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REVIEW ARTICLE

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Could motor intervention programs have a positive association with the motor competence of children with typical development aged 6 to 10 years? – A Systematic Review

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ABSTRACT

Motor competence plays a significant role in predicting physical activity in the youth and is an integral component of youth health and performance. The motor competence interact with physical activity during early childhood. This study aimed to synthesise evidence on the associations between motor competence and physical activity, training/sports practice, and physical education in children. The review was registered in International Register of Systematic Reviews and carried out in accordance with Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines and the Grading of Recommendations, Assessment, Development, and Evaluations framework. Twelve thousand one hundred and eighty-nine articles were found in the following databases: PubMed, Web of Science, and Scopus. After the screening phase, the selection was reduced to 18 studies, all of which were randomised clinical trials that used validity and reliability methods, according to the eligibility criteria. The studies included a total sample of 2,858 children aged 6–10 years. As the analysis of the articles revealed, that all the intervention programs were beneficial for the development of motor competence, regardless of program (duration of program, weekly frequency and session duration) and instrument, as a proposal for the future, and based on the results of our research, it is proposing an intervention programme lasting 8 to 12 weeks, with sessions lasting 45 to 60 minutes and 2–3 times a week. The Test of Gross Motor Development, version 2, Test of Gross Motor Development Version 3 or KörperKoordinations Test für Kinder could be used as the proposed instrument for assessing motor competence.

KEYWORDS: motor competence; gross motor coordination; children; sports, physical activity.

INTRODUCTION

According to the Convention on the Rights of the Child (Waterston & Goldhagen, 2007) and the World Health Organisation (WHO) (Singh et al., 2019), a child means "every human being below the age of 18 years unless under the law applicable to the child, the majority is attained earlier." Early childhood is a critical period for the development of fundamental movement skills (FMS) (Hardy et al., 2010). Stodden et al. (2008) suggested that participation in physical activity (PA) is the most important component of early childhood. FMS are common motor activities with a general goal (Wickstrom, 1977), and are often differentiated into three subsets: locomotor skills (e.g., running and skipping), object-control/ball skills (e.g., throwing and catching), and stability skills (e.g., balancing and twisting) (Henderson & Sugden, 1992; Wickstrom, 1977). According to Okely et al. (2004), FMS, such as running, jumping, and throwing, serve as the building blocks for more complex gross motor

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skills (GMS), and their development in early childhood is essential for promoting PA and overall motor competence (MC), and improvement of FMS is positively associated with the development of GMS, as the former provide a necessary framework for the execution of larger, more coordinated movements that are critical for PA participation (Ulrich, 2000). Thus, the progression from FMS to GMS is a key element in children's motor development, in which mastering basic FMS facilitates the coordination and refinement of GMS necessary for lifelong PA (Gallahue & Ozmun, 2006).

Thus, PA plays a significant role in maintaining an active and healthy lifestyle (Khodaverdi et al., 2016). Habitual PA comprises a wide range of movements considered vital for independence and interaction with the environment, including personal safety, functionality, leisure, performance, and well-being (Utley, 2018). Several studies have demonstrated a relationship between PA and MC during childhood (Crane et al., 2023; Den Uil et al., 2023; Feitoza et al., 2022) and in middle and late childhood (Stodden, 2008). The WHO (2010) recommends that children should participate in sufficient PA by engaging in moderate-to-vigorous PA for at least 60 minutes daily per week. An increase in PA is associated with an increase in physical fitness (Bakker et al., 2018), which has a positive effect on health (Myers et al., 2019). The acquisition and refinement of proficiency in movement activities, involving interactions between the neuromuscular system and the environment, are commonly referred to in the literature as MC (Malina, 2014).

According to Armour and Macdonald (2012), physical education (PE) is structured, school-based teaching designed to promote PA, improve MC, and contribute to the overall development of individuals, and often encompasses a wide range of activities and skills, including sports, games, and exercise programs aimed at promoting fitness, health, and well-being. Therefore, children who develop strong MC through PE are better able to perform various exercises effectively, increasing the likelihood of continued engagement in PA and exercise routines into adulthood (Stodden et al., 2008).

The term "motor competence" is a globally understood term that describes the level at which children can execute FMS, which are basic gross movements used throughout the lifespan for activities of daily living and physically demanding pursuits (Haywood & Getchell, 2019). It is used to reflect various other terminologies, such as motor proficiency, motor performance, fundamental movement/motor skills, motor ability, and motor coordination (Lorås, 2020). It can be defined as a person's ability to execute different motor acts, including coordination of fine and gross motor skills that are necessary to manage everyday tasks (Barnett et al., 2016; Chow et al., 2001; D'Hondt et al., 2011; Hardy et al., 2013). On the other hand, GMS is often specified as proficiency in a range of FMS (e.g., throwing, catching, running) that are ideally learned during preschool and early school years (Branta et al., 1984; Gallahue & Ozmun, 2006). According to Chan et al. (2019), competence across a range of FMS may serve as a protective factor against the decline in PA typically observed during adolescence.

The development of MC during childhood is recognised as the main factor for engaging in regular PA throughout life (Stodden et al., 2008), and proficiency in GMS is a prerequisite for engagement in PA, including sports participation (Khodaverdi et al., 2016).

In the course of our work, we found that much research (Barnett et al., 2016, 2022; Santos et al., 2021) has dealt with or analysed only children's MC. Barros et al. (2022), Han et al. (2018), Luz et al. (2017), and Redondo-Tebar et al. (2021) have focused on the effects of health-related fitness in body mass index (BMI) or being overweight on the development of MC.

Considering that research on MC in children has important implications for public health policies, especially regarding the promotion of PA and the prevention of diseases from an early age, and given the lack of evidence of studies that compile, summarise the type of studies, the type of interventions in the age group of 6 to 10 years old or on a particular sport, the present systematic review aimed to summarise the current knowledge and present key questions for future investigations of the relationship between MC and PA, PE, FMS and sports in children. In addition, we think it will be important because it will help us identify variables associated with MC, such as BMI and sports practice, and assess the effects of intervention programs on MC. The following hypothesis was tested:

Hypothesis 1: Motor intervention programs are positively associated with the motor competence of children with typical development aged between 6 and 10 years old.

METHODS

Identification of studies

This systematic review used a protocol registered in the International Register of Systematic Reviews (PROSPERO) (code number CRD42023421118). The study was conducted following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Page et al., 2021) and the GRADE (Grading of Recommendations, Assessment, Development, and Evaluations) framework.

Three electronic databases (PUBMED, SCOPUS, and WEB OS SCIENCE) were used for this study.

The following descriptors were used: "Motor competence", "motor skill", "motor ability", "motor performance", "movement skill", "motor coordination", "motor development", "child", "kids", "minor", "sports", "training", "exercise", "physical activity". The Boolean operators "AND" and "OR" were used, and Mesh terms were included. Table 1 shows the research strategy.

Eligibility criteria

The PICOS strategy is defined as follows: Population - The target population includes children aged 6-10 years. Articles concerning developing children and excluding children with physical and mental disabilities; Intervention (s) - included study programs implemented in any context; Comparison - intervention group versus control group studies; Outcome (s)– the outcome was MC. To assess this, gross motor abilities of locomotion, object control, and balance were considered. Studies that used batteries to assess only fine motor skills or batteries to assess both gross and fine motor skills were excluded, and only studies that used instruments to assess GMS were selected.

