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Cognitive health outcomes of fundamental motor skill applications in children through cooperative learning method

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Abstract

Background Previous research has suggests that cooperative learning methods and the development of fundamental motor skills support children's cognitive development, and further studies covering various aspects are recommended. In this study, as an alternative to traditional physical education classes including fundamental motor skill activities, we investigated the impact of cooperative learning methods incorporating these skills on children's visual-motor integration and selective attention.

Methods A total of 60 boy children in the 10–11 age range were included in the study. Groups; classical method ($10.95 \pm 0.58_{age}$), and cooperative learning group ($10.91 \pm 0.42_{age}$). The study spanned a total of 24 physical education class hours. While the classical method group continued to attend physical education lessons with an FMS-based prepared program for 8 weeks, cooperative learning group participated in an FMS-based program prepared according to the cooperative learning method (40min/3days/8weeks).At the beginning and end of the study, children underwent the Bender-Gestalt test and the d2 test of attention.

Results Within-group pre-post test comparisons revealed improvement in visual-motor integration and selective attention for both the classical method and cooperative learning groups. In between-group post-test comparisons, the cooperative learning group demonstrated greater improvement in visual-motor integration and selective attention parameters compared to the classical method.

Conclusion The results support increasing the inclusion of fundamental motor skill activities in physical education classes and advocating for the use of cooperative learning methods in these classes. Enhancements in visual-motor integration and selective attention may contribute to children forming quality relationships, enjoying activities, learning stress management, and developing as a group.

Keywords Cooperative Learning, Motor Skills, Visual-Motor Integration, Selective Attention

Introduction

Fundamental motor skills (FMS) are foundational skills that facilitate participation in physical activities (PA) at various levels and influence the execution of dynamic movements [1, 2]. Proficiency in FMS is essential for engaging in complex physical activities [3]. FMS is categorized into three categories: (1) locomotor skills (running), (2) object control (throwing and catching a ball), and (3) balance and stability skills (standing on one foot) [4, 5]. Children who do not engage in sufficient sporting

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activities may experience developmental delays in acquiring FMS. The development of FMS is directly associated with beneficial health outcomes [6]. While only 11% of children aged 12–13 demonstrate proficiency in FMS [7], it has been noted that over 50% of children generally exhibit inadequacies in FMS [8]. A recent study has demonstrated that developing FMS adequately enables children to function independently in physical, social, and cognitive aspects [9]. Elementery school years are an ideal period for enhancing children's FMS proficiency, establishing physical activity habits, and benefiting from quality education and training related to FMS [10]. Research indicates that effective time spent during childhood is crucial for carrying PA into later years [11]. One of the methods that can be utilized for effective time management is employing different educational models, one of which is collaborative learning [12].

Cooperative learning emerged in response to observed low levels of interaction in classrooms. The learning model has been widely implemented and encouraged in the field of education since its development in the 1980s [13]. One of its main goals was to facilitate relationships among individuals during the educational process [14]. Students learn collaboratively with encouraging positive interactions from and with other students [15]. However, for cooperative learning to be effectively implemented in the classroom, the presence of five essential elements is necessary: interpersonal skills, group processing, positive interdependence, individual accountability, and encouraging interaction. In cooperative learning, students work together in small, heterogeneous groups to support each other collaboratively [16]. Studies on the implementation of cooperative learning in Physical Education (PE) classes suggest contributions to children's self-confidence [17], fundamental motor skills [18], motivation [15], and sensory learning [19] can be made. Legrain et al. (2019) stated that exploring the outcomes of cooperative learning is challenging yet crucial [20]. Gorucu (2016) noted that cooperative learning enhances cognitive skills. Through CL, teachers can motivate students more in PE classes during the development of FMS and guide students towards need-supportive behaviors. Therefore, examining the effects of cooperative learning [21] on children's cognitive skills, including visual-motor integration (VMI) and selective attention (SA), which are necessary for various learning skills, may be important.

