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Relationship of motor competence with parental factors, physical activity and temperament in children – A systematic review

Relación de la competencia motora con los factores parentales, la actividad física y el temperamento en niños: una revisión sistemática

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Abstract
This systematic review analyzes the relationship between actual and perceived motor competence, parental factors, physical activity, and temperament in preschoolers and school-aged children with typical development. A search for articles published between 1995 and 2025 was conducted on August 13, 2024, and repeated on January 31, 2025, to update the review, across PubMed, ScienceDirect, PsycINFO, Web of Science, Scopus, Medline, and Education Resources Information Center. Out of 2233 articles, 24 met the inclusion criteria. The results regarding preschoolers, showed inconsistencies between variables. For school-aged children, actual motor competence was positively correlated with physical activity, and perceived motor competence also showed a positive association with physical activity. Additionally, a strong positive association was observed between actual and perceived motor competence. No relationships were observed between motor competence and temperament, nor were parental factors. Understanding how individual and contextual factors relate to motor competence offers valuable insight into early motor development and highlights directions for future research.

Keywords: motor skills; children; activity; parenting.

Resumen
Esta revisión sistemática analiza la relación entre la competencia motora real y percibida, los factores parentales, la actividad física y el temperamento en niños en edad preescolar y escolar con desarrollo típico. Se realizó una búsqueda de artículos publicados entre 1995 y 2025 el 13 de agosto de 2024 y se repitió el 31 de enero de 2025 para actualizar la revisión, en las bases de datos PubMed, ScienceDirect, PsycINFO, Web of Science, Scopus, Medline y Education Resources Information Center. De 2233 artículos, 24 cumplieron los criterios de inclusión. Los resultados en niños en edad preescolar mostraron inconsistencias entre las variables. En los niños en edad escolar, la competencia motora real se correlacionó positivamente con la actividad física, y la competencia motora percibida también mostró una asociación positiva con la actividad física. Además, se observó una fuerte asociación positiva entre la competencia motora real y percibida. No se observaron relaciones entre la competencia motora y el temperamento, y los factores parentales no fueron examinados em los estúdios incluidos. Comprender cómo los factores individuales y contextuales se relacionan con la competencia motora ofrece una visión valiosa del desarrollo motor temprano destaca direciones para futuras investigaciones.

Palabras clave: habilidades motoras; niños; actividad; crianza.

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Introduction

Motor competence (MC) is crucial for a child's development, supporting cognitive, linguistic, social, and emotional growth. MC correlates with higher levels of physical activity (PA) and improved competence perceptions during adolescence (Kuzik et al., 2020), as well as heightened levels of PA and perception of motor competence (PMC) during adolescence (Webster et al., 2019). MC encompasses both fine motor skills (precise movements for object manipulation) and gross motor skills (movements for transportation and object handling) (Bardid et al., 2021). Gross motor skills are divided into locomotor skills (Loc), like running and jumping, and object control skills (OC), like striking and throwing (Bolger et al., 2020). MC includes actual motor competence (AMC), children's demonstrated ability to perform a particular task, and PMC, that refers to their self-perception of their capability to accomplish the same task (Gao et al., 2019). MC development is influenced by morphological, physiological, and neuromuscular factors, as well as social contexts like family and school. Preschool period is widely regarded as the most critical phase for the development of motor skills (De Niet et al., 2021; Wang et al., 2020).

Bandura's (1997) social cognitive theory proposes a triadic reciprocal influence model to explain the factors influencing children's outcomes. This model highlights the dynamic interplay between personal factors (e.g., parent's self-efficacy), agent behaviour (e.g., parenting practices), and the environment (e.g., family networks). According to this theory, its essential to consider multiple factors, including psychosocial and physical environments, individual characteristics, and the behaviour of individuals engaging in PA. Current understanding widely acknowledges the significant influence of family behavior on child behavior development (Wu, 2024). Family behavior encompasses a diverse range of factors that can influence both intellectual and motor development during infancy and childhood (Wang et al., 2020), including their interactions and attitudes towards PA, significantly impact the time and effort invested in children's development (Derikx et al., 2021; Wang et al., 2020). This includes not only direct interactions with children but also the attitudes and behaviors parents demonstrate towards various aspects of their children's lives, including PA (Ha et al., 2009; Kamionska et al., 2023).

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Several factors influence MC development in early childhood, including the interaction between children's behavior, temperament, and family environment. Temperament, defined as inherent personality traits with biological roots, affects parent-child interactions (Ferreira et al., 2021). A recent study (Nakagawa et al., 2024) investigated the associations between temperament and motor development in children aged 6 to 42 months. The results indicated that temperamental traits such as surgency and effortful control positively influenced both fine and gross motor development, while negative affectivity had a negative effect on this development. Child temperament plays a crucial role in shaping a child's developmental path, as it can either make them more receptive to or resistant to parental influences. Earlier research has highlighted that child temperament significantly influences the dynamics of parent-child interactions. Parents act as behavioral models, with their attitudes, reactions being observed and imitated by their children. The interaction between a child's temperament and parenting style significantly contributes to shaping the child's behavior over time. The family environment, together with learned behaviors and the child's personal characteristics, forms a system of mutual influences (Ferreira et al., 2021). Indeed, there is evidence that a child's temperament or individual reaction style is associated with their level of PA (Song et al., 2017). These findings highlight the importance of temperament in the progression of motor skills during early childhood.

Parental factors in the analysis of children's MC are essential, as motor development does not depend solely on biological aspects or the child's temperament, but also on the environment in which the child is immersed. Parents and caregivers play a crucial role as facilitators or limiters of motor opportunities. Encouragement of movement, provision of active play, and encouragement of PA are conditions directly influenced by parental attitudes. Moreover, according to Bandura (1997), behavior is largely learned through observation and imitation of significant models – such as the parents themselves. Physically active parents or those who demonstrate value for motor skills tend to promote similar behaviors in their children. Recent study (Martins et al., 2023), reinforce this view, showing that affectionate and encouraging parenting styles are associated with higher levels of MC, while less stimulating family environments may contribute to difficulties in the development of these skills. Therefore, understanding how

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parents interact with their children and adapt to their temperament allows for a more comprehensive and effective approach to support children's motor development. However, there is a lack of further investigation about the matter.

Harter (1985) proposed that PMC, influenced by AMC, significant shapes a child's motivation for PA. Stodden et al. (2008) also suggested that AMC and PMC impact PA and movement experiences, with AMC in early childhood being crucial for driving PA. As children engage in PA, their PMC increases, enhancing their motivation. The reciprocal relationship between MC and PA is particularly strong in early childhood, influenced by factors like the environment and parental influences (Harter, 1985). At this stage, MC is still developing, and PMC may be exaggerated, leading to limited research on PMC in young children. As children grow, PMC aligns more with their actual motor abilities (Stodden, 2008), and older children with lower MC may be more likely to refuse PA (Harter, 1985). A study investigated the relationship between PMC and PA practice in adolescents, considering the differences based on weight status. The results indicated that PMC could influence PA levels, particularly in adolescents with different weight statuses (Royo et al., 2021). De Meester et al. (2020) reviewed the relationship between AMC and PMC, concluding that the association is low to moderate among youth and does not vary by sex. Moreover, the degree of alignment between the measures of MC and PMC did not significantly affect the strength of this association. While the AMC-PA link is well-established, studies on young children show varied associations.