Inclusion and exclusion criteria

Inclusion criteria

For the selection of studies, the following inclusion criteria were considered: (i) randomised controlled trial (RCT's) studies because they are study with a stronger methodology; (ii) intervention studies of any duration, to achieve as many studies as possible; (iii) Interventions studies focused on MC, because MC is the main variable in our study; (iv) Conducted with children aged 6 to 10 years old with typical development; (v) Studies in which GMC was chosen as the outcome variable for the analysis since we focus mainly on gross motor skills; (vi) Written in English and Portuguese are the languages that authors master.

Exclusion criteria

Similarly, for the selection of studies, the following exclusion criteria were used: (i) studies that used instruments such as surveys or questionnaires; (ii) Did not clearly present the instruments for the assessment of MC or used only some tasks from the existing battery tests; (iii) articles that do not describe the intervention protocol for ST prescription; (iv) Non-intervention studies (iv) conducted to validate a given method were also excluded; (v) Articles written or published in a language that was not English or Portuguese, (vi) Doctoral thesis.

Table 1. Research strategy.

Research Number	Descriptors
1	("Motor competence" OR "motor skill" OR "motor ability" OR "motor performance" OR "movement skill" OR "motor coordination" OR "motor development") AND (child* OR kids OR minor) AND (sports OR training OR exercise OR "physical activity")

Information sources and research strategies

The search was completed on 14 November 2024, considering the maximum fallback period for the different databases, PubMed (title and abstract), Web of Science (title, abstract, and keywords), and Scopus (title, abstract, and keywords) databases, written in English and Portuguese; intervention studies relating to the association between PA, Sports Training, or PE and MC in children aged 6 to 10 years old with typical development.

The research was drafted by the first author and then discussed and adjusted in consultation with the other authors. All duplicates were removed from the system. Two reviewers selected the remaining articles regardless of the title or abstract. Disagreements were discussed, and articles were included in cases of doubt. A third researcher was also involved. After the review phase, the list of references for all included articles was analysed to identify those that met the inclusion criteria.

Data extraction (selection and coding)

Data were extracted by two researchers, and differences were discussed and resolved. In the first step, data were extracted using EndNote X7 and duplicates were removed. Some articles were then eliminated based on a review of their titles and abstracts.

Articles that did not meet the eligibility criteria were excluded. One researcher extracted the relevant information from the article and entered it into Table 2 (author/year/location, aim of study, sample, measurement, intervention programs, main outcomes, and scores).

Assessment of the quality of studies

GRADE (Grading of Recommendations, Assessment, Development, and Evaluations), displayed in Table 2, is a framework for developing and presenting evidence summaries and provides a systematic approach to making clinical practice recommendations (Guyatt et al., 2008). GRADE evaluates and assigns each study to 1 of 4 levels of evidence: very low, low, moderate, or high. RCTs start at high quality

Table 2. Characteristics and intervention program used in this review.

Author, year, and country	Aims	Context/ type of intervention	Sample	Intervention program	Program duration, frequency, session duration	Measurement	Main outcomes	Grade[b]
Abusleme-Allimant et al. (2023), Chile	Aimed to assess the impact of a physical education program, based on a model of structured and unstructured physical activity, on the motor development of kindergarten students at a private school for girls in Con, Chile	PE (PE Structured/ PE unstructured)	*n* = 34 Age = 6 years old The participants were randomly divided into two experimental groups.	The participants were divided into two groups: Group one participated in physical education classes with structured physical activity. Group two participated in physical education classes with unstructured physical activity.	12 weeks. 1 x week. 45 min/ session	MABC-2	Results: Structured physical activity improved gross motor skills more significantly than unstructured activity. Statistical details: $p = .001$; $\eta^2 = 0.132$ (large effect)	Moderate
Akbari et al. (2009), Iran	Investigate the effect of traditional games on fundamental motor skills in seven- to nine-year-old boys.	PE (Traditional games)	*n = 40* Age = 7–9 years Subjects were divided by random in two groups.	The intervention program was an eight-week traditional game program. The traditional game program consisted of three sections: 1) warming up with usage of simple games, 2) traditional games 3) cool down.	8 weeks. 3 days x weeks. 60 min/ session.	TGMD-2	Result: Traditional games significantly improved fundamental motor skills in 7–9-year-old boys. Statistical details: Not reported in full-text search.	High
Alipour et al. (2023), Iran	This study aimed to investigate the effect of games based on divergent and convergent thinking on motor competence and creativity in children aged 7–8 years.	PE (FMS)	*n* = 34 Age = 7–8 years old The participants were randomly divided into two experimental groups (*n* = 11) and one control group (*n* = 12)	The children participated in eighteen practice sessions (six-week period). Each child performed five minutes of warm-up, five minutes of cool-down, and 40 minutes of play for the experimental group in each exercise session.	6 weeks. 1 x week. 40 min/ session.	TGMD-2	Result: Games based on divergent thinking improved both motor competence and creativity. Statistical details: $p < .01$; $\eta p^2 = 0.321$ (motor competence), $\eta p^2 = 0.296$ (creativity)	Moderate
Chan et al. (2019), China	Evaluate the effectiveness of an assessment-based intervention that emphasizes fun, mastery, and support (A + FMS) on primary schoolchildren's fundamental movement skills, perceptions of physical and movement skill competence, teacher support and enjoyment	PE (FMS)	*n* = 282 Age = 8.4 years The sample size calculations were based on the standardised mean difference.	The A + FMS intervention was an assessment-based teacher-led FMS intervention. Teachers in the A+FMS group were required to attend six hours of training and integrate 550 min of assessment for learning strategies into their PE lessons for up to a maximum of 13 weeks.	13 weeks. 2 x week. 70 min/ session.	TGMD-3	Result: Significant improvements in FMS and some psychosocial outcomes. Statistical details: $p < .05$; effect sizes ranged from small to moderate across domains.	High

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Table 2. Continuation.

Author, year, and country	Aims	Context/ type of intervention	Sample	Intervention program	Program duration, frequency, session duration	Measurement	Main outcomes	Grade[b]
Cohen et al. (2015), Australia	Effect of a 12-month multicomponent physical activity and fundamental movement skills intervention on children attending primary schools	PE (FMS)	*n* = 460 Age = 8.5 ± 0.6 years	A 12-month school-based cluster randomized controlled trial designed to increase PA and improve FMS competency among children attending primary schools in low-income communities.	52 weeks. 1 x wee. 120 min/ session.	TGMD-2	Result: SCORES intervention improved physical activity levels and motor skills. Statistical details: $p < .05$; Cohen's d ~0.4–0.6 for various outcomes.	Moderate
Gallotta et al. (2017), Italy	Evaluate the effectiveness of two different 5-month physical education interventions conducted by a specialist PE teacher on primary school children's skill- and health-related outcomes	PE (PE Structured)	*n* = 230 Age = 8 and 11 years of age. Children were randomly assigned in three intervention groups.	The intervention period lasted 5 months. Experimental interventions differed in type and mode of physical activities in which children were engaged but they were equivalent in structure, overall duration and individual perceived exertion and consisted of 2 1-h sessions per week. Experimental interventions were designed by the same specialist PE teacher who conducted one of the two weekly lessons.	20 weeks. 2 x week. 60 min/ session.	KTK	Result: Intervention improved both skill- and health-related physical outcomes. Statistical details: $p < .05$; $\eta^2 = 0.15–0.18$ depending on domain	High
Idamokoro et al. (2024), South Africa	To examine the immediate and sustainable effects of a 9-week movement programme on fundamental movement skills of school children	Extracurricular (FMS/PA)	Ninety-three school children assigned to two groups.	This study was adapted from the SPARK Physical Education programme with additions made to align with the intended outcomes of the programme based on the CAPS curriculum of South Africa.	9 weeks. 2 x week 30 minutes	TGMD-3	Result: the program led to sustained increases in physical activity levels post intervention. *Statistical Details:* p < 0.05; effect sizes not reported.	Moderate

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Table 2. Continuation.