VMI is a critical component of acquiring and organizing information from the environment [22]. It is used in the perception, interpretation, and understanding of visual stimuli [23, 24]. Winnick (2005) emphasized that VMI is important not only for skills such as writing and drawing but also for FMS movements such as throwing, jumping, catching, and striking [25]. Deficiencies in VMI can contribute to a lack of control over FMS [26, 27]. The study demonstrated that educational encouragement, particularly in PE classes, can be a suitable way to improve both VMI and FMS [28]. Therefore, if exercise programs are not tailored to the dynamic characteristics of children, basic body position movements (walking/running) and sports-related movements may not develop adequately [29, 30]. VMI also reflects the efficiency of performing cognitive tasks [31]. Cognitive functions such as SA play a significant role in classroom behavior and learning processes, contributing to academic success [32, 33]. Consequently, regularly practicing FMS at school can have immediate positive effects on learning efficiency in the classroom. For example, FMS proficiency has been found to be related to children's working memory [34]. Therefore, children with better FMS respond more appropriately in situations where the cognitive factor (SA) is necessary for performance [34, 35]. The study highlighted a significant difference in VMI among children with inadequate gross motor skills [36, 37]. Thus, using effective FMS programs to understand the connection between VMI, SA, and PA in children may be important [24].

Childhood is a period of neurobiological and psychological changes that lay the foundation for health in later life [38]. Therefore, it is important to understand how health and education policies can be positively directed during childhood [39]. Evidence regarding children supports positive relationships between exercise and cognition [40], but the lack of studies on different types of PA, methodologies, and age differences makes it difficult to draw definitive conclusions. Studies have shown that FMS-focused programs (training/classes) can encourage children to engage in a variety of movement skills more than unstructured activities (free play) [41] and can lead to significant improvements in FMS proficiency (i.e., locomotor and object control skills) among school-aged children [42]. Therefore, providing more detailed procedures and information for FMS programs is essential. Pedagogical approaches related to education have rapidly developed over the past 50 years, with some being used in classes [43, 44]. Although these interventions are generally successful, there is still no clear explanation of the most effective pedagogical approach or type of curriculum [45]. Therefore, it is important to identify approaches that will increase children's interest in PA at an early age. The limited time and intensive curriculum in PE classes hinder PE teachers from providing effective and engaging lessons [46]. Consequently, PE classes are often taught by teachers using functional and rigid/classical methods [47]. Until motor skill specialization occurs, movements are broken down into segments, and correct execution is taught with minimal errors. However, this method is not suitable for all children. In this method, children develop an excessive dependence on instructions given by the teacher, limiting their autonomy [48]. Therefore, it is important to determine learning approaches suitable for children's development. Through CL, teachers can motivate students more in PE classes during the development of FMS and guide students towards need-supportive behaviors. This approach provides students with opportunities for choice and initiative (autonomy support), information transfer, feedback (competence support), and an emotional environment (relatedness support) [15]. With this method, regularly practicing FMS at school can have immediate positive effects on learning efficiency in the classroom. This is because motor skill interventions that are open-ended, strategic and sequential in nature are more effective. Environmental stimuli, interpersonal interaction, agility, coordination, and cardiorespiratory fitness can be considered as skill attribute moderators of motor skills to improve cognition [34]. This is because children with more developed FMS respond more appropriately in situations where the cognitive factor is necessary for performance [35]. This study aimed to examine the effects of two different school training models (Classical/Cooperative) incorporating FMS movements over 8 weeks in PE classes on VMI and SA in boys aged 10–11. We hypothesized that: H_1) both structured school training models incorporating FMS movements (Classical/Cooperative) would contribute to VMI and SA skills, and H_2) the CL model incorporating FMS movements would develop VMI and SA skills better than the CM.

Methods

Design and ethics

This study employed a pre/posttest experimental design with a comparison group. The dependent variables were Visual-Motor Integration, measured using the Bender-Gestalt Test, and Selective Attention, measured using the d2 Test of Attention. Due to demonstrated gender differences in motor skills [49] and cognitive skills [50], the study was conducted with a single-gender sample. Schools where the study would be conducted were preselected, and necessary legal permissions were obtained from the Directorate of National Education. Additionally, ethical approval was obtained from the relevant department of Uşak University (Decision: 2023 – 166; Number: E-89784354-050.99-154664). The procedures followed were in accordance with the Helsinki Declaration and its later amendments. The purpose and procedures of the research were explained to the school, parents, and children. Due to the involvement of child participants, signed consent was obtained from both the parents and the children.

