Unveiling the Impact of Metacognition on Academic Achievement in Physical Education and Activity Settings: A Comprehensive Systematic Review and Meta-Analysis of Qualitative Insights

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Purpose: The purpose of this study is to unveil the impact of metacognition on academic achievement in physical education and activity settings by conducting a comprehensive systematic literature review with a meta-analysis of qualitative findings.
Patients and Methods: Systematic searches identified English-language, peer-reviewed journal articles reporting the results of qualitative or mixed-methods studies of the emerging themes of metacognition on academic achievement in sports. PubMed, Web of Science, Scopus, ProQuest, and SPORTDiscus were searched from inception to June 2023.
Results: Data from 20 studies were included in the review. Thematic meta-analysis identified descriptive themes: 1) Metacognitive performance during the learning process in different sports disciplines; 2) Domains of metacognitive skills related to academic performance; 3) Self-regulation strategies related to academic performance; 4) Influencing factors of metacognition; 5) Metacognitive interventions on motor learning and academic performance. Generate an analytical theme based on five descriptive themes.
Conclusion: In-depth descriptions of the emerging themes related to metacognition and academic performance during motor learning were provided by different students and athletes. The conclusions reported in the study align with the theoretical models of metacognition. The research findings will provide strategies for physical education teachers, coaches, and trainers to enhance both physical and academic performance.
Keywords: metacognitive skill, self-regulation learning, learning performance, executive function

Introduction

Academic achievement in physical education and activity refers to the assessment and measurement of a student's success and performance in academic aspects related to the context of physical education and activity settings.[1] Metacognition refers to the awareness of one's cognitive processes and thinking activities.[2] It is a crucial area of study in educational psychology and cognitive psychology. A significant body of quantitative research in the field of metacognition, along with some meta-analyses, has offered valuable insights and evidence regarding the relationship between metacognition and academic achievement. However, existing studies seem to be primarily focused on the analysis of academic achievement outcomes, with limited exploration into the manifestations of academic performance related to the learning process. What specific themes related to academic performance emerge during the learning process? Hence, there is an urgent need for a systematic literature review and meta-analysis specifically addressing this aspect.

Achievement in Physical Education (PE) and Physical Activity (PA) are generally ascribed to various internal and external factors such as individual talent, psychology, environment, teaching, and training methods.[3] Psychological facets are the most complex internal factors affecting academic performance.[4] Understanding these complex psychological factors may provide

teachers, coaches, and trainers with valuable information and help participants improve their performance. Among these factors, a definite correlation exists between metacognition and academic performance.[5,6] Academic achievement in PE and PA encompasses a broader range of skills, knowledge, and attitudes related to physical health, fitness, and well-being.[7] Examples of these performances include knowledge and understanding of concepts related to fitness, sports rules, various motor skills development, physical activity experiences, and cognitive function.[8] Achievement and outcomes of numerous PE and PA are commonly associated with participants' academic performance.[9–11] Therefore, good intervention and research practices to improve participants' academic achievement are essential to optimize their overall performance in PE and PA.

Metacognition refers to an individual's cognition of their abilities and ongoing cognitive activities. Flavell operationalized metacognition into four essential components: metacognitive knowledge, metacognitive experience, goal-setting, and self-regulation strategies.[2] Metacognitive knowledge entails being aware of one's cognitive processes and understanding the factors that impact learning, such as attention, memory, and motivation.[12] Metacognitive regulation involves the capacity to plan, monitor, and evaluate one's learning activities.[13] Metacognitive experiences encompass the subjective aspects of learning, such as feelings of confidence, frustration, and enjoyment.[14] Examples of metacognitive skills could include the ability to monitor, regulate, and control one's thinking and learning processes.[15,16] Different models and frameworks have been developed to understand metacognition, such as the self-regulated learning model proposed by Zimmerman[17] and Pintrich's four-phase self-regulation learning model.[18]

Previous reviews and studies have extensively discussed the themes and underlying mechanisms involved in metacognition and human performance in PE and PA.[8,9] Indeed, the study of metacognition has expanded to cover various topics and domains. These themes include the degree of cognitive processing,[18,19] meta-cognitive knowledge,[20,21] meta-cognitive strategies,[4,22] problem-solving, cognitive flexibility;[23–26] metacognitive behavior;[27] metacognitive feelings,[28,29] decision-making and execution of skill;[30] meta-cognitive awareness;[31,32] meta-cognitive Judgments;[33] and self-regulating skills.[12,34–37] All of these studies show that metacognition-related themes are highly correlated with technical skill performance, academic achievement, and learning performance in PE and PA.