Author, year, and country	Aims	Context/ type of intervention	Sample	Intervention program	Program duration, frequency, session duration	Measurement	Main outcomes	Grade[b]
Jarani et al. (2016), Albania	Evaluate the effectiveness of two school-based physical education programmes (exercise-based and games-based) compared with traditional PE, on health- and skill-related physical fitness components in children	PE (FMS)	*n* = 767 Age = 6–9 years Participants were randomly assigned in three groups.	The EG intervention programme emphasised PA exercises (e.g., gait exercises to improve speed), while the GG intervention programme was focused on fun games (e.g., tag games to improve speed). Compared with traditional PE, we assumed that children would be more dedicated to this type of PE and would provide improvements in physical fitness measures during the 5-month period.	20 weeks. 2 x week. 45 min/ session.	KTK	Result: Both physical education programs improved fitness components. Statistical details: $p < .05$ across multiple components; exact effect sizes not stated but significant across groups	Moderate
Kelly et al. (2021), Ireland	Examine the immediate and long-term effects of an 8-week FMS intervention programme on 255 Year 3 and 4 Irish school children's (50% male, 7.4±0.6 yr.) FMS proficiency levels.	PE (FMS)	*n* = 255 Age = 7–8 years Participants were recruited and randomly assigned to three groups	The intervention replaced PE lessons and consisted of two 45-minute sessions per week over 8 weeks (i.e., a total of sixteen sessions, 720 min). The class teacher arranged and supervised alternative activities for non-participating children and did not assist with the intervention in any way. Like the structure of a previous community-based intervention, three skills were targeted during each lesson.	8 weeks. 2 x week. 45 min/ session.	TGMD-3	Result: Neuromuscular training improved psychomotor development and joint sense. Statistical details: $p < .001$; effect size $\eta^2 = 0.32$ (psychomotor), $\eta^2 = 0.29$ (joint sense).	High

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Table 2. Continuation.

Author, year, and country	Aims	Context/ type of intervention	Sample	Intervention program	Program duration, frequency, session duration	Measurement	Main outcomes	Grade[b]
Moura et al. (2021), Brazil	Verify the impact of two learn-to-swim programs, implemented for 12 weeks, in age school Brazilian children's aquatic readiness and motor coordination.	SP	*n* = 31 Age = 7–9 years old Participants were randomly divided into two groups.	The lessons in the BS were focused on basic swimming skills development and in the FS were focused on the formal development of swimming techniques. Both learn-to-swim programs were developed by the swimming teachers in cooperation with the research team. The swimming lessons were conducted by two swimming teachers.	13 weeks. 1 x week. 50 min/ session.	KTK	Result: School-based swimming improved aquatic skills and coordination. Statistical details: $p < .05$; effect size not clearly reported.	Moderate
Nobre et al. (2017), Brazil	Effects of 12 weeks of plyometric training on body composition, the performance in health-related physical fitness tests and gross motor coordination in boys who were overweight/ obese.	Extracurricular Sports	*n* = 59 boys. Age = 7–9 years. Subjects randomly assigned into 2 groups:	Training consisted of 20 min of lower extremity plyometric exercise. Health-related physical fitness was measured by handgrip strength, standing long jump, curlups, sit and reach, square test, running speed, and mile run test.	12 weeks. 2 x week. 20 min/ session.	KTK	Result: Plyometric training significantly improved motor performance in overweight/ obese boys. Statistical details: $p < .05$; large effect size reported (Cohen's d = 0.85)	Moderate
Oppici et al. (2020), Australia	Examine how learning a dance choreography with different teaching pedagogies and different cognitive challenge influenced the development of working memory capacity and motor competence in primary school children.	PE (FMS)	*n* = 80 Age = 8–10 years. Participants were randomly assigned to two experimental groups and a control group.	The intervention consisted in a choreography based on a Michael Jackson's song – Ease on Down the Road – and included a sequence of approximately fifty movements, some of which were repeated twice. Various movements were included in the drill section, such as marching, skipping, galloping, step-kicking, and chaines.	7 weeks. 2 x week. 55 min/ session.	CAMSA	Result: Dance program with cognitive challenge improved motor competence and working memory. Statistical details: $p < .05$; η^2 = 0.10–0.21 depending on outcome	Moderate

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Table 2. Continuation.

Author, year, and country	Aims	Context/ type of intervention	Sample	Intervention program	Program duration, frequency, session duration	Measurement	Main outcomes	Grade[b]
Pratt et al. (2023), England	Examines the effects of a 6-week swimming intervention on motor competence in children.	PE (Sport/ FMS)	A total of 107 children (*n* = 52 boys, *n* = 55 girls) aged 7.8 ± 0.63 years	A six-week progressive aquatic motor competence program, based on the learn to swim program. The intervention focused on the development of three aquatic strokes—front crawl, back crawl and breaststroke—and eight aquatic skills—push and glides, log rolls, sculling feet first and headfirst, treading water, jumping into the submersion, floating and tuck.	6 weeks. 2 x week. 50 min/ session.	TGMD-3	Result: Swimming intervention improved gross motor development. Statistical details: $p < .01$; large effect (partial η^2 = 0.37).	High
Sousa et al. (2016), Brazil	Evaluate the children's motor performance between 7 and 10 years, participants, and nonparticipants in a social sports program in fundamental motor skills mobility and control objects, according to sex.	Extracurricular (FMS/PA)	*n* = 75 Age = 7–10 years. Subjects Divided into two groups:	The students in the sample were registered on individual forms, with their personal details. The TGMD2 pre-test was administered in the second week of the PST centres' operation. After three months of PST centre activities, a post-test was carried out with the selected sample to reassess motor performance.	36 weeks. Frequency ND Session ND	TGMD-2	Result: Social sports program positively affected motor skills. Statistical details: $p < .05$; effect size not provided.	High
Skowroński et al. (2019), Poland	Investigate the changes in gross motor skills in children participating and not participating in a project of extracurricular physical education classes in primary schools called "From fun to sport"	Extracurricular (FMS/PA)	*n* = 31 Age = 7–8 years Children were in the first grade of primary school participated in the study (16 boys and fifteen girls).	Children from the experimental group participated in regular 45-minute physical education classes conducted by a primary education teacher three times a week, and in an additional 45-minute lesson a week taught by a PE teacher. This PA programme was held on Wednesdays from 3.00 p.m. to 3.45 p.m. at a school gym. The intervention approach was direct instruction. Running, hopping, and throwing games were played during these extracurricular PE classes.	32 weeks 3 x week 45 minutes	TGMD-2	Result: Extracurricular PE classes positively impacted gross motor development. Statistical details: $p < .05$; no effect size reported.	High

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Table 2. Continuation.

