It's Not Just What You Do but the Way You Do It: A Systematic Review of Process Evaluation of Interventions to Improve Gross Motor Competence

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Title: It's not just what you do, but the way you do it: A systematic review of process evaluation of interventions to improve gross motor competence

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Abstract

Background Motor competence is an important predictor of health behaviours. However, levels of motor competence are low in children and adolescents. Many interventions have improved motor competence, yet intervention effects were highly variable. Potential causes for such variations are not fully understood. Process evaluations can assist with the understanding of why an intervention worked or not, but its application and reporting in motor competence interventions have received little attention.

Objectives The primary aim of this review was to investigate whether process evaluations have been reported in interventions to improve motor competence and if reported, which process evaluation measures have been used). A secondary aim was to explore the association of intervention characteristics and process evaluation findings (outcomes of process evaluation measures) and intervention outcomes, in search for what process evaluation measures may impact on intervention functioning and outcomes.

Design The process of conducting and reporting this review adhered to Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA). The review protocol was registered with PROSPERO (CRD42019124412).

Data Sources A systematic search of seven electronic databases (i.e. MEDLINE [via EBSCOhost], Cochrane Central Register of Controlled Trials [CENTRAL], CINAHL, Academic Search Complete, Education Database, SPORTDiscus and Scopus) with no date restrictions was conducted.

Eligibility Criteria for Selecting Studies Eligibility criteria included (1) a study sample of typically developing children and adolescents aged 5–18 years, (2) an intervention aimed to improve motor competence, (3) an intervention included a control group, (4) a report of motor competence outcome at both pre and post-intervention. Only original articles published in English in peer-reviewed journals were considered.

Methods Process evaluation measures and findings were extracted using the UK Medical Research Council's process evaluation framework, in order to provide overarching descriptions on the implementation, mechanism of change and context of interventions. Univariable meta-regressions were performed to ascertain if selected study-level covariates moderated the improvement in motor competence outcomes in interventions.

Results The search identified 60 intervention studies. Only 30 studies (50%) reported process evaluation measures. No studies reported (or employed) theoretical frameworks to guide process evaluation. Process evaluation measures relating to implementation were most commonly reported with the most prevalent aspect being fidelity. This was followed by reporting on measures relating to mechanism of change and context of the intervention. Meta-regression results suggest intervention duration, dose, inclusion of process evaluation aim, provision of lesson plans, sample size and sex as potential moderators.

Conclusions Reporting of process evaluation measures may help build our understanding of the optimal characteristics of motor competence interventions. However, process evaluation is under-used and/or under-reported. This review serves as a call for more process evaluations and better reporting in motor competence interventions.

Key points:

- This article provides the first comprehensive review on the methods and findings related to process evaluation in motor competence interventions and revealed process evaluation is not sufficiently used and adequately reported in interventions when used.
- Within limited reporting of process evaluation, there is some evidence that process evaluation can help identify potential moderators of intervention effects.
- To better inform the future design and scale-up of motor competence interventions, more comprehensive evaluation with a pre-defined evaluation aim, as well as better reporting of interventions are recommended. This review provides an overarching summary on critical evaluation domains/measures for researchers' considerations in this respect.

Running heading: Process Evaluation in Motor Competence Interventions

Word count: 7000 excluding the abstract, references, figure legends and table captions

1 Introduction

Motor competence is a global term used to describe directed human movement [1]. It reflects a broad range of terminologies used across the various disciplines of motor development [2], including motor proficiency, fundamental movement skill (FMS), motor ability and motor coordination [1]. Gross motor competence in children and adolescents–the focus of this review–incorporates FMS including object control (e.g. throwing and catching), locomotor (e.g. running and jumping) and stability skills (e.g. balancing and twisting) [3]. These skills are considered as the foundation of more advanced, complex movements [4]. Level of motor competence has been associated with children's and adolescents' weight status [5], physical activity [1, 6], health related fitness [7] and other social and cognitive outcomes [8–10]. Yet, low level of motor competence in children's and adolescents has been widely observed [11–15]. To support motor competence development, children need the opportunity to learn and practise FMS [16] as maturation alone is not sufficient [17]. In view of this, an increasing number of interventions have emerged to improve children and adolescents' motor competence.

A diverse range of strategies that are developmentally and instructionally appropriate, such as motor learning, modified physical education (PE), and free play, have been used in interventions to improve motor competence [18]. Multiple systematic reviews have reported moderate to large intervention effects from such studies; however, they also report on substantial heterogeneity among studies [18–23]. Significant heterogeneity can arise from clinical diversity (e.g. variability in interventions strategies and outcomes) or methodological diversity (e.g. variability in study design and quality) [24]. For the latter, all reviews identified methodological weaknesses related to both internal and external validity with risk of bias analyses [18, 20–23]. In comparison, the potential causes for variations in intervention effect are not fully understood [19] which limits our understanding as to why interventions are effective (or not).

Based on the theoretical underpinning of motor learning, motor development is a multifaceted process where an individual's biology (e.g. sex, age) interacts with the surrounding physical and social environment (e.g. exposure to appropriate learning and practice opportunities) [17]. It is therefore expected that effects of interventions may vary as a response to this complex developmental process. Characteristics of participants may influence how they receive interventions and external factors such as socioeconomic environment and parental support may also influence the effect a motor competence intervention may have. Some reviews have delved into specific intervention characteristics in an attempt to determine which characteristics moderated intervention outcomes, and to what extent. For example, Logan, Robinson, Wilson and Lucas [22] and Morgan, Barnett, Cliff, Okely, Scott and Cohen et al. [23] were not able to establish a statistically significant association between intervention dose/duration and FMS outcomes. Jiménez-Díaz, Chaves-Castro and Salazar [18] conducted an exploratory analysis to ascertain the effectiveness of interventions of different types and concluded motor skill interventions were more effective than statutory PE and free play to improve motor competence. However, further analyses to identify potential moderators was not possible due to data unavailability. All three reviews reported difficulties in analyses due to inadequate intervention description and data reported [18]. Furthermore, two other reviews synthesised qualitative evidence on characteristics of teacher training and pedagogy in FMS interventions [25, 26], finding that whilst teachers and pedagogical approaches are important to the effectiveness of interventions, the limited depth and consistency of reporting of these characteristics posed challenges for being able to identity elements critical to optimise motor competence interventions [25, 26].

On account of this, improved understanding of factors that influence motor competence intervention effectiveness is needed [21]. One approach which may help is conducting and reporting process evaluations. Process evaluations investigate how and why interventions are effective or not, and for whom and under what circumstances [27]. Inclusion of process evaluations are encouraged in order to clarify the causal pathways and functioning of interventions, assess intervention delivery, investigate contextual variance, and ultimately inform intervention effectiveness and dissemination [28]. This might be particularly relevant for motor development research, since very few interventions have reported on the translation of research into routine practice, in the longer term [29].

Given the observed low motor competence levels and little understanding of how interventions operate for optimal and sustainable effects, there is emerging interest in conducting process evaluations in motor competence interventions [30]. In the broader context of motor development research, investigating the intervention process not only leads to a more comprehensive interpretation of the outcome efficacy, but it also echoes the historical examination on processes for motor behaviour changes as to "*why and how that particular outcome occurred*" (p. 184) [31]. Therefore, exploring process evaluation evidence in motor competence interventions is necessary and important [26]. Building evidence base of process evaluation in motor competence interventions is required to inform and prompt better practice in their development and evaluation, as well as to inform their future scalability and sustainability. In light of this, the primary aim of this review was to investigate whether process evaluations have been reported in interventions to improve motor competence and if reported, which process evaluation measures have been used (process evaluation methods). A secondary aim was to explore the association of intervention characteristics and process evaluation findings (outcomes of process evaluation measures) with intervention outcomes both quantitatively and qualitatively, in search for what process evaluation measures may impact on intervention functioning and outcomes. Considering reviews of interventions to date have only used a single-method approach (i.e. focus on either quantitative or qualitative data synthesis), this review employed a mixed methods approach whereby both narrative syntheses and meta-analyses were performed to analyse quantitative and qualitative data attempting to provide comprehensive and balanced findings [32].

2. Methods

The process of conducting and reporting this review adhered to Preferred Reporting Items for Systematic Reviews and Meta-Analyses [33]. The review protocol was registered with PROSPERO (CRD42019124412).

2.1 Study Selection Criteria

Inclusion and exclusion criteria were defined a priori, and outlined in Table 1

Insert **Table 1** here

2.2 Information Sources and Search

Relevant studies were identified through systematic searching of seven electronic databases and scanning reference lists of subsequently identified articles. Searched databases include MEDLINE (via EBSCOhost), Cochrane Central Register of Controlled Trials (CENTRAL), CINAHL, Academic Search Complete, Education Database, SPORTDiscus and Scopus. No publication date restrictions were imposed. The search was originally completed in February 2019 and updated in September 2020.