To the best of the authors' knowledge, only three systematic reviews published in the literature focus solely on metacognition on academic performance.[8,9,38] Most of the literature they included was quantitative research design, focusing on outcomes of academic achievement. Indeed, a rich qualitative literature is available relating variously to metacognition such as the influence of person, task and strategy factors, and emotional experience on performance in the context of PE, PA, and other sports settings. However, such evidence needs to be systematically compiled. A systematic review with meta-analysis may help to pinpoint gaps and shortcomings in the quantitative literature and provide practitioners or scholars with valuable insights on future research directions. Therefore, the primary purpose of this study is to explore the evidence published about the emerging themes of metacognition on academic achievement in PE and PA by conducting a systematic literature review with a meta-analysis of qualitative findings.

Materials and Methods

Protocol and Registration

Both the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) guidelines and the Joanna Briggs Institute (JBI) guidance for systematic reviews of qualitative evidence were followed in reporting this systematic review and meta-analysis.[39,40] The protocol was registered on inplasy.com.

Eligibility Criteria

The criteria include the following 1) Population: Inclusion of physically healthy students, athletes, players and any other participants (no gender restriction) of any age and competition level (no restriction); 2) Outcome: Reporting any emerging themes related to metacognition in schools' or in out-of-school settings' PE, acute or chronic PA, and physical exercises; 3) Language: Eligible studies were peer-reviewed English-language manuscripts; 4) Research design: Inclusion of primarily qualitative or mixed-methods, reporting first-hand information. Quantitative research, conference abstracts, books, book sections, opinions, letters, or papers not published in peer-reviewed journals were excluded. Only

qualitative data from mixed methods were analyzed. Studies reporting only on technical skills were excluded, but those discussing academic and psychosocial influences and learning abilities were included.

Search Strategy and Selection Process

On the 6th of June 2023, Web of Science Core Collection, SPORTDiscus, ProQuest, PubMed, and SCOPUS five electronic databases were searched to obtain articles pertinent to the topic. Considering the novel topic of metacognition to be studied, only articles published since 2000 were included. Previous reviews were used to help define our search strategy; keywords and Boolean operators were considered separately and in aggregation while searching the five databases (See Figure 1 and Table S1). This study employed the following terms and operators: ("metacognition*" OR "self-regulation learning") AND ("physical activity" OR "physical education" OR "physical exercise" OR "sport") AND ("qualitative study" OR "observational study" OR "interview study"). Moreover, we carefully reviewed relevant review articles published before June 30, 2023. Furthermore, our research team screened the reference lists of all the identified articles to discover any publications that were not detected by the initial search. Finally, we invited an experienced librarian to participate in the data collection process to ensure the search process was performed correctly.

Initially, we uploaded search results to Zotero (version 6.0.26.0). After removing duplicates, two reviewers (BL, XH) independently extracted data from each article based on all titles, abstracts, and full-text articles for eligibility criteria. The reason for exclusion was documented during the full-text screening phase. In case of any disputes regarding an article's eligibility, a third reviewer (KG) was consulted to discuss and resolve the matter.
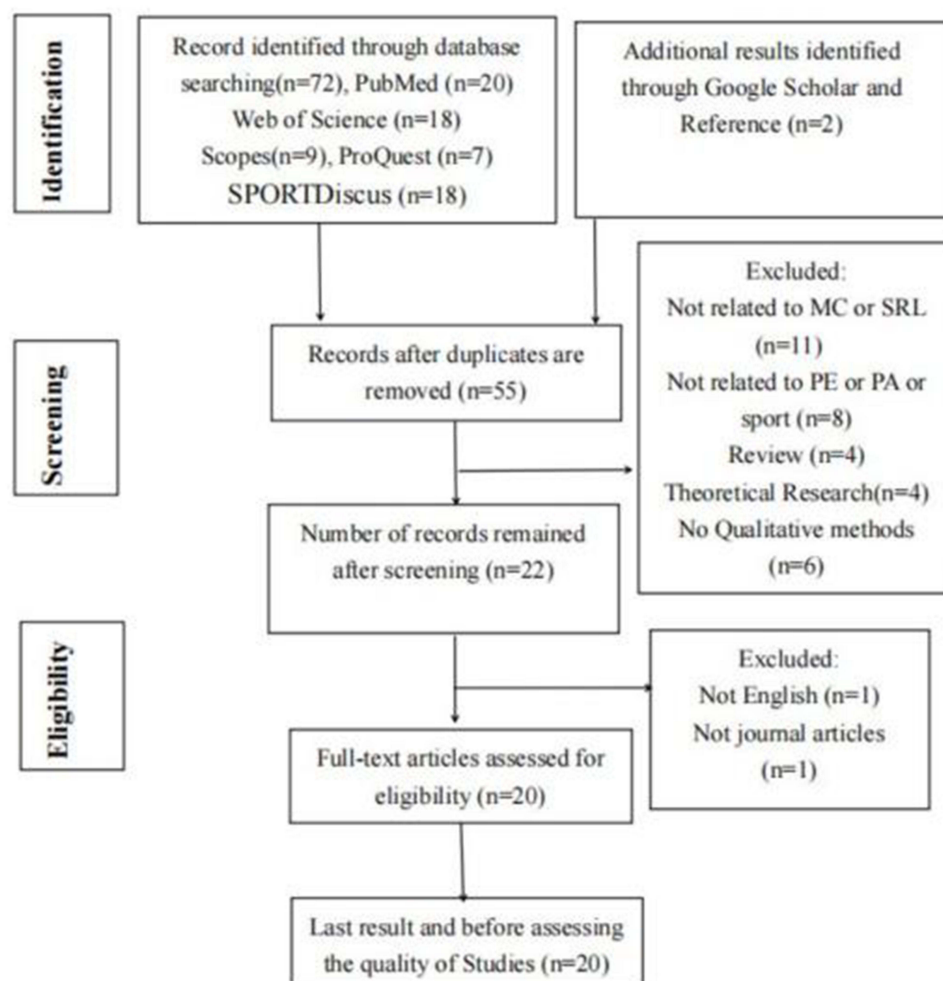