Author, year, and country	Aims	Context/ type of intervention	Sample	Intervention program	Program duration, frequency, session duration	Measurement	Main outcomes	Grade[b]
Sortwell et al. (2021), Australia	Examine the effect of a plyometric-based program on primary school students' motor performance skills, upper and lower body muscular power, and reactive strength index	PE (FMS)	*n* = 61 Age = 7–8 years old The participants were primary school students, twenty-nine girls and thirty-two boys, from two second grade PE classes.	The two groups participated in their regular eight-week PE lessons. During the study, the plyometric group performed a plyometric-based program in the 15-minute warmup of each class, while the comparison group performed regular warmup activities.	8 weeks. 2 x week. 50 min/ session.	TGMD-2	Result: Plyometric program improved motor performance and muscular power. Statistical details: $p < .01$; $\eta^2 = 0.24$ (large effect).	High
Sortwell et al. (2024), England	This study examined the effects of plyometric-based structured game active breaks on fundamental movement skills, muscular fitness, student self-perception, and teacher's rating of actual behavior in Grade 3 and 4 students	PE (FMS)	Primary school children aged 8–10 years old, from four classes, were cluster-randomly assigned to two groups.	The intervention consisted of plyometric-based structured game active breaks in the middle of a two-hour learning block in the class's daily routine. At the start of each game break, the classroom teacher, who had received training in delivering the games, demonstrated the proper game technique and reviewed procedures.	6 weeks. 5 x week. 10 min/ session.	CAMSA	Result: Active breaks enhanced FMS and muscular fitness. Statistical details: $p < .05$; $\eta^2 = 0.19$ (FMS), 0.21 (muscular fitness).	High
Šlosar et al. (2021), Slovenia	Effects of an exergame program (TennisVirtua-4, PlayStation Kinect) combined with traditional tennis training on autonomic regulation, tennis technique, gross motor skills, clinical reaction time, and cognitive inhibitory control in children	Extracurricular (Sport / FMS)	*n* = 63 Age = 7–9 years. Participants were randomized into four groups.	Children were randomized into four groups (1st – two exergame and two regular trainings sessions/ week, 2nd – one exergame and one regular training sessions/ week, 3rd – two regular trainings sessions/week, and 4th – one regular training session/week) and compared at baseline, 6-month immediately post intervention and at 1-year follow-up post intervention.	24 weeks. 1 x week. 60 min/ session.	TGMD-3	Result: Exergames improved cognitive-motor function but affected tennis technique. Statistical details: $p < .05$; $\eta^2 = 0.26$ for cognitive-motor performance.	Moderate

N: number of participants; FMS: fundamental movement skills; TGMD 2: test of gross motor development 2nd edition; TGMD 3: test of gross motor development 3rd edition; KTK: Körperkoordinationstest Für Kinder; CAMSA: Canadian agility and movement skill assessment; MABC-2: motor assessment battery for children 2nd edition; PE: physical education; T GROUP: plyometric training group; MVPA: moderate-to-vigorous physical activity; EG: experimental group; CG: control group; FS: formal development of swimming techniques; BS: basic skills; SLJ: standing long jump; AMP: aquatic movement protocol; GRADE[b]: grading of recommendations, assessment, development, and evaluations.

or evidence; due to residual confounding, observational studies start at low quality or evidence. The level of quality or evidence for a study is increased or decreased during the evaluation process using the GRADE criteria concerning the risk of bias, imprecision, inconsistency, indirectness, and publication bias (Guyatt et al., 2008).

Two reviewers independently assessed the risk of bias. The quality of the studies was assessed using the Critical Review Form-Quantitative Studies (Law et al., 1998), displayed in Figure 2, which comprises 16 items that assess the risk of methodological bias. It assesses the following items: Study purpose, literature review, study design, sampling, data collection, data analysis, overall rigour and conclusion and implications. Each assessed item was worth 1 point; if the total was 12 or more, the study was considered high quality; between 11 and 8, medium quality; and 7 or fewer, low quality. Differences were discussed, and when no consensus was reached, a third reviewer was consulted. The quality of the studies is discussed as part of the synthesis.

Strategy for data synthesis and analysis of subgroups or subsets

Qualitative synthesis was performed according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA-P) (Shamseer et al., 2015) and the GRADE criteria for risk of bias (Guyatt et al., 2008). A narrative synthesis of the included studies' results was also presented, structured around the characteristics of the studies, their study populations, and the results achieved. Regarding subgroup or subset analysis, we used subsets of studies, for example, studies focusing only on physical education or sports and studies combining physical education and sports.

RESULTS

The flow of studies through the screening process and reasons for exclusion are displayed in Figure 1. We found 12,189 articles across three databases: PubMed (1,631), Web of Science (3,920), and Scopus (6,638). The first filter for duplicate articles was used to eliminate 3,497 articles. After careful review of the titles and abstracts, 8,692 articles were screened, and 87 were excluded according to the exclusion criteria. After the screening phase, the selection was reduced to 19 articles due to eligibility.

Table 2 shows the author/year and country, aims, Context/Type of intervention, participants or sample, intervention program, program duration, frequency, and session duration, measurements, main outcomes, and the score/quality used in the included studies.

To facilitate our analysis, the studies have been subdivided into those conducted in PE contexts and those conducted in extracurricular contexts. We were also able to group the type or nature of each intervention within each subdivision. In this way, we were able to determine and/or identify the studies that were based on FMS, on PA and in sport.

Most studies (11/18) focused on interventions in the context of school PE, while 7 focused on interventions in extracurricular contexts.

Sample

This study included a total sample size of 2,858 children aged 6–10 years. The control group included 1,190 children, and the experimental group included 1,668 children.

Assessment

Regarding MC assessment, our research showed that five studies used the battery TGMD-2 (Abusleme-Allimant et al., 2023; Akbari et al., 2009; Skowroński et al., 2019; Sortwell et al., 2021; Sousa et al., 2016), six studies TGMD-3 - (Chan et al., 2019; Cohen et al., 2015; Idamokoro et al., 2024; Kelly et al., 2021; Pratt et al., 2023; Šlosar et al., 2021), four studies KTK (Gallotta et al., 2017; Jarani et al., 2016; Moura et al., 2021; Nobre et al., 2017) two studies CAMSA (Oppici et al., 2020; Sortwell et al., 2024), and one MABC-2 (Alipour et al., 2023).

