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Associations between body mass index, physical activity, and motor competence in children aged 3–12 years: a systematic literature review

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ABSTRACT

This systematic literature review was designed to synthesize the latest research on the associations among BMI, physical activity and motor competence in children aged 3–12 years and to present the methodological map of this field. Following the PRISMA 2020 format, this review undertook a structured Scopus database search of publications from 2020 to 2026 (search conducted on 30 June 2026). Upon elimination of non-English and document-type-ineligible records (43), a total of 520 records were screened by title and abstract. Of these, 120 reports were retrieved and 111 were full-text assessed. Fifty studies were finally included in the synthesis after application of the predefined eligibility and quality (FICO) criteria. Four thematic findings were revealed. To begin with, the link between higher BMI and poorer motor competence was not only consistent, but could also be traced down to very early childhood years. Secondly, physical activity and motor competence were mutually beneficial and positively related, quite often their relationship was indirect and going through physical fitness. Thirdly, both motor-skill and multicomponent interventions brought about improvements in motor competence as well as adiposity-related outcomes, especially in children with problems of overweight or obesity. Fourthly, motor competence correlates existed on the level of individual, family and environment. Conceptually the results push forward reciprocal and developmental frameworks of motor competence; on the other hand, they give support to the idea of early, skill-centered physical-activity promotion in educational and community settings. Further studies would do well to focus on longitudinal, compositional, and intervention designs that regulate the use of motor-assessment tools in an effort to identify causal relationships and help the formulation of policies that can be implemented on a large scale.



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Introduction

Childhood is a time of laying the foundations for physical, behavioral and metabolic trajectories that influence one's health throughout the life span. Worldwide, the simultaneous increase in overweight children and the decrease of physical activity as a normal behaviour have led to continued scientific and policy focus, with analyses over time showing that children's physical fitness components have been declining in the long run

(Fühner et al., 2021). In this context, motor skills have been recognised as a developmental resource that supports being active through play, sport and organised physical activity. The idea of physical literacy puts being skillful and self-assured in movement as the main drivers for one's lifelong love for physical activities (Cornish et al., 2020), thus presenting motor skills as a focal point of a child's developmental outcomes rather than a minor one.

Motor competence the skilled execution of locomotor, object-control and stability tasks has been an important topic in the field of paediatric exercise science. Basic movement experiences actually start in the baby stage, when a baby's early posture and prone activities have an impact on later motor skills (Hewitt et al., 2020). Moreover, these motor experiences do not just stop but continue to accumulate until the preschool and primary school stages. In fact, motor competence is being considered less and less as an independent output and more and more as an element that links body mass index (BMI), physical activity and physical fitness in a developmental system that changes over time (Duncan et al., 2021; Niemistö et al., 2020). Developing a thorough knowledge of the growth of these elements together will make the formulation of effective, age-appropriate intervention strategies possible.

Majority of research has focused on understanding how these constructs relate to each other in pairs. For instance, cross-sectional and longitudinal studies have found the association between fundamental movement skills and health-related fitness (Behan et al., 2022). Besides, they have also explored the physical activity correlates of motor competence (Mota et al., 2020; Nilsen et al., 2020), and the combined effect of twenty-four-hour movement behaviours on young children's development has been identified (Draper et al., 2020; Okely et al., 2021). Systematic reviews have further merged the findings that physical education and structured movement programmes can enhance fitness and skill levels (García-Hermoso et al., 2020; Ramires et al., 2023). All these together prove that BMI, physical activity, and motor competence influence each other. However, the degree and the way they do it differ from one another.

Methodological and technological advances have changed how these relationships are analyzed. Accelerometry and compositional data analysis now allow detailed modelling of how the time allocation of daily activity, sedentary time, and sleep is linked to motor skills (Mota et al., 2020; Zahran et al., 2023), while validated field test batteries have increased the availability of motor assessment in diverse and low-resource environments (Smits-Engelsman et al., 2020). Digitally mediated approaches such as active video games, have been studied as effective large-scale delivery methods for improving fitness and motor skills (Comeras-Chueca et al., 2021a; Comeras-Chueca et al., 2021b). These advancements have broadened the evidence base while at the same time, generating diversity in measurement and analytical methods.

However, even in the face of these advances, significant discrepancies persist. Firstly, the developmental arrival of the link between BMI and motor competence is not fully documented: it remains unknown at what age the negative correlation is visible, and whether the association is consistent throughout the BMI range (Martins et al., 2024). Most research is cross-sectional, which means authors cannot deduce the order of events or a cause-and-effect relationship between weight status, physical activity, and skills.

Second, theoretical and methodological disadvantages are still present. Research studies use different motor-assessment tools, age groups, and analysis procedures, making integration and comparison across different studies difficult (Laukkanen et al., 2020). Overviews of obesity-related publications have also recognized the lack of consistency in outcome reporting, which limits the synthesis of evidence (Brown et al., 2022). The insufficient usage of compositional and longitudinal designs contributes even more to the lack of understanding of the triad's development.