Figure 1 PRISMA summary of the selection process.

Study Quality Assessment

Two reviewers (BL, XH) used the Critical Appraisal Skills Programme (CASP) checklist for qualitative research to independently assess the methodological quality of the included articles. Differences were resolved through discussion or by involving a third reviewer (KG). Cohen's kappa (k) is used to establish inter-rater agreement. The intraclass correlation coefficient (ICC) was used to establish inter-rater reliability, ICC > 0.75 indicates good inter-rater reliability.

Data Extraction

Two reviewers (BL and XH) obtained information by using Covidence to extract the following information from the included articles: author, year and country of publication, population characteristics, phenomena of interest, methodological approach, data analysis methods, sport type, and academic achievement. A third reviewer (KG) verified its accuracy again.

Data Synthesis

We uploaded the full text of the articles included in the included studies to NVivo (v20.5.1.940) qualitative data analysis software and analyzed the Results section (including narratives and participant citations) as well as relevant supplementary material from the included studies, using thematic analysis to conduct a meta-analysis.[39] To ensure the accuracy of data synthesis, the research team first selected two associate professors who have rich teaching and practical experience and have been engaged in physical education teaching and academic research for more than ten years to code the data. First, one researcher BL applied inductive line-by-line initial coding individually to mark the relevant concepts raised in the findings. A second investigator, XH, randomly selected 20% (n = 4) of the articles included in the study and reviewed their coding accuracy. Then they constructed descriptive themes through discussion, and the entire discussion process and content were recorded with cameras to improve the reflectivity of researchers. Lastly, they further refined the coding paradigm using axial coding to detail the set of features operating within each descriptive theme. Descriptive themes were then analyzed to reflexively construct a hypothetical model of proposed relationships between themes.

Certainty of Evidence

The Grading of Recommendations Assessment, Development, and Evaluation–Confidence in Evidence from Reviews of Qualitative Research (GRADE-CERQual) approach was used to establish the degree of confidence that can be applied to the descriptive findings.[41]

Aggregate Critical Skills Appraisal Programme (CASP) checklist results for contributing studies were used to assess the methodological limitations of contributing studies for each integrated finding.[42] The coherence,[43] adequacy,[44] relevance[45] of synthesis findings are assessed separately. As with all GRADE CERQual standards, the evaluation begins with the assumption that there were no concerns for each discovered data body, and the rating is downgraded based on the results of the evaluation. However, the evidence shows that the GRADE CERQual method is only suitable for descriptive topics and not for analytical topics.[46]

Results

Study Characteristics

The PRISMA flow chart was reported in the search outcomes (Table S2). Finally, 20 studies met the eligibility criteria and were included in the systematic literature review. Among them, 8 articles were published in Western European countries (1 in France, 6 in the United Kingdom, and 1 in the Netherlands); 8 articles were published in North American countries (6 in the United States and 2 in Canada); 1 article in a North African country (Tunisia); 1 in Oceania (Australia); and 2 in Southeastern European countries (Croatia),14 studies published since 2015. The mean sample size was 17.5 (range from 1–81, SD=19.4). The age range spans from 7–41 years old. Among these, 7 articles (35%) explored metacognitive processes (metacognition) and self-regulation (strategies, experiences) in high-level athletes across different sports training and competitions. Additionally, 9 (45%) articles focused on self-regulated learning in primary and secondary school students with developmental coordination disorder (DCD) or learning disabilities (LDs)

during physical education classes or physical activities at school or out-of-school settings. 3 (15%) articles explored metacognition and self-regulation processes in adults participating in various sports activities. 15 (75%) studies used interviews and observation as data collection methods. The remaining articles employed a combination of research methods, likely including a mix of observational methods and other survey research techniques. Most studies used thematic analysis as data analysis methods (n = 9, 45%), content analysis (n = 7, 35%), case study (n = 2, 10%), and grounded theory (n = 2, 10%). The sports covered in the research encompass a wide range of activities, including soccer, gymnastics, endurance running, golf, taekwondo, yoga, martial arts, table tennis, hockey, online gaming, and physical education activities. Characteristics in detail of the included studies were summarized in Table S3.

