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Effect of Teaching Interventions on Metacognitive Skills in Physical Education

A systematic review

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Metacognitive skills (MCSs) is one of the emerging research fields of metacognition. The literature has proven that different teaching interventions impact various sports performance and individuals' MCSs. However, there is a lack of detailed systematic review about this topic. The primary aim of this study is to investigate the effects of teaching interventions on MCSs in physical education. A comprehensive search was conducted using five databases. The results indicate that notable impacts were observed on metacognitive knowledge and metacognitive behavior, less significant effects on metacognitive experiences. The sports types primarily focus on team ball sports, with limited research in individual sports. These results provide a valuable resource for physical teachers, coaches, and trainers. However, there is still significant room for research in comparing the effects of different interventions on populations among different genders, ages, and levels of sports using various research designs. Consequently, future research should prioritize in-depth exploration in these aforementioned areas.

Key words: Teaching interventions; Metacognitive skills; Physical education; Physical performance.

Introduction

Learning skills in physical education (PE) refer to the abilities and strategies that facilitate effective learning and acquisition of knowledge and motor skills (Jassim et al., 2022; Tuononen et al., 2023). Assessing these complex

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skills can provide valuable information for teachers, coaches, and trainers regarding specific instructional, competitive, or athletic requirements, and help students, players and athletes improve their academic, motor and physical performance (Álvarez-Bueno et al., 2017). Among these skills, psychological skills represent the most complex aspect. Consequently, in recent years, an increasing number of scholars in the field of psychology have been shifting their research focus from general cognitive skills to specific cognitive skills and from external motor control research to internal control research, all to optimize the learning and educational processes (Pintrich et al., 1993; Pintrich, 2004; Mehrangiz SHoaakazemi et al., 2013; Mucha et al., 2020). The study of metacognitive skills (MCSs) is one of these emerging research fields (Flavell, 1979;1992; Hacker et al., 2009; Hameed & Cheruvalath, 2021).

Numerous studies have shown that employing MCSs often leads to effective learning outcomes and academic achievement (Malambo et al., 2022). These skills can be categorized based on the degree of cognitive processing involved (Pintrich et al., 1993; Pintrich, 2004). High levels of MCSs have a positive correlation between individuals' happiness, self-confidence, well-being, and academic achievement (Mehrangiz SHoaakazemi et al.,2013; Adaryani, 2013). Moreover, high levels of MCSs increase a person's chances of success (Neriman Ataseven et al., 2016); are correlated with self-efficacy (Šafranj, 2019), self-concept (Durodolu, 2018), and positively influence self-directed learning during problem-solving, helping to develop critical thinking (Elhamifar et al., 2019; Worley et al., 2019; Breed and Bailey, 2018; Tachie, 2019; Kumar et al., 2022; Atman Uslu, 2022), learning strategies (Nasser Al Rawahi, 2015; Berger and Karabenick, 2016), academic performance (Langdon et al., 2019), and self-regulating skills (Kermarrec et al., 2004; Shimon & Petlichkoff, 2009; Šteh & Šari, 2020; Trabelsi et al., 2022). Additionally, MCSs help to control and regulate negative thoughts, emotions, beliefs, and sad memories (Davis et al., 2010; Hameed & Cheruvalath, 2021).

Currently, several scholars have introduced various concepts related to MCSs including metacognitive awareness (Davis et al., 2010; Gündo du & Celebi, 2017), metacognitive emotions (Dong QI, 1989), metacognitive feelings (Goudas et al., 2017a), metacognitive strategies (Adaryani, 2013; Berger & Karabenick, 2016; Liu et al., 2019), metacognitive judgments (Palmer et al., 2019), metacognitive behavior (Chatzipanteli et al., 2015b), and metacognitive knowledge (Elhamifar et al., 2019; Worley, 2019; Stephanou and Karamountzos, 2020). However, there is no universally agreed-upon definition of MCSs within academic circles. Some scholars have specifically explained this, as they believe that MCSs are indeed about thinking about one's own thinking and using that awareness to enhance learning, problem-solving, and decision-making abilities (Hameed & Cheruvalath, 2021; Neriman Ataseven & Oguz, 2016; Thompson, 2012). Therefore, in this study, we initially conceptualized MCSs in accordance with metacognitive theory as any reflective thoughts, knowledge, behaviors, and experiences related to metacognition within the context of learning processes (Flavell, J. H, n.d.1979).

Moreover, numerous scholars have operationalized MCSs as the scientific study of the mind's ability to monitor and control itself. An increasing number of articles have focused on the influences of various sports fields, including different physical education (PE) courses such as football teaching (Kent et al., 2022; Price et al., 2018; YASUO SUSAKI, n.d.,2021), volleyball teaching (Chatzipanteli, Digelidis, Karatzoglidis, et al., 2016), basketball teaching (Cleary, et al., 2006; Kolovelonis et al., 2012; Chatzipanteli et al., 2015b; Stephanou and Karamountzos, 2020), and yoga teaching (Jiang Rong, 2019). Furthermore, a systematic review on the association between PE, physical activity (PA), cognition, metacognition, and academic performance (Marques et al., 2016; Álvarez-Bueno et al., 2017; Malambo et al., 2022;) has been conducted. Based on existing reviews, the effects of metacognition on physical performances and technical skill performance have been proven positive. However, limited research discussed the impact on psychological aspects, especially on MCSs, and What are the other emerging themes of MCSs in school-based settings PE. The existing research has not provided a comprehensive literature review or a clear summary of these aspects. This evidence needs to be compiled systematically. Therefore, the primary purpose of this systematic review is to analyze the evidence published about the effects of different interventions On Mcss And Physical Performance In School-Based Settings PE.

Methodology

Protocol and Registration

This study has been registered on the International Registration System Evaluation and Meta-Analysis Protocol Platform under the registration number CRD42022362842.

Eligibility Criteria

PICOS (Population, Intervention, Comparison, Outcome, and Study Design) criteria were used as the inclusion criteria for this review (see Table

Table I
Inclusion Criteria According To The PICOS Framework

Items	Detailed inclusion criteria
Population	PE students (female/male) (no age restrictions), Professional athletes were excluded.
Intervention	Any metacognitive-related PE teaching methods, strategy or styles in different sports classes (not limited by activity items).
Comparison	No metacognitive interventions employed
Outcome	Included any form of MCSs (metacognitive knowledge, metacognitive behaviors, metacognitive feelings, etc.)
Study designs	RCTs and nRCTs

Note: RCTs: randomized controlled trials; nRCTs: non-randomized controlled trials.

