

Motor Development in Children: A Narrative Review of Theoretical Foundations, Determinants, and Implications for Sports Education

Hilmy Aliriad¹, Hasan Saifuddin², Nurman Ramadhan³, Wahyu Setya Kuscayaning Putri⁴, Achmad Nurilfaza⁵

{hilmy@unugiri.ac.id, hasan@unugiri.ac.id, nurman@unugiri.ac.id wahyu10@unugiri.ac.id achmadfaza391@gmail.com}

Universitas Nahdlatul Ulama Sunan Giri Bojonegoro^{2,3,4,5}

Abstract. Motor development, the age-related change in movement behavior, underpins children's participation in play, physical activity, and learning. This narrative review synthesizes the theoretical foundations, determinants, assessment, and pedagogical implications of childhood motor development for sports education. Seminal works and key systematic reviews were purposively selected and analyzed thematically. Explanations have shifted from maturational accounts toward dynamic-systems and constraints-based perspectives, in which movement emerges from interacting organism, environment, and task factors. Fundamental motor skills are consistently associated with physical activity, fitness, weight status, and perceived competence, although much of the evidence is correlational, and structured interventions are effective. Implications include developmentally appropriate task design, ample practice, a mastery-oriented climate, process-based assessment, and culturally familiar traditional games. Empirical research in Indonesian schools is needed to test these propositions.

Keywords: motor development, fundamental motor skills, physical education, constraints-based approach, children

1 Introduction

Movement is one of the first ways in which children explore the world. Motor development is commonly defined as a continuous, age-related process of change in motor behavior that results from the interaction of the individual, the environment, and the task [1]. Learning to reach, crawl, walk, run, jump, throw, and catch is not only a matter of physical growth; it shapes how children play, interact with peers, and take part in learning activities at school. Infants themselves accumulate an enormous amount of practice: observational work shows that toddlers take thousands of steps and fall dozens of times each day while learning to walk [2].

For a long time, motor skills were assumed to emerge more or less automatically as children matured. More recent work challenges this assumption. Fundamental motor skills are not simply “picked up” with age; children need opportunities to practice, appropriate equipment, and developmentally suitable instruction to reach proficiency [3, 4]. Seefeldt [5] described a “proficiency barrier”: children who do not reach an adequate level of fundamental skills may find it difficult to move on to the more specialized skills required in games and sports. For many

children, physical education is the main structured setting where such opportunities are offered, which places teachers and curriculum designers in a central position. In Indonesia this subject is delivered as PJOK (*Pendidikan Jasmani, Olahraga, dan Kesehatan*), and its quality depends heavily on how well teachers understand how children's motor skills develop.

A further reason to revisit motor development is the changing context of childhood. In what the conference theme calls the post-digital era, children's daily routines combine screens, structured schooling, and, in many communities, traditional forms of play. Global guidelines recommend that children and adolescents accumulate an average of at least 60 minutes of moderate-to-vigorous physical activity per day [6], which makes it important to understand how motor competence can support, and be supported by, an active lifestyle.

This article therefore reviews the literature on motor development in childhood and discusses its meaning for sports education. It addresses five questions: (1) which theoretical perspectives explain motor development; (2) which phases and determinants characterize it; (3) how motor competence relates to physical activity, health, and cognition; (4) how motor development can be assessed and supported in children, including those with motor difficulties; and (5) what the evidence implies for the design of adaptive physical education that draws on local wisdom. A note on terminology is needed: the literature uses "fundamental motor skills" and "fundamental movement skills" with overlapping but not identical meanings [7]. In this article the terms are used interchangeably to refer to basic locomotor, object control, and stability skills.

2 Method

2.1 Review design and source selection

This study is a narrative literature review, chosen because the aim is to integrate theoretical perspectives with empirical findings from several sub-fields (developmental psychology, motor learning, physical education, and public health) that differ too much in method for quantitative pooling. Sources were selected purposively to cover (a) foundational textbooks and theoretical papers on motor development, motor learning, and pedagogy, and (b) systematic reviews and meta-analyses on motor competence, physical activity, health, cognition, and motor skill interventions in children and adolescents. Sources were included when they were conceptually influential, methodologically rigorous (with priority given to systematic reviews and meta-analyses), and relevant to childhood and school settings.