Participant recruitment and selection

To determine the sample size required for the hypotheses, a power analysis was conducted using G*Power (3.1.9.6). When the effect size for the study was set at 80% power and the significance level at 0.05, the sample size was calculated as 49 (total). 60 male childeren (30 for each group) were included finally to reduce the impact of possible losses during this study. In studies where similar populations are used and statistical analysis is adjusted accordingly, such numbers are considered sufficient. In order for the study to be applicable to real life, a counterbalanced design with repeated measures to evaluate the participants in two conditions (classical method and cooperative learning) was considered appropriate [51].

The study was designed as a single-blind, randomized, two-arm intervention comparing FMS interventions in Cooperative Learning Group (CL) and Classical Method (CM) groups. A control group (CM) was established against the CL group in the study. Participants meeting the study criteria were allocated into two groups using a block randomization scheme with a 1:1 allocation ratio (4 classes, each with 15 children). Participants were randomized using a minimization method, considering their class, age, height, weight, and health status. Random allocation was ensured, and the statistician was blinded to the assignments. Out of 127 children invited to participate, 60 were deemed eligible for the study. The inclusion criteria for participants were: a) Male, b) Voluntary, c) At the same academic performance and grade level (10–11 years old), d) Without chronic health issues that would prevent physical activity, e) Similar sociodemographic development, f) Regular attendance in classes, and g) Not participating in or planning to participate in any exercise/sporting activities outside of school. Participant demographic information is provided in Table 1.

In order to align the study schedule with the curriculum, elective class hours were utilized. During this time, children regularly participate in elective activities of their choice (geography, science, volleyball, football,

Table 1 The anthropometric characteristics of study groups

Groups (boys)	*N*	Age *(Years)*	Height *(cm)*	Body Weight *(kg)*
Classic Method	30 (M±SD)	10.95±0.58	145.06±6.68	39.33±8.16
Cooperative Learning	30 (M±SD)	10.91±0.42	143.68±8.48	38.13±10.27

etc.). The participant groups were formed using the elective courses available in the curriculum (4 classes, each with 15 children). The elective classes for each group were scheduled at different times to minimize the risk of contamination between the CL and CM interventions. Outside of the study, children continued their regular curriculum in their classes.

Cooperative learning intervention program

None of the children had previously experienced collaborative learning as a pedagogical model. Each session of the program was designed to incorporate the five essential elements of collaborative learning. The first phase included 1: interpersonal skills (*Students encouraged each other. Students deliberately shared resources*), 2: group processing (*Students reflected individually and together, Students shared ideas to solve the tasks*) 3: positive interdependence (*The tasks ended when all the classmates have completed it, Students switched from one activity to another when all members were ready*) 4: promotive interaction (*Students interacted during the tasks to finish them, Students performed the tasks in direct contact with each other*) and 5: individual accountability (*Each student performed his/her role during the tasks, Each student performed his/her part of the task*) [52]. The sessions focused on body awareness, body management, movement concepts, breathing-relaxation, balance, and coordination. The second phase included activities focused on FMS, locomotor skills, and throwing and catching. Various collaborative learning techniques or structures were utilized in each session. Learning Teams: Students worked in groups of four, each taking on a role (teacher, observer, equipment manager) and rotated roles every few trials to learn a new skill. Cooperative Play: Students cooperated to achieve a group goal focused on coordination (e.g., the entire group had to cross the gym stepping only inside hoops). Pairs-Control-Practice: Students worked in pairs to improve their locomotor skills (e.g., jumping over various obstacles), with one acting as the practitioner and the other as an instructor, switching roles every few trials. Think-Share: Students faced challenges while working on throwing and catching skills (e.g., throwing and catching while navigating obstacles), encouraging them to share ideas, negotiate, think, and try different solutions to overcome the problem. Collective Score: The entire class worked together to solve a task to achieve a "class score" (e.g., passing a ball using hands for one minute). In learning teams, students worked in small groups of four to develop their locomotor skills (e.g., crawling, jumping, navigating over/under an obstacle course) by performing only two roles [52].