Search strategies used in the databases included combinations of key text words and indexing terms where applicable (e.g. MeSH) as recommended by the Cochrane handbook for

Systematic Reviews of Interventions [34]. The search terms were divided into three groups: (1) population (e.g. child* OR student* OR adolescen* OR child[MeSH Terms] OR adolescent[MeSH Terms]); (2) intervention (e.g. "Fundamental Movement Skill*" OR "FMS" OR "fundamental motor skill*" OR "motor skill*" OR "motor ability" OR "motor learning*" OR "motor competence" OR "motor proficiency" OR "motor development" OR coordination OR co-ordination OR "motor pattern*"); (3) study design (e.g. Intervention* OR “intervention stud*” OR evaluat* OR effect* or clinical trial as topic [MeSH Terms]). The Boolean phrase “AND” was used between groups, and phrases “OR” was used within groups. An example search syntax has been provided in Electronic Supplementary Material Appendix Table S1.

Following the initial search, JM removed all duplicates and screened the titles and abstracts of remaining records in a non-blinded standardised manner via a web-based application (Rayyan [35]). In the cases of uncertainty as to whether a study met the inclusion criteria, studies were reviewed and discussed between JM and IE. Any disagreements were resolved by discussion with EE or MD. Full-text articles were then retrieved for all remaining records. All full-text articles were further evaluated separately for relevance by JM and IE via an online-based systematic review tool (Covidence [36]). Cases of disagreements following full-text review were reviewed and discussed by both reviewers to reach consensus. The reference lists of included articles were scanned to identify additional relevant articles.

2.3 Data Extraction

Given the scope of the current review, extraction on process evaluation measures was guided by a comprehensive evidence-based process evaluation framework published by the UK Medical Research Council (MRC) [27]. As defined in this guidance, a process evaluation is *“a study which aims to understand the functioning of an intervention, by examining* *implementation, mechanisms of impact, and contextual factors"* (p. 10). The MRC guidance provides a "lens" to review process evaluation measures of motor competence interventions in a systematic and exhaustive way. Specifically, we used three evaluation domains (as summarised in Table 2 from the MRC guidance as a coding framework for data extraction and synthesis purposes.

Data of each included study were extracted relating to: the general study characteristics (i.e. author, date, country, sample, study design, intervention theory and content, intervention duration, measures and outcomes), and the reporting of process evaluation measures as coded by the MRC framework. Data on process evaluation measures in the domains of implementation, mechanism of change and contextual factors were extracted relating to their evaluation questions, collection methods and findings. Extraction was conducted by JM with 15% of the randomly selected subsample checked by IE on Covidence. JM developed and set up a data extraction form on Covidence. The form was piloted and refined prior to data extraction. No significant discrepancies were found in the subsample. All key findings were checked by IE for accuracy.

Insert **Table 2** here

2.4 Risk of Bias

Each of the included studies was independently analysed by JM and MD using a 10-item tool adapted from the Consolidated Standards of Reporting Trials statement [37] and previously used quality criteria [23] (see Table 3). The risk of bias assessment tool was set up on Covidence to obtain consistent data across all studies, as well as to enable two assessors to independently extract quotes and add comments to support their judgements. As recommended by the PRISMA statement [33], items of risk of bias assessment were not summarised to provide final scores, instead each criterion was considered in isolation. Each item on the scale was coded as “explicitly described and present” (+), “absent” (-) or “unclear” or “inadequately described” (?). Interrater reliability for the assessors was calculated on a dichotomous scale (+ = 1 vs. – or ? =0) using percentage agreement and Cohen’s *k*. Some items were coded as not applicable (N/A) due to study design and therefore not included in agreement calculations. Disagreements were discussed and resolved between assessors.

Insert **Table 3** here

2.5 Data Synthesis and Analysis

A two-phase data analysis was conducted according to review aims. Phase 1: To ascertain whether process evaluation has been reported in motor competence interventions (Primary Aim), we reviewed all included studies to determine a numerical value of how many studies reported process evaluation. Phase 2: Intervention studies that reported process evaluation measures were analysed in Phase 2. Written summaries and tabulation of extracted data in relation to process evaluation were presented in a narrative form. Collection methods for process evaluation measures were synthesised by evaluation domains to describewhat and how process evaluation measures were used (process evaluation methods). To achieve the secondary aim that (i.e. if intervention characteristics and process evaluation findings of studies are associated with intervention outcomes), outcomes of process evaluation measures were analysed in relation to the magnitude and direction of intervention effects both quantitatively and qualitatively. A convergent segregated mixed methods approach to analysis was used [38].

2.5.1 Qualitative synthesis

Qualitative research findings related to process evaluation were categorised by three evaluation domains to provide overarching descriptions on the implementation, mechanism of change and context of interventions. Where applicable, results were thematically assembled to produce sets of factors that affect intervention implementation, mechanism and outcomes. To provide a clear summary to describe contextual influences, these factors were grouped according to the Durlak and DuPre framework [112]. We chose this framework for its established usability to compare facilitators and barriers in school-based physical activity interventions [113, 114], which the MRC framework does not offer.

2.5.2 Quantitative synthesis

Firstly, DerSimonian-Laird inverse variance random-effects meta-analysis was conducted in R environment (package: *metafor*)[39, 40] to determine the association of the interventions with improved intervention outcomes (overall motor competence outcomes) compared with controls. Intervention effects were calculated as standardised mean differences (SMD) using Hedges *g* [41]. For studies that include post-test and follow-up assessments, the assessments completed closest to the intervention endpoint were included in meta-analyses. When studies reported outcomes using other statistical analyses such as ANOVA and regression rather than the raw difference, statistical results (e.g. F value, coefficients) were used to calculate SMD [42] in R using *esc* package [43]. Statistical heterogeneity was assessed using forest plots and the χ^2 and I^2 statistics. By convention, I^2 values of 25% were considered low, 50% moderate, and 75% high [41]. The potential for publication bias was assessed using funnel plots and Egger's test. A baujat plot was used to identify studies contributing significantly to the heterogeneity. A sensitivity analysis was conducted after excluding highly influential studies.

Secondly, a series of random-effects univariable meta-regressions were performed. Extracted quantitative data were, where available, included as study-level covariates in meta-regression analyses to examine their associations with intervention outcomes and if they explained heterogeneity in effect sizes (if I^2>50%). Investigated moderators (also used in a previous meta-analysis [18]), were: duration (total length of intervention in terms of weeks), intensity (session frequency per week), mean age of study sample, and sample size of each study. These were coded into binary variables based on the calculated median (i.e. above or below the median). Other included binary variables coded according to extracted qualitative data were: whether studies included a process evaluation aim, the use of a theoretical concept, provision of lesson plans, involvement of family, and teacher training. Sex was also included as a moderator (two groups; interventions targeting boys or girls only, or where both sexes were targeted) as it was reported to have influenced intervention outcomes in process evaluation findings included in our review.

2.5.3 Integration of quantitative and qualitative evidence

Meta-regression results and synthesised qualitative findings were juxtaposed and organised into a line of argument to produce an overall configured analysis [38] on the links between interventions and process evaluation findings, in an attempt to achieve the secondary aim. Studies with insufficient data were excluded from meta-regression or qualitative synthesis. This information was outlined the Electronic Supplementary Material Appendix Table S2.

3 Results

The initial search identified 7265 papers. The updated search in September 2020 identified 4565. The PRISMA flowchart for the screening is shown in Fig. 1. This resulted in the inclusion of 67 publications, which covered 60 interventions. All 60 interventions were analysed in Phase 1. In Phase 2, due to data availability, 37 interventions were included in the quantitative synthesis. For example, some studies did not provide sufficient data for standard effect sizes to be calculated. This therefore limited the number of studies that could be included in the meta-regression. Thirty interventions that reported process evaluation measures were included in the qualitative synthesis.

Insert **Fig. 1** here

3.1 Study Characteristics

Study characteristics of all included 60 studies are shown in the Electronic Supplementary Material Appendix Table S2. Most interventions were school-based, with five studies in secondary schools examining adolescents (13-15 years) [44–48], and 49 studies in primary schools examining children (5-12 years) [49–97]. The remaining studies were conducted in after-school [56, 98–101], community [102–107], and family settings [108]. The vast majority of interventions (n=38) used PE as delivery medium and 12 interventions used a whole-school approach or included multiple components that involved a wider target audience such as parents [47, 48, 52, 53, 57, 61, 72, 83, 85, 96, 108, 109]. Three interventions targeted boys only [55, 65, 67], four targeted girls only [44, 46, 48, 66], the remaining 53 targeted both sexes. The targeted sex was unclear in one study [64]. The median sample size was 150. The duration of interventions ranged from two weeks [64] to four years [57, 96] with a median of 12 weeks.