2.2 Analysis and limitations

The selected material was analyzed thematically and grouped into five themes: theoretical perspectives, phases and determinants, outcomes and assessment, instruction and intervention, and implications for adaptive, culturally grounded physical education. Where findings were mainly correlational, this is stated. The last theme is partly interpretive and is presented as propositions rather than established findings. Because the selection was not exhaustive or protocol-driven, the review may be subject to selection bias and should be read as an integrative synthesis rather than a systematic evidence appraisal. The sources are also predominantly from international research settings, and their transfer to Indonesian classrooms needs to be verified empirically.

3 Results and Discussion

3.1 Theoretical perspectives

Early accounts of motor development were largely maturational and normative: development was described as an orderly sequence of stages driven by neural maturation, with age-based milestones as the main reference. This tradition remains useful for describing what typically happens and when. Classic developmental theory, such as Piaget's [8] account of the sensorimotor period, also placed action at the heart of early cognition. However, purely maturational accounts explain poorly why children of the same age differ so much, and why the same child performs differently across settings.

Bernstein [9] framed a central puzzle: the body has many more degrees of freedom than are needed for any single movement, so learning to move involves discovering how to organize and control them. Dynamic systems theory builds on this insight. Movement is seen as emerging from the self-organization of many interacting components, including muscles, posture, perception, motivation, and the surrounding environment, rather than from a single central program [10, 11]. Variability and exploration are therefore not noise but a resource for learning, in line with the ecological view that perception and action are tightly coupled in exploratory behavior [12].

Newell [13] formalized this view in the constraints-based model, in which coordination arises from the interaction of organism, environment, and task constraints (Fig. 1). Clark and Metcalfe [14] used the metaphor of a "mountain of motor development" to portray the same idea: children climb through successive periods, and some do so along more supported routes than others. More recent syntheses stress that motor development is embodied, embedded in physical and social contexts, enculturated through the practices of a community, and enabling for other domains of development [15, 16]. For sports education, this perspective shifts attention from "waiting for readiness" toward designing environments and tasks that invite rich, varied practice.

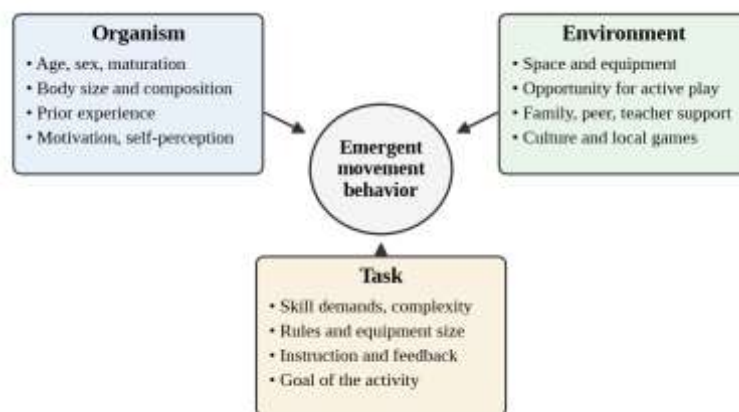


Fig. 1. Constraints-based model of motor development (adapted from [13]).

3.2 Phases of motor development

A widely used descriptive framework divides motor development into four overlapping phases [1], summarized in Table 1. The ages are approximations, and children progress at different rates.

Table 1. Phases of motor development (adapted from [1]).