Both AMC and PMC significantly influence children's willingness to engage in PA. When children feel confident in their motor skills, they are more likely to participate in sports and games, which in turn contributes to their overall physical health, cognitive development, and social skills in children and adolescents (Goodway et al., 2019). Research supports the idea that enhancing children's motor skills can lead to increased PA, which is crucial for their development (De Niet et al., 2021).

Many variables have been studied in relation to MC, for example, in study by Molina-Márquez and colleagues (2025), they explored AMC and PMC in Chilean primary school students, using maximum height velocity as a parameter. The results provided insights into the discrepancies between AMC and PMC among the students. Carrasco-López and colleagues (2025), investigate the applicability of Body Mass Index

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(BMI) and the Tri-Ponderal Index (TPI), as tools to assess MC in schoolchildren. The results suggest that both BMI and TPI are useful tools for evaluating the relationship between body composition and MC. Also, Almeida et al. (2023), explored different profiles of AMC and the accuracy of PMC in children. Findings revealed that children with higher MC and accurate PMC also had better physical fitness and lower body fat.

Barnett and colleagues (2016) conducted a review to examine de correlates of gross MC among children aged 3 to 18 years. The findings revealed that age was positively associated with AMC, with older children demonstrating higher levels across all skill domains. PA participation was positively correlated with gross MC. However, evidence regarding psychological and cognitive influences was limited and highlights the need to consider individual, behavioral and contextual factors.

Currently it appears that there is a gap in the study of the relationship between MC, including both AMC and PMC, parental factors (PF), PA and temperament, specifically concerning preschool and school-aged children. While there is existing research demonstrating the association between the development of MC and regular PA engagement with various health benefits, the specific interplay among these factors in the context of young children's development remains relatively understudied. This systematic review seeks to address the existing gap in the literature by examining how various factors, including AMC, PMC, PF, PA and temperament, interrelate in children with typical development.

Materials and methods

This systematic review followed the guidelines defined in the Preferred Reporting Items for Systematic Reviews and Meta-analysis (PRISMA) (Moher, 2010). The review was registered with PROSPERO, the International Prospective Register of Systematic Reviews, with the registration number CRD42020215399. Searching for relevant studies was conducted on multiple databases, including Pubmed, ScienceDirect, PsycInfo, Web of Science, Scopus, Medline, and Education Resources Information Center. The initial search was conducted on August 13, 2024, and it was repeated on January 31, 2025, to update the review. Search strategy included the following search keywords presented in table 1. Truncation with an asterisk was used to search for variants of word endings,

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enhancing the comprehensiveness of the search. Dissertations, conference abstracts, reviews and theses were not included. In addition, a snowballing literature search technique was employed to identify additional relevant references beyond the initial search results.

Table 1. Search strategy

Group search 1 (Child* OR Children OR Infant* OR Childhood OR Preschool* OR Infancy OR Toddlers OR Kindergarten* OR School aged children OR Primary aged children)
Group search 2 (Motor competence OR Locomotor play OR Locomotor exercise play OR Locomotor skill OR Gross motor skills OR Manipulative skills OR Motor proficiency OR Fundamental motor skills OR Fundamental movement skills OR Fundamental motor patterns OR Motor skill OR Motor development OR Motor ability OR Motor performance OR Motor Coordination OR Motor proficiency OR Motor learning OR Motor practice OR Motor fitness OR Fine motor skills OR Movement patterns OR Physical literacy OR Psychomotor skills OR Motor function)
Group search 3 (Perceived motor competence OR Perception of locomotor play OR Self-perceived locomotor exercise play OR Estimation motor proficiency OR Judgment fundamental motor skills OR Self-perceptions fundamental movement skills)
Group search 4 (Physical activity play OR Exercise play OR Locomotor play OR Rough and tumble play OR Physical activity behavior OR Recreation OR Outdoor play OR Play-fighting OR Chase games OR Free play OR Playful activity OR Superhero play OR Wrestling OR Protect games OR Rescue games OR Pretend fighting OR Indoor play)
Group search 5 (Parental stress OR Parental expectations OR Parental alliance OR Parental style OR Parental role OR Parenting practice OR Parental attitudes OR Parent beliefs)
Group search 6 (Temperament OR Internalized symptoms OR Externalized symptoms)
Combination's search: Combination 1 (Group 1+ Group 2+ Group 3+ Group 4); Combination 2 (Group 1+ Group 2+ Group 3+ Group 5); Combination 3 (Group 1+ Group 2+ Group 3+ Group 6).

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Combination 1	Combination 2	Combination 3
(Child* OR Children OR Infant* OR Childhood OR Preschool* OR Infancy OR Toddlers OR Kindergarten* OR School aged children OR Primary aged children) AND (Motor competence OR Locomotor play OR Locomotor exercise play OR Locomotor skill OR Gross motor skills OR Manipulative skills OR Motor proficiency OR Fundamental motor skills OR Fundamental movement skills OR Fundamental motor patterns OR Motor skill OR Motor development OR Motor ability OR Motor performance OR Motor Coordination OR Motor proficiency OR Motor learning OR Motor practice OR Motor fitness OR Fine motor skills OR Movement patterns OR Physical literacy OR Psychomotor skills OR Motor function) AND (Perceived motor competence OR Perception of locomotor play OR Self-perceived locomotor exercise play OR Estimation motor proficiency OR Judgment fundamental motor skills OR Self-perceptions fundamental movement skills) AND (Physical activity play OR Exercise play OR Locomotor play OR Rough and tumble play OR Physical activity behavior OR Recreation OR Outdoor play OR Play-fighting OR Chase games OR Free play OR	(Child* OR Children OR Infant* OR Childhood OR Preschool* OR Infancy OR Toddlers OR Kindergarten* OR School aged children OR Primary aged children) AND (Motor competence OR Locomotor play OR Locomotor exercise play OR Locomotor skill OR Gross motor skills OR Manipulative skills OR Motor proficiency OR Fundamental motor skills OR Fundamental movement skills OR Fundamental motor patterns OR Motor skill OR Motor development OR Motor ability OR Motor performance OR Motor Coordination OR Motor proficiency OR Motor learning OR Motor practice OR Motor fitness OR Fine motor skills OR Movement patterns OR Physical literacy OR Psychomotor skills OR Motor function) AND (Perceived motor competence OR Perception of locomotor play OR Self-perceived locomotor exercise play OR Estimation motor proficiency OR Judgment fundamental motor skills OR Self-perceptions fundamental movement skills) AND (Parental stress OR Parental	(Child* OR Children OR Infant* OR Childhood OR Preschool* OR Infancy OR Toddlers OR Kindergarten* OR School aged children OR Primary aged children) AND (Motor competence OR Locomotor play OR Locomotor exercise play OR Locomotor skill OR Gross motor skills OR Manipulative skills OR Motor proficiency OR Fundamental motor skills OR Fundamental movement skills OR Fundamental motor patterns OR Motor skill OR Motor development OR Motor ability OR Motor performance OR Motor Coordination OR Motor proficiency OR Motor learning OR Motor practice OR Motor fitness OR Fine motor skills OR Movement patterns OR Physical literacy OR Psychomotor skills OR Motor function) AND (Perceived motor competence OR Perception of locomotor play OR Self-perceived locomotor exercise play OR Estimation motor proficiency OR Judgment fundamental motor skills OR Self-perceptions fundamental movement skills) AND (Temperament OR

