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Evaluating motor competence in children and youth: a narrative review

review paper
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ABSTRACT
Motor competence (MC) refers to the ability to execute a range of motor tasks, including the coordination and control necessary to perform everyday activities effectively. Interest in MC has grown over the past two decades, as reflected in an increasing number of publications on the topic. However, there is still no consensus on how to assess MC, with various test batteries available. A single test is insufficient for evaluating MC, as it encompasses a set of fundamental skills essential for daily life. These skills are typically categorised into fundamental movement skills, although discrepancies exist in their definitions. Some frameworks recognise two components – locomotor and manipulative skills – while others include a third component: stability skills. This review aims to analyse why, when and how MC should be assessed in children and adolescents. It was observed that MC assessments are essential at a young age, with physical education classes providing an ideal context for their implementation. Such assessments promote sports participation, aid in talent identification and highlight the positive correlation between MC and lifelong physical activity. Selecting an appropriate test battery requires careful consideration of the evaluator's objectives, participant age, required materials and the three pillars of fundamental movement skills: locomotor, stabilising and manipulative skills. Future research should refine the concept of MC and ensure that the validity of test batteries is rigorously examined. Additionally, using the same test battery across identical subjects and evaluating ecological validity will enhance the sensitivity and applicability of assessments, facilitating their use for both characterisation and intervention.
Key words: children, coordination, youth, fundamental movements skills, measurement

Introduction

Motor competence (MC) is defined as the ability to perform a wide range of motor actions, including the coordination and control required to achieve specific outcomes necessary for managing everyday tasks [1]. Although the importance of this concept is widely accepted, its precise nuances remain difficult to define. In fact, the definition of MC is often inconsistent, with terms such as fundamental movement skills, motor development, motor proficiency, motor coordination, motor ability, and motor fitness frequently used interchangeably [2]. This lack of clarity may help explain why, over the past two decades, there has been a significant increase in studies focused on the assessment of MC, as researchers aim to refine methods and improve measurement tools. A quick search on PubMed reveals that the term "motor competence" appears over 45,000 times as of December 2024, with hundreds of results in 2011, rising to more than 1,000 in 2012 and reaching over 8,000 in 2024 alone. These figures underscore the growing emphasis placed by researchers on understanding the development of MC.

In studies measuring MC, the main topics addressed include (i) group characterisations or cross-cultural comparisons [3, 4], (ii) analysis of perceived MC [5–7], (iii) studies examining associations between MC, health and physical activity [8, 9] and (iv) a few exploring the relationship between MC and sports participation [10–12]. Characterising groups or comparing different environments (e.g., countries) provides a logical starting point for gaining a broader understanding of the subject. Perceived MC includes constructs such as self-esteem and self-efficacy, and its significance lies in the theory that children with higher self-perceptions are more motivated to engage in physical activities, thereby

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further developing their MC [13, 14]. Subsequently, a strong link between MC and health has been well established. This is particularly important, as developing MC during childhood can positively influence health-related physical fitness, both directly and indirectly, becoming more robust over time and supporting better long-term health outcomes in children and adolescents [2, 14, 15]. Therefore, physical fitness may serve as a mediator in the connection between MC and physical activity [14]. Evidence has demonstrated an inverse relationship between MC and body weight status, alongside positive associations with cardiorespiratory fitness, musculoskeletal fitness and flexibility in children and adolescents of both sexes [2, 16]. Positive associations have also been identified between MC and mental health [17], as well as cognitive and social-emotional outcomes [18]. Additionally, MC appears to play a beneficial role in children's health markers [19]. The relationship between MC and sports participation is crucial, not only to understand how MC influences sports involvement but also to explore how sports participation can enhance MC development in children and adolescents.

Various tests and test batteries have been used in the studies mentioned above. Some are product-oriented, focusing on the outcome or performance, while others are process-oriented, emphasising technique or movement quality [2]. The former methods are generally easier and more practical to implement, while the latter focus on critical movement components and typically require a more advanced understanding of these components. Some test batteries categorise motor skills into two primary groups: locomotor and object control skills, while others include a third category, stability skills. Additionally, the target age ranges and the complexity of the tests included may vary slightly between batteries. Understanding these differences is crucial when selecting the most appropriate test battery. Therefore, the aim of this review is to discuss why, when and how MC in children and adolescents can be measured.

Why measure MC?

There are several compelling reasons to assess MC in children and adolescents. First, health outcomes are closely tied to MC. Evidence suggests that MC correlates with various health indicators [2, 20], making it an important metric for identifying individuals at potential risk of health issues due to low MC levels. Moreover, MC is a key element within the broader framework of motor development, which, in turn, is integral to overall human development [21]. Assessing MC is essential for determining whether developmental progress is on the expected trajectory, allowing educators and researchers to distinguish between typical and delayed motor skill development.

This rationale is further supported by educational considerations. MC is fundamental to physical literacy, which encompasses the knowledge, skills and attitudes necessary for a healthy lifestyle, as well as the ability to inspire others to do the same [22]. MC is widely recognised as a critical component of childhood development, with lasting impacts on health throughout the lifespan [1, 14]. Consequently, MC provides the foundation for an active lifestyle, as individuals with strong motor skills are more likely to engage in regular physical activity, leading to improved fitness and health outcomes [14].