Classical method intervention program (traditional method)

Physical Education lessons based on linear pedagogy were designed following the principles of information processing theory and direct instruction concepts: (1) Teacher-led Dynamic Warm-up, (2) Implementation of FMS, (3) Performance/Game Activity to Apply Learned FMS, (4) Cool-down. During the early learning of a movement skill, teachers were encouraged to review previously learned material and provide corrective feedback, paying particular attention to recurring mistakes made by the children during each activity. The children were instructed to perform and repeat the FMS previously demonstrated by the educators. When the skill showed signs of automatization, they were encouraged to practice independently in increasingly open environments. Gentile's classification principles and the Challenge Point framework were utilized by teachers to facilitate the progression of skill practice toward more open environments [48].

Implemented FMS activities

The study spanned a total of 24 PE class hours (40 minutes/session, 3 days/week, for 8 weeks). Each intervention session lasted 40 minutes and included three activity segments: (1) a 5-minute dynamic warm-up, (2) 30 minutes of FMS training, and (3) a 5-minute cool-down. During the 30-minute FMS training, participants were engaged in activities according to their proficiency levels. The same PE teacher conducted all sessions in both classes. The implementing teacher had over 10 years of theoretical and practical experience in the pedagogical model. The FMS intervention included 12 fundamental motor skills: jumping, running, galloping, hopping, leaping, sliding, kicking, striking, catching, dribbling, underhand rolling, and overhand throwing. The 24-session (3x8) program was adjusted according to previously conducted and recommended programs. *1. Runing: 2. Underhand Rolling: 3. Jumping: 4. Striking: 5. Galloping: 6. Catching: 7. Sliding: 8. Kicking: 9. Hopping: 10. Dribbling: 11. Leaping: 12. Overhand throwing: 13. Galloping & Sliding: 14. Catching & Kicking: 15. Jumping & Hopping: 16. Striking & Dribbling: 17.Running & Leaping: 18. Underhand Rolling & Overhand throwing: 19. Galloping & Sliding: 20. Catching & Kicking: 21. Jumping & Hopping:22. Striking & Dribbling: 23. Running & Leaping: 24. Underhand rolling & Overhand throwing* [40].

Bender-Gestalt Test

The Bender-Gestalt Test (BGT) was developed by Bender to assess principles related to visual-motor integration. It is widely used and correlates with general cognitive ability, intellectual development, fine motor skills, and short-term memory [53, 54]. The test is considered valid and reliable for evaluating visual-motor integration. The scoring reliability (re-scoring) is estimated at 0.92, and the interscorer reliability is 0.89. The BGT consists of 9 figures printed on 8.5–11 inch cards, with increasing difficulty levels. In standard administration, participants are shown the cards in a specific order, and they are required to draw each figure on an A4-sized paper. The first card is labeled as "A," and subsequent cards are numbered from 1 to 8. The most commonly used scoring system for children is the developmental Koppitz scoring system, where each error in the figures is given a score of "1" point. The maximum score that can be obtained from the test is 30. Normative values for Turkish children have been established. A lower score on the test indicates healthier performance by the child [55, 56].

d_2 Attention Test

The d_2 Attention Test was used to measure the selective attention of children in our study. This test is applicable across the age range of 9–60 years (Brickenkamp, 2002) and is widely used internationally [57]. The d2 Test assesses the capacity to focus on a stimulus while ignoring distractor letters. It demonstrates high test-retest reliability coefficients ranging from .95 to .98 for all parameters [57–60]. The test consists of 14 lines, each containing 47 characters with the letters "p" and "d", where each has one, two, three, or four dashes. Participants are instructed to scan each line and mark all instances of the letter "d" with two dashes while ignoring other characters. The d2 Test provides 5 main outcomes (parameters): (a) TN-processing speed, (b) TN-E/Focused attention, (c) CP-Concentration performance, (d) Accuracy-E% /Learning Ability, and (e) Fluctuation rate (sustained attention-FR) [58, 59].

Accuracy (E%) and Concentration Performance (CP) are not inflated by excessive skipping as they are based on the number of target and non-target characters cancelled as opposed to processing speed which can be influenced by test strategies. In our study, we therefore used Accuracy and CP as dependent variables due to their resistance to falsification. Processes of selective attention are required for successful completion since not only the letter *d* is orthographically similar to the letter *p*, but there are many distracting letters with more or less than two dashes. High scores on the test indicate symptoms of attention deficits, while low scores reflect normal attention levels.