Methodological Quality of Studies

Two reviewers, BL and XH, independently conducted a detailed methodological quality assessment of the 20 articles using the (CASP) checklist, and none of the studies were excluded. Cohen's kappa k = 0.842 (p < 0.001), indicating a strong level of agreement between the assessors. The ICC = 0.891 (95% CI 0.91–0.94, p < 0.001), indicating excellent inter-rater reliability. Out of 20 articles, 17 articles (85%) have a clear statement of the aims of the research, an appropriate qualitative methodology, and a clear statement of findings. The majority of the articles employed appropriate research designs (n=17, 85%) recruitment strategies (n=18, 90%), data collection methods (n=18, 90%), and data analysis (n=18, 90%) to address the research questions. Few studies (n=4, 20%) thoroughly considered the relationship between researchers and participants, and ethical issues (n=10, 50%). This is a common issue found in the articles included in the study, and it's also a challenge that qualitative research often overlooks (See Table 1 for details).

Certainty of Evidence

Two reviewers, BL and XH, independently assessed the confidence of the included studies using the GRADE-CERQual method. In case of disagreement, a third reviewer KG will be invited to facilitate discussion and reach a consensus. Finally, most of the descriptive themes achieved a moderate level of confidence. The specific assessment results are detailed in Table S4.

Thematic Synthesis

From the 20 literature sources included in the study, five descriptive themes were extracted, which are as follows: 1) Metacognitive performance during the learning process in different sports disciplines. 2) Domains of metacognitive skills related to academic performance; 3) Self-regulation strategies related to academic performance; 4) Influencing factors of metacognition; 5) Exploring the metacognitive interventions on motor learning and academic performance (Table 2).

Descriptive Theme 1: Metacognitive and Academic Performance During the Learning Process in Different Sports Disciplines

Data from 20 studies all contributed to this theme. Most of the data focus on performance in three aspects during learning processes: 6 articles (30%) focus on metacognitive processes,12 articles (60%) focus on self-regulation, and two articles (10%) focus on executive functions. The sports disciplines include soccer,[30,47,62] gymnastics,[48] endurance running,[14,51,55] golf,[49] taekwondo,[50,60] MMA,[54,56,61] yoga,[52] table tennis,[57] hockey,[63] and metacognition-related physical education programs.[53,58,59,64] Most studies indicate that metacognitive performance varies across different sports disciplines. There is a greater emphasis on researching the metacognitive performance of individual sports as compared to team sports. Specifically, metacognitive performance appeared to be more prominent in endurance running, martial arts, and yoga.

Descriptive Theme 2: Domains of Metacognitive Skills Related to Academic Performance

Data from 18 (90%) studies contributed to this theme which described the domains and performances of various metacognitive skills. Five articles related to metacognitive skills included execution, monitoring, and control of

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Table 1 Results of CASP Quality Appraisal (N=20)

Reference numbers	1. Was There a Clear Statement of the Aims of the Research?	2. Is a Qualitative Methodology Appropriate?	3. Was the Research Design Appropriate to Address the Aims of the Research?	4. Was the Recruitment Strategy Appropriate to the Aims of the Research?	5. Was the Data Collected in a Way that Addressed the Research Issue?	6. Has the Relationship Between the Researcher and Participants Been Adequately Considered?	7. Have Ethical Issues Been Taken into Consideration?	8. Was the Data Analysis Sufficiently Rigorous?	9. Is There a Clear Statement of Findings?
[47]	I	I	I	I	I	0	I	I	I
[48]	I	I	I	I	I	0	I	I	I
[30]	I	?	I	I	I	0	I	I	I
[14]	I	I	I	I	I	I	I	I	I
[49]	I	I	I	I	I	0	I	I	?
[50]	I	?	I	I	I	I	?	I	I
[51]	I	I	I	I	I	0	I	?	I
[52]	?	I	I	I	I	0	?	I	I
[53]	I	?	I	I	I	?	0	0	I
[54]	?	I	I	I	I	?	0	I	I
[55]	I	I	I	I	I	?	?	I	I
[56]	I	I	I	I	I	?	I	I	I
[57]	I	I	I	I	I	I	0	I	?
[58]	I	I	I	I	I	?	?	I	I
[59]	I	I	I	I	?	0	?	I	I
[60]	?	?	?	I	I	?	?	I	I
[61]	I	I	I	?	I	?	I	I	I
[62]	I	I	?	?	I	?	I	I	?
[63]	I	I	?	I	?	I	?	I	I
[64]	I	I	I	I	I	?	I	I	I

Note: "Blank color" I =Yes; "Orange color" 0 = No; "Blue color" ? = Unclear.