From a sports perspective, assessing MC enables coaches and trainers to tailor interventions aimed at improving fundamental motor skills, which can enhance performance and skill acquisition in young athletes. Previous research in talent identification has demonstrated that overall MC levels are linked to future success in various sports [23–25] and may help distinguish between athletes of different competition levels across sporting domains [26, 27]. In a recent systematic review on the topic [27], the few available longitudinal studies (only six) and cross-sectoral studies reported a positive association between levels of MC and performance in different sports. Therefore, the authors suggested that incorporating MC assessments into talent identification programmes would be beneficial for sports professionals. Moreover, fostering strong MC can cultivate a positive attitude towards physical activity and sports, thereby reducing dropout rates in youth sports programmes.

Finally, timely assessment of MC provides teachers and coaches with vital information for effective intervention. For children with developmental delays or disorders, early identification of MC challenges allows for targeted interventions, promoting goal attainment and future planning. In early childhood, gross motor skills are essential for mastering movement and interacting with objects while exploring the environment. As individuals grow, well-developed gross motor skills contribute to smoother functioning in a variety of activities. Furthermore, fine motor skills are crucial for acquiring basic self-help abilities and serve as the foundation for drawing and writing [28, 29]. As individuals progress through life, proficient fine motor skills become just as important as gross motor skills [29]. Physical education classes provide an ideal context for fostering and assessing MC, particularly fine motor skills. Evidence consistently demonstrates a positive association between MC and cognitive as well as socio-emotional development [18]. Specifically, fine motor skills have been shown to predict reading proficiency in Grade 1 [30], while fine motor integration at the same grade level is a significant predictor of mathematical performance [31]. These findings underscore the importance of incorporating MC assessment as a fundamental component of school readiness indicators [32]. Indeed, regardless of the type of assessment, participant age or class duration, physical education classes consistently have a positive impact on the development of MC during childhood and adolescence [33].

When to measure MC?

As noted previously, MC is integral to and influences overall human development. Today, the concept of development – particularly motor development – is understood to extend beyond the visible changes that primarily occur in the first two decades of life [34, 35]. Instead, it encompasses continuous, cumulative and sequential changes in functional abilities that persist throughout the lifespan. Therefore, although not solely age-dependent, this process is related to age. While these changes are ongoing, the extent of visible transformation may vary, becoming more or less pronounced at different stages of life [36].

For this reason, MC can be analysed across the lifespan; however, childhood remains a primary focus for researchers and educators. This is because it is a critical period for developing fundamental movement skills, typically occurring between the ages of 2–3 and 6–7 years [35]. Gallahue's lifespan model of motor development illustrates that this process is sequential: rudimentary skills form the foundation for fundamental movement skills, which, in turn, shape the development of specialised movements. Additionally, the Long-Term Athlete Development (LTAD) model [37] identifies the ages of 6 to 9 as key for the "FUNdamental" phase, which emphasises the exploration and integration of fundamental movement skills.

These skills are classified into distinct categories: locomotion, object control and stability skills, each following typical developmental progressions both within and across categories. Research indicates that children must master specific stability skills before advancing to locomotor skills and that rudimentary stability and locomotor skills generally precede the development of object control skills [34, 38]. Furthermore, the healthy development of MC plays a crucial role in motivating children to maintain physical activity or sports participation throughout their lives. This aligns with the concept of physical literacy, which emphasises the positive association between MC and sustained engagement in physical activity [39, 40].

Thus, the early years are critical for assessing motor development, particularly in identifying delays that may benefit from intervention. However, given the understanding of development across the lifespan [41], this analysis should extend beyond early childhood years.

How to measure MC?

Given that MC assessment encompasses fundamental movement skills, the selected tests should cover its various categories. Consequently, evaluating MC effectively requires a battery of tests rather than relying on a single test. Table 1 presents the most commonly used test batteries in studies involving children and adolescents.

Table 1. Description of the batteries to measure motor competence

Name	Target ages	Orientation	Origin	Number of tests	Domains and tests included	Time per subject	Score
KTK [42]	5 to 14 years	Product	Germany	4	Locomotor (2): jumping from side to side, moving sideways. Stability (2): keeping balance when walking backwards, one-legged hopping.	~20 min	The final analysis could be per task, by adding up the scores on the four tasks and by the motor quotient, calculated by adding up the scores.
KTK3+ [43]	6 to 19 years	Product	Netherlands	4	Locomotor (2): jumping from side to side, moving sideways. Stability (1): keeping balance when walking backwards Manipulative (1): eye hand coordination	~20 min	Raw scores for each test item were converted into norm values, and a movement quotient (MQ) was calculated by combining these values.