1 for details). The review included articles that met the following inclusion criteria: (1) assessment of any forms of MCSs and physical performance after specific interventions; (2) inclusion of student populations in different school-based settings; (3) utilization of interventions aimed at influencing MCSs and physical performance; (4) use of specific instruments or scales to test and assess MCSs; (5) inclusion of any form of sports; and (6) utilization of randomized controlled trials (RCTs), non-randomized controlled trials (nRCTs), in the study design. The data collection process, following the PRISMA guidelines, is illustrated in Figure 1.

Search Strategy and Selection of Literature

The methodology was conducted following the latest Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) statement (Page et al., 2021). A comprehensive search was performed on scholarly literature published before May 2023 using five prominent databases: PubMed, Web of Science, SPORTDiscus, Scopus, and China National Knowledge Infrastructure (CNKI). To ensure the reliability of the retrieval method, data retrieval was assisted by experienced librarians. The search terms were utilized both individually and in combination to search the aforementioned five databases. Additionally, Google Scholar was searched to identify any literature that may not have appeared in the main database search results. The search terms used were as follows: (“metacognition” OR “meta-cognition” OR “metacognitive skill*”

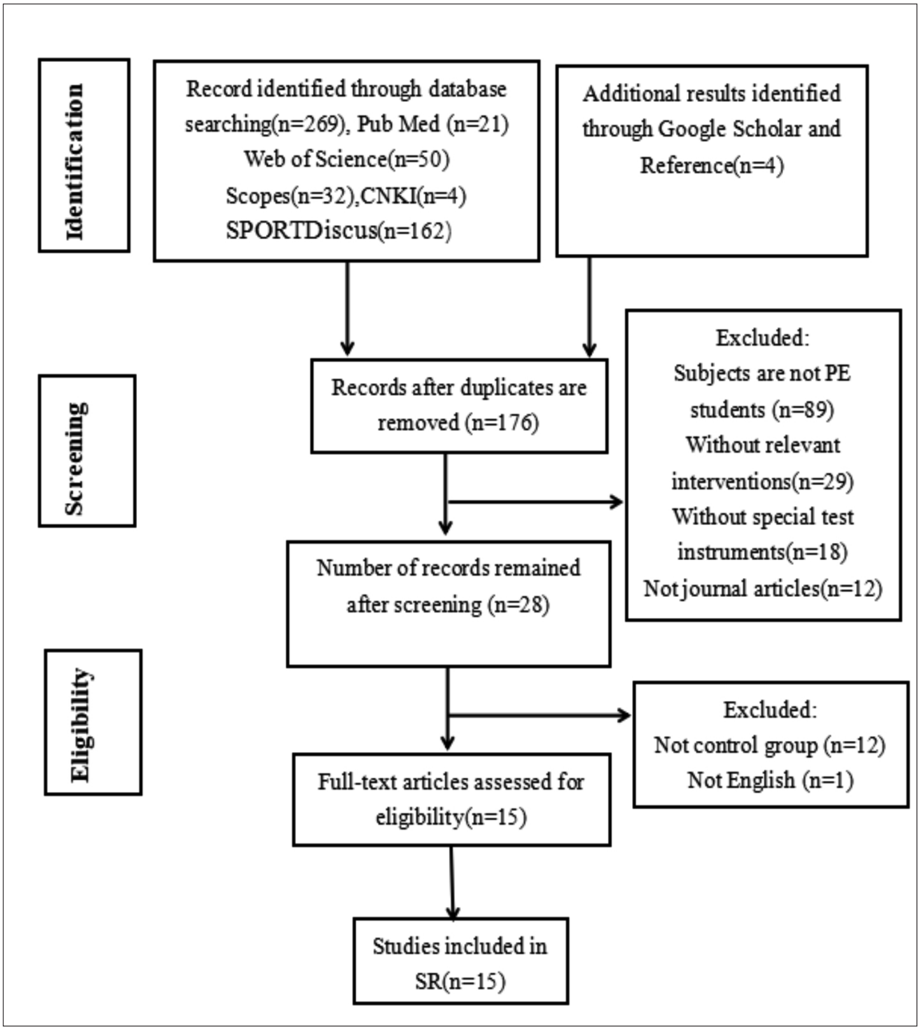

Fig. 1. - Flowchart of study selection.

OR “meta-cognitive skills*” OR “metacognitive intervention*” OR “metacognitive teaching” OR “metacognitive training”) AND (“student performance” OR “technical skill*” OR “skill*” OR “technique” OR “performance”) AND (“physical education” OR “PE” OR “school sport*”).

The study selection included four significant processes (Fig. 1). Initially, the search process began by examining the titles and keywords in each database. Then we upload search results to Zotero (version 6.0.26.0). Duplicate articles were eliminated, and the title and abstract were determined in the second stage. Subsequently, articles related to other subjects or written in other languages were excluded, and this review only includes articles written in English. This decision was made because, upon inspection, it was found that only one article was written in Spanish, and due to the difficulty of translation, it was excluded. Additionally, conference abstracts, books, book chapters, and research not published in peer-reviewed journals, were also excluded. Two independent reviewers (LB and JZ) completed this process without knowledge of the authors and institutions of the research (They were blinded to the authors and institutions of the research) for eligibility criteria. There was some controversy during the review process regarding studies on the theme of "executive function", and a third reviewer (NJ) was invited to discuss and ultimately reached an agreement to include them. The differing opinions of the two reviewers were addressed after a full-text review. If disagreements persisted, discussions were held with the third reviewer until a consensus was reached. Detailed records of exclusion reasons were maintained during the full-text screening phase. Articles retrieved from other databases using the same search strategy (title and/or abstract) were independently screened by two reviewers to determine if they met the inclusion criteria.

Data Extraction and Analysis

Two reviewers (LB and JZ) obtained information to extract the following information from the included articles: author, year of publication, country, population characteristics (sample size, sex, age, grade) interventions and instruments, comparison, duration, metacognitive skills, sport type, and outcomes. A third reviewer (NJ) verified its accuracy again.