Table 2 Overview of Emerging Themes of Metacognition and Relevant Academic Achievement in Review Findings

Study Numbers	Reference Numbers	Phenomena of Interest	Emerging Themes of Metacognition	Subthemes of Metacognition	Relevant Academic Achievement
I	[47]	Cognitive process and strategy used for problem-solving	ACTA, metacognitive process	Selection, execution, monitoring and control of cognitive strategy, self-knowledge	Solving problems, knowledge; understanding, and learning on the task in soccer.
2	[48]	Assessing the impact of VMEs on students' self-regulated learning experiences	Self-regulated learning strategies	Repeated viewing, self-talk, and mental imagery practices.	Acquire motor skills and knowledge in gymnastics.
3	[30]	Implementing a PT program to improve decision-making and execution of skill among premier league academy soccer players	Executive functions and motivational regulations	Fluency, accuracy, speed, inhibition of execution function.	Confidence, meta-cognitive skills, and challenge appraisals.
4	[14]	To understand the self-regulatory processes facilitating optimal experiences in running	Self-regulation and optimal experiences	Task movies and task analysis, monitoring, metacognitive experiences, affective responses, motivation, and control.	Cognition and manage feelings of difficulty in running.
5	[49]	To construct a theoretical understanding of meta-attention in golfers.	Meta-attention	Metacognitive reflections of logistic and shot resources	Attentional control in golfers.
6	[50]	Explore the benefits of taekwondo for student learning, health, and well-being.	Self-regulation	Self-confidence, self-discipline, self-motivation, respect	Self-regulating abilities: self-discipline and self-motivation in Taekwondo
7	[51]	Explore the metacognitive processes and attentional focus of recreational endurance runners.	Metacognitive processes activity	Metacognitive skills and regulation of cognition	Metacognitive processes and attentional of recreational endurance runners.
8	[52]	Investigate teachers' perceptions of yoga in a school setting.	Self-Regulation and Behavioral Benefits	Self-regulation skills: take deep breaths to calm and relax the body, calmness	Physical development, self-regulation skills, and social-emotional skills, behavioral and cognitive benefits of yoga.
9	[53]	Compare the self-regulatory performance of children with and without DCD.	SRL skills	Goal setting, planning, self-monitoring, evaluation, using strategy, self-evaluation	The self-regulatory skill of motor learning and motivational regulation in CO-OP program of Children with DCD.
10	[54]	Using integral-mindfulness martial arts to address self-regulation challenges in youth with learning disabilities.	Self-regulation challenges	Calmness; thinking before acting; self-understanding and communication; tolerating and accepting discomfort	Self-regulation challenges: calm, tolerance and acceptance of distress, and self-understanding in MMA.

(*Continued*)

Table 2 (Continued).

Study Numbers	Reference Numbers	Phenomena of Interest	Emerging Themes of Metacognition	Subthemes of Metacognition	Relevant Academic Achievement
11	[55]	Exploring the dynamic control of attention and cognition in elite-level endurance runners from a metacognitive perspective	Metacognitive processes activity	Planning, monitoring, reviewing and evaluating, and metacognitive experiences (metacognitive feelings, metacognitive judgments, and estimates).	Metacognitive strategies and metacognitive experiences in endurance running.
12	[56]	Examining the use of self-regulation strategies to enhance performance in MMA athletes	SRL strategies	Using behavioral processes of change, developing embodied emotions, and using psychological strategies	Self-regulation and performance of MMA
13	[57]	Exploring the similarities and differences in self-regulated learning processes in sport and academics of a student-athlete.	Self-regulated learning	Task understanding, goal setting, monitoring and evaluating, challenges, adapting	Regulation in sport and academics of table tennis training.
14	[58]	Explore the experience of an adolescent male gamer as he develops his metacognition and self-scaffolding in MMORPGs	Metacognitive and self-scaffolding processes	Self-awareness, self-scaffolding of directions, stating existing self-knowledge, questioning self-knowledge.	Metacognitive functions and self-awareness for the participant and the researcher.
15	[59]	Examining change in metacognitive performances during motor learning	Metacognitive performances	Metacognitive knowledge, metacognitive control	Metacognitive performances during motor learning.
16	[60]	Understanding the self-regulation involved in training and competition in MMA.	Self-regulation	External factors: environmental regulation, social support, and structured amnesty. Internal factors: self-efficacy	Self-regulation is involved in training and competition in MMA.
17	[61]	Evaluating Taekwondo implemented in public middle school PE.	Executive function	Self-discipline, self-efficacy experience, self-control, concentration, and pay attention.	Self-discipline, self-efficacy experience, self-control, concentration and pay attention in PE.
18	[62]	Examining behavioral correlates of self-regulation in elite youth soccer players.	Self-regulation behavior	Planning, self-monitoring evaluation, reflection, effort	Behavioral correlates of self-regulation in elite youth soccer players
19	[63]	Examine the domain-specific self-regulatory skills of boys with DCD.	Self-regulation skills	Goals, knowledge, emotion, monitoring, and evaluation	Specific self-regulatory skills of boys with DCD in Hockey.
20	[64]	Investigating the self-regulation components employed by students in a natural PE setting.	Self-regulation components	Self-regulation learning strategies, self-regulation management strategies, self-regulation knowledge	Self-regulation components employed by students in PE setting.