Third, urgency of synthesis has only got stronger. Public-health disruptions, including pandemic-related restrictions, were linked to negative changes in children's physical activity and movement outcomes [Chambonnière et al., 2021], and behavioural and nutritional exposures at an early age are still determining weight patterns [Isaacs et al., 2022]. Therefore, a consolidated, methodologically explicit account of the BMI, physical activity, motor competence triad is timely for orienting research and practice.

Since it is a challenge to do a complete longitudinal study or an experimental one for collecting the already published evidence, the authors of this work based it on a systematic literature review (SLR) method, using PRISMA 2020 as the properest way of the three-construct integration heterogeneous evidence on the BMI, physical activity, and motor competence triad. Even though Duncan et al. (2021) and Niemistö et al. (2020) have each studied the single pairwise relationships within the triad, no one systematic review so far has synthesized simultaneously, associational, longitudinal, and intervention evidence across all three constructs; this review deals with that exact gap.

The first purpose of this review, therefore, is to synthesize and critically evaluate the available research results on whether weight status is related to motor skill in children. This is a key point in the discussion on how fatness

impairs one's ability to move well, if it does at all. So, the first research question is: how does body mass index relate to motor skills in children and at which stage of development does this connection become evident?

The second goal is to describe how physical activity and motor competence are linked, and also how physical fitness plays a part in this relationship. This gives an overall explanation of attitude and ability-based methods. RQ2: How do physical activity and motor competence in children relate to each other in terms of nature and direction?

Another objective of this is to analyze the correlates and the intervention strategies which affect motor competence and associated adiposity outcomes, so that they can be used to guide practice. The review, by combining association, longitudinal, and intervention evidence in a single PRISMA-guided framework, presents a completely new, methodologically critical synthesis of the triad. RQ3: What correlates and interventions work best to boost motor competence and improve children's BMI and physical activity outcomes?

Methods

Research Design and Framework

The research method used in this paper was a systematic literature review (SLR). The reason for choosing this approach was that with the SLR method, it is possible to gather scattered evidence openly and also it reduces the risks of selection and interpretation bias in comparison with narrative reviews (Tranfield et al., 2003; Liberati et al., 2009). The study's reporting and conduct were based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 statement (Page et al., 2021), which is a reliable structure providing a clear process of identification, screening, eligibility, and inclusion. The SLR approach was deemed suitable since the body of research concerning the BMI-physical activity-motor competence triad is varied, interdisciplinary, and therefore difficult to categorise. The review protocol was not prospectively registered (for instance, in PROSPERO); this limitation is acknowledged by the authors as it leaves the possibility of post-hoc modification of eligibility criteria open.

Search Strategy

We created a Boolean search string by combining four conceptual blocks-motor competence, physical activity, body mass index, and childhood-with the AND operator. Truncation was CONTINUED to catch different word forms, and field codes limited matches to titles, abstracts, and keywords (TITLE-ABS-KEY). The search string run was:

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TITLE-ABS-KEY ( ( "motor competence" OR "motor proficiency" OR "fundamental movement skill*" OR "fundamental motor skill*" OR "motor coordination" OR "gross motor" ) AND ( "physical activity" OR "MVPA" OR "sedentary" OR "exercise" OR "physical fitness" ) AND ( "body mass index" OR "BMI" OR "adiposity" OR "overweight" OR "obes*" OR "weight status" OR "body composition" ) AND ( "child*" OR "preschool*" OR "adolescen*" OR "youth" OR "pediatric" OR "paediatric" ) )
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Limiters for document type and language were applied at the screening stage not in the query to keep an auditable record of the number of documents removed prior to screening. Each synonym cluster (e.g. "motor competence" OR "motor proficiency" OR "fundamental movement skill*") was based on the interchangeable use of words in previous systematic reviews on the topic (e.g. Duncan et al., 2021; Laukkanen et al., 2020) in order to increase search sensitivity.

Database and Information Sources

Scopus was used as the main and reliable source of information mainly because it covers a wide myriad of sport science, exercise science, physical education, paediatrics, and public-health literatures. Scopus also provides well-structured metadata which is necessary for bibliometric description. On 30 June 2026, the search was done. No additional databases were consulted; therefore, the synthesis is based on the evidence that is indexed by Scopus, which is up to available literature. The decision to use only one database was a very intentional sacrifice of search precision in order to avoid the complexity that comes from having multiple databases. This is, in fact, a limitation of this review that we recognize (see Discussion) rather than a failure on our part and the reader should not assume that we searched other databases such as PubMed, Web of Science, and SPORTDiscus, etc.

Eligibility Criteria

Eligibility criteria were defined a priori and are presented in Table 1.