Test administration details

The tests were administered face-to-face by experts trained in test procedures. Each test session included groups of 15 participants (1 class). Testing took place in a quiet classroom with a room temperature of 21°C, during the school's first lesson period. The test procedures were explained to the children in their native language. Children were motivated to take the tests seriously. They were informed that their test responses were confidential and did not contain any personal data. Tests were administered simultaneously to the entire class, and results were collected simultaneously for later evaluation.

Data analysis

All analyses were conducted using the Statistical Package (IBM, SPSS, Version 25.0). The pre- and posttest data related to Cognitive health outcomes (VMI and SA) were analyzed. Descriptive statistics, mean, standard deviation and prevalence were reported. The Kolmogorov-Smirnov test was used as goodness-of- fit test. The normality test of the distributions was examined by means of skewness and kurtosis tests. Data analyses included (pretest, posttest) 2×2 (CL ve CM) mixed factor ANOVA tests for the VMI and SA measures, followed by an independent samples t-test using difference scores (pretest-posttest score). These tests were run separately for the VMI and SA measures. When significant F values were determined ($p \leq 0.05$), the Bonferroni post-hoc test was performed to check type 1 errors. Finally, Cohen's was calculated for the independent samples t-test, for which sizes of null (0.0–0.19), small (0.20–0.49), medium (0.50–0.79), and large (≥ 0.80) [61].

Results

Based on the study results, there was a significant difference between the pre- and post-test scores of VMI for the CM and CL groups ($p < 0.05$). Both educational models were effective on VMI, with CL demonstrating a higher level of effectiveness (Effect Size $.519_{medium}$/ $.928_{large}$). There was also a significant difference in Accuracy (E%) and CP between the pre- and post-test values of CM and CL. Accuracy and CP scores improved in both groups, but CL showed a higher effect size (Accuracy Effect Size $.449_{small}$/$.746_{medium}$–CP $.438_{small}$/$.793_{medium}$). The results indicate that both FMS-based methods (CM and CL) improved Visual Motor Integration and Selective Attention, with CL showing a greater effect (Table 2).

When comparing the post-test values of the CM and CL groups in the study, there was a significant difference in favor of CL for VMI, Accuracy, and CP ($p < 0.05$). Examining the effect sizes (CM/CL), CL had a higher effect size in VMI ($.853_{large}$), Accuracy ($.473_{small}$), and CP ($.604_{medium}$). The results indicate that the FMS-based CL method is more effective on VMI and SA (Table 3).

Table 2 Pre- and post-test values for visual motor perception and attention

Parameteres	*Groups*	*İntra Group*	*M*	*SD*	*t*	*P-Value*	*Cohen's d*
Visual motor integration	***CM***	Pre Test	4.95	0.97	1.12	**.044***	**.519***
		Post Test	**3.83***	0.87			
	CL	Pre Test	4.25	0.68	2.48	**.000***	**.928***
		Post Test	**1.77***	0.18			
Selective Attention							
Accuracy-E% (Learning Ability)	***CM***	Pre Test	8.46	2.27	-2.16	**.035***	.449
		Post Test	**10.62***	2.02			
	CL	Pre Test	8.73	1.79	-3.88	**.002***	**.746***
		Post Test	**12.61***	1.67			
Concentration Performance	***CM***	Pre Test	95.64	16.33	-15.53	**.045***	.438
		Post Test	**111.17**	15.45			
	CL	Pre Test	100.83	12.41	-30.80	**.000***	**.793***
		Post Test	**131.63***	11.14			

CM Classic Method,*CL*Cooperative Learning

*$p< 0.05$

Table 3 Comparison of visual motor integration and selective attention post-test results

Parameters	*Groups*	*M*	*SD*	*F*	*P-Value*	*Cohen's d*
Visual motor integration	***Classic Method***	3.83	0.87	2.06	**0.013***	**.853***
	Cooperative Learning	1.77	0.18			
Selective Attention						
Accuracy-E% (Learning Ability)	***Classic Method***	10.62	2.02	1.99	**0.003***	.473
	Cooperative Learning	12.61	1.67			
Concentration Performance	***Classic Method***	111.17	15.45	12.46	**0.000***	**.604**
	Cooperative Learning	131.63	11.14			

*$p< 0.05$

Discussion

Our study results indicate that both FMS-based teaching methods (CM/CL) are effective on Visual Motor Integration (VMI) and Selective Attention (SA) based on within-group pre-post test parameters. However, it was found that CL supported greater improvement in VMI and SA. It is evident that these results should be interpreted in two different ways: 1) the effect of FMS movement exercises; 2) the effect of the method.