Abbreviations: ACTA, Applied Cognitive Task Analysis; VMEs, video modeling examples; PT, pressure training program; DCD, developmental coordination disorder; CO-OP, program, Cognitive Orientation to daily Occupational Performance; PACS, the Paediatric Activity Card Sort; SR, self-regulation; MAI, Martial Arts Inventory; MMA, Mindfulness Martial Arts; MC, Metacognition; VR, Virtual reality (VR) technology; DLVR teaching, deep learning-based VR-assisted teaching; DBH-CNN, deep Binary Hashed Convolutional Neural Network; LP, learning passion; LDs, Learning Disabilities; MHC, Mental Health Challenges; M; male; FM, Female; TA, thematic analysis; CA, content analysis; MMORPGs, massively multiplayer online role-playing games.

cognitive strategy, self-knowledge,[47,51] meta-attention;[49] planning, monitoring, reviewing, and evaluating, along with metacognitive experiences (metacognitive feelings, metacognitive judgments, and estimates);[55] and metacognitive knowledge, metacognitive control.[59] 11 articles mentioned self-regulation skills. Most of them considered these skills to include goal setting, planning, self-monitoring, using strategies, and self-evaluation.[53,56,57,61–63] 1 article suggests that self-regulation skills include self-confidence, self-discipline, self-motivation, and respect.[50] Another article suggests that self-regulation skills encompass self-regulation challenges.[54] Two articles have mentioned executive functions.[30,60]

Most studies indicated that the metacognitive skills contributed to enhancing the acquisition of motor skills and knowledge,[47,48] controlling cognition, managing feelings of difficulty,[14] facilitating attentional control,[49] fostering social-emotional skills, and providing behavioral and cognitive benefits.[52] They also help develop students' self-discipline, self-efficacy, self-control, concentration, and attention in different PE or PA.[60] These skills are particularly beneficial for students with developmental coordination disorders (DCD),[53,59,63] and Learning Disabilities (LDs)[54] during their motor learning.

Descriptive Theme 3: Self-Regulation Strategies Related to Academic Performance

Data from 12 (60%) studies contributed to this theme. Most studies considered self-regulation to be an important strategy of metacognition. These strategies include goal setting, planning, self-monitoring, and self-evaluation. In addition, three other articles suggest the inclusion of self-confidence, self-discipline, self-motivation,[50] self-regulation challenges, such as calm, tolerance, and acceptance of distress, and self-understanding were self-regulation strategies,[54] and self-regulated learning strategies, self-regulated management strategies, and self-regulated knowledge.[64] These studies suggested that the self-regulation learning strategies contributed to acquiring motor skills and knowledge in gymnastics, managing feelings of difficulty in running, motivational regulation, task understanding, goal setting, monitoring and evaluating, facing challenges, and adapting in both sports and academics.

Descriptive Theme 4: Factors Influencing Metacognition

Data from 11 (55%) studies contributed to this theme. The result showed that during the learning process, factors that influence metacognition include two categories: external factors and internal factors. External factors encompass social interaction, such as environmental regulation, social support, structured amnesty,[14,53,61] and educational resources.[62] Internal factors consist of psychological factors such as metacognitive awareness,[58] metacognitive knowledge,[63,64] goal setting and planning, learning strategies, self-monitoring,[14,53,57] self-efficacy,[61] and emotion regulation.[52,56] Motivation and self-evaluation helped learners self-regulate and manage external and internal factors related to physical and academic performance.

Descriptive Theme 5: Exploring the Metacognitive Interventions on Motor Learning and Academic Performance

Data from 9 (45%) studies contributed to this theme. The research findings indicate that individually tailored or combined use of various interventions, based on individual needs and goals, could enhance metacognitive abilities, this in turn, improves the efficiency and quality of learning, problem-solving, and decision-making, and holds significant value for both personal performance and academic achievements. These intervention measures include Applied Cognitive Task Analysis (ACTA),[47] video modeling examples (VMEs),[48] pressure training programs (PT),[30] Cognitive Orientation to daily Occupational Performance (CO-OP),[53] massively multiplayer online role-playing games (MMORPGs),[58] as well as self-talk and mental imagery practices.[48] Additionally, research has shown that certain precision-oriented individual sports and activities, such as long-distance running, martial arts, yoga, and golf, had a significant impact on metacognition when it came to their teaching and training programs.