BOT-2 [44]	4 to 21 years	Product	USA	53 items subdivided in 8 subtests Short version: 14 items	Locomotor (1): shuttle run Manipulative (7): dropping and catching a ball-both hands, dropping and catching a ball-one hand, catching a tossed ball-both hands, catching a tossed ball-one hand, dribbling a ball-one hand, dribbling a ball-alternating hands, throwing a ball at a target Stability (14): jumping jacks, jumping in place-same sides synchronized, jumping in place-opposite sides synchronized, standing with feet apart on a line-eyes open, walking forward on a line-eyes closed, walking forward heel-to-toe on a line, standing on one leg on a line-eyes closed, standing on one leg on a balance beam-eyes open, standing heel-to-toe on a balance beam, standing on one leg on a balance beam-eyes closed, stepping sideways over a balance beam, one-legged stationary hop, on-legged side hop, two-legged side hop Fine motor skills (20): filling in shapes-circle, filling in shapes-star, drawing lines through paths-crooked, drawing lines through paths-curved, connecting dots, folding paper, cutting a circle, copying a circle, copying a square, copying overlapping circles, copying a wavy line, copying a triangle, copying a diamond, copying a star, copying overlapping pencils, making dots in circles, transferring pennies, placing pegs into a pegboard, sorting cards, stringing blocks	45 to 60 min Short version: 15 to 20 min	The scoring system differs for each item. Adding the scores of all categories together yields a total motor composite score. The result could be presented in standard score, scale score or a percentile.
PDMS-2 [45]	birth to 6 years	Product	USA		Locomotor (89): thrusting legs, turning from side to back, thrusting arms, bearing weight, extending trunk, symmetrical posture, propping on forearms, rolling, extending arms and legs, flexing legs, extending arms and legs, extending arm, flexing body, pushing up, extending arm, rolling, rolling,, moving forward, raising shoulders and buttocks, creeping, scooting, pivoting, standing, creeping bouncing, cruising, lowering, stepping, pivoting, standing, standing, stepping, standing up, walking, walking, standing and moving balance, creeping up stairs, walking, creeping down stairs, walking up stairs, walking fast, walking backward, walking down stairs, walking backward, running, standing, walking sideways, walking line, jumping forward, jumping up, jumping down, walking up stairs, walking down stairs, walking backward, jumping up, walking line, walking up stairs, jumping down, walking in tiptoes, running speed, jumping forward, jumping down, jumping hurdles, walking on tiptoes, walking up stairs, running speed, jumping forward, walking line, running form, walking line forward, walking down stairs, jumping forward on 1 foot, jumping up, running balance/coordination, walking line backward, jumping forward, hopping, walking line backward, rolling forward, galloping, jumping forward, turning jump, hopping forward, jumping hurdles, running speed and agility, skipping, jumping sideways, skipping, hopping speed Manipulative (24): catching ball, rolling ball, flinging ball, kicking ball, throwing ball, kicking ball, throwing ball-overhand, throwing ball-underhand, kicking ball, catching ball, throwing ball-overhand, throwing ball-underhand, kicking ball, catching ball, throwing ball-overhand, hitting target-underhand, catching ball, hitting target-overhand, throwing ball-underhand, hitting target-overhand, bouncing ball, catching ball, kicking ball, catching bounced ball	20 to 30 min Whole test: 45–60 min	The overall motor score is calculated by adding together the scores from all six subtests. The assessment employs a 3-point rating scale: a score of 2 indicates a skill that has been mastered, 1 signifies a skill that is in progress, and 0 denotes a skill that has not been achieved. This system allows for tracking progress over time. Each item includes specific criteria for each rating.

					Stability (27): rotating head, aligning trunk, aligning head-front, aligning head-back, aligning head, extending head, aligning head, aligning head, stabilizing trunk, aligning head, sitting, sitting/reaching, pulling to sit, sitting, sitting with toy, sitting, raising to sit, sitting up, kneeling, standing on 1 foot, standing on 1 foot, standing on tiptoes, standing on 1 foot, standing on tiptoes, standing on 1 foot, imitating movements, standing on 1 foot. Fine motor skills (98): grasping reflex, grasping cloth, releasing rattle-disappearing reflex, grasping rattle, holding rattle, manipulating rattle, grasping rattle, pulling string, securing paper, grasping cube, grasping cube, shaking rattle, shaking rattle, grasping cube, grasping pellets, manipulating paper, grasping pellets, grasping pellets, grasping cube, grasping cubes, grasping marker, grasping marker, unbuttoning button, buttoning button, grasping marker, touching fingers, tracking rattle, tracking rattle-side, placing hand, perceiving rattle, regarding hands, tracking ball-left to right, tracking ball-right to left, tracking rattle, extending arms, approaching midline, fingering hands, bringing hands together, extending arm, retaining cubes, transferring cube, touching pellet, banging cup, poking finger, removing pegs, combining cubes, clapping hands, retaining cubes, manipulating string, removing pegs, releasing cube, removing socks, placing pellet, placing cubes, turning pages, stirring spoon, removing pellets placing cubes, placing pegs, tapping spoon, inserting shapes, placing pellet, scribbling, building tower, inserting shapes, building tower, turning pages, inserting shapes, building tower, imitating vertical strokes, removing top, building tower, snipping with scissors, imitating horizontal strokes, stringing beads, folding paper, building train, stringing beads, building tower, building bridge, copying circle, building wall, cutting paper, lancing string, copying cross, cutting line, copying cross, dropping pellets, tracing line, copying square, cutting circle, building steps, connecting dots, cutting square, building pyramid, folding paper, coloring between lines, folding paper		
TGMD-3 [46]	3 to 10 years	Process	USA	12	Locomotor (6): run, gallop, hop, skip, horizontal jump, slide Manipulative (6): two-hand strike of a stationary ball, on-hand stationary dribble, two-hand catch, kick a stationary ball, overhand throw, underhand roll	15 to 20 min	A score of 1 is given for correct performances, while incorrect ones receive a score of 0. The final score for each item is determined by adding the scores from both performances.
MOT 4–6 [47]	4 to 6 years	Product	Germany	18	Locomotor (6): carrying balls from box to box, forward jump in a hoop, jumping sideways, jumping in a hoop on one foot standing on one leg, jumping over a cord, jumping and turning in a hoop. Manipulative (3): catching a dropped stick, throwing a ball to a target, catching a ring Stability (6): walking forward, walking in backward direction, passing through a hoop, jumping jacks, rolling around the length axe of the body, standing up holding a ball on the head Fine motor skills (3): making dots on a sheet, grasping a tissue with toes, collecting matches	15 to 20 min	A score of 0 (skill not mastered) to 2 (skill mastered) is attributed. The scores of all seventeen tasks are then added and their sum constitutes the child's total raw motor score, ranging between 0 and 34. A normalized motor score determined for each age.