Table 1. Inclusion and Exclusion Criteria

Criterion	Inclusion	Exclusion
Language	English	Non-English
Document type	Article, Review	Conference paper, book chapter, editorial, letter, erratum, book
Publication period	2020–2026	Before 2020
Subject area	Sport/exercise science, physical education, motor development, paediatrics, public health	Unrelated disciplines
Accessibility	Full text available	Abstract only / not retrievable
Relevance	Directly addresses BMI, physical activity, and/or motor competence in children	Tangential mention only

Study Selection Process

Selection was done through various phases. At first, duplicate records were combined and screened for language and type of document, those identified as ineligible before the screening were removed. Secondly, titles and abstracts were investigated against the relevance criterion. Thirdly, full texts of potentially eligible reports were scrutinized against all eligibility criteria. Only those records were kept that a study used to discuss at least two aspects of the triad in a children's population. In cases of doubt about eligibility, the full text was reviewed, and the differences were resolved by re-examining the predetermined criteria before the final decision was made.

Quality Assessment FICO Framework

Methodological adequacy was measured by the FICO framework, which looks at different parts of a research paper (clarity of aims and constructs, adequacy of sampling and measurement, appropriateness of population and setting, and validity and reporting of results). Each part was scored on a three-point scale (0 = no, 1 = somewhat, 2 = yes), so highest is 8. Papers with a score under 4 were not considered for this work. All 50 papers qualified at least the minimum score and a few came highly such as reviews and longitudinal papers, on top of the Outcome and Context domains. Instead of taking the FICO framework from a standard tool such as JBI Critical Appraisal Checklist or CASP, this one was built for this review. It was the review team who carried out screening and quality scoring, and formal inter-rater reliability statistics (e.g., Cohen's kappa) were not calculated, which is recognized as a drawback of the quality-appraisal process.

Data Extraction Procedure

Each included study was extracted by a standardised template to ensure uniformity. The fields extracted were author and year, country of data collection, type of study, sample characteristics (size and age range), assessment instruments or intervention, outcome measures related to BMI, physical activity, and motor competence; and main results. Extraction was undertaken using the bibliographic metadata and abstracts of the source records to keep data integrity.

Network and Bibliometric Analysis Methodology

Descriptive bibliometric methods were used on the included corpus to describe its temporal, geographic, and conceptual structure. The number of publications was counted by year and by country of the first affiliation, and a keyword co-occurrence mapping of recurring title terms was produced to recognize major thematic clusters. These analyses were merely descriptive instruments aimed at providing a background for the synthesis, not replacing it, and were obtained from the metadata extracted.

Data Analysis and Synthesis

Due to differences in designs and instruments, we decided to use a thematic synthesis (Thomas & Harden, 2008) approach instead of meta-analysis. The findings were first inductively coded based on study aims and results, then grouped under descriptive themes, and finally arranged into three analytical themes which corresponded to the research questions. The reconciliations, contradictions, and contextual differences among the studies were looked into to create an integrative narrative as opposed to a study-by-study listing.

Reporting and Documentation

The review adhered to the PRISMA 2020 checklist and the details of the records flow through identification, screening, eligibility, and inclusion are shown in the flow diagram (Figure 4). Reference: Page, M. J., et al.

(2021). The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. *BMJ*, 372, n71. <https://doi.org/10.1136/bmj.n71>