Phase	Approx. age	Main characteristics
Reflexive movement	Fetal period to about 1 year	Primitive and postural reflexes; involuntary movements that support information gathering and the later emergence of voluntary control.
Rudimentary movement	Birth to about 2 years	First voluntary movements: rolling, sitting, crawling, standing, walking, reaching, and grasping; growing control of posture and manipulation.
Fundamental movement	About 2 to 7 years	Development of locomotor (run, jump, hop), object control (throw, catch, kick), and stability (balance) skills, progressing from initial to emerging to proficient levels.
Specialized movement	About 7 years onward	Fundamental skills are refined, combined, and applied in sport, dance, games, and recreation; can extend to lifelong use.

The fundamental movement phase is particularly relevant to primary schooling. Children who leave this phase without adequate proficiency may find it harder to enjoy and succeed in the more demanding, sport-specific activities of the specialized phase, which is the practical meaning of the proficiency barrier [5]. This is why fundamental motor skills are treated as a foundation for later participation [4].

3.3 Gross and fine motor development

Motor development is often divided into gross motor skills, which involve large muscle groups (for example running, jumping, and throwing), and fine motor skills, which involve precise control of the hands and fingers (for example grasping, cutting, and drawing). The two are not independent: a longitudinal study found that early fine and gross motor performance was related to later motor and cognitive ability [17], suggesting that early motor experiences have a broad influence on development. Although most of the literature reviewed here concerns gross motor skills, teachers in early grades should keep both domains in view, because a child who struggles with one is likely to meet difficulties in classroom activities that rely on the other.

3.4 Determinants of motor development

Under the constraints-based view, determinants can be grouped into three categories. Organism constraints include age, sex, body size and composition, and neuromuscular maturation. Children of the same chronological age can differ considerably in biological maturity, which affects size, strength, and performance [18]. Sex differences also vary by skill: a meta-analysis of motor performance across age found that differences were large for some skills, such as throwing, and small for many others in childhood [19]. A systematic review and meta-analysis of correlates of gross motor competence reported that age, sex, weight status,

physical activity, and fitness are among the factors associated with motor competence in children and adolescents [20].

Environmental constraints include opportunities for active play, available space and equipment, family and peer support, and cultural expectations about how children should move and play [15]. Vygotsky's [21] sociocultural perspective adds that skills are often learned through guided participation: a more capable peer, parent, or teacher can scaffold a task just beyond what the child can currently do alone. Task constraints include the nature of the skill, the equipment used, the rules of the activity, and the quality of instruction and feedback.

These categories interact. A child with limited prior experience (organism), a crowded schoolyard with too few balls (environment), and a task that demands a full game situation (task) will have few chances to practice successfully. Changing any one of these constraints can change the outcome, which is exactly why teachers can influence motor development through deliberate design. The importance of the environment is illustrated by an intervention with disadvantaged preschool children, in which a structured motor skill program produced greater improvement in fundamental skills than free play [22].

3.5 Motor competence, physical activity, health, and cognition

Stodden et al. [23] proposed a developmental model in which motor skill competence and physical activity influence each other reciprocally over time, with perceived motor competence and health-related fitness as mediating factors (Fig. 2). In early childhood, the association is expected to be weaker; it becomes stronger through middle childhood and adolescence as children's perception of their own competence matures. Later reviews support this general picture. Motor competence is associated with physical activity, cardiorespiratory and muscular fitness, weight status, and perceived competence [24, 25, 26, 27, 28]. Hulteen et al. [4] extended these ideas into a lifespan model in which foundational movement skills support continued physical activity into adulthood.

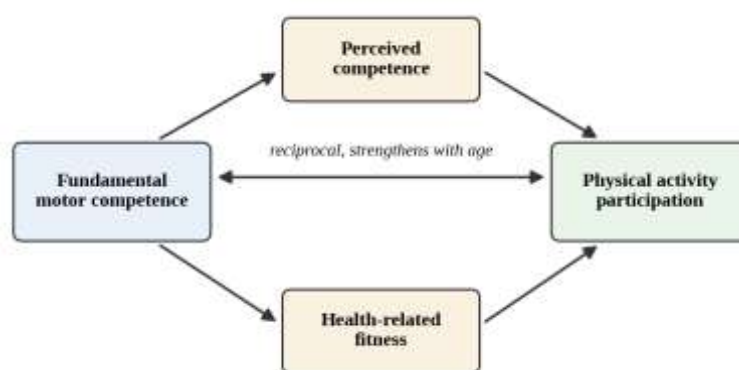


Fig. 2. Conceptual model of the relationship between motor competence and physical activity (adapted from [23]).

