be treated as integrated design variables rather than separate checklists.

6.2 Hierarchical design as an embedded differentiation strategy

Rather than treating differentiation as an external instructional strategy applied after materials are made, the findings show that hierarchical difficulty can be built into the material itself. Balance beams of graduated widths, throwing targets at tiered heights, and crawling nets at varying elevations allowed children to self-select challenges that matched their current motor competence. Observations revealed that children with higher ability levels naturally gravitated toward narrower beams and higher targets, while less confident children re-

mained on wider surfaces until they were ready to advance. This self-selection process is consistent with Suprayogi's (2017) differentiated instruction model, but it shifts the locus of control from teacher decision-making to child agency. The material functions as a silent assessment tool: by observing which level a child chooses and how long they persist, the teacher gains diagnostic information without formal testing.

Moreover, the combination of collective and individual play spaces created a dual-structure environment that supported both scaffolded instruction and autonomous practice. Collective games provided the social modeling and turn-taking norms necessary for skill acquisition, while adjacent free-play stations allowed children to rehearse and refine movements at their own pace. Teachers who maintained this dual structure reported fewer behavioral disruptions and longer sustained engagement, suggesting that the organizational architecture of the play space is as influential as the materials themselves. The study therefore proposes that effective physical play programming should be understood as a material-environment-organization system rather than a collection of discrete activities.

This study identified six key principles for designing play materials for junior kindergarten physical play: visual appeal and safety, material texture aligned with psychological needs, playfulness and dynamic interaction, variability and combinational functions, hierarchical design accommodating individual differences, and support for proprioceptive and spatial perception development. Additionally, the study outlined strategies for organizing physical play activities that balance collective and individual play, scientific exercise intensity, and progressive skill development. These principles and strategies emerged from long-term action research in a Chinese kindergarten context and are grounded in constructivist learning theory, dynamic systems theory, ecological perception theory, and differentiated instruction theory.

Despite these limitations, the study offers several practical recommendations. First, effective materials can be created from low-cost, recycled resources such as cardboard boxes and fabric scraps, which has significant implications for resource-limited settings. Second, hierarchical design can be implemented through simple variations of the same material, such as drawing different throwing lines or using hoops of different sizes. Third, teachers should prioritize materials that provide dynamic, multi-modal feedback over static equipment, as responsive materials are more likely to sustain engagement and promote repeated practice.

Several limitations of this study should be acknowledged. First, the research was conducted in a single kindergarten with a relatively homogeneous population, which may influence the generalizability of the findings to more diverse populations. Second, the action research methodology entails inherent subjectivity, as the lead author's dual role as teacher and researcher may have introduced observational bias. Third, the study focused on observable behaviors rather than employing standardized motor assessments to quantify developmental outcomes.

The study makes both theoretical and practical contributions. Theoretically, it integrates multiple developmental

and educational theories to create a coherent framework for understanding how material design influences young children's motor and cognitive development in physical play contexts. Practically, it provides kindergarten teachers with concrete, evidence-based guidance for designing and implementing physical play materials and activities. The detailed examples of teacher-made materials—such as decorated throwing nets, textured crawling hoops, responsive hanging bells, and adjustable foam-board obstacles—demonstrate that effective physical play programming does not require expensive commercial equipment but rather thoughtful design that aligns with children's developmental characteristics and individual differences.

Future research should extend this work in several directions. First, multi-site studies involving diverse kindergarten populations would strengthen the generalizability of the findings. Second, the incorporation of quantitative motor assessments would enable researchers to establish more definitive causal links between specific material designs and developmental outcomes. Third, the use of technology-enhanced observation methods, such as wearable accelerometers or motion-capture systems, could provide more precise data on how children interact with different materials. Finally, comparative studies examining the effectiveness of teacher-made materials versus commercial equipment would help educators make informed decisions about resource allocation in early childhood physical education.

Ethical Statement

This study was approved by the institutional ethics committee. Informed consent was obtained from the parents or guardians of all participating children, and the kindergarten's name and location have been anonymized to protect participant privacy.

Conflict of interest

The author declares no conflict of interest.

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