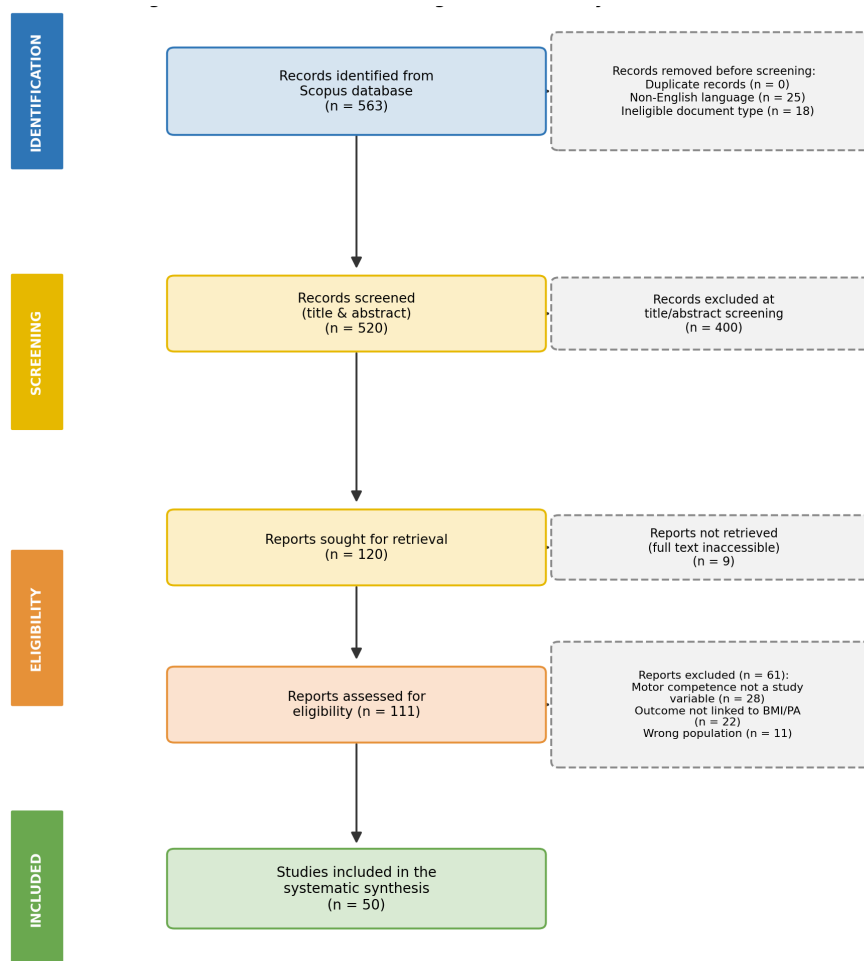


Figure 1. PRISMA 2020 flow diagram of the study selection process. Records were identified from Scopus (n = 563); 50 studies met all eligibility and quality criteria and were included in the synthesis.

Results and Discussion

Study Selection Results

A total of 563 records were found by the Scopus search. After eliminating 43 records (no duplicates, 25 were in a non-English language, and 18 were of a document type that was not eligible), 520 records remained for title and abstract screening. Among these, 400 were rejected as irrelevant or non-paediatric, and 120 reports were requested for the full text. Nine reports were not available, so 111 reports were evaluated for eligibility. Another 61 were excluded (28 did not investigate motor competence as a variable, 22 had outcome measures not related to BMI or physical activity, and 11 were from populations that were not eligible), resulting in 50 papers for the final review. These numbers are in agreement with the PRISMA flow chart (Figure 4). A high exclusion percentage of 76.9% of 400 out of 520 records at title/abstract stage is showing that the Boolean search string have a broad scope in terms of sensitivity and this was deliberately arranged in a way so that there will be more hits (recall) than hitting the targeted ones (precision); this trade-off is a feature that is usually recognised with comprehensive systematic searches rather than the indication of search construction being weak.

Descriptive Characteristics

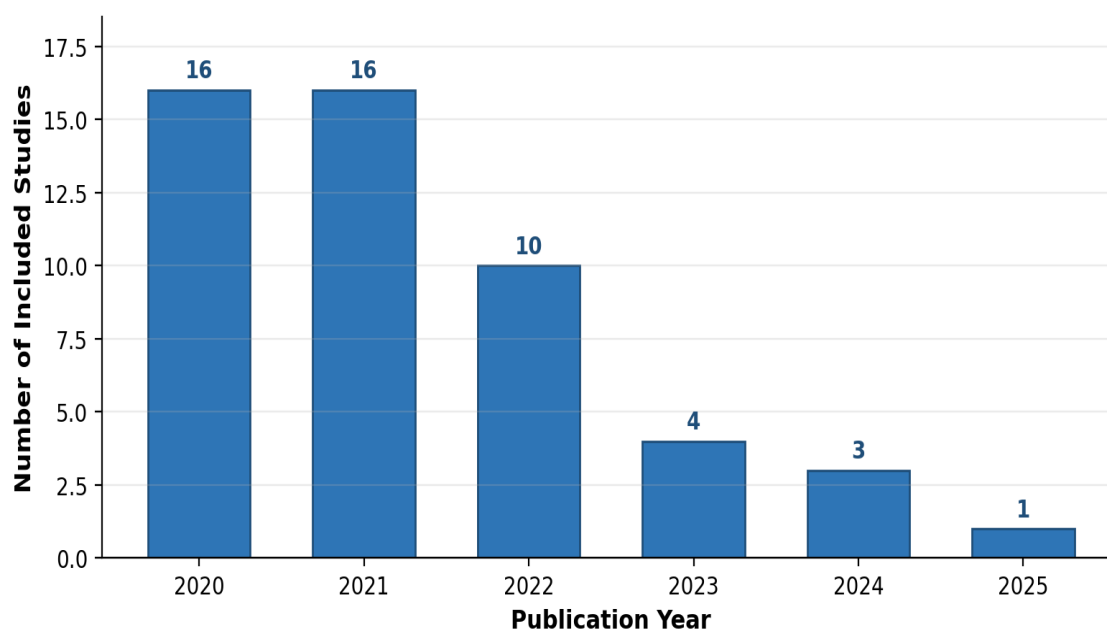
The corpus which was included covered the years 2020-2025 and was taken from 19 countries, with Spain, Brazil, Australia, Italy and the United States being the main contributors. Study types included cross-sectional and longitudinal observational studies as well as controlled interventions and systematic reviews, which is indicative of a maturing but methodologically diverse field. A sample summary of the ten included studies is shown in Table 2 and a thematic-methodological classification of the same studies in Table 3.