3.2 Risk of Bias

Table 3 summarises the results of risk of bias assessments for the 60 included studies. Interrater reliability for the assessment indicated consistent agreement across 450 items (percentage agreement 90%, k=0.60). Information on power calculation for motor competence was only presented in 15 studies (25.0%) and dropout rate was unclear in 21 studies (35.0%). Assessor blinding information was not clearly reported in more than half of studies (n=37, 61.7%). Intervention descriptions were not clear or adequate in 19 studies (31.7%).

Insert **Table 4** here

3.3 Primary Aim: The extent of reporting on process evaluation

This and the next section describe results pertaining to the primary aim of the review, that is, to investigate the extent to which process evaluations have been reported in interventions and which process evaluation measures have been used if reported. Of all 60 included studies, 30 (50.0% out of 60) included process evaluation measures and were carried onto Phase 2. Among these 30 studies, 26 studies (86.7% out of 30) reported measures in the domain of implementation, 15 (50.0%) reported in the domain of mechanism of change and 12 (40.0%) reported in the domain of context.

In total, there were 82 process evaluation measures reported across 30 studies. A summary of measures by studies is provided in Table 5. There were 17 (20.7% out of 82 measures) in the domain of context, 42 (51.2%) in the domain of implementation, and 23 (28.0%) in the domain of mechanism of change (see Fig 2.). In the domain of implementation, 32 measures were reported including fidelity (42.9%), reach (23.8%), dose delivered (14.3%), implementation process (7.1%), recruitment and retention (7.1%) and adaptation (4.8%). In the domain of mechanism of change, 20 measures were reported including participant responses (60.1%), mediator/s (13.0%), dose received (13.0%) and unintended consequences (13.0%). In the domain of context, recorded factors (n=14) include moderator (35.3%), barriers (23.5%), facilitators (17.6%), cross-contamination (11.8%) and other contextual factors (e.g. difference between intervention sites) (11.8%). Fig. 3 provides a summary of all reported measures by evaluation domains.

Insert **Fig. 2** here

Insert **Fig. 3** here

Insert Table 5 here

3.4 Primary Aim: Process evaluation methods

3.4.1 Research aims

Of 30 studies which included process evaluation measures, 17 (56.7%) proposed a priori research aims in relation to the process evaluation (see Table 5). These aims covered a range of process evaluation questions regarding how the intervention was anticipated to work, including feasibility and acceptability of intervention components [48, 99, 106], contextual variations [78], implementation completeness [94], participant perception [52, 102] and hypothesised moderators [108] and mediators [95]. Five interventions (16.7%) [44, 52, 63, 83.,85] had an explicit design of process evaluation (i.e. explicitly reported the design in a "Process Evaluation" section in the article or in a separate publication). None of these 30 studies reported (or employed) theoretical frameworks to guide process evaluation.

3.4.2 Data collection methods

A wide range of collection methods were used to collect process evaluation data. Table 6 summarises all methods and their applications in studies by evaluation domains. Most common methods used to measure implementation were documentation and on-site observation, whereas for mechanisms of change the most common methods of data collection were self-report questionnaires.

Insert Table 6 here

3.5 Secondary Aim: Process evaluation findings

Reported process evaluation measures and their findings in each study are detailed in the Electronic Supplementary Material Appendix Table S3. Results in this and next section are concerned with the secondary review aim, that is, to describe the findings from process evaluation and intervention characteristics and explore their associations with intervention functioning and outcome.

3.5.1 Implementation

In 26 studies that reported implementation measures, the general reach of school-based activities to students were high, ranging from 79%[48] to 100%[110]. In comparison, the reach of extracurricular activities to students and parents were low (e.g. 44% attendance rate for after school sports club [48]) and tended to be lower in intervention maintenance periods (e.g. 54% phone calls received during follow-up [102]). The reach to teachers were more varied, ranging from 69.2%[110] to 100%[111]. In terms of intervention dose, prescribed dose was generally reported across studies, but not the actual dose delivered (see Table 5).

Results suggests that, despite the various focus of different prescribed intervention activities, fidelity of skill-based sessions or PE lessons were successfully adhered to (e.g. teachers successfully adhered to using a game centred approach to teach FMS[94]). Few interventions documented modifications and adaptations of intervention activities [63, 85]. Studies that assessed fidelity at different time points reported teachers and deliverers' adherence to the intervention protocol increased over time [25, 83, 93, 94]. Difference of implementation between intervention arms were also found regarding teaching styles [69, 70] and use of teaching resources [78].

3.5.2 Mechanisms of change

In 15 studies that reported measures related to the intervention mechanism, student enjoyment of intervention activities was the primary focus of process evaluation (10/14, 71%). Across different interventions, student participants found programmes enjoyable when programmes comprised one or more of the following components: active video games [98], assessment-based skill learning [63], group sports or game sessions [48, 69, 83, 102], home challenges [83, 102] and student peer-led sessions [95]. Only one study reported children's enjoyment by subgroups and found boys preferred games and sports while girls enjoyed specific and varied physical activities [52]. Children's enjoyment of physical activity were quantitatively examined as mediators in two interventions [52, 94] with authors of one study reporting enjoyment in the intervention group increased over the intervention period and to a larger extent than that of control group. Students' leadership skills were found to be a significant mediator in one study [95].

Teacher's engagement with interventions was assessed when teachers were intervention deliverers. High satisfaction was reported towards the provision of teaching resources and professional learning opportunities provided by the research team [44, 63, 72, 85]. This was reported to increase teachers' knowledge, motivation and confidence as well as decrease perceived barriers on teaching and assessing FMS, which was evidenced in one intervention study where teacher's competence and self-efficacy were assessed pre- and post-intervention [44]. One study collected qualitative data with teachers but did not report their findings [93].

Parental engagement was assessed in four multi-component interventions and suggested parental perceived intervention programme to be helpful for their children [52, 83, 102, 108]. Compared to other participant groups, parents were less involved in intervention activities [72].

3.5.3 Contextual factors

A total of 72 findings related to intervention context were reported to have influenced intervention implementation, mechanism functioning and therefore intervention outcomes. Given the large number of findings and we would like to provide a clear summary to describe these context influences, these findings were thematically grouped into 34 factors under the five domains relating to the Durlak and DuPre framework [112] (See Table 7). 19 factors were associated with implementation (10 barriers and 9 facilitators) and 15 factors were linked to mechanisms and outcome (one barrier and 14 facilitators). Descriptive summary is given here and detailed discussions on these factors are to be discussed in section 4.3.

Insert **Table 7** here

3.6 Secondary Aim: Moderators of association with intervention outcomes (univariable meta-regression)

A total of 37 studies were included in the meta-regression. Medium effect sizes for overall motor competence was revealed (SMD=0.82, 95% CI 0.63-1.00, p<0.01). There is large heterogeneity between studies (I^2=93.4%). A Baujat plot was used to identify studies contributing significantly to the heterogeneity. A sensitivity analysis was conducted after excluding these highly influential studies, and the results still indicated a moderate effect for overall motor competence (SMD=0.72, 95% CI 0.57-0.87, p<0.0001) and the heterogeneity was significantly lower (I^2=60.00%). A funnel plot was used to assess publication bias; there was considerable asymmetry of the plot. Eggers test for asymmetry of the funnel plot was significant (Coef: 4.71, p<0.01), indicating evidence of smaller studies without statistically significant effects remaining unpublished.

The results of univariable analyses are shown in Table 8. The p < .15 threshold was conservative to avoid prematurely discounting potentially important explanatory variables [115]. Short intervention duration (⩽12 weeks) and smaller dose (shorter duration per session) seemed to be related to larger intervention effects. Inclusion of process evaluation aims, provision of lesson plans as well as small sample size and mixed sex population were also potential factors associated with improved overall motor competence.

Insert **Table 8** here

4 Discussion

4.1 Principal Findings

This is the first systematic review that has attempted to comprehensively investigate the extent to which process evaluation has been conducted and reported in motor competence interventions. We identified 60 motor competence interventions and only 30 (50%) reported process evaluation measures. Given process evaluation can help identify characteristics that optimise intervention functioning and effectiveness, our findings highlight that process evaluation is under-used and/or under-reported in motor competence interventions. The limited reporting suggests missed opportunities to identify intervention elements that can be optimised and generalised.