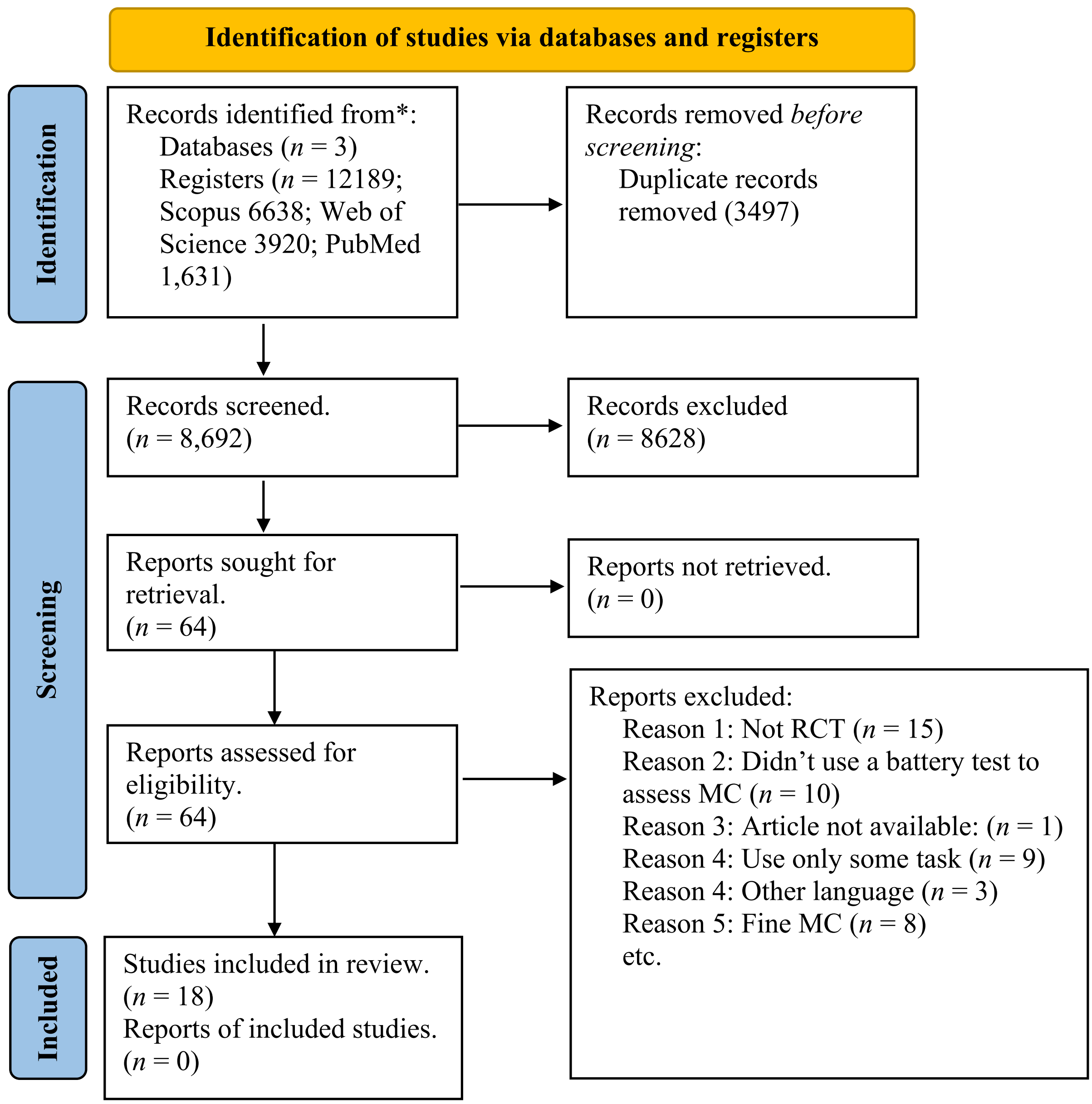
Intervention program

Duration of the program

Regarding the duration of the program, three studies (Alipour et al., 2023; Pratt et al., 2023; Sortwell et al., 2024) lasted six weeks, one (Oppici et al., 2020) seven weeks, three (Akbari et al., 2009; Kelly et al., 2021; Sortwell et al., 2021) eight weeks, one (Idamokoro et al., 2024) nine weeks, one (Skowroński et al., 2019) ten weeks, two (Abusleme-Allimant et al., 2023; Nobre et al., 2017) twelve weeks, one (Chan et al., 2019) thirteen weeks, two (Gallotta et al., 2017; Jarani et al., 2016) twenty weeks, one (Šlosar et al., 2021) twenty-four weeks, one (Sousa et al., 2016) thirty-six weeks, and one (Cohen et al., 2015) fifty-two weeks.

Weekly frequency

All programs had a weekly frequency of one to three sessions. Six studies had one session per week (Abusleme-Allimant et al., 2023; Alipour et al., 2023; Cohen et al., 2015; Moura et al., 2021; Pratt et al., 2023; Šlosar et al., 2021), seven studies had two sessions per week (Chan et al., 2019; Gallotta et al., 2017; Idamokoro et al., 2024; Jarani et al.,



RCT: randomized controlled trial; MC: motor competence.

Figure 1. Preferred Reporting Items for Systematic Reviews and Meta-Analyses flow diagram of study selection.

2016; Kelly et al., 2021; Nobre et al., 2017; Oppici et al., 2020; Sortwell et al., 2021), two studies had three sessions per week (Akbari et al., 2009; Skowroński et al., 2019), one study five sessions (Sortwell et al., 2024), and finally one study (Sousa et al., 2016) did not present the weekly frequency.

Session duration

In four studies (Akbari et al., 2009; Gallotta et al., 2017; Pratt et al., 2023; Šlosar et al., 2021) the session lasted 60 minutes, in five studies (Abusleme-Allimant et al., 2023; Chan et al., 2019; Jarani et al., 2016; Kelly et al., 2021; Skowroński et al., 2019) 45 minutes, in two (Nobre et al., 2017; Sortwell et al., 2021) fifty minutes, in one fourty minutes (Alipour et al., 2023) in one (Oppici et al., 2020) fifty-five minutes, in one (Cohen et al., 2015) one hundred and twenty minutes, in one (Idamokoro et al., 2024) thirty minutes, in one (Nobre et al., 2017) twenty minutes, in one (Sortwell et al., 2024) ten minutes, and in one study (Sousa et al., 2016) we did not find any details regarding the duration of the sessions.

	Items																
Studies	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Scores
1	1	1	1	1	0	1	1	1	1	1	0	1	1	0	0	1	12
2	1	1	1	1	0	1	1	1	1	1	0	1	1	0	0	1	12
3	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	1	14
4	1	1	1	1	1	1	1	1	1	0	1	1	1	1	0	1	14
5	1	1	1	1	0	1	1	1	1	1	1	1	1	0	0	1	13
6	1	1	1	1	1	1	1	1	1	0	0	1	1	1	1	1	14
7	1	1	1	1	0	1	1	1	1	1	1	1	1	0	0	1	13
8	1	1	1	1	1	1	1	1	1	0	0	1	1	0	0	1	12
9	1	1	1	1	0	1	1	1	1	0	0	1	1	0	0	1	11
10	1	1	1	1	0	1	1	1	1	0	1	1	1	1	0	1	13
11	1	1	1	1	0	1	1	1	1	0	0	1	1	0	0	1	11
12	1	1	1	1	0	1	1	1	1	0	1	1	1	1	1	1	14
13	1	1	1	1	0	1	1	1	1	1	1	1	1	0	0	1	13
14	1	1	1	1	1	1	1	1	1	0	0	1	1	1	0	1	13
15	1	1	1	1	1	1	1	1	1	0	0	1	1	1	0	1	13
16	1	1	1	1	1	1	1	1	1	0	0	1	1	1	1	1	14
17	1	1	1	1	1	1	1	1	1	0	0	1	1	1	0	1	13
18	1	1	1	1	1	1	1	1	1	1	0	1	1	1	0	1	14

Figure 2. Assessment of Quality of Studies.