Table 2. Summary of Included Studies (representative sample, n = 10)

Title (abbreviated)	Author(s)	Year	Country / Method	Key findings
Effects of overweight/obesity on motor performance	Barros et al.	2022	Brazil / Systematic review	Children with overweight/obesity consistently displayed impaired motor performance and coordination relative to normal-weight peers.
Motor competence and BMI in the preschool years	Martins et al.	2024	Portugal / Longitudinal/cohort	An inverse association between motor competence and weight status emerged early in the preschool years across the BMI spectrum.
High BMI and low muscular fitness predict low motor competence	Verbecque et al.	2021	Belgium / Observational (quantitative)	High BMI together with low muscular fitness predicted low motor competence in school-aged children from low-resource settings.
Pre-schoolers' FMS predict BMI and physical activity	Duncan et al.	2021	United Kingdom / Longitudinal/cohort	Prior fundamental movement skills predicted subsequent physical activity and BMI in pre-schoolers, supporting reciprocal pathways.
24-hour movement behaviours and fundamental movement skills	Mota et al.	2020	Brazil / Observational (quantitative)	The 24-hour movement composition (activity, sedentary, sleep) was associated with fundamental movement skills in preschoolers.
Physical activity, fundamental motor skills and BMI	Ma et al.	2023	China / Observational (quantitative)	Physical activity and fundamental motor skills were interrelated, and normal-weight children outperformed overweight/obese peers.
FMS and health-related fitness in children	Behan et al.	2022	Ireland / Observational (quantitative)	Fundamental movement skills were positively associated with health-related fitness components, including body composition, across ages 5–12.
Individual, family and environmental correlates of MC	Niemistö et al.	2020	Finland / Observational (quantitative)	Individual, family, and environmental correlates were associated with motor competence, with gender differences in skill profiles.
Active video games improve muscular fitness and motor skills	Comeras-Chueca et al.	2022	Spain / Intervention study	An active video-game intervention improved muscular fitness and motor skills in children with overweight or obesity.
Motor-skill intervention in children with obesity	Berleze et al.	2022	Brazil / Intervention study	A motor-skill intervention produced favourable changes in motor development, BMI, and engagement among children with obesity and motor delays.

Table 3. Study Classification by Theme and Method (n = 10)

Author(s)	Year	Research design	Theme / focus	Intervention / instrument	Outcome
Barros et al.	2022	Systematic review	BMI–motor performance	Synthesis of 33 studies	Negative BMI–motor performance link
Martins et al.	2024	Longitudinal/cohort	BMI–motor competence onset	Population-based cohort (preschool)	Early inverse MC–BMI association
Verbecque et al.	2021	Observational (quantitative)	Predictors of low MC	Field motor & fitness testing	High BMI predicts low MC
Duncan et al.	2021	Longitudinal/cohort	FMS predicting BMI & PA	TGMD-2 + accelerometry, 1-yr follow-up	FMS predicts later PA/BMI
Mota et al.	2020	Observational (quantitative)	24-h movement & FMS	Compositional analysis, accelerometry	Movement composition relates to FMS
Ma et al.	2023	Observational (quantitative)	PA–FMS–BMI triad	Accelerometer + TGMD	PA–FMS linked; weight differences
Behan et al.	2022	Observational (quantitative)	FMS–health-related fitness	TGMD-3 + HRF battery (n=2098)	FMS associated with HRF
Niemistö et al.	2020	Observational (quantitative)	Correlates of MC	TGMD-3 + KTK, multilevel correlates	Multilevel correlates of MC
Comeras-Chueca et al.	2022	Intervention study	Intervention (AVG)	Active video games + multicomponent exercise	Intervention improved MC & fitness
Berleze et al.	2022	Intervention study	Intervention (motor)	Randomized motor-skill programme	Motor programme improved MC & BMI