Reporting process evaluation with greater methodical rigour is also needed. Of the 30 studies in which process evaluation measures were reported, only five explicitly stated a process evaluation component (i.e. written out as a section in the paper or reported in a separate publication) and no study mentioned the use of an evaluation framework. In this review, the lack of consistency in reporting and depth in analysing process evaluation measures hindered the comparability of interventions and the understanding of causal pathways underpinning the intervention functioning. This may be explained by the lack of presence of evaluation frameworks within motor development literature, given the guidance on process evaluation began to emerge in the early 2000s as motor competence interventions were gaining traction. On the other hand, the ad hoc reporting of process evaluation measures in these interventions surfaced as early as in 2002 [59]. This suggests researchers have the intuitive understanding of the necessity of process evaluation, that is, to understand how the intervention brings about changes that lead to the hypothesised outcomes. This understanding can be harnessed by a systematic, comprehensive and consistent reporting of process evaluation measures.

4.2 What and how was process evaluation conducted and reported

There was considerable variability in what was measured and reported, and types of methods used in evaluating intervention processes. Notably, across all three evaluation domains, measures relating to implementation were most commonly assessed and reported. Half of the implementation measures were related to intervention fidelity, and as such, it was the most prevalent of all reported process evaluation measures. Intervention fidelity refers to the degree to which an intervention is delivered as intended [116]. Thewidespread of fidelity theories in health intervention literature, which makes fidelity a putative essential element that needs to be assessed. Indeed, among the studies reviewed, fidelity was measured to ensure the internal validity of the study and help researchers to interpret outcome effectiveness accurately [117]. As an example, in one study that reported teachers' instruction approaches in both arms, the use of intended teaching approach increased over time among teachers in the intervention group but not in the control group [94]. Supported by the findings on fidelity, when interpreting the outcome that favoured students in the intervention group, researchers could confidently conclude the prescribed teaching approach was one key contributor to the intervention success. While skill and curriculum-based interventions can be successfully adhered to, fidelity to non-sessional intervention components (e.g. school policy, recess activities, community sports events) can be low [83] and may decrease over time [58]. Interpretations of these results were not reported which exposes the ambiguity in describing the purposes of fidelity assessment. This may be explained by researchers' poor knowledge and understanding of how fidelity is conceptualised and operationalised [118]. Within our review this issue was also reflected in the collection methods and analyses pertinent to fidelity. We found the assessment of fidelity often employed a standardised intervention checklist that codifies delivery characteristics of the intervention. While documenting intervention delivery is essential and a checklist may be a practical decision to record and report fidelity in a way that can be quantified, there are other aspects that are equally important but more challenging to measure.

Fidelity is a multi-faceted concept that comprises more than intervention delivery [119]. Apart from the fidelity to the intervention content, there is also theoretical fidelity that measures whether the delivered intervention was congruent with the logic that underpinned the intervention design [120]. Measuring theoretical fidelity is vital for validating intervention theories and translating interventions for other contexts [116]. It may also offer a solution for the 'fidelity/adaptation dilemma' [121] whereby the intervention effectiveness is contingent on the balance between intervention standardisation and its contextual adaptations [120]. Hawe, Shiell and Riley [122] further argued that allowing contextual changes may even induce greater fidelity (which may be referred to as theoretical fidelity). This could be particularly pertinent for motor competence interventions given their reported responsivity to contexts [123]. However, measuring theoretical fidelity was rarely done within the reviewed studies; except for two successful interventions which measured fidelity to teaching principles over time and provided ongoing consultation to deliverers [25, 63], in order to enhance intervention consistency. Additionally, a lack of clarity in intervention mechanism and its evaluation thereof is evident–only 68% of studies provided adequate intervention description according to our quality assessment. Without a strong understanding and clear description of intervention theory, it is unlikely that a meaningful assessment of implementation will occur [27, 124]. Documenting the actual implementation process and capturing adaptation may also contribute to a better evaluation.

While fidelity is a fundamental area requiring attention in process evaluation, it is too narrow a concept to cover a whole range of implementation of interventions [125]. Focusing solely on fidelity could leave unanswered the questions about whether the intervention reached its intended participants. In this review, we found intervention reach can vary depend on types of activities and target group and may decrease over the intervention period. This suggests that even if the programme is implemented in full, its functioning can still depending on how intended participants actively interact and engage with the intervention[126]. Additionally, the actual dose (e.g. time participants spent on skill practice) was only recorded in four interventions limiting the comparability of true intervention effects. In a real-world setting, prescribed intervention doses are not always delivered in full [23]. It has been continuingly underscored to record actual 'on-task' time in motor competence interventions[23], so that researchers can establish dose-response relationships in interventions.

Within our review, participant responses was the second most reported measure. Mostly it was examined through quantitative measures, including satisfaction, acceptability, self-efficacy and enjoyment. Despite its suitability for the direct comparison of engagement among heterogeneous participants, only one study in our review compared participant responses by subgroups [52], limiting our understanding regarding for whom the intervention worked most effectively. Exploring sex differences in response to interventions can provide valuable information. Boys showed favourable intervention outcomes compared to girls in one study in our review, and this was attributed to sex differences in children's preference for different intervention components–girls preferred varied physical activity whereas boys preferred games and sports [52]. These findings may provide important intervention implications for future interventions, hence a more thorough analysis of participant responses is encouraged.

Conversely, quantitative measures can be limited as they are less likely to capture the interactive nature of how participants respond and may overlook negative experiences of participants [28]. Lack of qualitative measures were identified within our review [95]. For example, some target groups (e.g. parents) were less involved in the intervention and reasons for this could have been explored qualitatively. For studies that reported qualitative findings, interpretations were not explicit as to how these findings contributed to the learning of the intervention. Overall, by undertaking qualitative research, researchers can gain more in-depth understanding about the intervention which feeds back into optimising external validity of the intervention [127, 128]. In recent implementation research exploring maintenance of a teacher-led FMS intervention, through focus groups with teachers, several drivers for sustained engagement (including those of students) with the intervention were identified and recommended for future trials [123]. With the majority of included interventions being school-based, unsurprisingly, deliverers (e.g. teachers) were surveyed, since they were considered as one key driver of the intervention success. A variety of assessments were used to measure deliverers' responses, including satisfaction of training workshops, perceived use of intervention content and knowledge and competence of teaching and assessing FMS. As identified by Lander, Eather, Morgan, Salmon and Barnett [25], teachers' engagement with interventions and values of physical activity and FMS determine the effectiveness of their role of as facilitators. However, we were not able to gather sufficient information to conclude on the optimal strategies to enhance engagement. Consistent with previous reviews, reporting on teacher's roles and pedagogy remains poor [25, 26].

Intervention functioning can be also explored by formally examining mediators with statistical tests [27]. Mediators are termed as intervening causal variables that are necessary to complete a causal pathway between an intervention and its outcome [129]. Despite several calls to test mediations in the context of an intervention [129–131], only three studies within our review did so [52, 94, 95]. Surprisingly, perceived motor competence that was theorised and reported as a specific mediating variable to improve children's actual motor competence [132, 133] was not tested in any study. Given the multifactorial nature of motor development [1], it is imperative to investigate and report mediating variables so that effective intervention strategies can be identified.

The relationship between an intervention and its outcomes can also vary depending on the surroundings that may influence intervention implementation or outcomes, known as *Context* [134]. The breadth and variety of reported contextual factors and moderators within our review confirm motor development is a complex entity. These factors are further expanded in the next section.

In summary, although we identified 66 process evaluation measures across 26 intervention studies, the heterogeneity (or absence) among the reporting and interpreting of their findings prevented the data from being reviewed fully. Moreover, some measures were collected but not analysed, defeating the purpose of conducting process evaluation in the first instance. It is also noteworthy that most of the studies did not set out a priori evaluation aims to assess the link between process evaluation measures and intervention outcomes. This can be problematic since evaluation without raising questions for investigation can increase the tendency to collect excessive data that are beyond intervention and research capacity [27]. Our review is therefore timely, highlighting the paucity of process evaluation evidence in motor competence interventions and the need for further research to expand and support the suggested findings in this review.

4.3 Factors that influenced intervention functioning and outcome

We adopted a mixed methods approach to review the links between intervention related factors and motor competence outcomes. As a first step, we collated contextual factors arising from process evaluation findings and categorised them under the Durlak and Dupre framework [112]. We then tested intervention specific covariates in meta-regressions. We made attempts to compare and integrate both qualitative and quantitative findings to explore where they converge, diverge or relate [135]. As aforementioned, we encountered a meagre literature base that explicitly described the link between process evaluation measures and outcome; therefore, limiting our interpretations of findings.