Program context

Because the program differed for each one, to facilitate analysis, two groups were created: a PE intervention group and an Extracurricular intervention group. In the first group we had ten studies (Abusleme-Allimant et al., 2023; Chan et al., 2019; Cohen et al., 2015; Gallotta et al., 2017; Idamokoro et al., 2024; Jarani et al., 2016; Kelly et al., 2021; Pratt et al., 2023; Skowroński et al., 2019; Sortwell et al., 2024) and eight in the second group (Akbari et al., 2009; Alipour et al., 2023; Moura et al., 2021; Nobre et al., 2017; Šlosar et al., 2021; Sortwell et al., 2021; Sousa et al., 2016). To improve the MC, selected studies featured different interventions program, four based on school PE programs (Gallotta et al., 2017; Jarani et al., 2016; Kelly et al., 2021; Skowroński et al., 2019), two on games (Akbari et al., 2009; Alipour et al., 2023), four on FMS (Abusleme-Allimant et al., 2023; Chan et al., 2019; Cohen et al., 2015; Idamokoro et al., 2024), eight (Moura et al., 2021; Nobre et al., 2017; Oppici et al., 2020; Pratt et al., 2023; Šlosar et al., 2021; Sortwell et al., 2021, 2024; Sousa et al., 2016) on PA programs more specific to certain areas or activities.

Main outcomes

All the selected studies had a significant impact on MC, and results showed improvement in several parameters: locomotor (Akbari et al., 2009; Chan et al., 2019; Gallotta et al., 2017; Idamokoro et al., 2024; Kelly et al., 2021), object control (Akbari et al., 2009; Sortwell et al., 2024; Sousa et al., 2016), and ball skills (Idamokoro et al., 2024; Kelly et al., 2021; Šlosar et al., 2021). Oppici et al. (2023), Pratt et al. (2023), Skowroński et al. (2019), and Sortwell et al. (2021) only presented analyses of the results obtained and their association with MC. Table 2 shows the results of each study.

Quality of studies

The mean quality of the selected papers, displayed in Figure 2, was 13, indicating excellent methodological quality, and no articles obtained the maximum score. Two articles had a score of 11 (Gallotta et al., 2017; Skowroński et al., 2019), three articles had scored 12 (Akbari et al., 2009; Nobre et al., 2017; Oppici et al., 2020), seven had 13 (Abusleme-Allimant et al., 2023; Alipour et al., 2023; Jarani et al., 2016; Moura et al., 2021; Pratt et al., 2023; Sortwell et al., 2021; Sousa et al., 2016), and finally six had scored 14 (Chan et al., 2019; Cohen et al., 2015; Idamokoro et al., 2024; Kelly et al., 2021; Šlosar et al., 2021; Sortwell et al., 2024).

DISCUSSION

This systematic review aimed to investigate the relationship between MC and PA, FMS, and sports in children aged 6 to 10 years old with typical development. MC has been widely studied by researchers worldwide (Akbari et al., 2009; Cohen et al., 2015; Jarani et al., 2016; Kelly et al., 2021; Sortwell et al., 2021; Sousa et al., 2016). To provide an initial overview and support the discussion of our findings, it is important to highlight that our review focused specifically on RCTs related to GMC. We conducted searches across three databases — PubMed (1,631 articles), Web of Science (3,920 articles), and Scopus (6,638 articles) — which yielded a total of 12,189 articles. The subsequent sections discuss the main aspects of MC intervention programs identified in the selected studies.

The analysis of the included intervention studies allowed us to categorise them into two primary groups: those conducted within the context of PE and those in Extracurricular settings. Furthermore, we classified interventions based on their objectives in the domains of Sport, PA, and FMS. Despite this classification, initial analysis reveals consistent evidence that structured and intentional movement programs positively influence children's MC, physical fitness, and overall well-being. This supports our hypothesis that motor intervention programs are beneficially associated with MC in typically developing children aged years old.

Assessment

The assessment tools most frequently used to measure MC in the reviewed studies were the Test of Gross Motor Development (TGMD) and the Körperkoordinationstest für Kinder (KTK). This aligns with recent research (Bizinotto et al., 2022). The choice of the tool appears to depend on study objectives: when assessing overall MC and diagnosing motor disorders, the KTK is predominantly employed (Gorla et al., 2015; Kiphard & Schilling, 1974). Conversely, the TGMD is favoured for evaluating FMS such as locomotion and object manipulation (Ulrich, 2000).

The KTK, developed by Kiphard and Schilling (1974), for children aged 5 to 14 years old, consists of four subtests that measure different aspects of dynamic balance and coordination: Walking Backwards on a Balance Beam, jumping Sideways (Lateral Jumping Test), Hopping for Height (Monopedal Hopping Test) and Moving Sideways on Boxes (Shifting Platforms Test). The TGMD, designed by Ulrich (1985) for children aged 3 to 10 years, includes two subtests: Locomotor Skills (e.g., running, galloping, skipping) and Object Control Skills (e.g., striking, dribbling, catching, kicking).

Program duration

Intervention durations ranged from 6 to 48 weeks, with most programs lasting 8 to 12 weeks. The optimal duration for developing MC likely depends on factors such as target population, motor skills focus, frequency, and intensity. Godoy-Cumillaf et al. (2024), and Riethmuller et al. (2009) suggest that interventions between approximately 12 weeks and 5 months can effectively enhance MC.

Frequency and session duration

The frequency of training sessions ranged from 1 to 3 per week, with a tendency toward 2 or 3 sessions per week, consistent with the American College of Sports Medicine (ACSM) guidelines, which recommend 2–5 sessions per week (ACSM, 2017). Session durations ranged from 30 minutes to 2 hours, most commonly between 45 and 60 minutes, aligning with the World Health Organisation's recommendation of 60 minutes of moderate-to-vigorous PA daily (WHO, 2010). Typical session structure included warm-up, main activity, and cool-down phases, in accordance with ACSM standards.

Main outcomes

Our analysis revealed that various intervention types — including traditional games (Akbari et al., 2009; Alipour et al., 2023), game-based programs (Gallotta et al., 2017), enjoyment and FMS activities (Chan et al., 2019; Cohen et al., 2015), dance (Oppici et al., 2020), school-based multicomponent programs (Cohen et al., 2015), traditional PE (Jarani et al., 2016; Skowroński et al., 2019; Sortwell et al., 2021), and structured/unstructured PA-based programs (Abusleme-Allimant et al., 2023) — positively impacted children's MC, particularly in locomotor, manipulative, ball skills, and object control domains. These findings corroborate prior literature on the positive relationship between PA and MC (Barnett et al., 2011; Chow et al., 2001; Crozier et al., 2022; Hardy et al., 2010; King-Dowling et al., 2020; Lubans et al., 2010). However, they contrast somewhat with Barnett et al. (2022), who call for further evidence.

Additionally, interventions involving plyometric training, strength conditioning, aquatic-based activities, and social sports programs demonstrated benefits for locomotor skills, object control, and ball skills (Nobre et al., 2017; Pratt et al., 2023; Sortwell et al., 2021; Sousa et al., 2016). The moderate association between MC and musculoskeletal fitness may reflect the physical effort required for locomotor and object control tasks (Sacko et al., 2018).

While differences in study design, duration, and participant characteristics complicate comparisons, all reviewed programs showed positive effects on MC, providing valuable insights for future program development. Effective interventions should be tailored to the sample, objectives, assessment tools, duration, session frequency, and length. Incorporating games, enjoyable activities, strength and plyometric training, coordination exercises, object control, and stability components is recommended.