Quality Assessment

The methodology of each included study was assessed for quality using the quantitative assessment tool QuaIlSyst (Kmet et al., 2004), which is a widely recognized method in quantitative research. Two authors (LB, HX) independently utilized the QuaIlSyst tool. The results were cross-checked by the third author (NJ) and all three reviewers achieved agreement. QuaIlSyst consists of 14 items, and scores were assigned to each study based on the extent to which specific criteria were met (Yes=2, Partial=1, No=0). Items marked with "NA" were not applicable to the study design and were not included in the calculation of the total score. The summary score for each

Table II
Assessment Of "Qualsyst"

Publication	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	Total Score	Rate %	Study Quality
Kolovelonis and Goudas, 2023	**2**	**1**	**2**	**2**	**2**	**0**	**0**	**2**	**2**	**2**	**2**	**1**	**2**	1	21	75	H
Chen et al., 2022	2	1	1	2	2	0	2	1	2	2	2	0	2	2	21	75	H
Kolovelonis et al., 2022	2	1	2	2	0	2	0	1	2	2	2	0	2	2	20	71	M
Kent et al., 2022	2	2	2	2	1	2	0	2	1	2	2	0	2	2	22	79	H
Yasuo Susaki, 2021	2	1	1	2	0	0	0	2	2	2	2	0	2	2	18	64	M
Stephanou and Karamountzos, 2020	2	2	1	2	2	0	0	2	2	2	2	0	2	2	21	75	H
Chatzipanteli et al., 2016	2	2	2	1	2	0	0	1	2	2	2	0	1	2	19	68	M
Chatzipanteli et al., 2015a	2	2	2	2	2	0	0	2	1	2	2	0	2	2	21	75	H
Chatzipanteli et al.,2015b	2	2	2	2	0	0	0	2	2	2	2	0	2	2	20	71	M
Jiang Rong, 2019	1	1	1	2	2	1	1	2	1	2	1	0	2	2	19	68	M
Goudas et al., 2017	2	2	2	2	2	0	0	2	2	2	2	0	2	2	22	79	H
Papaioannou et al., 2012	2	2	1	1	2	0	0	2	1	2	2	0	2	2	19	68	M
Kolovelonis et al., 2012	2	2	2	1	2	0	0	2	2	2	2	1	2	2	22	79	H
Cleary et al., 2006	2	2	2	1	2	0	0	2	2	2	2	1	1	2	21	75	H
Lakes and Hoyt, 2004	2	2	1	2	2	0	0	2	1	2	2	0	2	1	18	64	M

Note. NA: Not applicable; 2 = Yes; 1= Partial; 0 = No Quality. Quality scores: ≧75% =High; 55%-75% = Medium;≦55%= Low; L: Low; R: Rating; H: High; M: Medium. I: Question/Objectives described; II: Appropriate study design; III: Appropriate subject selection; IV: Characteristics sufficiently described; V: Random allocation; VI: Researchers blinded; VII: Subjects blinded; VIII: Outcomes measured well defined and robust to bias; IX: Appropriate sample size; X: Analytic methods well described; XI: Estimate of variance reported; XII: Controlled for confounding; XIII: Results reported in detail; XIV: Conclusion supported by results?

study is calculated by summing up the total points earned and dividing by the maximum possible points. The scores ≤55% indicate low quality, 55%-75% represent medium quality, and ≥75% indicate high quality. Low-quality studies were excluded from the systematic review. Table 2 shows that out of the 15 included articles, 8 were rated as high-quality and 7 as moderate quality. All the included articles met the quality requirements.

Study Risk of Bias

The Risk of Bias in Randomized Trials 2 (RoB 2) tool was used to assess the publication risk of bias in randomized controlled trials and consists primarily of five domains: randomization process, allocation concealment, blinding, incomplete outcome data, and selective reporting. For each study, the risk of bias in each domain was assessed as "low risk," "some concerns," or "high risk". Based on the risk of bias level in each domain, an overall summary of bias risk for the entire trial was determined. Finally, all trial-specific bias assessments were aggregated to assess the risk of bias in the entire systematic review. To enhance the credibility and reliability of the assessment, a risk of bias assessment was conducted independently by two authors (LB and JZ) and discrepancies were resolved through discussion. For specific assessment results, please refer to Supplementary Material 2- Study Risk of Bias.

Results

In this study, 269 articles were screened, and 176 articles remained after duplicates were removed. After filtering the titles and abstracts, 28 articles remained, and after filtering for experimental groupings, only 15 highly relevant articles were selected for this systematic review. As shown in Table 2, the quality evaluation results revealed that eight of the selected articles were of high quality, and seven were of moderate quality. After discussion and evaluation by the research team, 15 articles were included in this systemic literature review.

Table 3 presents the detailed characteristics of the included studies, including the following aspects:(1) Country – ten articles (67%) conducted in European (9 in Greece, and 1in United Kingdom), two (13%) conducted in United States of America, and three conducted (20%) in Asia (2 in China, and 1in Japan); (2) sample size – a total of 1,959 respondents were included in the 15 articles, with participant ages ranging from 5 years olds (Chen et al., 2022) to 22 years (Cleary, et al., 2006); (3) gender distribution – most study samples consisted of both male and female respondents, although there were two studies that focused solely on male participants (Kent et al., 2022; Yasuo Susaki, 2021), and one study that did not provide specific details regarding the gender(s) of the participants (Jiang Rong, 2019); (4) Population classification – two articles (13%) included junior high school students as respondents (Stephanou and Karamountzos, 2020; Chatzipanteli et al., 2015b), nine articles (60%) included elementary school students and kindergarten (Lakes and Hoyt, 2004; Kolovelonis et al., 2012, 2022; Papaioannou et al., 2012; Chatzipanteli et al., 2015a, 2016b; Goudas et al., 2017; Chen et al., 2022; Kolovelonis and Goudas, 2023) , one article (7%) included both junior high and high school students (Kent et al., 2022b), and three articles (20%) included college students (Cleary et al., 2006a; Jiang Rong, 2019a; Yasuo Susaki, 2021).

Methodological Characteristics

Among the 15 included articles, 3(20%) utilized mixed research methods, combining qualitative and quantitative approaches, while the remaining 12 articles (80%) employed purely quantitative experimental teaching methods. In mixed research, the research only extracted the quantitative data for analysis. 12 articles employed randomized controlled trials (RCTs) for their interventions, 3 articles did not explicitly specify the allocation method. The duration of the interventions varied across the articles, ranging from 12 minutes to 10 months. Among them, four articles utilized acute experiments focusing on gaming, dart-throwing, basketball free-throws, and shooting techniques, while four articles examined metacognitive performance in PE settings over a span of 2-4 weeks. The remaining seven articles employed teaching experiments lasting more than 10 weeks. Among the 15 articles, 11 utilized metacognitive interventions specifically targeted at PE teaching, while 4 articles implemented interventions related to sports training. These studies encompass various types of PE classes with an equal split between team projects (8 articles) and individual projects (7 articles). Out of the eight-team studies, three focused on various techniques within soccer and basketball classes, two examined basketball shooting performance, two explored tactical techniques (one in volleyball and one in basketball), and two delved into the basketball and soccer curriculum. Three studies investigated games related to metacognition in PE classes, and the remaining three covered yoga classes, taekwondo, elementary PE classes, and dart throwing, each with one study. Further details can be found in Table 3.