As shown in Table 7, more factors emerged in relation to intervention implementation, which confirms researchers' emerging interests and perceived challenges of implementation. Most reported barriers were related to delivery system (e.g. school environment). Challenges include time constraints and competitive demands that overload teacher's schedules [63]. Our meta-regression identified shorter intervention duration can lead to larger intervention effects (see Table 7). Aligned with findings with a recent meta-analysis on the association of PE and motor competence, it may be the quality of PE, rather than quantity, that is associated with the increase in motor competence outcomes [136]. Our speculation is the longer the intervention is, the more likely that intervention implementation is disrupted and therefore less sustained due to lack of organisational support. These findings reflect the need for a supportive school climate/environment, which aligns with findings from previous reviews [113, 114, 137]. The importance of schools and the support of change agents in the delivery of interventions is well documented in implementation research [113, 138]. In motor development, involving teachers in decision making in order to adjust programmes to school and curriculum configurations for ongoing implementation has been recommended [123]. The organisational support also includes those from managerial level (e.g. school's administrative supports) and other agencies (e.g. community clubs, local councils), as identified barriers are also concerned with staffing, resources and communications between school, home and local community (as shown in Table 7).

Facilitators that can enhance adoption and implementation of interventions were mostly associated with characteristics of provider (e.g. self-efficacy) and innovation (e.g. contextual fit). Specifically, several intervention characteristics that appeared to optimise intervention implementation were identified, including compatibility with existing curriculum [143], self-assessment [63] and increased active time [84,102]. Further elements that make interventions more appealing to participants include a competitiveness component [85,90,98], novice and transferable skill component [90,102], quality resources [52,69], and adaptability [90,44,140]. Interestingly, even though high fidelity was reported to support intervention functioning, having flexible delivery and malleable elements seem to augment the intervention mechanism. Similarly, in our meta-regression, provision of lesson plans did not appear to be a significant moderator of effectiveness. This could be because adaptation may have encouraged programme ownership by the deliverers' [123]. Deliverers characteristics and engagement with the programme was another identified facilitator. Teacher's understanding of the intervention and assessment as well as pedagogical approaches were direct influences on intervention outcomes. Consequently, the training offered to teachers could increase intervention effectiveness. Although we did not find statistical significance of teacher training as a moderator, training was reported to be a critical intervention component and comprehensively discussed in previous reviews [25, 26].

Additionally, our meta-regressions found inclusion of a process evaluation aim significantly moderated the overall effectiveness and reduced study heterogeneity. This is consistent with previous reviews on implementation which revealed that programmes with monitored implementation obtained larger effect sizes than those which reported no monitoring [112]. Combining with the fact that reported contextual factors can be interpreted with the broad literature on implementation sciences (i.e. Durlak and DuPre framework), our findings underline the need to consider the valuable role of process evaluation data in explaining the variability and ‘real-world’ implementation issues in motor competence interventions. Finally, the majority of included studies presented statistically significant intervention effects in overall motor competence, which could be the publication bias found in our meta-analysis. Our analyses suggest publication bias favoured effective interventions with large sample sizes. This further presents the need to conduct and report process evaluations that can help understand and learn from negative findings. This also requires researchers to conduct thorough evaluation planning, taking account of the selection of evaluation measures.

4.4 Strengths and limitations

Major strengths of this study include the comprehensive review (with no date restrictions) and mixed methods analysis of quantitative and qualitative process evaluation data in motor competence intervention literature, using an established framework of process evaluation. The review expanded the literature base regarding the issues faced in evaluating motor competence interventions and optimal intervention characteristics. As one of the first studies to introduce implementation science literature in motor development research, this review provides an overarching summary on critical evaluation domains/measures for researchers' considerations with an ultimate aim to promote better reporting and evaluation practice. Table 7 provided information that can be considered by researchers to reinforce intervention mechanisms and enhance 'buy-in' of target stakeholders and participants to optimise interventions.

Limitations of this review include the limited scope of mixed-methods findings. Due to data availability, some aspects of the quantitative results could not be explored in qualitative findings and some variables identified in qualitative findings could not be tested quantitatively (e.g. we could not ascertain if increase in activity time has induced larger intervention effects due to absence of activity data). Additionally, a small number of studies in category groups (e.g. targeted sex) in meta-regressions affected our confidence in ascertaining moderating effects. This also serves as a call for researchers to conduct more and consistent process evaluation and the analytic interpretation of process evaluation findings should be in-depth and where possible, supported by quantitative analysis. A further limitation is that we did not investigate the intervention effects by skill subcategories. This may have provided further intervention implications; however, this was not practical to do within one single review.

5 Conclusion

Process evaluation in motor competence interventions is in its infancy. We view our findings as a call to action to consider the valuable role of process evaluation in understanding intervention effectiveness and functioning. The persistently found variation in intervention strategies and outcomes suggests that perhaps the optimal intervention programme is not just about *what is being done*, but *the way* a theoretically sound and contextually appropriate programme can be well implemented. We need to appreciate evaluation of interventions puts forward an opportunity to observe motor behaviour changes and what causes these processes for changes. Furthermore, our findings suggest a mandate for better reporting of interventions. To achieve the ultimate goal of scaling up and sustaining effective interventions that benefit population health, we need more robust evidence to help build the scientific case on what works and what does not in practice.