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Playful activity OR Superhero play OR Wrestling OR Protect games OR Rescue games OR Pretend fighting OR Indoor play)	expectations OR Parental alliance OR Parental style OR Parental role OR Parenting practice OR Parental attitudes OR Parent beliefs)	Internalized symptoms OR Externalized symptoms)

Process for study inclusion

Two authors independently assessed eligibility based on the following inclusion criteria: (1) studies in English, Portuguese, or Brazilian Portuguese; (2) randomized control trials, cross-sectional, or longitudinal studies; (3) studies examining MC (actual and perceived) and at least one of these variables – PA, PF, child temperament; (4) studies with preschool and/or school-aged children (ages 5-12, attending elementary school) with typical development; (5) studies published between 1995 and 2025; (6) studies evaluating child PA using objective measures (e.g. accelerometers) or subjective measures (e.g., questionnaires); (7) studies reporting total or individual domains of AMC scores (e.g., Loc skills). Exclusion criteria included: (1) PA assessed only through organized activities; (2) studies not evaluating direct associations between variables; (3) PMC assessed by parents; (4) PA measured for less than 3 days using accelerometers or pedometers, with a maximum recording time of 5 hours; (5) PA assessed over 6 months ago using questionnaires.

Study selection and data extraction

Initial database and snowballing literature searches were conducted by the first author (LC). Duplicates were removed, and articles were filtered on title and abstract using the predefined inclusion and exclusion criteria by two authors (LC and GA). When doubts emerged or insufficient information was available, the full text of articles was analyzed by a third author (JM). The START platform was used as a database for identified articles. Full-text articles were screened by two authors, with a third author brought in to resolve any disagreements or doubts. Standardized data extraction was performed to collect relevant information from each included study (authors, publication

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year, study design, number of participants, age, gender, constructs associated, instruments used and study findings).

Criteria for Risk of Bias Assessment

Three authors assessed the risk of bias in the selected studies. The criteria for assessing risk of bias were adapted from the Strengthening the Reporting of Observation Studies in Epidemiology (STROBE) (Vandenbroucke et al., 2007) statement, as presented in De Meester et al. (2020) study. As done by these authors, eight essential criteria were used to assess the risk of bias in each identified study, adapted to the study design. Each criterion was independently assessed by two authors scoring '1' for low risk of bias or '0' for high risk of bias. Prior to starting the scoring, five studies were assessed by all authors to create clear criteria and ensure optimal agreement. Differences in assessment were discussed and resolved through meetings, leading to refinements in the assessment criteria. Another set of five studies were then assessed by all three authors using the refined criteria and any remaining ambiguities were discussed in a second meeting. Additional adjustments to the criteria were made based on the discussions during the meeting. Subsequently, all remaining studies were divided among the three authors, with each criterion being assessed by one author and double-checked by two authors. In case of disagreement, the final decision was made by two authors during a meeting. The final version of the eight criteria for risk of bias assessment is presented in Table 2.

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Table 2. Summary of the assessment criteria of the risk of bias (From De Meester, 2020 with permission)

1.	Were the schools and/or participants randomly selected from the target population? '1' The sample was randomly selected from the target population. '0' Convenience sampling was used OR the process of random sampling was not adequately described.
2.	Did the study report the sources and details of RMC assessment and were valid measure used for all RMC assessments? '1' The study reported the sources and details of the assessment (i.e., at least the name and reference of an existing, previously validated test battery was used OR, if not, a clear description of the assessment was provided) AND used valid measurements (if there is available information about the validation of the instrument in the same age group OR provides other validation data in the manuscript). '0' The study did not report the sources and details of assessment AND/OR used at least one measurement that had not been validated for the study population.
3.	Were reliable measures for all RMC assessments used? '1' The study used reliable measurements (if there is available information about the reliability statistics of the instrument OR provides other reliability data in the manuscript). '0' The study did not used reliable assessments OR at least one of the reliability assessments was not accepted.
4.	Did the study report the sources and details of PMC assessment and were valid measure used for all PMC assessments? '1' The study reported the sources and details of the assessment (i.e., at least the name and reference of an existing, previously validated test battery was used OR, if not, a clear description of the assessment was provided) AND used valid measurements (if there is available information about the validation of the instrument in the same age group OR provides other validation data in the manuscript). '0' The study did not report the sources and details of assessment AND/OR used at least one measurement that had not been validated for the study population.
5.	Were reliable measures for all PMC assessments used? '1' The study used reliable measurements (if there is available information about the reliability statistics of the instrument OR provides other reliability data in the manuscript). '0' The study did not used reliable assessments OR at least one of the reliability assessments was not accepted.
6.	Did the study report the sources and details of PAP/temperament assessment and were valid measure used for all PAP/temperament assessments? '1' The study reported the sources and details of the assessment (i.e., at least the name and reference of an existing, previously validated test battery was used OR, if not, a clear description of the assessment was provided) AND used valid measurements (if there is available information about the validation of the instrument in the same age group OR provides other validation data in the manuscript). '0' The study did not report the sources and details of assessment AND/OR used at least one measurement that had not been validated for the study population.
7.	Were reliable measures for all PAP/temperament assessments used? '1' The study used reliable measurements (if there is available information about the reliability statistics of the instrument OR provides other reliability data in the manuscript). '0' The study did not used reliable assessments OR at least one of the reliability assessments was not accepted.
8.	Did an adequate proportion of the initial sample have completed data for the RMC, PMC and PAP/temperament measurements? '1' The study clearly described (or it is obvious from the tables) that no more than 20% of data was missing from a cross-sectional study and no more than 30% from a longitudinal study? OR whenever no drop out has been reported, it is assumed that all have completed data. '0' 20% or more of data was missing from a cross-sectional study and 30% or more was missing from a longitudinal study.