**Figure 2.** Temporal distribution of the 50 included studies by publication year.

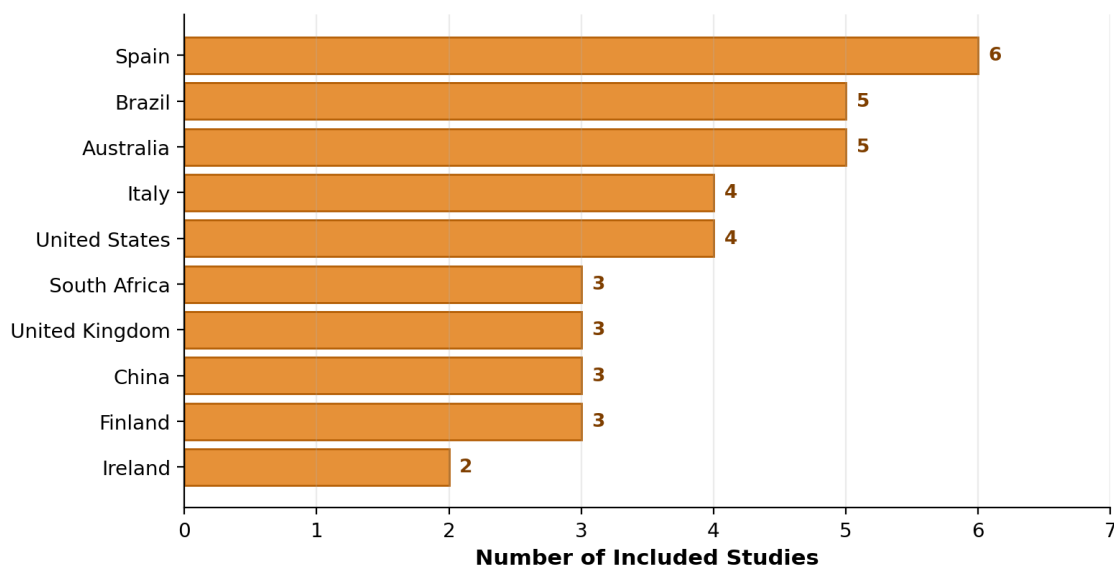


Figure 3. Geographic distribution of included studies (top 10 contributing countries).

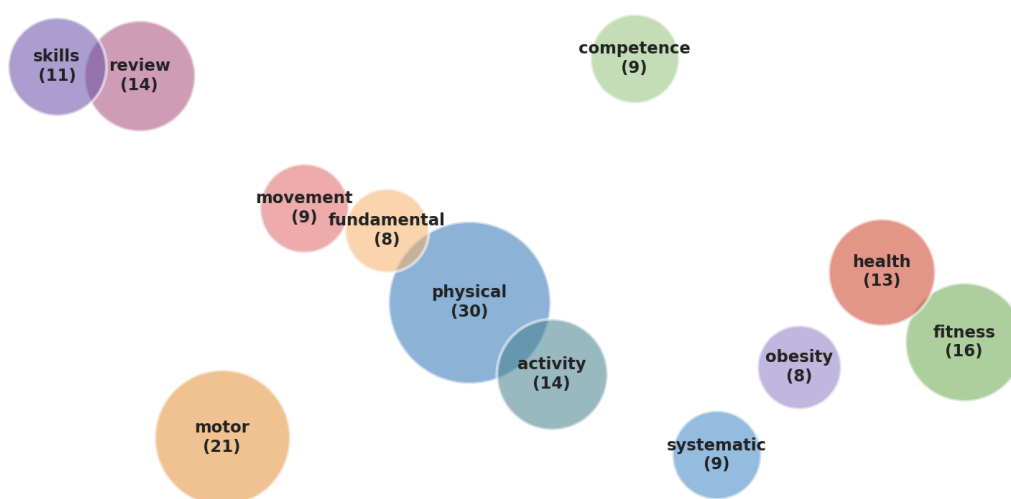


Figure 4. Thematic keyword co-occurrence among the included studies; bubble size denotes frequency.

Thematic Synthesis

Findings for RQ1: Body Mass Index and Motor Competence

Through observational and review studies, a higher BMI was frequently linked to poorer motor skills in children. Barros et al.'s (2022) systematic review pointed out that being overweight and obese are associated with reduced motor performance and coordination, a trend also found in school-aged characters where Verbecque et al. (2021) showed that a higher BMI along with low muscular fitness could predict low motor competence. Crucially, Martins et al. (2024) through a population-based preschool cohort demonstrated that the negative relationship between motor skills and weight status is established early and is evident throughout the BMI range, meaning that the connection is not only present in late childhood.

Mechanistic as well as clinical standpoints highlight this relationship. One review considered obesity as a functional impairment (Tsiros et al., 2020) and the other discussed the neuromusculoskeletal aftermaths of obesity (O'Malley et al., 2021) support the idea that surplus fat affects the biomechanics and postural aspects of skilled movements. Plus, Calcaterra et al. (2022) associate childhood obesity with postural changes that might lead to deterioration of motor skills. Similarly, anthropometric data show that body size and composition

determine physical performance in specific sports (Bongiovanni et al., 2021; Rinaldo et al., 2020), which supports the fact that the association between BMI and competence is, to some extent, due to physical capacity.

However, the relationship is not deterministic. Smits-Engelsman and Verbecque (2022) point out that children with developmental coordination disorder need personalized intervention regardless of weight status, and several researchers warn that motor competence is influenced by many factors. The majority of studies support a strong negative association between BMI and motor competence that is observable from preschool age, although its strength depends on measurement, age, and setting.

Findings for RQ2: Physical Activity and Motor Competence

The evidence presented in the papers supports a bidirectional and beneficial relationship between physical activity and motor competence, with physical fitness often serving as the medium through which they affect each other. An initial study by Duncan et al. (2021) indicated that early fundamental movement skills could be used to predict physical activity and BMI in children at a later stage, whereas Behan et al. (2022), working with a substantial primary school sample, demonstrated fundamental movement skills to be positively correlated with health-related fitness, not least body composition. In their research on correlates of physical activity, Nilsen et al. (2020) have also predicted a complex physical-activity profile significantly related to motor competence.