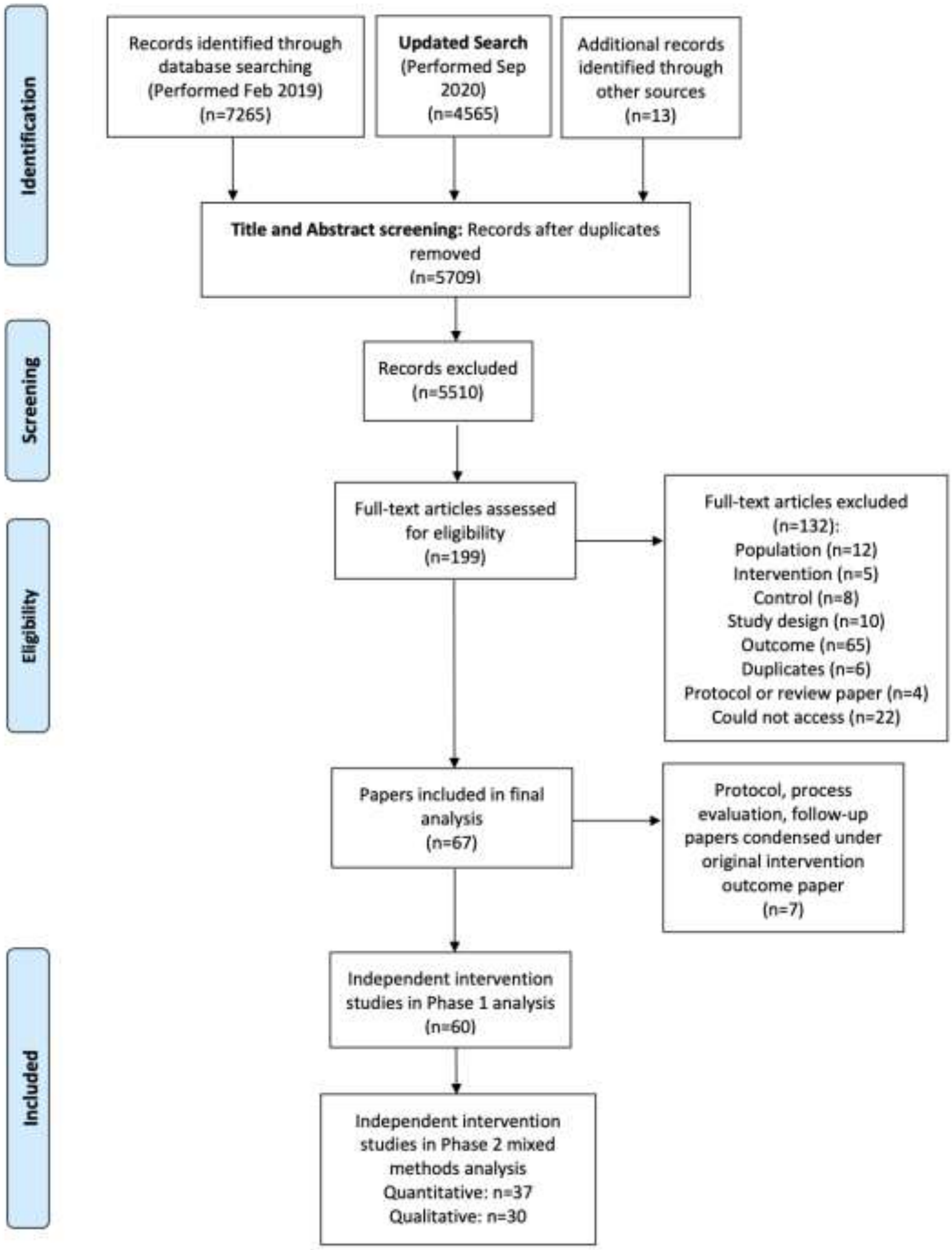

Fig. 1 Systematic reviews and meta-analysis (PRISMA) statement flowchart

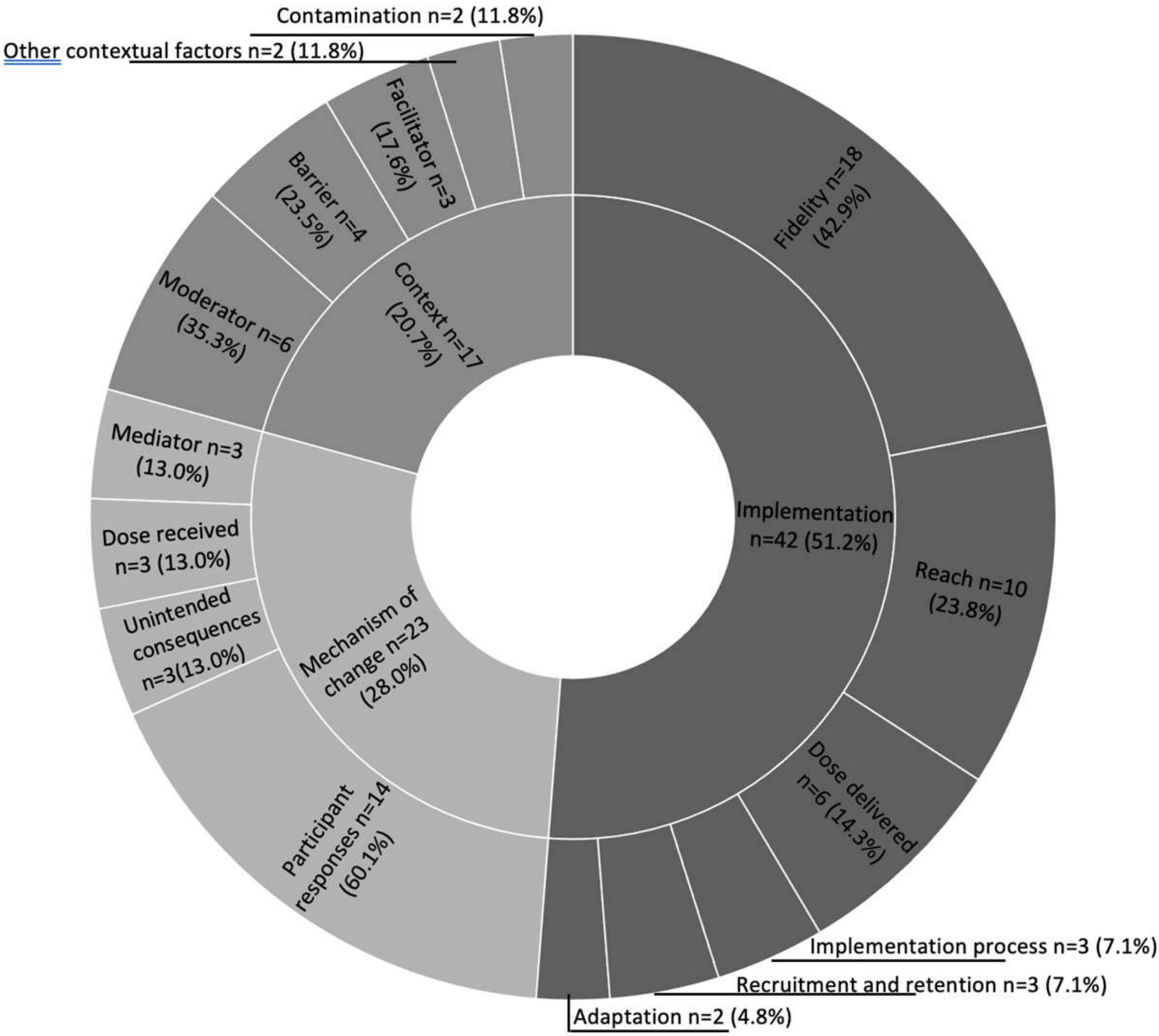

Fig. 2 An overview of reported process evaluation measures across 30 interventions

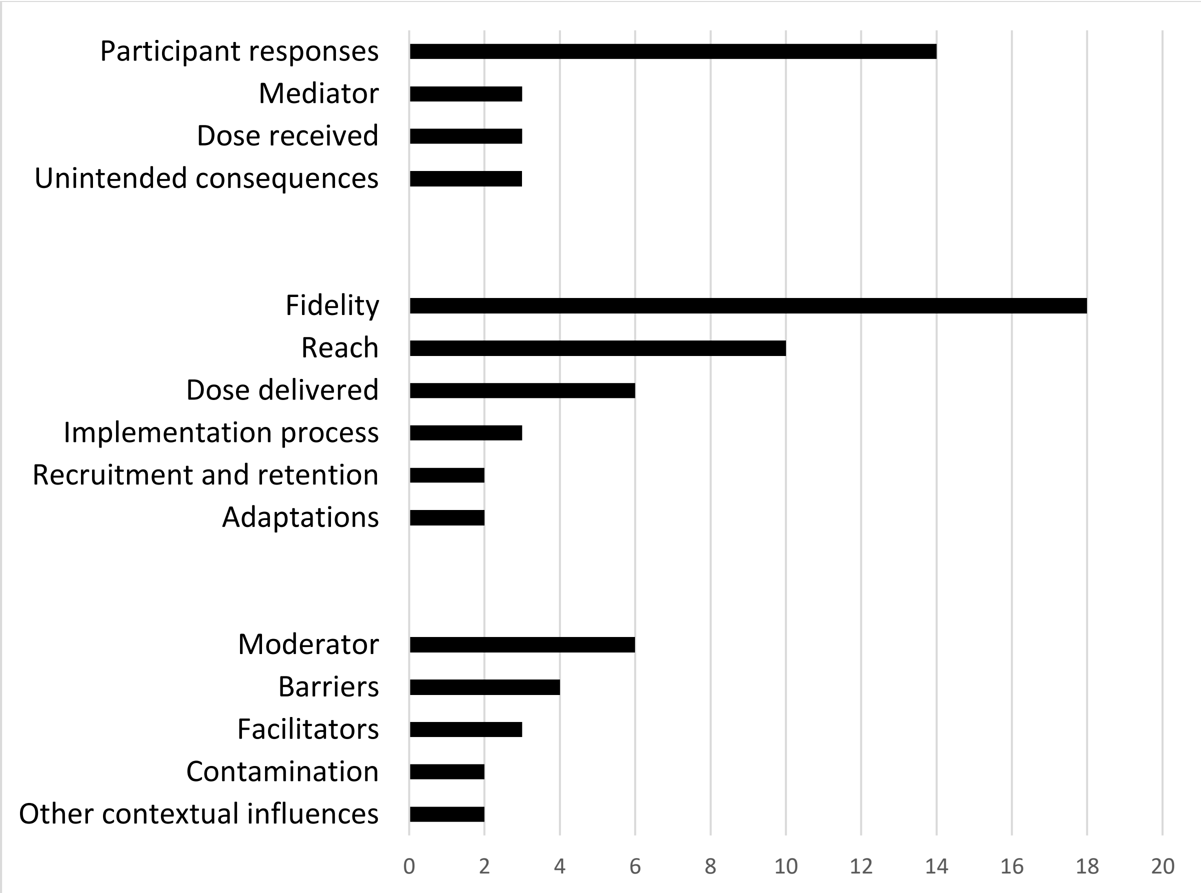

Fig. 3 Frequency of process evaluation measures reported across 30 interventions

Table 1 Study inclusion and exclusion criteria

	Included	**Excluded**
Population	• Primary/elementary (approximately 5-12 years old), middle (approximately 12-14 years old) and/or secondary/high school (12-18, or 14-18 years old) students • Typically developing children or adolescents, which could include overweight or obese or socio-economically disadvantaged students as per the criteria used in a previous review [23]	• Target participants were from specific populations (e.g., children with disabilities such as cerebral palsy or identified as having developmental coordination disorder or conditions such as intellectual, psychological or cognitive disabilities)
Intervention	• Interventions aimed at improving motor competence with any delivery/instruction method, duration or setting (school-, community- or home-based etc.)	• Interventions conducted in early childcare, preschool or kindergarten
Study design	• Randomised controlled trial (RCT), Cluster randomised controlled trials, non-randomised trials, quasi-experimental trials with a pre-post design	• Systematic review
Comparator	• Interventions included a comparison/control group that was identified as no treatment, usual care or wait list control	• Interventions compared two active intervention arms without a comparison/control group
Outcomes	• Intervention reported statistical analyses of motor competence at both pre-intervention and a minimum of one other post-study time point; • Reported process or product assessment or a global motor competence score or at least one skill (e.g.: run, jump, throw, catch, balance), or categorised in groups of commonly described similar skills such as locomotor, object control skills, or balance	• Interventions assessed only fine motor skills, or skills unique to a particular sport (e.g. climbing, dribbling)
Publication type	• Peer reviewed journal articles	• Conference abstract, dissertation and book; • Not published in the English language