RMC – Real Motor Competence, PMC – Perceived Motor Competence, PAP – Physical Activity Play.

Results

The systematic review search, which included selected databases and additional sources like forward and backward referencing, yielded 2233 articles. After removing duplicates, 1628 articles remained. Title and abstract screening by two reviewers excluded 1521 articles, leaving 107 potentially eligible articles. After in-depth analysis

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and applying the inclusion and exclusion criteria, 24 articles were selected for data extraction (Figure 1).

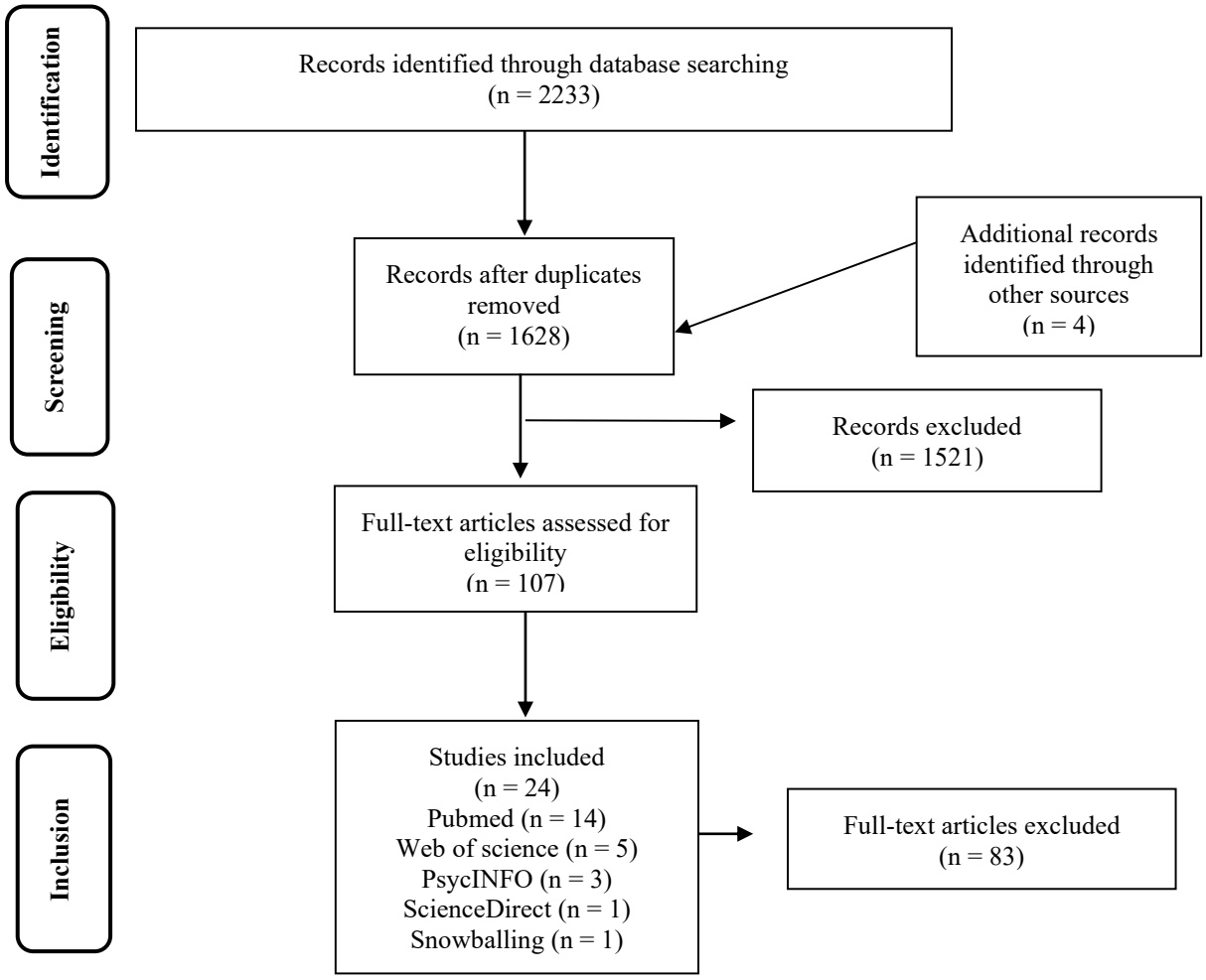

Figure 1. PRISMA flow diagram.

Study characteristics

The review includes 24 studies published in English between 2012 and 2024, across four continents: Europe (n=6), North and South America (n=7), Oceania (n=4), and Asia (n=7). Of these, 21 were cross-sectional (7 preschoolers, 14 school-aged children) and 3 were longitudinal (1 preschoolers, 2 school-aged children). Sample sizes varied: 2 studies had 26-50 participants, 9 had 101-200, 4 had 201-300, and 9 had ≥301. Studies focused on preschoolers (3-5/6 years, n=8) and school-aged children (6/7-12 years, n=16), with one study including both groups. One study included only males, three only females, and 20 included both genders. Tables 3 and 4 provide further details.

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Table 3. Overview of the included studies – preschool aged children.