Analytic Theme: The Mechanism of Metacognition in PE and PA Contexts

First, guided by metacognitive theory, academic performance in PE and PA settings is highly correlated with metacognitive skills. These metacognitive skills broadly encompass three domains: metacognitive knowledge, metacognitive behaviors, and
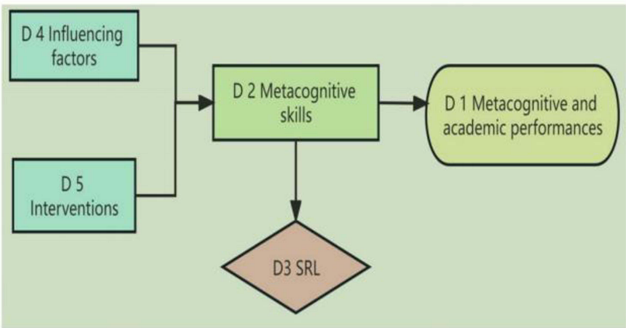
Figure 2 Hypothetical model of relationships among the descriptive themes.

metacognitive emotions. External factors from social support, social feedback, and educational resources, along with internal factors such as self-awareness, motivation, goal setting, planning, self-regulation, and self-evaluation collectively influence and intervene in metacognitive skills. Consequently, these metacognitive skills play a role in affecting problem-solving abilities, executive functions, decision-making, and other aspects of academic performance. See Figure 2 the hypothetical model below for details.

Confidence in the Review Findings

Two independent authors (LB and HX) conducted an overall assessment of confidence in five descriptive themes using the GRADE CERQuality approach. In cases of disagreement, a third author KG was invited to join the discussion until a consensus was reached. In the end, all five descriptive themes were rated. This indicated that most themes were likely a reasonable representation of the existing evidence (Table 3).

Table 3 Assessment of Confidence of Review Findings: Summary Score per GRADE CERQual Domain

Emerging Themes	Studies Number Contributing to Theme	Assessment of Methodological Limitations	Assessment of Relevance	Assessment of Coherence	Assessment of Adequacy	Overall CERQual Ratings
D1 Metacognitive performance during the learning process in different sports disciplines.	1–20	Moderate concerns	Moderate concerns	No or very minor concerns	No or very minor concerns	Moderate confidence
D2 Domains of metacognitive skills related to academic performance.	1–13, 15–19	Moderate concerns	Moderate concerns	Minor concerns	Minor concerns	Moderate confidence
D3 Self-regulation strategies related to academic performance.	2, 4, 6, 8–10, 12, 13, 16, 18–20	Moderate concerns	No or very minor concerns	No or very minor concerns	No or very minor concerns	Moderate confidence
D4 Factors influencing metacognition.	1–7,10–12,14	Moderate concerns	Moderate concerns	Minor concerns	No or very minor concerns	Moderate confidence
D5 Exploring the metacognitive interventions on motor learning and academic performance.	1–3, 6, 9–11, 14, 16	Moderate concerns	Moderate concerns	No or very minor concerns	Minor concerns	Moderate confidence

Notes: CASP scoring of individual studies contributing to a theme; iiFit between original study aims, context and the review aims and context; iiiFit between original study findings and review themes; ivThe extent to which themes are supported by quantitative evidence (number of studies and nodes supporting theme) and qualitative evidence (richness of data supporting a theme); VOverall rating based on judgements for the four domains and scored as: High, moderate, low, or very low.

Discussion

From an academic research perspective, contemporary physical education studies often find themselves constrained by a prevailing bias towards the biological aspects of the human body. This research tendency leads to a consistent focus on the "human body" rather than "human motor behavior". Consequently, research outcomes frequently fall short of accurately capturing the intricate relationships within human motor behavior.[65] Metacognition offers a fresh perspective and methodology to address the practical issues and challenges in physical education practice. The descriptive themes identified in this study provide rich evidence for the aforementioned questions.

Descriptive theme 1 suggested that the performance of metacognitive skills varies across different sports and influences academic performance differently. Team sports such as basketball,[12,27,29,66] soccer,[30,67] and volleyball[68] can cultivate participants' tactical thinking, teamwork awareness, and executive functions. Martial arts[50,54,69–71] and gymnastics activities[48] can enhance participants' physical control. Some precision sports like darts-shooting,[34] and golf[49] can develop athletes' metacognitive skills. Yoga[52,72] and taekwondo[50,60] programs can improve students' and athletes' emotional regulation and attention. Cognitive challenge games[11,35] can enhance participants' executive functions, cognitive abilities, and self-regulation skills. These findings align with those from quantitative research and also address the deficiency of emotional aspects of metacognition in quantitative studies.[73]

Currently, numerous scholars have confirmed that metacognitive skills are important skills that relate to academic performance. Scholars have also introduced various concepts related to metacognitive skills, such as metacognitive awareness, metacognitive feelings, metacognitive emotion, metacognitive judgments, and metacognitive behaviors. However, the academic community still lacks a unified definition of metacognitive skills, and some scholars also use the term metacognitive abilities[74,75] interchangeably with metacognitive skills. There are also new concepts related to metacognitive skills proposed in descriptive theme 2. Nevertheless, all these concepts related to metacognitive skills can be broadly categorized into three aspects, namely metacognitive knowledge, metacognitive behaviors (including metacognitive strategies and metacognitive regulation), and metacognitive emotions, which align with the principles of metacognitive theory.[76]