Table 2 Summary of evaluation domains of process evaluation according to the UK Medical Research Council (MRC) framework [27]

Evaluation domain	Subthemes
Implementation *What is actually delivered and how?*	Implementation process: the structures, resources and mechanisms through which delivery is achieved Fidelity: the consistency of what is implemented with the planned intervention Dose delivered: the amount of intervention delivered to participants Reach: the extent to which the target audience come into contact with the intervention Adaptation: alterations made to an intervention in order to achieve better contextual fit
Mechanism of change *How does the delivered intervention produce change?*	Dose received: the amount of intervention received by participants Participants responses: participants' engagement with and experiences of the intervention Mediators: intermediate processes which explain subsequent changes in outcomes Unintended consequences: unanticipated pathways and events occurred and captured during the intervention
Context *How does the context affect implementation, mechanism and outcomes?*	Barriers, facilitators and other moderators external to the intervention which could affect and be affected by implementation, mechanisms and outcomes

Table 3 Risk of bias checklist

Item	Description
A	Randomisation
B	Valid and reliable measures of FMS used
C	Blinded outcome assessment
D	Participants analysed in group they were originally allocated to, and participants not excluded from analysis because of non-compliance for treatment or because of missing data
E	Covariates accounted for in analysis
F	Power calculations reported for FMS outcome
G	Presentation of baseline characteristics separately for treatment groups (age, sex, and >1 FMS outcome)
H	Drop out for FMS measure described with <20% drop out for studies with follow-up of 6-months and <30% drop out for follow-up with >6 month follow-up
I	Summary results for each group and estimated effect size (difference between groups) and precision
J	Adequate description of the intervention: number of intervention components/aspects, type of intervention, frequency of sessions, intensity of intervention

FMS fundamental movement skills

Table 4 Risk of bias assessment

Study	Blinded outcome assessment	Covariates analysed	Dropout described	Intervention description	Participant analysed	Power calculations	Baseline characteristics	Randomisation	Summary results	Reliable and Valid FMS measure
Akbari et al (2009) [72]	?	✗	?	✓	?	✗	✗	?	✗	✓
Andruschko et al (2018) [48]	✓	✓	✓	?	✓	✓	✓	✓	✓	✓
Azeem et al (2015) [71]	?	✗	?	✗	?	✗	✓	✗	✗	?
Bakhtiari et al (2011) [73]	✗	✗	?	✗	?	✓	✗	✓	✓	✓
Bardid et al (2017) [103]	✓	✓	✓	✓	✓	?	✓	✓	✓	✓
Barnett et al (2009) [109]	✓	✓	?	?	✓	?	?	N/A	✓	✓
Barnett et al (2015) [98]	?	✓	✓	✓	✓	✓	✓	✓	✓	✓
Boyle-Holmes et al (2010) [84]	?	✓	✓	✓	✓	✗	✗	N/A	✓	✗
Bolger et al. (2019) [94]	?	✓	✓	✓	✗	✗	✓	N/A		
Capio et al (2015) [69]	✓	✓	✓	✗	✓	✗	✓	N/A	✓	✓
Chagas et al (2018) [62]	?	?	?	✗	✓	✗	✓	N/A	✓	✓
Chan et al (2016) [70]	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Cliff et al (2011) [102]	✓	✓	?	✓	✓	✗	✓	✓	✓	✓
Cohen et al (2015) [110]	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Costello et al. (2020) [96]	?	✗	✓	✓	✓	✗	✓	N/A	✓	?
Colella et al. (2019) [97]	?	✗	✓	✗	✓	✗	✓	N/A	✗	✓
Daziell et al. (2019) [95]	✗	✗	✓	✓	✗	✓	✓	N/A	✓	✗
Duncan et al (2018) [83]	?	✓	?	✓	✓	✓	?	✓	✓	✓

Ericsson et al (2008) [79]	?	✓	?	✓	✓	✗	✓	✓	?	✓
Fahimi et al (2013) [74]	?	✗	?	✗	?	✗	✗	?	✗	✓
Foweather et al (2008) [100]	?	✓	?	✓	✓	✗	?	?	✗	✓
Gallotta et al (2017) [75]	?	✓	✓	?	✓	✓	✓	✓	✓	✓
Graf et al [65] (2008)	?	✓	✓	✗	✗	✗	✓	?	✗	?
Gu et al (2018) [85]	✓	?	?	✓	✓	✗	✓	✓	✓	✓
Guerrero et al (2018) [104]	✓	?	✓	?	✓	✗	✓	N/A	✓	✓
Hajihosseini et al (2016) [46]	?	✗	✓	?	✓	✗	✓	✓	✗	✓
Invernizzi et al (2019) [76]	?	✓	?	✓	?	✓	✗	✓	✓	✓
Jarani et al (2016) [49]	?	✓	✓	?	✓	?	✓	✓	✓	✓
Johnson et al (2016) [99]	✓	✓	✓	?	✓	?	✓	✓	?	✓
Johnstone et al (2017) [105]	✓	✓	✓	✓	✓	?	✓	✓	✓	✓
Johnstone et al. (2019) [106]	✗	✓	✓	✓	✗	✓	✓	N/A	✓	✗
Kalaja et al (2012) [45]	?	✓	?	✓	✓	✗	✓	N/A	✗	✓
Karabourniotis et al (2002) [67]	✗	?	?	✓	?	✗	✗	✓	✗	✓
Lander et al (2017) [44]	✓	✓	✓	✓	✓	?	✓	✓	✓	✓
Laukkanen et al (2015) [108]	?	✓	✓	✓	✗	?	✓	✓	✓	✓
Mathisen et al (2016) [78]	?	✓	?	✓	✓	✗	✓	N/A	✗	✗
Matvienko et al (2010) [101]	?	✓	✓	✓	✓	✗	✓	✗	✗	✗
McGrane et al (2018) [47]	✓	✓	✓	✓	✓	✗	✓	✓	✓	✓
McKenzie et al (1998) [86]	?	✓	?	✓	✗	✗	✓	✓	✓	✓
Miller et al (2015) [54]	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Miller et al (2016) [55]	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
McGann et al. (2020) [93]	?	✓	✓	✓	✓	✗	✓	N/A	✓	✓
Nathan et al (2017) [56]	✓	✓	?	✓	✓	✗	✓	N/A	✓	✓
Nobre et al (2017) [63]	?	?	✓	✓	✓	✗	✓	N/A	✓	✓
Okely etl al (2017) [57]	✓	✓	✓	✓	✓	✗	✓	N/A	✓	✓
Oppici et al. (2020) [92]	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Pesce et al (2016) [77]	?	✓	✗	✓	✓	✗	✓	✓	✓	✓
Platvoet et al (2016) [82]	?	✓	✓	✓	✓	✗	✓	N/A	✓	✓
Rudd et al (2016a) [58]	?	✓	✓	✓	✓	✓	✓	N/A	✓	✓
Rudd et al (2017b) [59]	?	✓	✓	✓	✓	✗	✓	N/A	✓	✓
Salmon et al (2008) [61]	✓	✓	✓	✓	✓	?	✓	✓	✗	✓
SilvaSilveira et al (2018) [64]	?	✓	?	✓	✓	✗	✓	✓	✓	✓
Skowroński et al. (2020) [91]	✗	✗	✓	✗	✓	✗	✗	N/A	✗	✓
Sollerhed et al (2008) [81]	?	✓	?	✗	✓	✗	✗	N/A	✗	✓
Top et al. (2020) [107]	?	✗	✓	✗	✓	✗	✓	N/A	✗	✓
Telford et al. (2020) [90]	✗	✓	✓	✓	✓	✗	✓	✓	✓	✓
van der Fels et al (2020) [89]	?	✓	✓	✓	✓	✓	✓	✓	✓	✓
Vernadakis et al (2015) [68]	?	?	?	✓	?	✗	✗	✓	✗	✓
Ye et al (2018) [87]	?	✓	✓	✗	✓	✗	✓	?	✓	✓
Zhang et al (2019) [88]	?	✓	?	✗	✓	✗	✗	N/A	✓	✓

? unclear or inadequately described, ✓ explicitly described and presented, ✗ absent, *N/A* not applicable, *FMS* fundamental movement skills