M-ABC-2 [48]	3 to 16 years (3 age bands)	Product	USA	8	Age band 1: Locomotor (1): jumping on mats Manipulative (2): catching beanbag, throwing beanbag Stability (2): one-leg balance, walking heels raised Fine motor skills (3): posting coins, threading beads, drawing trail Age band 2: Locomotor (1): hopping on mats Manipulative (2): catching with 2 hands, throwing beanbag onto mat Stability (2): one-board balance, walking heel to toe forwards Fine motor skills (3): placing pegs, threading lace, drawing trail Age band 3: Locomotor (1): zigzag hopping Manipulative (2): catching with one hand, throwing at wall target Stability (2): two-board balance, walking toe-to-heel backwards Fine motor skills (3): threading beads, drawing trail, turning pegs	15 to 30 min	After applying the tests, the gross scores are transformed into standard scores. These are summed within each skills category to yield the total score for the motor components. By aggregating these scores, the standard test score or overall result is derived. Both the standard scores and total results are then compared against a percentile table, enabling the ranking of the children's motor performance.
MAND [49]	3 to 25 years	Process and product	USA	10	Locomotor (1): standing long jump Stability (2): heel toe walk, one foot stand Fine motor skills (5): breads in box (right and left), breads on rod (eyes open and closed), finger tapping (right and left hand), nut and bolt (large and small bolt), rod slide (right and left hand)	~25 min	The raw scores for each item are transformed into scaled scores according to the participant's age. The overall assessment of motor skills, known as the Neuromuscular Developmental Index, is calculated by summing the ten scaled scores.
MOBAK [50]	6 to 7 years and 8 to 9 years	Product	Germany	8	MOBAK-1 Locomotor (2): moving sideways, jumping Manipulative (4): throwing, catching, bouncing, and dribbling Stability (2): balancing, rolling MOBAK-3 Locomotor (2): moving variably, rope skipping Manipulative (4): throwing, throwing and catching, bouncing, dribbling Stability (2): balancing, rolling	10 to 12 min	The score ranges from 0 to 2 points, with each area (object movement and self-movement) allowing a maximum of 8 points, leading to a total maximum score of 16 points as a measure of motor competence. From this scoring, a category for total motor competence was established, with 16 points as the highest possible score.
TMC [51]	5 to 83 years	Product	Norway	4	Locomotor (1): figure-8 speed and agility test Stability (1): tandem walk balance Fine motor skills (2): duplo™ brick placement speed and build a tower as fast as possible	10 to 12 min	Gross scores are converted into standard scores, which are summed within each skills category to determine the total motor component score. This total score, along with the standard scores, is then compared to a percentile table to rank the children's motor performance.
MCA [52]	3 to 23 years	Product	Portugal	6	Locomotor (2): standing long jump, shuttle run Manipulative (2): ball kicking velocity, ball throwing velocity Stability (2): lateral jumps, shifting platforms	~10 min	Normative percentile values considering age and sex.

KTK – Körperkoordinations Test für Kinder, BOT-2 – Bruininks-Oseretsky Test of Motor Proficiency, PDMS-2 – Peabody Developmental Motor Scales, TGMD-3 – Test of Gross Motor Development, MOT 4–6 – Motoriktest für vier- bis sechsjährige Kinder, MABC-2 – Movement Assessment Battery for Children, MAND – McCarron Assessment of Neuromuscular Development, MOBAK – Motorische Basiskompetenzen, TMC – Test of Motor Competence, MCA – Motor Competence Assessment

Körperkoordinationtest für Kinder (KTK)

The KTK [42] is a shortened version of the Hamm-Manburger Körperkoordination Test, originally developed by Kiphard and Schilling in 1974 [43], which reduced the number of items from six to four. This assessment tool, developed in Germany, is designed to evaluate non-sport-specific gross body coordination in children. Its predictive validity has been supported by its ability to differentiate between brain-damaged and typically developing children. Recently, a new version, the KTK3+ [44], was developed, incorporating manipulative skills. This updated version arose from the hypothesis of reducing the test battery to three tests by removing the hopping test [45]. The KTK3+ has already proven its validity and practical applicability [46–48].

The KTK consists of four non-sport-specific subtests that assess gross motor coordination, including balance, rhythm, laterality, speed and agility, distributed across the four tasks [49]. The first task, reverse balancing, requires participants to walk backwards along three balance beams, with increasing difficulty as the width of the beams decreases from 6 cm to 4.5 cm, and then to 3 cm. The second task, moving platforms, involves participants laterally moving across the floor for 20 s using two wooden platforms. Participants step from one platform to another, moving the first platform in the direction of travel. The third task, hopping for height, requires participants to hop on one leg over an increasing number of 5 cm foam blocks, up to a maximum of 12 blocks. They must begin hopping 1.5 m away from the blocks, clear them and perform an additional two hops. The final task, continuous lateral jumping, requires participants to complete as many sideways jumps as possible over a wooden slat in 15 s with feet together.

In the new version (KTK3+), the hopping task was replaced with an eye-hand coordination test. In this test, children are required to throw a tennis ball with one hand at a rectangular target (137 cm high, 152.5 cm wide, positioned 1 m above the ground) on a flat wall, from a distance of 1 m, and catch the ball correctly with the other hand as many times as possible within 30 s. The highest number of correct catches recorded across two attempts is used as the raw score.