A second line of evidence concerns cognition. Diamond [29] noted the close interrelation between motor and cognitive development, linking it to the shared involvement of the cerebellum and prefrontal cortex. A systematic review concluded that physical activity in early childhood is associated with better motor skills and cognitive development [30].

These findings should be interpreted with care. Much of the evidence is cross-sectional or correlational, the strength of associations varies by age and measure, and causal direction cannot always be established. The claim that motor competence “causes” later health benefits is therefore best framed as a plausible, partly supported pathway rather than a proven effect.

3.6 Children with motor difficulties

Some children show persistent motor difficulties that go beyond normal variation. Developmental coordination disorder (DCD) is a neurodevelopmental condition characterized by marked impairment in motor coordination that interferes with daily activities and school performance, and it is estimated to affect around 5–6% of school-age children [31]. International recommendations emphasize that DCD should be identified through a comprehensive assessment by qualified professionals and that intervention should address both motor performance and psychosocial aspects such as participation and self-esteem [32].

For physical education teachers, the practical point is not to diagnose but to notice and respond. Children who consistently avoid activities, fall behind their peers on many basic skills, or show frustration during movement tasks may need adapted tasks, extra practice time, and, where appropriate, referral to a health or education professional. An inclusive, adaptive pedagogy treats these children as part of the class and modifies the task, not the child's participation.

3.7 Assessment of motor development

Assessment instruments generally follow either a process-oriented or a product-oriented approach, and the choice of method should follow the purpose of assessment [33]. Process-oriented tools, such as the Test of Gross Motor Development (TGMD-3), evaluate the quality of movement patterns (for example, the position of the arm and trunk when throwing) in locomotor and ball skills for children roughly aged 3 to 10 years [34]. Norm-referenced batteries such as the Movement Assessment Battery for Children-2 (MABC-2) are used to identify children with movement difficulties across a broader age range of 3 to 16 years [35].

For classroom use, teachers can adapt the performance criteria of process-oriented tools into simple observation checklists that guide feedback, while formal identification of movement difficulties should be left to trained professionals.

3.8 Motor learning and instruction in physical education

Knowledge from motor learning research can help teachers turn developmental principles into lesson design. Fitts and Posner [36] described learning as passing through cognitive, associative, and autonomous stages, and these stages are still widely used to explain why beginners need simple, clear cues, whereas more advanced learners benefit from variation and more challenging conditions [37]. A related body of work shows that directing learners' attention to the effect of the movement on the environment (an external focus), rather than to body parts (an internal focus), generally supports better performance and learning [38]. In practice, “push the ball toward the cone” may work better than “straighten your elbow.”

The motivational climate also matters. In a mastery-oriented climate, success is defined by personal improvement, effort, and learning, whereas in a performance-oriented climate it is defined by outperforming others [39]. Because children with lower skill levels are most vulnerable to negative comparison, a mastery-oriented climate is especially important in classes where skill levels differ widely.

3.9 Interventions and implications for sports education

Evidence from intervention studies is encouraging. A meta-analysis of motor skill interventions found that children who took part in such programs had better motor skills than comparison groups [40], and a systematic review and meta-analysis of fundamental movement skill interventions in youth reported that such interventions are effective in improving skill proficiency [41]. This suggests that motor competence is trainable and that school-based programs can make a difference.

Drawing together the theoretical and empirical strands above, Table 2 outlines pedagogical implications organized by constraint category. These are propositions derived from the reviewed literature and need to be tested in Indonesian school contexts.

Table 2. Implications of the constraints-based view for physical education practice.