Table 5 Process evaluation measures reported across 30 studies: summary table

			Implementation					Mechanism of change				Context
Study	RQ	Implementation process	Fidelity	Dose delivered	Reach	Recruitment &retention	Adaptation	Dose received	Participant responses	Mediator	Unintended consequence	Contextual factors
Andruschko et al (2018) [48]	✔			✔	✔	✔			✔			✔
Barnett et al (2009) [109]		✔										
Barnett et al (2015) [98]	✔							✔	✔			✔
Boyle-Holmes et al (2010) [84]	✔	✔	✔	✔								✔
Chan et al (2016)[a] [70]	✔		✔	*			✔		✔			
Cliff et al (2011) [102]	✔		✔	*	✔				✔			✔
Cohen et al (2015)[a] [110]	✔		✔	*	✔			✔	✔		✔	
Duncan et al (2018) [83]				*	✔							
Daziell et al (2019) [95]			✔						✔			
Graf et al (2008) [65]			✔									
Gu et al (2018) [85]				*					✔			
Invernizzi et al (2019) [76]	✔		✔	*					✔			
Jarani et al (2016) [49]				*	✔							
Johnson et al (2016) [99]				*				✔				✔
Johnstone et al (2017) [105]			✔	*	✔	✔						
Kalaja et al (2012) [45]			✔	*								
Karabourniotis et al (2002) [67]	✔		✔	*								

Lander et al (2017)[a] [44]	✔		✔	*		✔			✔			
Laukkanen et al (2015) [108]	✔			*	✔				✔			✔
Miller et al (2015) [54]			✔	*								
Miller et al (2016) [55]	✔		✔	*						✔		
Nathan et al (2017) [56]	✔			✔	✔				✔	✔		✔
Okely etl al (2017) [57]	✔								✔			✔
Pesce et al (2016) [77]	✔		✔	*								
Rudd et al (2017a) [58]			✔	*								
Rudd et al (2017b) [59]			✔	*								
Salmon et al (2008)[a] [61]	✔		✔	✔				✔	✔	✔	✔	✔
SilvaSilvera et al. (2018) [64]					✔							
Telford et al (2020)[a] [90]	✔	✔	✔	✔			✔		✔		✔	✔
van der Fels et al (2020) [89]	✔			✔	✔							✔
Total	17	3	18	6	10	3	2	4	14	3	3	11

[a]Studies had an explicit design of process evaluation (i.e. explicitly reported the design in the "Process Evaluation" section in the article or in a separate publication), *RQ,* research questions related to process evaluation , * Studies reported dose prescribed but not the actual dose delivered

Table 6 Data collection methods of process evaluation measures in motor competence interventions

Collection Methods	Application	References
	Implementation	
Documentation	Using trial logs, routine records, attendance sheets and written lesson plans to determine quantity and quality of intervention delivery, mainly reported by researchers or deliverers	[44,48,49,56, 61,64,70,83,84, 89,90,102,108]
On-site observation	Structured and unstructured (random) observations by researchers or independent trained assistants against standardised checklists	[44,45,51,54,65 ,67,70,95,97, 102,109,110]
Video analysis	Retrospective analysis of video recordings of intervention sessions against standardised checklists to quantify the qualitative characteristics of PE teaching or skill sessions	[76,77]
Interview	Interviews with deliverers and school staff to get in-depth perceptions on quality of intervention delivery	[65,90,110]
Ongoing consultation	Researchers providing feedback and reinforcement during the intervention period and allowing for ongoing adaptations	[44,70]
	Mechanism of Change	
Self-report questionnaires	Questionnaires administered to: Deliverers, assessing competence, self-perception, programme satisfaction; Participants, assessing programme satisfaction, enjoyment, peer leadership skills; Parents, assessing their Involvement and engagement with the programme, satisfaction	[44,48,54,56,61 ,70,76,102,108, 110]
On-site observation	Using standardised observation forms to document children's responsiveness during intervention sessions, including on-task time and responses to different skill trainings	[70,98,99,102]
Documentation	Having routine records or logs to document hypothesised an unintended intervention mechanism	[61,90,110]
Interview and focus group	Interviews and/or focus groups with participants to obtain in-depth perception of interventions and intervention deliverers	[57,76,98]

	Also done with intervention deliverers to learn their understanding of intervention.	
Video analysis	Retrospective analysis of video recordings of intervention sessions to gather knowledge on children's engagement both quantitatively and qualitatively	[76]
Context		
Interview	Interviews with participants and deliverers to gain knowledge on barriers and facilitators during the intervention implementation	[57,61,84,90,102,108]
On-site observation	Informal researcher observations on causes for contextual variations	[48,57,90,102]
Self-report questionnaire	Questionnaires administered to parents to collection information on socioeconomic status, gaming and ball sports experience	[98,99]
Secondary data analysis	Analysing routinely collected data such as sex and seasonal variation as potential moderator of intervention effects.	[56,61,108]

PE, physical education

Table 7 Reported contextual factors that influenced intervention implementation, intervention mechanism and outcome categorised by Durlak and DuPre [41] domains

	Implementation	Mechanism and outcome
Community level factors	– Logistics[48,64] + Linking schools to community sport[48,90,110]	+ Incentives provided to participants[102]
Provider characteristics	+ Teacher's understanding of assessment[70,111] + Understanding of the programme and its benefits and changing process[56,57,90,95] + Improved confidence in PE teaching[70,102,111]	+ Teaching style [54,55,76,77] + Clear instruction and encouragement[70,76,90,111]
Innovation characteristics	+ More activity time for students[76,102] + Student self-assessment[70] + Integration of a new programming [57]	+ Novice skill and activities [76,102] + Transferability of skills [90,98] + Competitive and engaging component of activities[85,90,98] + Availability and quality of resources [61,108] + Adaptability [84,90,111]
Factors related to the prevention delivery system	– Staff turnover[57] – Time and scheduling[70,102,108] – School environment/climate[90]	+ High fidelity/adherence to project protocol/principles[54,55,102,110,111] + Shift in school culture[90]

	– Administrative support[57,84] – Lack of champion [90] – Classroom management[102]	
Factors related to the prevention support system	+ Ongoing consultation, feedback and reinforcement [108,111]	+ Teacher/deliverer training[84,110,111]
Others	+ Confidence in PA[102] – Weather[105,108] – Participant fatigue[102,108] – Language/cultural barrier[57,90]	+ Prior sports experience[98,99] + Satisfaction of the programme[56,57,61,70,76, 102,110,111] – Lack of home practice[102] + Engagement and support from parents[61,64,102,108,110]

+ facilitator, - barrier, *PA,* physical activity

Table 8 Univariable meta-regressions for gross motor competence

Covariate of Interest (Univariable)	**n**	**β (95% CI)**	**P Value**	**I^2, %**	**R^2, %**
Implementation					
Duration (⩽12weeks vs >12weeks)[a]	23 vs 23	-0.86 (-0.74 to -0.08)	**0.02**	93.24	1.22
Dose (mins)	41	-0.01(-0.02 to 0.00)	**0.05**	92.17	0.00
Intensity (⩽2 sessions per week vs >2 sessions per week)	11 vs 25	0.27 (-0.21 to 0.76)	0.27	92.47	0.00
Mechanism of change					
Use of theoretical concept (no vs yes)	16 vs 28	-0.28 (-0.66 to 0.11)	0.16	92.63	0.00
Provision of lesson plans (no vs yes)	17 vs 15	0.41 (-0.06 to 0.88)	**0.08**	93.24	0.00
Involvement of family/parents (no vs yes)	11 vs 36	-0.03(-0.49 to 0.43)	0.90	93.49	0.00
Teacher training (no vs yes)	10 vs 15	-0.17 (-0.47 to 0.12)	0.25	82.84	8.07
Context					
Sample size (⩽150 vs >150)	24 vs 23	-0.70(-1.07 to -0.33)	**0.0002**	93.01	5.73
Sex (targeted sex vs mixed sex)	6 vs 41	-1.35(-1.92 to -0.77)	**<0.0001**	92.31	15.26
Age (yr)	45	-0.06(-0.15 to 0.03)	0.20	92.32	0.00
Process evaluation aim (no vs yes)	8 vs 16	0.32(-0.09 to 0.72)	**0.12**	90.98	0.00

n, number of studies included in the regression model in each category

R^2, amount of heterogeneity accounted for. I^2, heterogeneity. [a] reference categories are those on the left for binary variables

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Conflicts of Interest
Jiani Ma, Natalie Lander, Emma Eyre, Lisa Barnett, Inimfon Essiet and Michael Duncan declare that they have no conflicts of interest relevant to the content of this review.

Data Availability Statement
All data generated or analysed during this study are included in Electronic Supplementary Material Appendix Table S2 and S3

Code Availability
R codes used for meta-regressions available upon request from the first author.

Author contribution
JM conceived the review, designed the review methods, wrote and edited the manuscript, ran the literature search, screened all identified title and abstract, assisted with the full text screening, the risk of bias assessment, lead the data extraction and ran the meta-analyses. NL advised on and assisted with the data analysis, revised and edited the manuscript. EE advised on the full text screening and data analysis, revised and edited the manuscript. LMB advised on the data analysis, revised and edited the manuscript. IAE assisted with the full text screening, data extraction and revising the manuscript. MD assisted with risk of bias assessment, advised on the data analysis, revised and edited the manuscript. All authors read and approved the final manuscript.

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