One of the strengths of the KTK battery is its ease of application and the minimal time required for administration. However, the original version, which is the most commonly used, primarily assesses stability and locomotor skills. This limitation has been addressed in the new version. Nevertheless, both versions do not include fine motor skills.

Bruininks-Oseretsky Test of Motor Proficiency (BOT-2)

The BOT-2 [44] is derived from the Bruininks-Oseretsky Test of Motor Proficiency (BOTMP) [50] and is specifically designed to identify individuals with mild to moderate motor coordination deficits. It is recommended for diagnosing motor impairments, conducting screenings, making placement decisions, developing and evaluating motor training programs and supporting research objectives.

This battery consists of both long and short versions. The long version includes 53 items divided into eight subtests:

– Fine motor precision (7 items: filling in shapes – circle, filling in shapes – star, drawing lines through crooked paths, drawing lines through curved paths, connecting dots, folding paper, cutting a circle)

– Fine motor integration (8 items: copying a circle, a square, overlapping circles, a wavy line, a triangle, a diamond, a star, overlapping pencils)

– Manual dexterity (5 items: making dots in circles, transferring pennies, placing pegs into a pegboard, sorting cards, stringing blocks)

– Bilateral coordination (7 items: touching nose with index fingers – eyes closed, jumping jacks, jumping in place – same sides synchronised, jumping in place – opposite sides synchronised, pivoting thumbs and index fingers, tapping feet and fingers – same sides synchronised, tapping feet and fingers – opposite sides synchronised)

– Balance (9 items: standing with feet apart on a line – eyes open, walking forwards on a line – eyes closed, walking forwards heel-to-toe on a line, standing on one leg on a line – eyes closed, standing on one leg on a balance beam – eyes open, standing heel-to-toe on a balance beam, standing on one leg on a balance beam – eyes closed)

– Running speed and agility (5 items: shuttle run, stepping sideways over a balance beam, one-legged stationary hop, one-legged side hop, two-legged side hop)

– Upper limb coordination (7 items: dropping and catching a ball – both hands, dropping and catching a ball – one hand, catching a tossed ball – both hands, catching a tossed ball – one hand, dribbling a ball – one hand, dribbling a ball – alternating hands, throwing a ball at a target)

Strength (5 items: sit-ups, push-ups, standing long jump, wall sit, V-up).

The items within each subtest increase in difficulty. The short version consists of selected items grouped into specific tests, covering

– Fine motor precision (drawing lines through crooked paths and folding paper)
– Fine motor integration (copying a square and copying a star)
– Manual dexterity (transferring pennies)
– Bilateral coordination (jumping in place – same sides synchronised and tapping feet and fingers – same sides synchronised)
– Balance (walking forwards on a line and standing on one leg on a balance beam – eyes open)
– Running speed and agility (one-legged stationary hop)
– Upper-limb coordination (dropping and catching a ball – both hands)
Strength (push-ups and sit-ups).

While this battery provides a comprehensive assessment for identifying developmental issues – evaluating both fine and gross motor skills – it may be excessively detailed. The distribution of fundamental movement skills appears unbalanced. Specifically, only one item is categorised as locomotor, while there are seven manipulative skills, 14 related to stability and 20 fine motor skills. Additionally, some movements are more closely associated with physical fitness. Although MC and physical fitness are correlated, they are distinct constructs. The primary aim of the BOT-2 seems to be clinical rather than solely focused on measuring MC. The test includes a broad range of skills developed during childhood, which aids in identifying delays in typical developmental trajectories.

Peabody Developmental Motor Scales (PDMS-2)

The PDMS-2 [51] is an updated version of the original Peabody Developmental Motor Scales (PDMS), first published in 1983 [52]. It consists of six subtests: four assess gross motor skills (reflexes, stationary performance, locomotion and object manipulation), while two focus on fine motor skills (grasping and visual-motor integration). This battery is designed for children from birth to six years of age, comparing their performance to standard developmental trajectories. Additionally, the PDMS-2 is intended for both assessment and intervention planning for children with disabilities.

As a comprehensive assessment tool, the PDMS-2 evaluates both gross and fine motor abilities. The gross motor subtests include reflexes (8 items: walking reflex, positioning reflex, Landau reaction, protective reaction forwards, protective reaction sideways, protective reaction backwards, righting reaction forwards and protective reaction backwards), stationary skills (30 items), locomotion (89 items) and object manipulation (24 items). The fine motor subtests include grasping (26 items) and visual-motor integration (72 items) (see Table 1). Some tests share names but differ in complexity to target specific developmental stages. This battery includes 37 normative tables associated with motor development milestones, allowing it to dynamically reflect changes in motor abilities across ages. A checklist is used to assess each skill to determine whether it has been fully acquired, partially acquired or not yet acquired.

The PDMS-2 offers several advantages. It is widely used internationally, with normative data available across various populations, enabling the identification of developmental delays and deviations from typical motor development. Additionally, the PDMS-2 encompasses a broad range of fundamental gross and fine motor skills. However, administering the full battery can be time-consuming (45–60 min), particularly for children with motor difficulties, which may cause fatigue and affect performance. Moreover, trained professionals are required to administer the test accurately and ensure the validity of the results.

Test of Gross Motor Development (TGMD-3)

The TGMD has three versions: the first was developed in 1985 [53], revised in 2000 [54], and the third edition was introduced in 2013 [55]. The revisions primarily focused on the movements assessed, while maintaining the structure of two branches: locomotor and object control (manipulative), each consisting of six movements. In the latest version, locomotor skills include running, galloping, hopping, skipping, horizontal jumping and sliding. The manipulative skills assessed are two-hand striking of a stationary ball, one-hand stationary dribbling, two-hand catching, kicking a stationary ball, overhand throwing and underhand rolling. Participants perform each skill twice. It is worth noting that stability skills are absent from this battery.