Study	Country	Sample and Design	Constructs associated*	Instruments	Findings
Capio et al., 2021 [1]	Japan	N = 230 (girls n=121, boys n=109; M_{age}= 67.41 months, SD = 8.16) Cross-sectional	AMC PMC PA	TGMD-2 (Loc, OC) PSPCSA (PPC) Pedometers (Daily step counts)	Loc (PPC): r= 0.43**, Loc (Daily step counts): r= (n.s.) OC (PPC): r= 0.25*, β=0.28* OC (Daily step counts): r= 0.29**, β=0.18* PPC (Daily step counts): r= - 0.28*, β= -0.31*
Crane et al., 2015 [2]	Canada	N = 116 (girls n=49, boys n=67; M_{age}= 5 years 7 months) Cross-sectional	AMC PMC PA	TGMD-2 (Loc, OC) PSPCSA (PPC) Accelerometers (MVPA)	OC (MVPA): β=0.281 Loc (MVPA): β= (n.s.) PPC did not mediate the relationship between MVPA and OC.
***Feitoza et al., 2022 [3]** ***results for preschool and school-aged children**	Brazil	N = 379 (girls n=171, boys n=208; Age: 4-10 years; M_{age}=8.2, SD = 1.7 years) Early childhood N = 105 Middle Childhood N = 274 Cross-sectional	AMC PMC PA	TGMD-2 (TMC, Loc, OC) PSPMSC Children's Leisure Activities Study Survey (leisure time physical activity)	<u>Early childhood</u> PA (TMC, Loc, OC): r= (n.s) PA (PSPMCS total, Loc, OC): r= (n.s) PSPMCS Total (TMC, Loc, OC): r= (n.s) PSPMCS Loc (TMC, Loc, OC): r= (n.s) PSPMCS OC (TMC, Loc, OC): r= (n.s) <u>Middle childhood</u> (analyzed in school-aged children results) PA (TMC, Loc, OC): r= (n.s) PA (PSPMCS total): r= 0.17* PA (PSPMCS Loc): r= 0.13* PA (PSPMCS OC): r= 0.14* PSPMCS total (TMC): r= -0.18* PSPMCS total (Loc): r= -0.14* PSPMCS total (OC): r= -0.15* PSPMCS Loc (TMC, OC): r= -0.17* PSPMCS Loc (Loc): r= (n.s) PSPMCS OC (TMC): r= -0.13* PSPMCS OC (Loc): r= -0.14* PSPMCS OC (OC): r= (n.s)
Hall et al., 2019 [4]	UK	N = 38 (girls n=14, boys n=24; M_{age}= 5.37, SD = 0.79) Cross-sectional	AMC PMC PA	TGMD-2 (TMC, Loc, OC) PSPMSC Accelerometers (TPA, MVPA)	No significant associations were found.
He et al., 2021 [5]	Japan	N = 148 (girls n=63, boys n=85; M_{age}= 4.52, SD = 0.67 years) Cross-sectional	AMC PMC PA	TGMD-2 (TMC, Loc, OC) PSPSCA (PPC, Ploc, POC) Accelerometers (LMVPA, MVPA)	TMC (PPC, Ploc, PPC): r= 0.206*, r= 0.171*, r= 0.179* TMC (MVPA): r= 0.246**, β= 0.228 TMC (LMVPA): r= 0.252** Loc (PPC, Ploc, POC): r= 0.223**, r= 0.165*, r= 0.213** Loc (MVPA, LMVPA): r= (n.s.) OC (PPC, Ploc): r= 0.172*, r= 0.168* OC (POC): r= (n.s.) OC (MVPA): r= 0.192*

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					OC (LMVPA): r= 0.210* PPC, Ploc, POC (MVPA, LMVPA): r= (n.s.)
Lopes et al., 2016 [6]	Portugal	N = 101 (girls n=48, boys n=53; M_{age}= 4.9, SD = 0.93 years) Cross-sectional	AMC PMC PA	M-ABC-2 (Bal, BS) PSPSCA (PPC) Accelerometers (MVPA)	PPC (Bal): r= 0.19* PPC, MVPA (BS): r = (n.s.) MVPA (Bal): r = (n.s.) MVPA (PPC): r = (n.s.) There are no predictor variables in the models for BS, Bal, and MVPA.
Mancini et al., 2017a [7]	Australia	Time 1 – baseline N = 197 (girls n=95, boys n=102; M_{age}= 5.40, SD = 0.30 years) Longitudinal	AMC PMC Temperament	BOT-2SF (TMC) PSPCSA (PPC) SDQ (Peer Problems) Social Skills Rating System (Internalizing Problems)	(Baseline) Peer Problems (TMC): r=−0.299**, β=−0.061* Internalizing Problems (TMC): r=−0.168*, β= (n.s) Internalizing Problems (PPC): r = (n.s.) PPC (TMC): r = (n.s.)
Robinson et al., 2012 [8]	USA	N = 34 (girls n=22, boys n=12; M_{age}= 57, SD = 6.31 months) Cross-sectional	AMC PMC PA	TGMD-2 (Loc, OC) PSPSCA (PPC) Pedometers (3-day steps-min)	Loc (3-day steps-min): r= 0.461* Loc (PPC): r= 0.465* OC (3-day steps-min): r= 0.435* OC (PPC): r= (n.s) Loc accounted for a significant amount of variance for the 3-day steps-min (R^2 = 0.213) in school-day PA.

Table 4. Overview of the included studies – school-aged children.

Study	Country	Sample and Design	Constructs associated*	Instruments	Findings
Bolger et al., 2019 [9]	Ireland	N = 419 (total) First class group N = 202 (M_{age}= 6.5, SD = 0.6 years) Fourth/Fifth class group N = 217 (M_{age}= 10.4, SD = 0.6 years) Cross-sectional	AMC PMC PA	TGMD-2 (TMC) PSPMSC Accelerometers (MVPA)	PSPMSC OC e PSPMSC Total was a significant predictor of the variance in MVPA.
Chai et al., 2023 [10]	China	N = 532 (girls n=248, boys=284; M_{age}= 9.37, SD = 1.8 years) Cross-sectional	AMC PMC PA	TGMD-3 (TMC) PSPMSC Physical Activity Questionnaire for Older Children (PAQ-C)	High results for AMC and PMC associated with high PA levels. Lower correspondence had lowest PA levels.
Chan et al., 2018 [11]	China	N = 763 (girls n=474, boys=289; M_{age}= 9.3, SD = 1.7 years) Cross-sectional	AMC PMC	TGMD-2 (Loc, OC) PSPCSA and SPPC (perceived physical competence – PPC and PMSC)	Loc (MVPA, TPA, PPC, PMSC): r= (n.s.) OC (MVPA, TPA, PPC, PMSC): r= (n.s.) MVPA (PPC): r=0.22** MVPA (PMSC): r=0.30**, β=0.59* TPA (PPC): r=0.37**, β=(n.s.)