Table III
Overview Of The Studies' Details

Study	Country	Population/ Sex	Age/Grade	Interventions/ instruments	Comparison	Duration	Metacognitive Skills	Sports type	Outcomes
Kolovelonis and Goudas, 2023	Greece	N=102 56M.46FM	MA= 10.13±0.57, G:4-5grades	CCPAG; DFT; ST, FT	EG1: CCPAG EG2: ADHRF CG: without PE	45min acute experiment	EFs: Fluency, Inhibition, Cognitive flexibility	PE Setting: CCPAG	EFs:EG1>EG2; EG1, EG2>CG;
Chen et al., 2022	China	N=47 27M,20FM	A:5-6 G: Kindergarten	CCMT, Anji Play Teaching Model; MKIQ, MMT	EG: CCMT CG: Routine teaching activities	12weeks, 2 sessions/w, 1.5h/s	Metacognitive skills: Knowledge and regulation of cognition, metacognitive experience	CCMT, Anji Play	MCs:EG>CG; EG:Post>Pre.
Kolovelonis et al., 2022	Greece	N=99 50M,49FM	MA= 9.37± 0.59, G:4-5grades	CCPAG; EFs DFT; ST; FT	EG: CCPAG CG: CCPAG; Cross-over design	4 weeks. 2 sessions/w, 45min/s.	Executive functions and motivational regulations	PE settings: CCPAG	DFT, ST; FT:EG>CG EFs: Post>Pre MR: Post↔Pre
Kent et al., 2022	UK	82M	A:11-18, MA:14.12±2.28	PT, CB work shops and reflective practice. Chi-squared	EG: Comprising PT, CB, and RP CG: PT alone	18 weeks	Decision making; Skill execution	Soccer: offensive and defensive techniques	DC, SE: EG>CG PP↑:EG>CG:
Yasuo Susaki, 2021	Japan	N=40M	MA:18.7±0.7 G: College students	Cyclical model of SRL, SE	EG: Self-regulated interventions CG: No self-regulated interventions	12 weeks 12 sessions 90 min/wk	Self-regulated learning strategies: goal setting, performance and control (effort, image monitoring, self-talk, help-seeking from classmates and teachers, self-reflection.	Soccer: dribbling skill, pass, dash	SRL, SE ↑, Post>Pre EG↔CG

(*Continued*)

(*Continued*) - Table III

Study	Country	Population/ Sex	Age/Grade	Interventions/ instruments	Comparison	Duration	Metacognitive Skills	Sports type	Outcomes
Stephanou and Karamountzos, 2020	Greece	N=41 18M, 23FM	G: Seventh graders	TGfU tactical-game approach MPIPEQ	EG: TGfU model CG: Technical skill-based approach	10 weeks, 10 sessions 45 min/w	Metacognitive knowledge (declarative procedural, conditional knowledge, information management), metacognitive regulation (planning, monitoring, problem solving strategies, evaluation, imagery)	Basketball: Teaching Games for Understanding tactical-game	MK: EG>CG EG: Post>Pre, MC, P ↑
Jiang Rong, 2019	China	N=120	G: College students	MB; POMS, CSMAS	EG: Metacognitive training CG:Conventional teaching method	10 months	MB: Planning, awareness, method, execution, feedback, remediation, summation.	Yoga	MB: Post>Pre CSMAS↑: EG>CG POMS ↔; PP↑: EG>CG
Goudas et al., 2017	Greece	N=88, 36M, 52FM	MA =11.34±0.43, G: Fifth-sixth graders	MF, MCT, SRL, MC, IM; FEDA, GSMCQ	EG1-EG3: Combined social feedback, simple practice, and process goal of practice CG: A simple practice-only	Two hours	Self-regulated learning: goal setting, observation, emulation, self-control, and self-regulation; Metacognitive feelings : effort, difficulty, and correctness.	Basketball: shooting performance, shooting knowledge, feelings of effort,difficulty, and correctness	MF, MCT, MC, IM: EG1-EG3>CG; SRL↑ PP: EG↔CG

(*Continued*)

(*Continued*) - Table III

Study	Country	Population/ Sex	Age/Grade	Interventions/ instruments	Comparison	Duration	Metacognitive Skills	Sports type	Outcomes
Chatzipanteli et al., 2016	Greece	N=71 32M, 39FM	A:11-12 G: Elementary-school students	TGfU four-stage model Think-aloud protocols	EG: TGfU tactical-game model CG: Technique-focused approach	4 weeks 8 lessons 45 min/T	Metacognitive behaviour: metacognitive knowledge, metacognitive regulation.	Volleyball: tactical scenarios	MB↑: Pre < Post EG>CG PP↑: EG>CG
Chatzipanteli et al., 2015a	Greece	N=601 318M, 283FM	A:13 G: Seventh graders	Student activated teaching styles: self-check, inclusion, guided discovery, convergent discovery, and divergent discovery styles, MPIPEQ	EG: Student-activated teaching styles CG:Teacher-centered teaching styles	16 weeks 38 lessons	Metacognitive activities: metacognitive knowledge (declarative procedural, conditional knowledge, information management), metacognitive regulation: (planning, monitoring, problem solving strategies, evaluation, imagery).	Basketball, Soccer curriculum.	MA, MK, IEM: EG>CG Post>Pre
Chatzipanteli et al.,2015b	Greece	N=71 32M, 39FM	A:11-12 G: Primary school students	TGfU tactical-game model MPIPEQ	EG: TGfU model CG: Skill-based approach	4 weeks 8 lessons 45 min/T	Metacognitive behaviour: metacognitive knowledge, metacognitive regulation.	Basketball	MB: EG>CG Post>Pre PP↑: EG>CG
Papaioannou et al., 2012	Greece	N=269, 119M, 141FM, 19 No provided gender	G: Elementary school students	AG, MC, IM; MPIPEQ	EG: Self-check teaching style CG: Practice" teaching style	2 weeks 2 lessons 45min/T	Metacognitive Self-Regulation: planning, monitoring, overall metacognitive activity.	Elementary schools PE class	IMI, MPIPEQ: EG>CG. PP↑: EG>CG

(*Continued*)

(*Continued*) - Table III

Study	Country	Population/ Sex	Age/Grade	Interventions/ instruments	Comparison	Duration	Metacognitive Skills	Sports type	Outcomes
Kolovelonis et al., 2012	Greece	N=85 40M, 45FM	MA:11.01±0.67 G: Fifth-sixth grades	SEI; SRL;Self-talk and goal setting Questionnaire	EG1-4: Combined goal setting and self-talk practice CG: Practice only	16-min	Self-regulation of learning: self-efficacy, satisfaction, and enjoyment.	Dart-throwing performance	SEI: EG= CG. SRL: EG>CG PP↑: EG>CG
Cleary et al., 2006	USA	N=50 10M, 40FM	MA:21.7±2.9 G: College students	SR; SRL; Adaptive Inferences Scale	EG1-3: Self-regulated instruction CG1-2: Practice-only and no-practice	12-min	Forethought phase process: goal setting, strategic planning, Performance phase process: self-record, self-control, self-observation, Self-reflection phase: self-judgment, self-evaluation, self-reaction.	Basketball free-throws: shooting performance, shooting adaptation.	SRL: EG>CG PP↑: EG>CG
Lakes and Hoyt, 2004	USA	N=193 94M, 99FM	G: Kindergarten through Grade 5	LEAD program SEI, CC, SRL; RCS	EG: Martial arts group, leadership education program CG: Traditional PE group.	12 weeks	Self-regulation in response to a challenge, strengths and difficulties, freedom from distractibility, self-esteem.	Martial arts: Tae Kwon Do.	EG: SEI↑ SRL↑, M>FM PP↑: EG>CG