This battery of tests is distinguished by its process-oriented approach, which emphasises the execution of movements, scored on a scale from 0 to 2. This scoring system allows for a clear understanding of progression over time. For each skill, components are marked as “present” or “absent”. Each skill includes 24 performance criteria, and if a child meets the efficiency criterion, they receive a score of 1; otherwise, they receive a score of 0 for each attempt. Scoring is adjusted based on the child’s age and sex for each subtest, helping to determine their developmental level, expressed as a gross motor quotient. This quotient is categorised into seven levels: very poor, poor, below average, average, above average, superior and highly superior.

As a process-oriented battery, its implementation and evaluation can be extensive. Researchers have attempted to shorten the evaluation time by using video recordings of the assessed individuals. However, this approach may require additional time for later assessment. Moreover, recording minors poses ethical challenges, and evaluators must be highly experienced to avoid introducing bias into the assessment. On the positive side, this battery provides a qualitative evaluation of fundamental movements, preventing high scores that may result solely from greater strength, rather than improved execution, which could ultimately lead to increased strength or speed.

Motoriktest für Vier-bis Sechsjährige Kinder (MOT 4-6)

The test is based on the Lincoln-Oseretsky Motor Development Scales (LOMDS) and the KTK, with adaptations made to ensure its suitability for preschool children. It was developed to identify delays or deficiencies in normal motor development [56].

This battery consists of 18 items covering locomotion, stability, object control and fine motor skills. The items include forward jump in a hoop, walking forward, making dots on a sheet, grasping a tissue with the toes, jumping sideways, catching a dropped stick, carrying balls from box to box, walking backwards, throwing a ball at a target, collecting matches, passing through a hoop, jumping in a hoop on one foot, standing on one leg, catching a ring, performing jumping jacks, jumping over a cord, rolling along the length axis of the body, standing up while balancing a ball on the head and jumping and turning in a hoop. No separate normative data for boys and girls are included, as there are no significant gender differences in total motor scores.

Although the battery is not balanced in terms of the number of items (see Table 1), it provides a wide range of tests across the three categories of fundamental skills, in addition to fine motor skills. Furthermore, as a product-oriented battery, it requires relatively little time for implementation. This enables researchers to efficiently assess the status of motor development and identify potential delays or deviations from the typical developmental trajectory. However, the narrow age target of this battery may limit its broader applicability.

Movement Assessment Battery for Children (M-ABC 2)

The M-ABC test is a revision of the Test of Motor Impairment (TOMI) and is derived from the Oseretsky scales for assessing motor capacity in children [57]. The original version was developed in 1992 [58] and revised in 2007 [59]. The revised edition [59] introduced qualitative observations, which do not impact scoring but help clarify the difficulties children face when performing motor tasks. The primary aim of the test is to assess the developmental status of fundamental movement skills, with an emphasis on identifying delays or deficiencies in motor development [60].

This battery consists of 32 items, divided into three age bands. Each band contains 8 individual test items that measure movement skills across three categories: manual dexterity, ball skills and balance. Age band 1 includes children aged 3 to 6 years, age band 2 includes children aged 7 to 10 years, and age band 3 includes children aged 11 to 16 years. For age band 1, the test assesses manual dexterity (placing pegs, threading beads and navigating a bicycle trail), aiming and catching (throwing and catching with both hands and catching a beanbag) and balance (balancing on a beam, heel-to-toe walking and jumping on mats). For age band 2, the number of tests per category remains the same: three for manual dexterity (placing pegs, threading lace and drawing a trail), two for aiming and catching (catching with two hands and throwing a beanbag onto a mat) and three for balance (one-board balance, walking heel-to-toe forwards and hopping on mats). The final age band includes the same categories and number of tests per category, but with increased complexity (see Table 1). As a result, locomotor skills are not included in the MC analysis for any of the age bands.

The M-ABC test has significant advantages, including its widespread use in Europe, cross-cultural validity supported by comparisons with local samples and ease of administration for large-scale screenings. However, the reviewed quantitative instruments also show some weaknesses, such as a limited range of motor tasks, a focus on coordination issues rather than overall MC, restricted applicability across age groups and limited relevance to key sports activities.

McCarron Assessment of Neuromuscular Development (MAND)

Originally designed as a screening and evaluation tool for clinicians, educators, allied health professionals and researchers, the MAND assesses children aged 3.5 to 18 years [61, 62]. The selection of included tests was informed by neuropsychological theory [63] and specific criteria, emphasising that disruptions in general or specific brain regions associated with motor functions can be detected through a series of motor tasks. The inclusion of both fine and gross motor tasks is based on McCarron's research, which suggests that deficits in these areas may serve as indicators of neurological dysfunction.

The MAND is an individually administered, norm-referenced assessment that includes both quantitative and qualitative measures. It evaluates five fine motor skills: (i) breads in a box (right and left hand), (ii) breads on a rod (eyes open and closed), (iii) finger tapping (right and left hand), (iv) nut and bolt (large and small bolt) and (v) rod slide (right and left hand); as well as five gross motor skills: (i) hand strength (right and left hand), (ii) finger/nose coordination (eyes open and closed), (iii) standing long jump, (iv) heel-toe walk (forwards and backwards) and (v) one-foot stand (eyes open and closed).