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			PA	Accelerometers (MVPA) PAQ-C (TPA)	TPA (PMSC): r=0.35**, β=(n.s.)
Crane et al, 2023 [12]	Canada	N = 129 (girls n=62, boys=67; M_{age}= 8.3 years) Cross-sectional	AMC PMC PA	TGMD-2 (Loc, OC) PSPCSA and SPPC (PPC) Accelerometers (MVPA)	<u>Boys</u> OC (MVPA): β= 0,34* OC (PPC): β= (n.s.) Loc (MVPA, PPC): β= (n.s.) PPC (MVPA): β= (n.s.) <u>Girls</u> OC (MVPA, PPC): β= (n.s.) Loc (MVPA, PPC): β= (n.s.) PPC (MVPA): β= (n.s.)
Estevan et al., 2022 [13]	Spain	Time 1 – baseline N = 124 (girls n=56, boys n=68; Age: 5-10 years; M_{age}=7.4, SD = 1.3 years) Longitudinal	AMC PMC PA	TGMD-3 (Loc, OC) PSPMCS Accelerometers (LPA, MVPA)	MVPA (TMC, Loc, OC): r=0.30**, r=0.28**, r=0.20* MVPA (PSPMCS Loc, PSPMCS OC, PSPMCS total): r= (n.s) LPA (TMC, Loc, OC): r= (n.s) LPA (PSPMCS total, PSPMCS BS): r= (n.s) LPA (PSPMCS Loc): r= 0.19* TMC (PSPMCS total, PSPMCS Loc, PSPMCS OC): r= 0.30**, r= 0.24**, r= 0.28** Loc (PSPMCS total, PSPMCS OC): r= 0.22**, r= 0.21** Loc (PSPMCS Loc): r= (n.s) OC (PSPMCS total): r= 0.26** OC (PSPMCS Loc, PSPMCS OC): r= 0.23**
Gu et al., 2017 [14]	USA	N = 262 (girls n=129, boys n=33; M_{age}= 10.87, SD = 0.77 years) Cross-sectional	AMC PMC PA (Self-reported)	PE Metrics (TMC; Gymnastics/LOC; Soccer/OC) Self-report questionnaire (PPC) Godin Leisure-Time Exercise Questionnaire – LTPAQ (Leisure-time Physical Activity)	Leisure-time Physical Activity (PPC): r=0.30** Loc (PPC): r=0.21** OC (PPC): r=0.38** Loc (Leisure-time Physical Activity): r = (n.s.) OC (Leisure-time Physical Activity): r=0.24** TMC (PPC): r=0.38** TMC (Leisure-time Physical Activity): r=0.21**
Khodaverdi et al., 2013 [15]	Iran	N = 352 (girls; M_{age}= 8.7, SD = 0.3 years) Cross-sectional	AMC PMC PA	TGMD-2 (TMC) Self-Description Questionnaire-1 – SDQ-1 (PPC) (physical ability sub-scale) PAQ-C (MVPA)	TMC (MVPA): r=0.39**, β = 0.339** PPC (MVPA): r=0.33**, β = 0.225** TMC (PPC): r=0.22*
Khodaverdi et al., 2015a [16]	Iran	N = 352 (girls; M_{age}= 8.7, SD = 0.32 years) Cross-sectional	AMC PMC PA	TGMD-2 (TMC, Loc, OC) Self-Description Questionnaire-1 – SDQ-1 (PPC) PAQ-C (MVPA)	Loc (MVPA)β =0.32** PMC (MVPA) β =0.28** Loc (PPC) β =0.22** OC (PPC): r= (n.s.) Loc (PPC): r=0.22** TMC (PPC): r=0.22** MVPA (PPC): r=0.33** MVPA (OC): r= (n.s) MVPA (TMC, Loc): r=0.39**, r=0.44**

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					There was an effect of Loc on MVPA mediated by PMC
Khodaverdi et al., 2015b [17]	Iran	N = 352 (girls; M_{age}= 8.76, SD = 0.32 years) Cross-sectional	AMC PMC PA	TGMD-2 (Loc, OC) Self-Description Questionnaire-1 – SDQ-1 (PPC) PAQ-C (MVPA)	MVPA (Loc): r=0.447**, β= 0.648** MVPA (OC): r= 0.135* MVPA (PPC): r=0.332**, β= 0.117** Loc (PPC): r= 0.220** OC (PPC): r= 0.119*
Mancini et al., 2017b [18]	Australia	N = 164 (girls n=83, boys n=81; M_{age}= 9.93, SD = 1.10 years) Cross-sectional	AMC PMC Temperament	M-ABC-2 (TMC) SPPC (Perceived Athletic competence) SDQ-P (Peer and Internalizing problems)	Perceived Athletic Competence (TMC): r = (n.s.), β= 0.0688* Peer problems (TMC): r=−0.183*, β =−0.0231* Internalizing problems (TMC): r=−0.294*, β =−0.0391* Peer problems (Perceived Athletic Competence): r = (n.s.) Internalizing problems (Perceived Athletic Competence): r=−0.447**, β = (n.s.)
Morgan et al., 2008 [19]	Australia	N = 137 (girls n=79, boys n=58; M_{age}= 8.3, SD = 1.1 years) Obese Children Cross-sectional	AMC PMC PA	TGMD-2 (TMC, Loc, OC) PSPCSA, SPPC (PPC) Accelerometers (CPM, MPA, VPA)	Boys MPA (TMC, Loc, OC): r=0.46**, r=0.28*, r=0.50** MPA (TMC): r=0.46** MPA (PPC): r = (n.s.) VPA (OC): r=0.53** β =0.38** VPA (TMC, Loc): r=0.49**, r=0.31* VPA (PPC): r = (n.s.) CPM (OC): r=0.50** β =0.50** CPM (TMC, Loc): r=0.44**, r=0.24* CPM (PPC): r =(n.s.) Girls MPA (OC): r= n.s. MPA (TMC, Loc): r=0.35**, r=0.38** MPA (PPC): r = (n.s.) VPA (TMC, OC): r=0.26*, r=0.24* VPA (Loc): r= (n.s.) VPA (PPC): r = (n.s.) CPM (OC, Loc, TMC, PPC): r= (n.s.)
Peers et al., 2020 [20]	Ireland	N = 860 (girls n=410, boys n=450; M_{age}= 10.9, SD = 1.16 years) Cross-sectional	AMC PMC PA	TGMD-3 (TMC) PSPMSC PACE + (MVPA)	TMC (MVPA): r=0.17**, β=0.08** PSPMSC (MVPA): r=0.24**, β=0.10** PSPMSC (TMC): r=0.29**
Slykerman et al., 2016 [21]	Australia	N = 109 (girls n=50, boys n=59; M_{age}= 6.5, SD = 1.0 years) Cross-sectional	AMC PMC PA	TGMD-2 (Loc, OC) PSPMSC Accelerometers (MVPA)	Boys Loc, OC, PSPMSC (MVPA): *B*= (n.s.) Girls OC, PSPMSC (MVPA): *B*= (n.s.) Loc (MVPA): *B*= 3.66

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Utesch et al., 2018 [22]	German	Time 1 – baseline N = 718 (Gender data not available; M_{age}= 9.0, SD = 0.72 years) Longitudinal	AMC PMC PA	General Sportmotorix Test for Children (OC) Self-perception scale of the physical self-concept questionnaire Self-report questionnaire	Higher MC and PMC levels associated with greater PA.
Zhang et al., 2020 [23]	USA	N = 215 (boys; M_{age}= 10.55, SD= 0.53 years) Cross-sectional	AMC PMC PA	PE Metrics (TMC, OC – Basketball, Striking, Overhand throwing) Perceived Competence Scale (Total PCS, basketball, striking, overhand throwing) PAQ-C (TPA)	Basketball, Striking, Overhand throwing (PCS Basketball): r=0.26**, r=0.21**, r=0.22**, respectively Basketball, Striking, Overhand throwing (PCS Striking): r=0.28**, r=0.39**, r=0.26**, respectively Basketball, Striking, Overhand throwing (PCS Overhand throwing): r= 0.28**, r=0.28**, r=0.27**, respectively PCS basketball, PCS striking, PCS Overhand throwing (TPA): r=0.36**, r=0.37**, r=0.34**, respectively Basketball, Striking, Overhand throwing (TPA): r's= (n.s.) Total PCS (TMC): β=0.58** Total PCS (TPA): β=0.44**
Zhang et al., 2015 [24]	USA	N = 288 (girls n=149, boys n=139; Age: 10-12 years; M_{age}= not available) Cross-sectional	AMC PMC PA	PE Metrics (TMC) Perceived Competence Scale (Total PCS) PAQ-C (TPA)	<u>Boys</u> TPA (TMC): r= (n.s.) TPA (Total PCS): r=0.28*, β=0.19* TMC (Total PCS): r=0.26* <u>Girls</u> TPA (TMC): r= (n.s.) TPA (Total PCS): r=0.40*, β=0.36** TMC (Total PCS): r= (n.s.)