Constraint	Key consideration	Pedagogical implication
Organism	Age, body size, prior experience, and readiness differ widely within a class.	Differentiate tasks by readiness rather than age alone; prioritize broad fundamental skills before sport-specific ones.
Environment	Opportunity to practice, space, equipment, and social support.	Maximize practice trials per child; provide enough equipment; encourage active play with family and peers outside school.
Task	Complexity, equipment, rules, and feedback.	Modify equipment (lighter balls, lower targets), progress from simple to complex, give clear cues with an external focus, and foster a mastery-oriented climate.
Culture and local wisdom	Familiar games carry meaning and motivation for children.	Use traditional games such as engklek (hopscotch), egrang (stilt walking), and gobak sodor (a tag-type team game) to practice hopping, balance, running, and dodging.

3.10 Adaptive pedagogy in the post-digital era

Adaptive pedagogy means adjusting teaching to the needs, readiness, and context of learners rather than applying one uniform lesson to all. Applied to motor development, it implies three practices: teachers observe children's current skill level and let them choose an easier or harder version of the same activity; teachers change constraints (distance, equipment size, number of players) instead of correcting each child individually; and teachers use simple, ongoing assessment to decide what to change next. Digital tools may support these practices, for example short video recordings for comparing movement patterns or checklists filled in on a tablet, but screen-based activities can also compete with active play for time and space. The proposition here is that technology should support observation, feedback, and reflection while most of the lesson time remains active. These ideas are reasoned extensions of the motor learning and assessment literature reviewed above and remain to be evaluated empirically.

3.11 Local wisdom as a context for motor skill development

The conference theme highlights local wisdom, and Indonesian traditional games offer a natural context for practicing fundamental skills. Many of these games are already familiar to children and their families, require little equipment, and can be played in small spaces. Table 3

presents an analytical mapping, made by the authors, between selected traditional games and the fundamental skills they are likely to involve.

Table 3. Analytical mapping of selected Indonesian traditional games to fundamental motor skills.

Traditional game	Main skills involved	Possible adaptation
Engklek (hopscotch)	Hopping, single-leg balance, aiming and tossing a marker.	Vary the number and spacing of squares; allow two-foot landings for beginners.
Egrang (stilt walking)	Balance, stability, coordination of arms and legs.	Start with low stilts or supported walking; progress to longer distances.
Gobak sodor	Running, dodging, changing direction, and agility.	Adjust field size and number of guards to match children's readiness.
Lompat tali (jump rope)	Jumping, rhythm, timing, and coordination.	Begin with a low or still rope; progress to a turning rope.
Bola kasti (rounders-type)	Throwing, catching, and striking.	Use soft, lighter balls and larger targets to promote success.
Congklak (mancala-type)	Grasping and in-hand manipulation (fine motor).	Use it as a quiet fine motor activity, alongside active games.

These games can be integrated into lessons by keeping their cultural form while making deliberate adjustments to constraints, such as changing distances, equipment, or rules, so that all children can succeed. Whether such programs produce measurable gains in fundamental motor skills is an empirical question; the studies reviewed here did not test them directly, and future research should evaluate them with validated instruments such as the TGMD-3.

4 Conclusion

Motor development is best understood as a dynamic process shaped by the interaction of the child, the environment, and the task. The literature reviewed here indicates that fundamental motor skills are associated with physical activity, fitness, weight status, perceived competence, and early cognitive outcomes, and that structured interventions can improve these skills. For sports education, the implication is that motor competence should be deliberately taught rather than left to chance: teachers can adjust tasks, equipment, and practice opportunities, observe movement quality systematically, support children with motor difficulties, and draw on culturally familiar games to make practice meaningful.

This review has limitations. It is narrative rather than systematic, and it relies mostly on international literature. Future research should include longitudinal and experimental studies in Indonesian primary schools, examine the effect of traditional-game-based programs on fundamental motor skills, and investigate how teacher training can support the routine assessment of motor development.

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