The assessment can be administered to individuals aged 3.5 to 18, requires minimal space and is suitable for individuals with disabilities, including wheelchair users. Importantly, it integrates both qualitative and quantitative components. However, there are some limitations. The assessment lacks a focus on manipulative skills, which are crucial for motor coordination, and many of its tests do not closely resemble familiar activities or sports for children, which could limit its relevance.

Motorische Basiskompetenzen (MOBAK-1 and MOBAK-3)

MOBAK [64, 65], which stands for basic motor competencies, is an assessment tool designed to evaluate the mastery of motor skills in specific contexts. The tool focuses on outcomes, emphasising the successful execution of motor skills to solve predefined problem situations. Notably, MOBAK distinguishes between basic motor competencies (MOBAK) and basic motor qualifications (MOBAQ) [66]. The former are not directly observable, whereas the latter are. Basic motor competencies (MOBAK) represent overall performance dispositions based on observable bhaviours linked to basic motor qualifications. Consequently, basic motor qualifications (MOBAQ) establish educational standards expressed as can-do statements (e.g., “can throw”, “can catch”), which describe students' performance.

MOBAK-3 is not a newer version of MOBAK-1, but rather the same test battery adapted for different age groups. MOBAK-1 is aimed at children aged 6 to 7 years, while MOBAK-3 targets those aged 8 to 9 years. Both assessments are similarly structured, divided into “object movement” and “self-movement” categories, incorporating similar movements with varying levels of complexity. For younger children, the battery includes tests for throwing, catching, bouncing and dribbling in the object movement category, and balancing, rolling, jumping and moving sideways in the self-movement category. For older children, the tests for the first subgroup are similar – throwing, catching, bouncing and dribbling – while the second subgroup includes balancing, rolling, rope skipping and variable movement.

Both MOBAK-1 and MOBAK-3 are easy to administer and quick to complete. While they assess all three components of MC – locomotor, manipulative and stability – there is an imbalance in the distribution of fundamental motor skills, particularly in locomotor skills.

Test of Motor Competence (TMC)

Developed in Norway in 2016, the TMC is an assessment battery divided into fine and gross motor tasks [67]. The fine motor skills component focuses on manual dexterity, while the gross motor tasks assess dynamic balance.

The first fine motor task involves a speed test for placing Duplo™ bricks. Participants are required to arrange the bricks on a 3 × 6 board as quickly as possible. Seated at a table, they complete a practice run before the actual test. The bricks are placed in rows of three with the active hand, while the other hand stabilises the board. Both hands are evaluated. The second fine motor task challenges participants to build a tower using twelve Duplo™ bricks as quickly as possible. Holding one brick in each hand, participants assemble the tower in the air without resting their arms on the table. Timing stops when the last brick is placed. This task, performed while seated, has been widely used in motor performance assessments.

The gross motor tasks include the tandem walk balance test and the figure-8 speed and agility test. The tandem walk task, adapted from the tandem walking test, measures dynamic balance. Participants walk 4.5 m along a straight line, placing their heel against the toes of the opposite foot with each step, as quickly as possible. The figure-8 test, also adapted from the original figure-of-eight test, requires participants to walk or run as quickly as possible in a figure-of-eight pattern around two marked lines. Line 1 is 1 m from the starting point, and Line 2 is 5.5 m away. Participants can choose their direction, and timing stops when they return to the starting point. All participants are required to wear appropriate footwear.

This battery is easy and quick to administer and has the advantage of covering a wide age range, from 5 to 83 years. However, it includes only one test for stability and one for locomotor skills, while manipulative skills are not assessed.

Motor Competence Assessment (MCA)

The MCA was developed to measure MC across the lifespan [68]. However, normative values are currently available only for individuals aged 3 to 23 years [69].

The assessment comprises six tests, divided into three subtests: locomotor, stability and manipulative (see Table 1). The locomotor category includes the standing long jump and the 10m shuttle run. The stability category encompasses lateral jumps and shifting platforms. The manipulative tests assess ball kicking velocity and ball throwing velocity. All normative values are dependent on age and sex.

This battery is both easy and quick to administer, making it suitable for use from childhood (3 years of age) through adulthood (23 years of age), although the authors intend for it to be applicable across the entire lifespan. Additionally, there is a balanced number of tests for each component of fundamental motor skills, with two tests for each category. However, like other product-oriented assessments, the MCA focuses solely on performance and does not account for the quality of movement.

Discussion

The aim of this review was to discuss why, when and how we should measure MC in children and adolescents. In summary, it is crucial to include MC assessments from an early age, with physical education classes providing an important context for these evaluations. Furthermore, MC assessment is recognised as a valuable tool for promoting sports participation, particularly in talent identification. By integrating both contexts, it is important to emphasise the positive relationship between MC and health outcomes, which can foster a lifelong commitment to physical activity for children and adolescents. Given the wide range of available test batteries, their selection should align with the evaluator's goals – whether the focus is on fine motor skills, gross motor skills or both. Moreover, it is essential to consider the age of the participants, the materials required for the assessment and the evaluation of the three pillars of fundamental movement skills: locomotor, stabilising and manipulative skills.