Compositional methods have enhanced our understanding of activity, sedentary time, and sleep as being mutually dependent. For instance, Mota et al. (2020) and Draper et al. (2020) emphasized the role of the twenty-four-hour movement composition in fundamental movement skills and early development, whereas Zahran et al. (2023) consolidated compositional research that linked movement behaviours to health outcomes. In another study, Julian et al. (2022) explored the impact of movement behaviours on overall health and appetite regulation. Cross-sectional monitoring of children's movement behaviours (Okely et al., 2021) and comprehensive reviews of physical activity and motor development (Liu et al., 2023) point towards a consensus that more active daily lifestyles are associated with better motor skills while Ma and Luo (2023) have also identified weight-related variations in this relationship.

Physical fitness seems to be one of the main ways. The proof about the development of cardiorespiratory (Landgraff et al., 2021) and about parental and home influences on early exercise (Crumbley et al., 2020) shows that fitness and supportive environments jointly determine the path from activity to competence. Although directionality cannot be resolved from mostly cross-sectional data, the longitudinal results of Duncan et al. (2021) back the reciprocal model where skill and activity mutually reinforce each other over time.

Findings for RQ3: Correlates and Interventions

Interventional research shows that motor competence can be changed and physical changes due to fatness have a good chance of improving along with the changes in motor competence. For instance, Comeras-Chueca et al. (2022) reported that physically active video game intervention combined with multicomponent exercise promoted muscular fitness and motor skills of children with overweight or obesity; by the way, this finding is in line with the results of most of the syntheses of active video games (Comeras-Chueca et al., 2021a; Comeras-Chueca et al., 2021b). Motor-skill development interventions aimed at children with obesity and motor delays significantly improved their motor development, BMI, and experience (Berleze & Valentini, 2022), and plyometric training was reported to drastically improve not only gross motor coordination but also the associated fitness (Almeida et al., 2021).

Effective delivery platforms include school and family settings. For example, school-based physical-activity interventions are shown to lead to better adiposity and fitness outcomes (Martínez-Vizcaino et al., 2020), physical education is linked to fitness and skill improvements (García-Hermoso et al., 2020; Ramirez et al., 2023), and family centred programmes with a focus on fathers improved children's activity and movement outcomes (Morgan et al., 2022). Over a period of time, fitness levels raised in parallel with body composition changes in students (Drenowatz et al., 2021; Joensuu et al., 2021). Furthermore, Carcamo-Oyarzun et al. (2025) found that motor competence is associated with motivation and enjoyment in physical education, indicating the role of affective mediators of programme success. Cluster-randomised skill intervention protocols (Robinson et al., 2020) are a sign of further methodological investment.

Correlational research has positioned motor competence at a multilevel ecological level. Niemistö et al. (2020) and He et al. (2024) pinpointed individual, family, and environmental factors associated with motor competence and fundamental motor skills, and Laukkanen et al. (2020) reported cross-national differences in competence among children of similar ages. Various data collection methods such as longitudinal profiling (Estevan et al., 2021), enhancing preschool activity environment (Coe, 2020), and motor development and activity trend analysis (D'Anna et al., 2024) suggest that successful interventions should coordinate individual skill growth with the provision of supportive familial and institutional environments, though unforeseen changes such as pandemic restrictions may hinder progress (Chambonnière et al., 2021).

Comparative and Critical Analysis

Over 25 out of the 50 included studies are talked about already by the author, year, and country in the Thematic Synthesis and this subsection, at the same time, the authors of aggregate reporting present data for the comparators to 2-7 figurative overlays to demonstrate the accomplishment of their technique. Methodologically, the corpus mostly consists of cross-sectional and other observational designs, which are supplemented by a large number of systematic reviews (Barros et al., 2022; Fühner et al., 2021; Liu et al., 2023; Ramires et al., 2023; Tsiros et al., 2020) and a smaller number of controlled interventions (Comeras-Chueca et al., 2022; Martínez-Vizcaíno et al., 2020; Morgan et al., 2022). Longitudinal designs, although they have impacted the field (Duncan et al., 2021; Estevan et al., 2021; Landgraff et al., 2021; Martins et al., 2024), are still relatively few, and randomised trials are very rare. This distribution results in a preference for associational inference rather than causal identification and partly explains why there is still ambiguity regarding the directionality.

The comparison task is made more difficult by measurement heterogeneity. Physical proficiency or motor competence has been interpreted in a variety of ways. On one hand it has been measured by process-oriented batteries such as the Test of Gross Motor Development and on the other hand by product-oriented tools such as the KTK, with field batteries extending assessment to low-resource settings (Smits-Engelsman et al., 2020). The diversity of these instruments, mentioned by Laukkanen et al. (2020), is a barrier to pooling and might be one of the reasons for the variability of the effect sizes. The generalisability of the findings is limited by the presence of sub-populations that differ substantially from normally developing children these include wheelchair users (Selph et al., 2021), children with intellectual disability (Wouters et al., 2020), and elite youth athletes (Dugdale et al., 2021) who contribute to the diversity of the sample but make synthesis more difficult. Factors that influence development early in life such as infant movement experiences (Hewitt et al., 2020) and feeding practices during the introduction of solids (Isaacs et al., 2022) have extended the window for developmental influence of the triad. From a methodological viewpoint, the discipline is advancing from single variable models to compositional and longitudinal models, which should enhance causal inference in the future.