Note. AMC=Actual Motor Competence, BOT= Bruininks-Oseretsky Test, CPM – counts per minute; KTK=Korperkoordinationstest fur Kinder, Loc=Locomotor skills, LPA=Light Physical Activity, M-ABC= Movement Assessment Battery for Children, MVPA= Moderous-Vigorous Physical Activity, OC= Object Control skills, PAE=Physical Activity Environment, PA= Physical Activity, PE= Physical Education, PF=Parental Factors, PPC=Perceived Physical Competence subscale, PSPCSA = Pictorial Scale of Perceived Competence and Social Acceptance for Young Children, PSPMSC= Pictorial Scale for Perceived Movement Skill Competence for Young Children, SDQ=Strength and Difficulties Questionnaire, SPPC= Self-Perception Profile for Children, SSRS=Social Skills Rating System, Str= Strength, TGMD= Test of Gross Motor Development, TMC=Total Motor Competence, TPA = Daily Total Physical Activity, VPA= Vigorous Physical Activity; p<0.05*; p<0.

Overview of Study Risk of Bias

The risk of bias was determined based on eight criteria, the results of which are presented in Table 5. For the preschool sample studies, seven studies met seven criteria (87,5%), and one study met all six and two-thirds of one specific criteria (12,5%) (scored 0,66 for AMC and PMC, and 0 for PA). For school-aged children's studies, two studies

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met all eight criteria (12,5%), eleven studies met seven criteria (68,75%), two studies met six criteria (12,5%) and one study met five criteria (6,25%). In general, the studies showed a low risk of bias.

Table 5. Risk of bias – preschool and school-aged children.

Study	1.Selection procedure	2.Validity AMC assessment	3.Reliability AMC assessment	4.Validity PMC assessment	5.Reliability PMC assessment	6.Validity PA or Temp assessment	7.Reliability PA or Temp assessment	8.Data completeness a. AMC b. PMC c. PA or Temp	POINTS
Capio et al., 2021	0	1	1	1	1	1	1	1	7/8
Crane et al., 2015	0	1	1	1	1	1	1	1	7/8
Feitoza et al., 2022	0	1	1	1	1	1	1	1	7/8
Hall et al., 2019	0	1	1	1	1	1	1	1 AMC 1 PMC 0 PA	6,66/8
He et al., 2021	0	1	1	1	1	1	1	1	7/8
Lopes et al., 2016	0	1	1	1	1	1	1	1	7/8
Mancini et al., 2017a	0	1	1	1	1	1 Temp.	1 Temp.	1	7/8
Robinson et al., 2012	0	1	1	1	1	1	1	1	7/8
Bolger et al., 2019	0	1	1	1	1	1	1	1	7/8
Chai et al., 2023	1	1	1	1	1	1	1	1	8/8
Chan et al., 2018	0	1	1	1	0	1	1	0	5/8
Crane et al., 2023	0	1	1	1	1	1	0	1	6/8
Estevan et al., 2022	0	1	1	1	1	1	0	1	6/8
Gu et al., 2017	1	1	1	1	1	1	1	1	8/8
Khodaverdi et al., 2013	0	1	1	1	1	1	1	1	7/8
Khodaverdi et al., 2015a	0	1	1	1	1	1	1	1	7/8
Khodaverdi et al., 2015b	0	1	1	1	1	1	1	1	7/8
Mancini et al., 2017b	0	1	1	1	1	1 Temp.	1 Temp.	1	7/8
Morgan et al., 2008	0	1	1	1	1	1	1	1	7/8
Peers et al., 2020	0		1	1	1	1	1	1	7/8
Slykerman et al., 2016	0	1	1	1	1	1	1	1	7/8
Utesch et al., 2018	0	1	1	1	1	1	1	1	7/8

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Zhang er al., 2020	0	1	1	1	1	1	1	1	7/8
Zhang et al., 2015	0	1	1	1	1	1	1	1	7/8

Main findings in preschool children

Association and prediction analyses were used in this systematic review. Seven studies on the relationship between AMC and PA showed inconsistent findings [1,2,3,4,5,6.8]. For total motor competence (TMC), including Loc and OC skills, two studies showed inconsistencies [4,5]. Mixed results were also found for Loc skills, with one study [8] reporting a significant association with PA, while larger studies did not [1,4,5]. Inconsistencies were noted between PMC and PA, with three studies [4,5,6] finding no significant association and one study [1] reporting a negative association.

Analyses of AMC and PMC revealed further inconsistencies, especially between PMC and TMC [4,5]. Three studies [1,5,8] identified a positive link between Loc skills and PMC, while one study [4] found no association. The relationship between OC skills and PMC also showed inconsistencies.

Only one study [7] examined the relationship between AMC and temperament, finding a negative association between TMC and peer problems as well as internalizing problems. A negative predictive relationship indicated that peer problems decrease as TMC increases, but no predictive link was found between AMC and internalizing problems.

Main findings in school-aged children

Results from eleven studies [10,14,15,16,17,19,20,21,22,23,24] involving school-aged children showed a more consistent association between TMC and PA compared to preschoolers [10,14,15,16,17,19,20,21,22,23,24]. Six studies reported significant positive associations between TMC and PA [10,14,15,16,19,20], with three studies showing a positive predictive relationship [10,19,20].

While some studies found significant associations between Loc skills and PA [15,16,19], others did not [14,19]. Eleven studies [10,14,15,16,18,19,20,21,22,23,24] analyzed the relationship between PMC and PA, with seven studies reporting significant

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positive associations [14,16,17,18,20,23,24]. Only one study [19] found no association, while eight studies indicated a consistent positive predictive relationship [10,15,16,17,20,22,23,24].

Eight studies examined the relationship between PMC and TMC, with five finding significant positive associations [14,16,17,20,24]. Three studies showed a predictive relation between these variables [10,18,23]. Loc skills consistently showed positive associations with PMC across three studies [14,16,17], while associations for OC skills were inconsistent.

Only one study assessed the relationship between AMC, PMC, and temperament, finding negative associations between AMC (TMC domain) and peer/internalizing problems [18]. A negative association was also found between PMC (Perceived Athletic Competence) and internalizing problems, while no significant association was found between PMC and peer problems.

Discussion

The aim of this systematic review was to investigate and describe the relationship between MC (actual and perceived) and PF, PA and temperament in preschoolers and school-aged children with typical development.