Quality of studies

Most of the studies included in this review were classified as high quality, with only two receiving a medium-quality rating (Law et al., 1998). According to the GRADE framework (Guyatt et al., 2008), nine studies were rated as providing high certainty of evidence, while another nine were rated as moderate.

These assessments are particularly relevant for informing the design of future intervention programmes. Evidence from higher-quality studies provides a more robust basis for programme development, ensuring that interventions are grounded in reliable and valid data. Given the diversity of tasks and objectives inherent in intervention strategies, it is essential that their structure and content reflect the strengths and limitations of the available evidence.

A notable association was observed between the quality ratings derived from the critical review and the GRADE assessments. Specifically, studies assessed as having high methodological quality consistently received either high or moderate GRADE ratings. Importantly, no study rated as high quality in the critical review received a low-GRADE rating. Conversely, all studies assigned a low-GRADE rating originated from studies classified as having moderate or low methodological quality.

These findings underscore the importance of applying rigorous and transparent appraisal criteria when evaluating scientific literature. High-quality methodological design appears to be strongly associated with reduced risk of bias and increased reliability of findings, as reflected in the GRADE framework. This alignment reinforces the value of integrating structured critical appraisal tools in systematic reviews to ensure the credibility and applicability of conclusions drawn.

Physical activity and motor competence

Traditional games, game-based programs, FMS activities, dance, and structured PA interventions consistently enhanced manipulative and locomotor skills, aligning with prior research (Barnett et al., 2011; Chow et al., 2001; Crozier et al., 2022). While structured PA significantly improves MC (Abusleme-Allimant et al., 2023; Cohen et al., 2015), social sports programs may have a more modest impact (Sousa et al., 2016). Early physical literacy is key for long-term skill retention and engagement (Barnett et al., 2018; Logan et al., 2018). Habitual PA supports aerobic capacity and BMI regulation, which in turn facilitates MC (Janssen & LeBlanc, 2010).

Previous studies that examined the associations between MC and PA found positive interactions between the two variables (Burton et al., 2023; Logan et al., 2015), emphasising the importance of developing MC to promote active lifestyles in youth (Logan et al., 2015), indicated that general increases in PA were associated with modest gains in MC, echoing the work of Robinson et al. (2015), who stated that while PA contributes to MC, it is structured skill practice that leads to significant improvement.

Moreover, habitual PA, when embedded in daily routines, was associated with improvements in aerobic capacity and in the regulation of BMI, which, in turn, support MC (Janssen & LeBlanc, 2010). However, without targeted motor tasks, the development of more complex motor skills (e.g., object control) was limited, consistent with the observations of Barnett et al. (2016).

The findings from this study demonstrate that a structured and purposeful motor skills intervention had a significant impact on the development of FMS among primary school children. These results align with previous literature emphasising the importance of targeted PE interventions in enhancing children's MC (Barnett et al., 2016; Logan et al., 2012).

From a theoretical standpoint, the outcomes can be interpreted through the lens of the model proposed by Stodden et al. (2008) model, which posits that MC is a foundational component in promoting PA engagement and preventing sedentary behaviours. The model suggests a reciprocal and dynamic relationship between motor skill proficiency and PA participation, particularly during middle childhood. In this context, the observed improvements may help break the negative spiral of disengagement often seen in children with lower MC (Robinson et al., 2015).

Moreover, the intervention design was informed by principles of Motor Learning Theory (Schmidt & Lee, 2011), which underscore the importance of task variability, feedback, and progression in supporting skill acquisition. The application of differentiated instruction and developmentally appropriate activities likely contributed to the positive outcomes observed, particularly in locomotor and balance skills. This aligns with findings from studies by Rudd et al. (2020), who emphasise the pedagogical importance of structured, inclusive, and motivating environments in motor skill interventions.

Comparatively, our results resonate with those of True et al. (2017), who reported significant improvements in MC following 12-week intervention programs in similar age groups. However, unlike studies reporting marginal gains in object control skills (e.g., King-Dowling et al., 2020). This may be attributed to the integrative nature of our program, which deliberately emphasises both locomotor and object-control skills through a varied and engaging curriculum.

However, some limitations of the selected studies should be acknowledged. The short duration of the intervention and the relatively small sample size may limit the generalizability of the results. Additionally, although teacher feedback suggested high levels of student engagement and motivation, these were not formally measured. Including psychological constructs such as perceived MC or physical self-efficacy, as proposed by Barnett et al. (2016), would enrich future research and provide deeper insight into the mediating variables influencing skill acquisition.

Physical education and motor competence

PE programs emphasising plyometric training, technical skills, and social sports positively influenced locomotor skills and object control, consistent with literature underscoring PE's role in developing MC and promoting lifelong PA (Armour & Macdonald, 2012; Bailey, 2006; Logan et al., 2015). Enriched PE programs may also enhance cognitive functions alongside MC (Pesce et al., 2016).

The studies under PE consistently demonstrated that structured, curriculum-based PE contributes significantly to the development of FMS and MC. According to Armour and Macdonald (2012), PE's school-based nature enables systematic exposure to varied movement experiences. This aligns with the findings of Stodden et al. (2008), who emphasised the role of PE in forming foundational motor skills that promote continued PA engagement.

In programs emphasising traditional games or divergent movement tasks, children showed gains not only in MC but also in creative thinking, suggesting an overlap between cognitive and motor domains. These outcomes are supported by Pesce et al. (2016), who found that enriched PE programs improve executive functions and physical literacy.

From an applied perspective, the results carry significant implications for educational policy and curriculum design. The WHO (2010) and national educational frameworks advocate promoting physical literacy and active lifestyles from an early age. Our findings support the inclusion of systematic MC programs in the primary school curriculum, which not only foster physical abilities but also contribute to holistic child development, including social and cognitive dimensions (Giblin et al., 2014).

Sport-based interventions and motor competence

Sport-related interventions such as swimming, dance, rope skipping, and plyometrics demonstrated significant improvements in balance, coordination, and explosive power, consistent with neuromuscular adaptation theories (Faigenbaum et al., 2009; Granacher et al., 2011). Dance-based programs further improved rhythm and kinesthetic awareness (Kiefer et al., 2011).

Several studies within the Sport category (e.g., swimming, dance, rope skipping, and plyometric training) confirmed significant improvements in children's MC. For instance, both short-term (e.g., 12-week) and mid-term (e.g., 16-week) sport programs led to enhancements in balance, coordination, and explosive power. These findings align with Faigenbaum et al. (2009), who noted that neuromuscular adaptations occur early in training and are particularly effective when activities are varied and skill-oriented.

Notably, plyometric and rope-skipping activities were particularly effective in improving lower-limb power and coordination (Granacher et al., 2011), a result echoed in recent studies linking explosive training to both physical and cognitive gains (Lubans et al., 2010). Furthermore, dance-based interventions contributed to rhythm, balance, and kinesthetic awareness, supporting the claims of Kiefer et al. (2011) regarding the benefits of creative movement activities for MC.

Intervention programs

Most studies highlighted the importance of developing GMC during early schooling years (ages 6 to 10). While GMC is ideally acquired in preschool and early school years, it provides the foundation for more specialised motor skills such as sport-specific and lifelong PA sequences (Barnett et al., 2016; Branta et al., 1984; Lubans et al., 2010). Early childhood is a critical period for promoting PA, and MC at this stage supports a healthy, active lifestyle (Goodway et al., 2019).