Note. M: Male; FM: Female; G: Grade; A: Age; ↑: Higher; ↓: Lower; ↔: No significant difference; > : Great-than; <: Less-than:; CCMT: Metacognition enhancement program named Circling Curriculum for Metacognition Training ; MC: Metacognitive ability; MKIQ: Metacognitive Knowledge Interview Questionnaire; MMT: Metacognitive Monitoring Task; MST: Metacognitive Skill Task; ADHRF: activities for developing health-related fitness; CCPAG: Cognitively challenging physical activity games; DFT: The Design Fluency Test ;ST: The Stroop Test; FT: The Flanker Test; MR: Motivational regulations; MPIPEQ: Metacognitive Process in Physical Education Questionnaire; MK: Metacognitive knowledge; MB: Metacognitive behavior; POMS: Profile of mood states; MCT: Metacognition; PP: Physical performance; MA: Metacognitive activities; IEM: Intrinsic and extrinsic motivation; SE: Self-efficacy; PT: Pressure training; CB: Cognitive-behavior; RP: Reflective practice; DM: Decision making; SE: Skill execution; PT: Pressure Training; CB workshops: Cognitive-behavioral workshops; MF: Metacognitive feelings; FEDA: Feelings of effort, difficulty, and correctness; GSMCQ: Goal-setting Manipulation Check Questionnaire; AG: Achievement goals; MC: Motivational climate; IM: Intrinsic motivation; RCS: Response to Challenge Scale. SEI: Self-esteem Inventory; SRL: Self-regulated learning; SR: Self-reactions; AIS: Adaptive Inferences Scale; CC: Classroom conduct; CSMAS: College Students' Metacognitive Ability Scale; MM: Metacognitive monitoring; SMA: Self-monitoring ability; RCT: Randomized controlled trials. nRCTs: non-randomized controlled trials.

Teaching Interventions and Instruments

The intervention conditions for the experimental groups varied across the 15 included studies. Among the articles, five used different teaching models as their interventions: two employed the TGfU model (Stephanou and Karamountzos, 2020; Chatzipanteli et al., 2015b), one utilized the tactical-game model (Chatzipanteli et al., 2016), and one applied the Cyclical model of self-regulated learning (Yasuo Susaki., 2021). Two articles implemented different teaching styles in their experimental groups: one utilized a student-activated teaching style (Chatzipanteli et al., 2015a), and the other employed a 'self-check' teaching style (Kolovelonis et al., 2012). Five papers employed various acute and chronic intervention training methods, including metacognitive training methods (Jiang Rong, 2019), cognitively challenging physical activity games (Kolovelonis et al., 2022; Kolovelonis & Goudas, 2023)., and self-regulated instruction guided by metacognitive theories (Cleary et al., 2006). Two experimental groups used different practice methods, opting for pressure training and cognitive-behavioral and reflective practices, and cognitively challenging physical activity games in their interventions_(Kent et al., 2022). Another unique intervention utilized a combination of social feedback, simple practice, and process goals(Goudas et al., 2017a). Additionally, goal-setting and self-talk practices were employed in one study's intervention (Kolovelonis et al., 2012), while two articles (Chen et al., 2022; Lakes & Hoyt, 2004) used leadership teaching program and circling curriculum for metacognition training (CCMT) as the chosen intervention methods. The control groups were mostly subjected to traditional teacher-centered teaching models centered around skill transfer or teaching and training methods that did not involve metacognitive interventions.

Various instruments were used to measure MCSs across the twelve included articles. Four studies utilized the Metacognitive Process in Physical Education Questionnaire (MPIPEQ) to assess differences in respondents' MCS before and after interventions. One study employed the College Students' Metacognitive Ability Scale (CSMAS), and one study employed Metacognitive Knowledge Interview Questionnaire (MKIQ). Two studies employed The Design Fluency Test (DFT), The Stroop Test (ST); and the Flanker Test (FT) to test the execution functions. The remaining articles utilized measures of metacognitive knowledge (MK), metacognitive behavior (MB), metacognitive feelings (MF), and self-regulated learning (SRL) (see Table 3 for details).

Effects of Teaching Interventions on Metacognitive Skills

As different researchers have pointed out, scholars hold various perspectives on the concept of metacognitive skills (Neriman Ataseven & Oguz, 2016;

Thompson, 2012). Among the 15 articles included, the term "MCSs" encompasses a range of aspects, including metacognitive knowledge, metacognitive awareness, metacognitive behaviors, problem-solving skills, metacognitive strategies, decision-making abilities, skill execution, metacognitive consciousness, self-efficacy, and self-regulated learning abilities. However, in general, they all encompass three aspects: metacognitive knowledge, metacognitive regulation, and metacognitive experiences, which align with Flavell's proposed metacognitive theory and model (Flavells, 1979). Therefore, in this study, we adopted the two concepts of metacognitive knowledge and metacognitive experiences from Flavell's metacognition theory and collectively defined metacognitive regulation or self-regulation learning (planning, monitoring, problem-solving strategies, evaluation, imagery), executive functions, and decision making as metacognitive behaviors.

Metacognitive Knowledge

Out of the 15 articles, 5 studies provided data for metacognitive knowledge through employing a Circling Curriculum for Metacognition Training (CCMT) program (Chen et al., 2022), TGfU tactical-game approach (Chatzipanteli et al., 2015b, 2016), student-activated teaching styles (Chatzipanteli et al., 2015a); and self-check teaching style (Stephanou and Karamountzos, 2020) in Anji Play game, basketball, volleyball tactical-game, and soccer curriculum among kindergarten, primary school, and 7-grade students. The results revealed that in terms of cognitive knowledge ($p < 0.01$), online metacognition ($p < 0.01$), and offline metacognition ($p < 0.05$), the experimental group scored significantly higher than the control group (Chen et al., 2022). Regarding metacognitive knowledge, the results indicate significant effects of teaching methods ($F = 4.87$, $p < .05$, $\eta^2 = .059$), teaching experience ($F = 18.46$, $p < .01$, $\eta^2 = .19$), and a significant interaction effect between teaching experience and teaching methods ($F = 4.00$, $p < .05$, $\eta^2 = .48$), while the interaction of teaching approach with teaching experience had no significant effect on it ($F = 2.50$, $p > 05$) (Stephanou and Karamountzos, 2020). The TGfU model provides students with the opportunity to engage in implicit learning while playing games. Factors such as reduced environmental complexity, improved equipment, and decreased skill demands all lead students to focus more on game tactics, indirectly enhancing procedural knowledge and conditional knowledge (Chatzipanteli et al., 2015b, 2016). The student-activated teaching styles had a significant influence on procedural knowledge and information management, and moderate impacts on the other knowledge (Chatzipanteli et al., 2015a).