Descriptive Theme 3 indicated that self-regulated learning (SRL) was one of the most effective learning strategies in PE and PA settings. However, many scholars tended to conflate self-regulation, self-regulated learning, and metacognitive learning. The foundational theory behind SRL was based on Bandura's concept of self-regulation. Both metacognitive learning and self-regulated learning lacked universally accepted definitions. There was some overlap and interplay between these two concepts, making it challenging to delineate their relationship.[77,78] Through an analysis of the existing literature, most scholars consider metacognitive learning to be a subset of self-regulated learning. Self-regulated learning represents a higher-level approach to metacognitive learning.[79–82] Some scholars proposed that self-regulated learning also encompasses metacognitive learning strategies known as metacognition or metacognitive self-regulation, which involve planning, monitoring, and regulating cognitive strategies during the learning process.[83] This aligns with the majority of views presented in descriptive theme 3, suggesting that SRL encompasses goal setting, planning, self-monitoring, and self-evaluation. Therefore, distinguishing between the above-mentioned concepts is a key focus for future research.

Descriptive themes 4 and 5 confirmed the factors and interventions that influenced and enhanced metacognitive skills in PE and PA settings. In summary, factors influencing metacognitive skills can be categorized into two main groups: external factors and internal factors. External factors encompass the social environment, social support, educational resources, learning tasks, and learning environment. These factors provide the framework and conditions for learning, impacting individuals' learning experiences and opportunities. For instance, a supportive social environment and suitable learning tasks can foster the development of metacognitive skills.[61,84,85] Internal factors include metacognitive awareness, motivation, goal setting, metacognitive strategies, self-evaluation, and emotional control. These factors involve individuals' cognitive and emotional states and play a crucial role in the application and development of metacognitive skills. For example, having a high level of metacognitive awareness and clear learning goals can prompt individuals to more effectively utilize metacognitive strategies to solve problems.[31,73,86]

Currently, a large number of studies demonstrate that in the field of PE and PA, direct or indirect interventions related to metacognition, such as physical education teaching models,[12,87] teaching methods and teaching styles[27,88] had certain effects on students' metacognitive skills. Other methods include pressure training, cognitive-behavioral training, reflective

practice,[11,30,35] social feedback and process goals,[29,36] as well as other single or comprehensive training methods that incorporate metacognitive features.[66,67,89] Especially in the case of certain cognition-related games and training courses, the effectiveness of methods is more pronounced. Future research should continue to develop more effective measures to enhance metacognition.

Limitations and Directions for Future Research

This study conducted an exploration of emerging themes between metacognition and academic achievement in PE and PA settings using a systematic literature review and meta-synthesis, providing some compelling evidence. However, there are also some limitations. Firstly, although the GRADE CERQual method offers a systematic process for assessing the quality of study outcomes, it does not provide sufficient operational support for reviewers to judge the acceptability criteria and carries associated risks of bias. Secondly, the study was limited to research published in English-language journals, which may introduce publication bias. Finally, due to constraints in the data from the literature, no subgroup analyses related to population characteristics (such as age and gender) were conducted.

Further research is now needed to validate and translate the descriptive themes proposed in qualitative studies. Firstly, based on the analysis of descriptive themes, this study has proposed a model for metacognitive learning in PE and PA settings. Future research can further validate and refine this model. Secondly, the study has identified variations in metacognitive skill performance across different sports and exercise activities. Future research should expand the scope of practical studies to other sports and activities to further distinguish differences in metacognitive skill performance among them. Lastly, the study has highlighted a range of factors influencing and enhancing metacognition, along with intervention measures. Subsequent research should implement these measures and continue to develop teaching and training models that incorporate a "reflective" approach, with a specific focus on improving and enhancing intervention measures for internal influencing factors. Additionally, future research should emphasize comparative studies among different population groups and operationalize and provide precise definitions for various facets of metacognitive skills.

Conclusion

This systematic literature review and meta-analysis, by exploring the relationship between metacognition and academic performance in PE and PA settings, synthesized five emerging descriptive themes. Based on the relationships observed among these emerging themes, an analytical theme is proposed: the metacognitive learning model in PE and PA settings. This study provides a valuable information resource for PE teachers, coaches, and trainers. As well as it offers theoretical insights and empirical evidence to guide future research. In particular, it provides new perspectives for exploring the correlations between metacognition and physical performance as well as academic achievement in the context of motor learning, comparative studies involving different demographic groups, and the design of further intervention experiments.

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Author Contributions

All authors have made significant contributions to this work, whether in terms of conceptualization and ideation of the research, data screening, acquisition, analysis, and interpretation, or in the drafting, editing, and reviewing of the manuscript, culminating in the final approved version for publication. We have reached a consensus on the submitted journal article and agreed to take responsibility for various aspects of the work.

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