Analysis of intervention programs based on sport, fundamental movement skills, and physical activity in physical education context

School-based interventions that focus on sport, FMS, and structured PA have been shown to be effective in promoting MC in children. These approaches are particularly relevant during early primary education, a period when motor development is most receptive to external influences, and when the acquisition of basic motor skills forms the foundation for more complex skills and future sports participation (Gallahue & Ozmun, 2006). The reviewed studies reveal that structured and diversified PE programs are consistently more effective at enhancing FMS than unstructured or routine approaches.

Fundamental movement skills in the physical education context

Several interventions focused explicitly on developing FMS through games or skill-based activities. Studies by Chan et al. (2019), Cohen et al. (2015), and Jarani et al. (2016) adopted general FMS development programs, whereas others implemented more targeted methods. Akbari et al. (2009) utilised traditional games, while Oppici et al. (2020) employed dance-based learning. Sortwell et al. (2024) integrated structured games and plyometric exercises. Interventions focused on the FMS of locomotion, object control, traditional or structured games, and stability are widely supported in the literature as essential to successful participation in future physical activities and to enhancing both motor proficiency and motivation in children (Logan et al., 2012).

These results align with the meta-analysis by Morgan et al. (2013), which highlighted that structured FMS interventions in school contexts are significantly more effective in improving MC, particularly when interventions are frequent, specific, and goal-oriented. Programs that emphasise repeated, varied, and feedback-driven practice of these skills in structured and safe environments foster more consistent gains in MC (Lubans et al., 2010). According to Robinson et al. (2015), children who master FMS are more likely to engage in regular PA, creating a positive cycle of competence and motivation.

Sport intervention in physical education context

When pedagogically embedded into school programs, sport can promote motor, social, and emotional development. Sports-based programs that include age-appropriate games and activities have been associated with improvements in coordination, agility, balance, and strength (Faigenbaum et al., 2014).

Only a few school-based studies, such as Pratt et al. (2023), explicitly integrated sports (e.g., swimming) into the PE curriculum alongside FMS. Their results suggest that the dual focus on sport-specific training and FMS enhances both motor proficiency and physical conditioning. This agrees with Barnett et al. (2016), who emphasised that multi-sport participation during early childhood supports the development of a broad motor skill foundation.

Studies such as those by Jarani et al. (2016) demonstrate that regular school-based sports interventions significantly enhance MC and physical fitness in children aged 6 to 10 years, especially when combined with play-based methods and qualified instruction.

Physical activity in physical education context

Abusleme-Allimant et al. (2023) and Gallotta et al. (2017) examined PE programs with varying levels of structure (e.g., structured vs. unstructured PE), revealing that structured sessions yielded superior outcomes in FMS and PA engagement. Sortwell et al. (2021) also reported positive effects of plyometric training integrated into regular PE, suggesting that higher-intensity functional training can be effectively incorporated into the school day.

These findings support prior literature indicating that structure, progression, and deliberate practice are essential for motor learning in youth (Lubans et al., 2010). Furthermore, the findings Gallotta et al. (2017) resonate with those of Donnelly et al. (2016), who emphasised that high-quality PE is more effective when planned, developmentally appropriate, and supported by trained professionals.

The school environment is ideal for implementing structured PA programs due to its universal access and the substantial time children spend there. Interventions integrated into PE classes or extracurricular activities have shown benefits not only for MC but also for overall health, self-esteem, and academic performance (Donnelly et al., 2016). Additionally, studies such as Cattuzzo et al. (2016) highlight an association between MC and moderate-to-vigorous PA levels in school-aged children, reinforcing the need for consistent, well-structured interventions.

Analysis of intervention programs based on sport, fundamental movement skills, and physical activity in extracurricular context

Extracurricular programs, often characterised by flexible and informal formats, also serve as effective avenues for the development of MC, particularly when access to quality school PE is limited. The included studies demonstrate a range of approaches from sports-specific training to innovative technology-based interventions.

Fundamental movement skills and physical activity in extracurricular context

Studies such as Idamokoro et al. (2024), Sousa et al. (2016), and Skowroński et al. (2019) implemented interventions that combined FMS and general PA. These programs tend to focus on free play, games, and structured physical challenges. Nobre et al. (2017) and Sortwell et al. (2021) introduced plyometric components in extracurricular settings, enhancing explosive strength and coordination.

The success of these programs aligns with findings from Wick et al. (2017), which demonstrated that motor skill interventions outside school—when guided and structured—can significantly improve children's FMS, particularly when using task variation, repetition, and feedback.

Sports program in extracurricular context

Moura et al. (2021) and Šlosar et al. (2021) reported on extracurricular sport-based interventions, such as swimming and tennis, sometimes augmented with digital tools (exergames). Šlosar et al. (2021) introduced a hybrid program combining exergames and tennis, reflecting a growing trend toward gamification in motor learning.

These findings echo those of Gao et al. (2015), who suggested that exergames can enhance motivation, enjoyment, and participation, provided they are carefully designed to challenge and develop key motor skills. Furthermore, traditional sports, when combined with skill development frameworks, offer comprehensive physical and psychosocial benefits (Barnett et al., 2016).

Future directions for motor competence intervention programmes

The findings of this systematic review offer a solid empirical basis for the development and implementation of MC intervention programmes targeting children aged 6 to 10 years old with typical development. However, in addition to the specific content of the interventions, it is essential to account for structural variables such as the duration of the intervention, the frequency of sessions, and their length, as these elements may significantly influence outcomes.

Given the considerable variability across studies in terms of design, intervention length, and reported quality, it remains challenging to determine the most effective intervention model. Therefore, future programmes should be contextually adapted to the developmental characteristics of the target population and aligned with the specific objectives of each study, to optimise their effectiveness.

Despite methodological heterogeneity, all included studies reported positive effects on MC development, particularly when interventions were structured, engaging, and delivered by qualified professionals. Nevertheless, the potential for publication bias and the limited representation of socially diverse populations necessitate a cautious interpretation of the findings.

To enhance the robustness and generalisability of future research, the following priorities are recommended: (i) Adoption of longitudinal study designs to evaluate the sustainability of MC gains and their long-term impact on PA behaviours; (ii) Exploration of moderating factors such as gender, socioeconomic status, and school context in shaping intervention outcomes. (iii) Use of mixed-methods approaches that incorporate qualitative data from educators, caregivers, and children to better understand contextual influences on MC; (iv) Active involvement of children in the design of intervention activities to ensure alignment with their interests, motivations, and lived experiences.

By integrating these considerations, future research can contribute to the development of more inclusive, effective, and culturally responsive pedagogical practices that support MC development in early childhood.

CONCLUSIONS

This systematic review highlights the effectiveness of pedagogical interventions—such as PA, FMS, and sports—in enhancing MC in children aged 6-10 years with typical development. Effective programs typically include locomotor, manipulative, and stability-related activities, and may be strengthened by incorporating strength-based exercises, speed drills, and playful or recreational components. While some studies underrepresented balance and stability, this may reflect a gap in the literature rather than a lack of relevance. Overall, the findings support integrating evidence-based practices in primary education to promote the holistic development of physically literate and active children.

In conclusion, this study underscores the efficacy of targeted pedagogical interventions in promoting MC in primary education. The results advocate for a broader integration of evidence-based practices in PE to support the development of physically literate and active children.

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