Metacognitive Behaviors

15 studies provided data support for metacognitive behavior. Among them, 6 studies specifically supported self-regulated learning (SRL) (planning, monitoring, problem solving strategies, evaluation, imagery) (Zimmerman, 2000). Most of the research showed that, following interventions using various teaching and training methods, Post-experiment scores were higher than pre-experiment scores, and the experimental group demonstrated a significant improvement in SRL skills compared to the control group. One research findings regarding metacognitive regulation reveal significant effects of teaching methods ($F = 7.90$, $p < .01$, $\eta^2 = 0.92$) and teaching experience ($F = 4.82$, $p < .05$, $\eta^2 = .058$), while interactive teaching experience did not have a significant impact ($F = 2.50$, $p > .05$) (Stephanou and Karamountzos, 2020). TGfU tactical-game model helped students to increase the regulation of cognition (Chatzipanteli et al., 2015b, 2016). However, some studies found no significant effect on SRL between the experimental and control groups (YASUO SUSAKI, 2021). One study indicated gender differences in self-regulation, with males outperforming females (Lakes and Hoyt, 2004). 3 studies provided data support for executive functions and 1 study supported decision-making. Two studies suggest that cognitively challenging physical activity games (CCPAG) served as effective means to enhance students' executive functions (Kolovelonis et al., 2022; Kolovelonis & Goudas, 2023). Pressure training, cognitive-behavior work shop and reflective practice intervention players scored significantly higher in their decision-making ($p= .028$) and skill execution ($p= .005$) (Kent et al., 2022).

Metacognitive Experiences

4 studies provided data support for metacognitive experiences. Kolovelonis et al. suggested that cognitively challenging physical activity games (CCPAG) motivated students to engage in enjoyable and fun physical activities (Kolovelonis and Goudas, 2023). One study showed that there were no significant effects on metacognitive feelings for both the experimental group and the control group students after the experiment, specifically in terms of feelings of effort, difficulty, and correctness (FEDC). However, there was a negative correlation between students' post-experiment basketball shooting performance and their perceived difficulty, while a positive correlation was observed between their performance and the perception of correctness (Goudas et al., 2017). Before and after the experiment, there were no differ-

ences among the groups in terms of self-efficacy, satisfaction, and enjoyment (Kolovelonis et al., 2012). After the experiment, the self-efficacy of the experimental group increased, but there was no significant difference between the experimental group and the control group (Lakes and Hoyt, 2004).

Effects of Teaching Interventions on Physical Performance

In addition to examining various aspects of MCSs, the 15 articles included in this review analyzed different physical and technical performances. These performances encompassed areas such as general physical fitness, passes in football, dart-throwing, solving tactical problems in basketball shooting skills, and yoga and Taekwondo techniques. Most studies indicate that after the intervention, the experimental group's physical performance in various PE classes significantly improved compared to their performance before the intervention and compared to the control group. However, there were two studies showed the effects were not found to be significant (Goudas et al., 2017b; Yasuo Susaki, 2021).

Discussion

Methodological Characteristics

Among the 15 articles included in this study, 3 employed a combination of quantitative and qualitative methods, while 12 (80%) out of 15 employed a quantitative research design. From a scientific perspective, adopting an experimental design to collect quantitative performance data before determining the effectiveness of an intervention is an objective approach to studying metacognition. However, human behavior is complex, and relying solely on objective data to ascertain the authenticity of human behavior can be challenging. Therefore, it can be argued that using interviews and other qualitative methods in research to establish a chain of evidence is a more scientific and comprehensive approach, incorporating both objective and subjective aspects of human behavior (MacIntyre et al., 2014). Currently, there is a growing trend among scholars to advocate for the utilization of a combination of qualitative and quantitative methods in metacognition research (MacIntyre et al., 2014; van Rens et al., 2021; Kermarrec et al., 2022; Atman Uslu, 2022). In the field of metacognitive skills in physical education, some skills can be effectively measured through quantitative experiments. For instance, metacognitive knowledge, metacognitive awareness, and self-regulated learning skills have well-established measurement scales. However, subjective aspects such as metacognitive experiences and metacognitive feelings cannot be accurately captured through precise quantitative research methods. This review included articles that also suggested that quantitative research designs may not accurately capture metacognitive experiences in PE classes. Therefore, in future research, it is crucial for researchers to select research designs that are appropriate for their research questions and objectives, particularly concerning different metacognitive skills.

Teaching Interventions and Instruments

In today's society, a student's ability to adapt to the reality of a highly competitive job market, which is saturated with talent, and to withstand society's overly critical view of newcomers, depends on their belief in 'lifelong learning' and their capacity for continuous learning (Álvarez-Bueno et al., 2017; Langdon et al., 2019; Liu et al., 2019). Consequently, new pedagogical curriculum standards place special emphasis on reforming students' learning styles, shifting from the traditional passive and mechanical rote learning to an active and creative learning style (Dignath & Veenman, 2021; Huff & Nietfeld, 2009; Smith et al., 2020). From a pedagogical perspective, teaching strategies, styles, and methods share certain similarities but also have different focuses.

Research has shown that different teaching styles and strategies can enhance various students' abilities (Langdon et al., 2019; Popelka & Pavlović, n.d.). According to the Spectral Theory, teaching styles can be categorized as replicative and productive. The 'productive' teaching style is called so because it is student-centered and yields productive outcomes. In this style, students take the initiative in learning, playing an active role in the learning process. Productive teaching supports students' cognitive learning, helps them develop positive attitudes toward learning, and influences their interest in studying similar subjects in the future (Butler & Winne, 1995; Lyon et al., 2013; Orakci & Durnali, 2022). Since metacognitive skills are advanced cognitive skills, productive teaching is necessary to enhance them.

The academic field has always held two opposing views on the training of MCSs. The first view suggests that direct training of MCSs is challenging and that MCSs cannot be taught directly to students or learned through general teaching methods. This perspective holds that MCSs can only be gradually acquired by students over their long-term learning process as natural skills accumulate through practice. The other commonly held view argues that metacognition requires specialized teaching and that explicit and direct training methods are more effective in teaching MCS (İDawati et al., 2020; Lyon et al., 2013). Currently, numerous studies focus on promoting and enhancing metacognition through specific interventions. In the field of education, improving students' metacognition through specific teaching and training methods is a well-received and established approach. This systematic literature review demonstrated that the use of appropriate teaching models, methods, and training techniques can enhance students' metacognitive skills. Especially when addressing metacognitive knowledge and metacognitive behavioral skills.