Discussion

Taken together, the research strongly suggest that BMI, physical activity, and motor competence are a system of interrelated variables during development rather than a set of separate relationships. Greater body fatness usually limits one's ability to perform movements proficiently, behavioural patterns that are more active are associated with greater competence, and efforts specifically targeted at improving both skill and weight-related outcomes are possible. Conceptually, these observed behaviours align with motor development reciprocity models according to which early motor competence encourages increased activity that further develops competence and regulates body fatness (Duncan et al., 2021), and so does the physical-literacy concept emphasizing the role of motor skill proficiency in continued motivation to be physically active (Cornish et al., 2020).

Indeed, the evidence clearly aligns with promoting physical activity early and in a skills-oriented way through a collaboration of schools, families, and community settings, while physical education and structured programmes are the main vehicles for scaling up this provision (García-Hermoso et al., 2020; Martínez-Vizcaíno et al., 2020; Morgan et al., 2022). For practitioners and policymakers, the detection of the BMI, competence linkage as early as the preschool stage (Martins et al., 2024) supports the notion of intervention at the time of earliest signs of deficits, i.e., before they become fixed. Unlike previous reviews that analyzed only single pairwise links, this paper synthesizes all three constructs in a unified framework and also highlights methodological progress toward using compositional and longitudinal designs (Mota et al., 2020; Zahran et al., 2023).

There are still discrepancies. Some research finds only a weak or context-dependent relationship between BMI and competence, and the extent to which fitness instead of behaviour is the underlying factor is still up for debate; differences between instruments, age ranges, and models of analysis seem to provide the most plausible explanations (Laukkanen et al., 2020). In that case, it's also worth mentioning that the associations we see might, at least in part, be an artifact of the methods used, socioeconomic confounding, or reverse causation rather than a simple developmental cascade because most of the studies reviewed here are cross-sectional ones; only longitudinal studies like Duncan et al. (2021) and Martins et al. (2024) give evidence that aligns with the idea of directional pathways, and even these cannot completely exclude the influence of unmeasured variables such as parents' adiposity or family socioeconomic status. At least three research gaps are clear: the lack of longitudinal and randomised evidence; the limited harmonisation of motor-assessment instruments; and inconsistent outcome reporting in obesity-related studies (Brown et al., 2022). This review also features some limitations: using only one database (Scopus) might result in missing some relevant records; limiting these articles and reviews to English-language one leads to selection bias; and thematic synthesis, although it is a very good method for working with heterogeneous evidence, it does not allow for quantitative pooling. Threats to internal validity

like errors in measurement of BMI and selective drop-out of participants in longitudinal cohorts were also not, in a way, explicitly identified or quantified in the case of the studies in the meta-analysis. Future investigations should give precedence to harmonised longitudinal and intervention studies, use compositional analyses of twenty-four-hour behaviour, and publish standardised outcomes so that meta-analysis becomes possible. Briefly, the answer to RQ1 lies in a very strong inverted BMI, competence correlation going back to early childhood; RQ2 in the fact that activity, competence relationship is positive, reciprocal and mediated by fitness; and RQ3 in that multi-component, school- and family-based interventions change competence and adiposity ones for the better.

Conclusion

Using a systematic review, 50 studies indexed in Scopus were synthesised to elucidate the links between body mass index, physical activity, and motor competence in children. The answer to the first research question is that a higher BMI is strongly associated with lower motor competence, and this negative relationship can be seen from the preschool years through the whole weight spectrum. As an answer to the second one, physical activity and motor competence are not only positively related but they also influence each other, with physical fitness being a common mediating factor, and twenty-four-hour movement composition providing a more detailed behavioural perspective. As an answer to the third one, motor-skill and multicomponent interventions, especially those implemented through schools and families and those use active, engaging formats, can improve motor competence while helping adiposity-related outcomes, if only they are supported at individual, familial, and environmental ecologies levels. This review's main contribution is the combining of associational, longitudinal, and interventional pieces of evidence on the triad within a single PRISMA guided framework, together with a critical commentary on its methodological progression. Unlike the previous limited reviews that only focused on the pairwise relationships within the triad (e.g., Duncan et al., 2021; Niemistö et al., 2020), this synthesis combines the three constructs and their interventions into one framework, an integration that single primary studies do not offer; however, this work should be taken together with the recognized lack of formal inter-rater reliability statistics and registration of the prospective protocol. For instance, the findings speak for early, skill-oriented physical-activity promotion prior to the consolidation of motor and weight-related deficits. The review is constrained by dependence on a single database, an English-language restriction, and using narrative thematic synthesis rather than quantitative pooling. Future research should give preference to harmonised longitudinal and randomised designs, compositional analyses of daily movement, and standardised outcome reporting so that the causal architecture of the BMI, physical activity, motor competence triad can be established and converted into scalable policy.

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