Findings regarding preschoolers show inconsistencies, highlighting the need for more research to clarify results. Given the significant health benefits associated with PA in children throughout their lives, it is crucial to gain a better understanding of how MC contributes to promoting adequate levels of participation in PA during childhood, as well as identifying potential mediators that could influence this relationship. Current inconsistencies between AMC, TMC, Loc and OC skills, and PMC hinder definitive conclusions, emphasizing the need for further research. As children's cognitive abilities develop, they become better at assessing their skills (Harter, 1999). As such, supported by research, it has been suggested that the strength of the association between AMC and PMC tends to increase over time as children age, especially during the transition from early to middle childhood (Klein & Linhares, 2010).

Weak evidence indicates a relationship between AMC and temperament, highlighting the need for further research to clarify connections between MC and

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temperament in children. Indeed, temperament is recognized as a personal variable that interacts with environmental factors and can significantly influence child development pathways. Furthermore, child temperament plays a crucial role in shaping parental behaviors. This highlights the importance of understanding the interplay between temperament and other developmental factors, such as MC, to comprehensively understand the mechanisms underlying child development (Klein & Linhares, 2010).

The most robust evidence comes from studies involving school-aged children, showing a significant positive association between both AMC, PMC, and PA. However, more longitudinal studies are needed for causal inferences. There is limited evidence on the relationships among AMC, PMC, temperament and parental factors in preschoolers and school-aged children.

According to Stodden and colleagues (2008) conceptual model, which proposes that age serves as a significant moderator of the association between AMC and an individual's PMC, this systematic review also examined and analyzed studies involving school-aged children on this subject. Hence, concerning school-aged children, most studies demonstrated a significant positive association between AMC (specifically in the TMC domain) and PA. Moreover, some studies indicated a positive predictive relation between TMC and PA. Furthermore, most of the studies supported a significant association between AMC (specifically in the TMC domain) and PMC. This consistency across studies suggests a strong association between AMC and how children perceive their motor skills. There is a potential explanation for this association, supported by literature indicating that as children age, their perceptions become more aligned with their AMC, thereby better reflecting their true motor abilities. As children mature, they develop a greater awareness and understanding of their motor skills, leading to more accurate perceptions of their MC. This alignment between AMC and PMC may contribute to the significant association observed between the two constructs in school-aged children. A significant positive predictive relation was also identified between PMC and PA in most studies. This finding indicates that children who perceive themselves as more competent in motor skills also tend to engage in higher levels of PA. In school-aged children's studies, weak evidence, as indicated by one study, was also found regarding the

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relationship between AMC and temperament, as well PMC and temperament. Further studies are warranted to explore and clarify these relationships.

This systematic review had several strengths, including the inclusion of studies from a wide range of years, ensuring a comprehensive analysis of the literature, and the use of diverse keywords to minimize the risk of overlooking relevant studies. However, it is important to acknowledge certain limitations. We limited our search for articles in English, Portuguese, and Brazilian Portuguese. Incorporating studies that investigate children's temperament and considering gender differences can enhance the comprehensiveness of the systematic review. Despite the inclusion of many studies, a notable limitation was the diverse methodologies used to assess AMC, PMC, and PA. The variation in tools and procedures for measuring similar motor skills across studies presents a significant challenge in comparing results. This lack of standardization highlights the importance of establishing uniform assessment protocols or using validated measurement instruments to enhance the reliability and comparability of findings in future research, and to clarify the relationship between variables. Stodden et al. (2008) conceptualized a model suggesting a direct relationship between PA, AMC and PMC. In this model, the development of AMC is considered a fundamental mechanism that promotes engagement in PA. This conceptualization implies that as children develop greater MC, they are more likely to perceived themselves as competent in motor skills and, consequently, participate in PA at higher levels.

Furthermore, successful experiences in MC have been proposed to enhance PMC. However, our search did not uncover any studies elucidating the potential relationship between MC (both actual and perceived) and PF for preschool and school-aged children. It's worth noting that the ecological systems theory conceptualizes child behavior as a product of interactions among various influences that impact a child (Bronfenbrenner & Morris, 1988). These influences encompass characteristics associated with the child themselves, their family dynamics, and the broader environmental context in which they live and grow (Bronfenbrenner & Morris, 1988). It is widely accepted that the early development of children's MC depends on the interaction between environmental and biological factors (Barnett et al., 2011). The development of MC not only influences PA levels but is also closely related to cognitive functions. Therefore, it is crucial to

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understand the key factors that influence MC in children, such as PF. In this regard, it is our opinion that more studies are needed to evaluate how PF impacts children's MC, both actual and perceived.

Investigating the relationship between MC and PF can provide valuable insights into the mechanisms underlying motor development and inform strategies for promoting optimal motor skills in children from an early age. By comprehensively understanding the impact of PF on MC, interventions and programs can be tailored to enhance both PF and MC, leading to improve overall health and well-being.

Conclusions

As far as we are aware, this study represents the first attempt to analyze the association between MC (both actual and perceived) with PF, PA and temperament in preschoolers and school-aged children with typical development. Despite the limitations, such as the inclusion of many studies with diverse methodologies, tools and procedures, and studies about children's temperament, there are still valuable interesting results that merit consideration. OC skills and PAP were positively associated with preschool children, indicating that preschoolers with better OC skills tend to engage in higher levels of PA. Additionally, TMC was positively associated with PA in preschoolers, suggesting that preschool children with higher levels of overall MC are more likely to participate in PA. In the case of school-age children, it seems that TMC was positively associated with PA, and a predictive relationship was found. This implies that school-aged children with higher levels of TMC not only engage in more PA but are also more likely to sustain their participation in PA over time. Also, findings indicate a significant positive association between PMC and PA, suggesting that children who perceive themselves as more competent in motor skills tend to engage in higher levels of PA. Moreover, the results demonstrate a strong positive association between AMC, in TMC domain and PMC. This suggests that children with higher levels of overall MC are more likely to perceive themselves as competent in motor skills. More studies are needed to investigate the relationship between AMC or PMC and temperament in both preschool and school-aged children. It's notable that no studies were found regarding PF in relation to MC. Certainly, establishing the association between AMC and PA becomes important because it

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highlights the potential benefits of interventions aimed at enhancing MC and promoting PA in early childhood. Demonstrating this association becomes evident that interventions not only in the short term but also in the long term. Children's development is significantly influenced by the environment in which they live, including their home and school environments. Personal characteristics, such as temperament, also play a crucial role in shaping children's development, including their MC (both actual and perceived).

Establishing the association between AMC and PA is crucial for supporting interventions aimed at improving MC and promoting PA in early childhood. Understanding the relationship between MC and PF can provide insights into motor development mechanisms and guide strategies to promote optimal motor skills from an early age. Tailoring interventions to improve both PF and MC can contribute to better overall health and well-being for children.

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