Metacognitive Teaching Interventions

With the transformation of modern teaching concepts, the adoption of a teaching philosophy that prioritizes students as the primary focus and teachers as their leaders has gained public acceptance. Consequently, numerous new teaching models and methods have been invented and developed in recent years. Prominent teaching models in the field of physical education include the Personal and Social Responsibility model (Hellison, 1985), the Teaching Games for Understanding model (Bunker; Thorpe, 1986), the Sports Education Curriculum model (Siedentop, 1994), the Cultural Studies model (Kinchin & O'Sullivan, 1999), and the Fitness and Wellness model (Cordin, Lindsey, 1996). Many new teaching methods have been derived from these teaching models.

Out of the 15 reviewed studies, five employed different teaching models and methods as interventions to enhance students' metacognitive skills. These models and methods included the TGfU model, the cyclical model of self-regulated learning, the student-activated teaching styles, and the 'self-check' teaching style. We can observe that all of these teaching models utilized have a "productive" teaching style. Therefore, it can be inferred that teaching models with a direct "productive" teaching style have a certain impact on enhancing metacognitive skills. However, it cannot be ruled out that other teaching methods may also yield similar results. Hence, in future research, it is essential to develop and implement more productive teaching models in physical education to improve students' metacognitive skills.

Metacognitive Training Method Interventions

Various studies have shown that specific training methods used as interventions to promote MCSs are effective. In the field of education, most of these training methods have been developed based on the theory of metacognition. Currently, academia has adopted several metacognitive training methods, including the targeted learning training method, the self-questioning method, the knowledge transfer method, the 'others questioning' method, the think-aloud method (Shi Baoguo, 2002; Augustyn and Rosenbaum, 2005.), and the cognitively challenging physical activity games. In the literature reviewed for this study, six articles were found to use training methods that differ from those commonly employed in MCSs research. These methods include pressure training, cognitive-behavioral training, reflective practice (Kent et al., 2022a; Kolovelonis et al., 2022; Kolovelonis & Goudas, 2023), social feedback and process goals (Kolovelonis et al., 2012; Goudas et al., 2017), as well as other single or comprehensive training methods that incorporate metacognitive features (Cleary et al., 2006a; Jiang Rong, 2019a; Yasuo Susaki, 2021). Especially in the case of certain cognition-related games, and training courses, the effectiveness of methods is more pronounced.

In summary, research on the theory and practice of MCSs has provided a wealth of resources for introducing "metacognitive training" into the field of physical education. However, this research primarily focuses on metacognitive teaching or training aimed at helping students master technical movements and enhance their motor skills. While studies have examined movement and other external aspects, limited attention has been given to the cultivation of students' internal cognition and learning abilities. Additionally, future researchers should address the question of whether alternative effective training methods can be utilized to promote students' other MCSs. The exploration of metacognitive skills training methods to improve students' MCSs represents a new direction in the field of metacognition, and further development and exploration of this area are warranted in the future.

Instruments

Currently, the measurement tools used for assessing metacognition primarily rely on international scales. The commonly employed tools include the Metacognitive Awareness Inventory (MAI) (Schraw, & Dennison, 1994), the Metacognitive Skills Inventory (MSI) (Pintrich et al., 1991), which is part of the Motivated Strategies for Learning Questionnaire (MSLQ), the Metacognitive Awareness Inventory for Children (MAI-C)(Schraw et al., 2006), Metacognition Assessment Interview (MAI) (Brown, 1987), the Cognitive and Metacognitive Strategies Scale (CMLSS) (Liu et al., 2019), and the College Students' Metacognitive Ability Scale (CSMAS), developed by Chinese scholars Kang Zhonghe (Kang Zhonghe, 2005). In the field of sports, there is another popular scale known as the Metacognitive Process in Physical Education Questionnaire (MPIPEQ), developed by Theodosiou and Papaioannou (Theodosiou & Papaioannou, 2006). It is based on Brown's 1987 framework and specifically created for studying metacognition in physical education. Out of the 12 articles included, four relied on the MPIPEQ, while one utilized the MAI, and another chose the CSMAS. The remaining articles employed other metacognitive assessment tools.

In general, measurement scales related to metacognition are relatively well-established. However, there are limited scales specifically designed for assessing different metacognitive skills. While some researchers have developed and validated the Metacognitive Skills Inventory (MSI) (Pintrich et al., 1991; Hameed and Cheruvalath, 2021), currently, there are only two metacognitive skills scales available. Additionally, the MPIPEQ is specifically designed for physical education teaching, but it does have certain limitations regarding its applicability to different populations. Therefore, in the future, it is important for scholars to focus on the development and application of metacognitive skill scales tailored to different academic stages and populations.

Effects of Teaching or Training Methods on Metacognitive Skills

The academic community has reached a consensus regarding the elements that comprise the composition and structure of metacognition. However, when discussing the specific skills that constitute MCSs, scholars still have varying theories. Some scholars believe that as long as there is a process of reflective thinking activity, a person's MCSs will continue to increase (Perry et al., 2019). In the field of physical education, metacognition in PE refers to students' cognition of the PE learning process, or, in other words, the students' cognitive ability to understand the PE learning process (Dong Dasi, 2005). MCSs refers to the skills of self-awareness, self-reflection, self-evaluation, and self-regulation employed in an individual's cognitive process.

Currently, a large number of studies demonstrate that in the field of physical education teaching, direct or indirect interventions related to metacognition, such as physical education teaching models, teaching methods, and teaching styles, have certain effects on students' metacognitive skills. These metacognitive skills include the degree of cognitive processing (Pintrich et al., 1993), critical thinking skills (Elhamifar et al., 2019; Worley & Worley, 2019), problem-solving skills (Breed and Bailey, 2018; Tachie, 2019; İDawati et al., 2020; Kumar et al., 2022), learning strategies (Nasser Al Rawahi, 2015), decision-making and execution of skill (Kent et al., 2022), metacognitive awareness (Gündoğdu and Celebi, 2017; et al., 2022; Sudirtha, et al., 2022), metacognitive monitoring (Huff & Nietfeld, 2009), meta-attention (Oliver et al., 2020), metacognitive feelings (Goudas et al., 2017a), and self-regulating skills (Lakes and Hoyt, 2004; Kolovelonis et al., 2012; Goudas et al., 2017; Šteh, B., and Šarić, 2020).