The rationale for assessing MC has been increasingly reinforced by recent studies, which highlight positive links between MC and health [17–19], as well as its role in distinguishing athletes and identifying future talent [26, 27]. Since the publication of Stodden et al. [14], which found a positive association between MC and physical activity, MC has received growing attention in public health [70]. Their model suggests that in early childhood, physical activity promotes MC, whereas in middle and late childhood, MC influences physical activity. A recent systematic review of longitudinal analyses examining the link between MC and health [71] found a strong negative association between weight status and MC, along with strong positive evidence supporting the path from MC to health-related fitness. The review also highlighted a bidirectional relationship between locomotor/coordination skills and fitness. However, the evidence for a pathway from MC to physical activity was inconclusive, and no evidence was found for the reverse. Furthermore, the relationship between MC and perceived MC lacked sufficient support. These conclusions were constrained by the cross-sectional nature of the studies and publication bias, emphasising the need for more robust longitudinal research that incorporates multiple variables and accounts for potential confounding factors. The connection between health outcomes has also been extended to encompass cognition and social-emotional behaviour. Hill et al. [18] proposed a conceptual model to guide research on the relationship between MC and cognitive and social-emotional development, emphasising the need to consider contextual and developmental influences. While many studies have explored this relationship without clear hypotheses or mechanisms, some evidence supports the link between MC, executive functions and academic performance. Future research should focus on designs that account for moderating factors to enhance understanding in this area.

To address the question of when to assess, recent literature, along with the new test batteries proposed (TMC and MCA), suggests that assessment should occur throughout life, in line with the concept of lifelong motor development [34, 25]. However, it is at younger ages where this assessment appears to be most important for early intervention, ensuring that the link to health is maintained throughout life. In this context, physical education classes play a key role in both intervention and assessment [33]. Additionally, the importance of MC in sports should not be overlooked, as recent publications on sports talent have identified MC as a discriminative factor for current and future athletes [26, 27]. Therefore, MC should be included in the test battery for identifying the next generation of elite athletes.

Regarding the origins of each assessment battery, it is clear that these tools were developed to identify delays or atypical patterns in the motor skill development of children [72–74]. Notably, while substantial motor deficits are often diagnosed before the age of two, milder deficits may not become evident until children reach preschool or primary school, when they encounter more complex tasks and are assessed against their peers [75].

An analysis of Table 1 reveals that nearly all assessment batteries prioritise product-oriented measures. This trend may stem from the relative ease of scoring product outcomes, as these measures tend to be less time-intensive and require less specialised training compared to process-oriented assessments [76]. Process-oriented assessments, on the other hand, rely on specific technical criteria that must be present or absent during a participant's movement execution. Qualitative methods allow for a more precise distinction between different stages of skill development, thus providing valuable insights to educators regarding specific skill components that a student may need to practise [77]. However, scoring process-oriented assessments often requires additional training, as evaluations can vary depending on the evaluator's level of expertise [78]. This raises the question of whether there is an ideal performance pattern. Traditionally, motor expertise has been defined as the ability to consistently replicate a specific movement pattern, thereby enhancing the automaticity of movement and minimising patterns deemed counterproductive to accurate execution. However, it is recognised that even elite athletes are unable to reproduce an identical movement pattern consistently, despite years of practice [77], demonstrating that exact movement repetition is unachievable.

An analysis of the fundamental movement skills within the batteries shows that locomotor skills are included in at least one test across all batteries. Manipulative or object control skills are present in nearly all assessments, except for the KTK (first version) and MAND. Stability skills, however, are not clearly analysed in the TGMD-3, while fine motor skills are incorporated in the BOT-2, PDMS-2, MOT 4-6, M-ABC-2, MAND and TMC. This variability among batteries seems to reflect the broad range of definitions surrounding the concept of MC and its components, potentially contributing to the lack of a definitive standard for assessing movement skill development.

Finally, a critical consideration when selecting an assessment battery is the role of the environment in human development [35]. Age- and sex-specific normative values, as well as the validation of assessments for specific populations, are essential factors for ensuring relevance and accuracy in different contexts. Recently, attention has been drawn to this topic, highlighting challenges related to the validity of traditional assessments of general MC in children, as these assessments often rely on isolated movement tasks (e.g., running, jumping, throwing) performed out of context [79]. Moreover, the literature remains unclear on whether having more tests within the same category truly enhances the information we can obtain about a subject's MC or whether they are redundant tests that do not add much value. For instance, the PDMS-2 and BOT-2 batteries include several tests for the same category, and while noticeable changes occur in the early years of life – which may justify a greater number of tests (as in the case of the PDMS-2, which assesses from birth to 6 years old) – there may be overlap in assessing the same content. Therefore, batteries with 3 to 6 tests that encompass fundamental movement skills could be used to assess gross motor coordination (such as the KTK3+, MAND, MOBAK-1, MOBAK-3 and MCA), while batteries that assess both fine and gross motor skills would be preferable, as they are more comprehensive, such as the MOT 4-6 and M-ABC-2, although all have their pros and cons.

Future directions

In the future, it will be essential to clarify the concepts related to MC to ensure that the entire scientific community can communicate using a unified language. This clarification will help to better understand the validity of various test batteries, as many are developed sequentially without critically examining the foundational concepts. Additionally, there is a need to increase research that employs the same test battery across identical subjects to identify which assessments are the most sensitive and determine whether they all measure the same constructs effectively. Consideration of the ecological validity of these tests is also important, as it promotes a connection between the assessments and the contexts in which they will be applied (e.g., country, sports level and specific sporting environments). Finally, it would be beneficial to advocate for the functional use of test batteries, not only as tools for characterisation but also for intervention purposes.

Ethical approval

The conducted research is not related to either human or animal use.

Informed consent

Informed consent has been obtained from all individuals included in this study.

Conflict of interest

The authors state no conflict of interest.

Disclosure statement

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