The 15 literature sources included in this study also demonstrate the effects of interventions on metacognitive skills. The MCSs utilized in the 15 selected articles include metacognitive knowledge, metacognitive behavior, problem-solving skills, metacognitive strategies, decision-making skills, skill execution, metacognitive feelings, metacognitive awareness, self-regulated learning, and metacognitive monitoring. However, compared to other fields, the MCSs involved in PE are relatively simplistic. Specifically, there is currently a lack of research on a comparative study of metacognitive skills among different genders, age groups, and sports disciplines. Future research in physical education should aim to address these gaps in knowledge.

Effects of Teaching or Training Methods on Physical Performance

Currently, most of the research on interventions related to metacognition and sports performance in physical education focuses on mastering and improving various sporting techniques, particularly those used in team sports. For instance, out of the 15 articles reviewed in this study, 8 were related to ball sports. There are relatively few studies on track and field, gymnastics, martial arts, and other sports. Future research should address this bias and consider investigating other types of sports about MCSs. Furthermore, most current studies predominantly emphasize the impact of intervention on physical performance or techniques, while overlooking other social-psychological outcomes and academic performance. This study examined the effects of interventions on MCSs, which is a research topic that should continue to be explored in future studies related to physical education and MCSs.

Conclusion

This systematic literature review, grounded in the metacognitive theory, introduces the concept of metacognitive skills and summarizes the findings from 15 articles investigating the impact of direct and indirect teaching interventions on MCSs in PE classes. It offers theoretical insights and empirical evidence to guide future research. The majority of the reviewed articles conclude that, firstly, specific teaching and training methods guided by metacognitive theory have a significantly positive impact on students' MCSs and physical performance, with varying effect sizes. Notable impacts were observed on metacognitive knowledge and metacognitive behavior, while metacognitive experiences showed less significant effects. Cognitive challenge games related to metacognition and self-reflective teaching interventions have proven to be effective intervention measures. The selected sports types primarily focus on team ball sports, with limited research exploring interventions in individual sports. Most of the research samples were concentrated on primary and secondary school students, with fewer studies targeting college students and other populations. These results provide a valuable resource for physical teachers, coaches, and trainers. However, there is substantial room for further research in the following areas. Firstly, existing intervention outcomes in the current research primarily emphasize the mastery and enhancement of external sports techniques, with limited attention to students' social-psychological aspects and learning abilities. Secondly, there is a significant gap in comparative studies of MCSs among different genders, age groups, and varying sports proficiency (e.g., high-level athletes, players, elites). Thirdly, there is a shortage of comparative research between different metacognitive intervention measures across diverse study designs. Consequently, future research should prioritize in-depth exploration in these aforementioned areas.

Limitations

This systematic review highlights several noteworthy limitations. Firstly, this rigorously conducted systematic review is not a meta-analysis. Furthermore, it solely focuses on metacognitive skills in physical education classes, defining metacognitive skills without encompassing other academic and technical performances, nor including other high-level athletes, players, and sports elites. Therefore, future research should consider studying them collectively to obtain a more comprehensive set of results. Lastly, the study's choice to select articles written in English and published may further constrain the representation of the results.

Supplementary Material 1

TABLE 1
Detailed search strategy

Database	Search Keywords	Results
PubMed	(1) (“metacognition” OR “meta-cognition” OR “metacognitive skill*” OR “meta-cognitive skills*” OR “metacognitive intervention*” OR “metacognitive teaching” OR “metacognitive training”), **4880** (2) (“student performance” OR “technical skill*” OR “skill*” OR “technique” OR “performance”), **2,831,926** (3) (“physical education” OR “PE” OR “school sport*”) **137,558** (4) **(1) AND (2) AND (3)**, **21**	21
Web of Science	(1) Ts= (“metacognition” OR “meta-cognition” OR “metacognitive skill*” OR “meta-cognitive skills*” OR “metacognitive intervention*” OR “metacognitive teaching” OR “metacognitive training”)**, 11,883** (2) Ts= (“student performance” OR “technical skill*” OR “skill*” OR “technique” OR “performance”), **8,781,010** (3) Ts=(“physical education” OR “PE” OR “school sport*”), **391,394** (4) **(1) AND (2) AND (3)**, **50**	50
SPORTDiscus	(1) “metacognition” OR “meta-cognition” OR “metacognitive skill*” OR “meta-cognitive skills*” OR “metacognitive intervention*” OR “metacognitive teaching” OR “metacognitive training”, **712** (2) “student performance” OR “technical skill*” OR “skill*” OR “technique” OR “performance”,**106,626** (3) “physical education” OR “PE” OR “school sport*”, **28,133** (4) **(1) AND (2) AND (3), 160**	160
Scopus	TITLE-ABS-KEY (“metacognition” OR “meta-cognition” OR “metacognitive skill*” OR “meta-cognitive skills*” OR “metacognitive intervention*” OR “metacognitive teaching” OR “metacognitive training”) AND (“student performance” OR “technical skill*” OR “skill*” OR “technique” OR “performance”) AND (“physical education” OR “PE” OR “school sport*”) **31**	31
CNKI:	TITLE-ABS-KEY (“metacognition” OR “meta-cognition” OR “metacognitive skill*” OR “meta-cognitive skills*” OR “metacognitive intervention*” OR “metacognitive teaching” OR “metacognitive training”) AND (“student performance” OR “technical skill*” OR “skill*” OR “technique” OR “performance”) AND (“physical education” OR “PE” OR “school sport*”), **4**	4

Supplementary Material 2

TABLE 2
Study risk of bias

Author(s)/Date	I	II	III	IV	V	VI:	VII
Kolovelonis and Goudas, 2023	L	L	S	L	L	L	L
Chen et al., 2022	L	L	H	L	L	L	L
Kolovelonis et al., 2022	S	L	H	L	L		L
Kent et al., 2022	S	L	H	L	L	L	L
Yasuo Susaki, 2021	S	L	H	L	L	L	L
Stephanou and Karamountzos, 2020	L	L	H	L	L	L	L
Jiang Rong, 2019	L	L	L	L	S	L	L
Goudas et al., 2017	L	L	H	L	L	L	L
Chatzipanteli et al., 2016	L	L	H	L	L	S	L
Chatzipanteli et al., 2015a	L	L	H	L	L	L	L
Chatzipanteli et al.,2015b	S	L	H	L	L	L	L
Papaioannou et al., 2012	L	L	H	L	L	L	L
Kolovelonis et al., 2012	L	L	H	L	L	L	L
Cleary et al., 2006	L	L	H	L	L	S	L
Lakes and Hoyt, 2004	L	L	H	L	L	L	L

Note: I Randomization Process; II: Allocation Concealment; III: Blinding of Participants and Personnel; IV: Blinding of Outcome Assessment; V: Incomplete Outcome Data; VI; Selective Reporting; VII: Overall Risk of Bias; L: Low risk; H: High risk; M: Medium risk; S: Some concerns.

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