The positive effect of FMS intervention on VMI and SA

Our results support the idea that the components of VMI and FMS do not function separately. VMI and FMS are interconnected. FMS develops in conjunction with how the body deciphers the environment and responds to stimuli [62–64]. VMI is the ability to perceive visual input, process information, and coordinate motor responses. VMI skills encompass hand-eye coordination, execution, visual perceptual skills, and gross and fine motor coordination. VMI is essential for numerous activities (academic and otherwise) [64, 65]. While FMS enables a child to perform PA and daily functions, VMI helps them make sense of and manipulate surrounding objects. The study showed that developing skills like FMS and VMI together ensures optimal development of sports skills [49]. Similarly, Bonifacci (2004) found a positive correlation between children's FMS and VMI skills [36]. Desoete et al. (2012) demonstrated in their study that children's visual perceptual and motor coordination abilities are directly related to their level of VMI skills [66]. Evidence of a connection in brain activity between FMS and VMI when performing any FMS skill supports the findings of our current study. The VMI scores of the intervention group in the study improved significantly, and the improvement in FMS had an impact on children's VMI skills. This may be because the same areas of the brain are activated when performing FMS and using VMI [67, 68]. VMI processes occur in the posterior parietal and premotor cortex, where specific parts of the body are selected to perform different movements. This brain area is activated when relationships form between motor movements effective on specific objects. FMS movements activate this brain area because these skills require appropriate motor responses to perform actions on specific objects [69].

There is evidence that children who participate in FMS-based PA show improvements in SA [70]. Another study demonstrates a correlation between FMS and SA [2]. Regular PA among children aged 13–14 has been shown to positively influence attention [71]. Sports involving FMS movement patterns, such as Karate and Football, have been highlighted as leading to better SA performance in children compared to those who prefer passive activities [72, 73]. A study focusing on PA outside the school environment found that PA participation increased SA in children aged 10–11 [74]. Budde et al. (2008) concluded that exercises involving FSM might activate brain regions responsible for executive functions such as attention [75]. Research by Chang et al. (2013) revealed that FSM-based exercise interventions provided better attention [76]. Even a single 12-minute aerobic exercise session improved children's SA. The study also noted the positive effects of both regular and irregular exercise [77]. These findings are supported by research on cognitive flexibility showing that cortical transcranial magnetic stimulation can manipulate subcortical cognitive functions [78]. As outlined above, various intervention trials confirm the beneficial effect of FMS-based PA on SA.

The effect of the method (CM & CL) on VMI and SA

Research in motor learning and sports pedagogy has shown that task-appropriate learning methods enhance FMS learning and performance [79]. Teachers have noted that cooperative learning approaches in PE are appropriate activities that promote skill development and student engagement [80]. In our study, key elements in the CL group (VMI and SA) significantly increased, indicating the successful application of the method. A study clearly indicated [81] that all core elements of CL must be fully implemented in the study, and failed applications were short and fragmented [12]. This study included the five core elements of CL and was applied beyond the recommended time (8 weeks/24 lessons) [52]. This is because it has been shown that CL does not produce the same positive results if not structured at the right level and content [82]. The increase in CL elements from pre-test to post-test in this study demonstrates that the FMS-based exercise model was sufficiently used and that the results can be evaluated as derived from this. Similarly, a study examined the impact of a CL-compatible movement education program on children's VMI development. This study found greater VMI development and noted that it was influenced by cooperative education. It was indicated that using motor functions as a tool to teach children various behaviors like cooperative performance increased VMI levels [83].

The PE teaching approach should be learning-oriented. Therefore, how sports are taught in PE is as important as the content of the sport. Sports exercises often focus on the technical element while other approaches are neglected [84]. This indicates the presence of deficiencies in cognitive structures in the teaching-learning process [52]. Moreno et al. (2010) stated that declarative knowledge includes theoretical knowledge covering both the technical-tactical aspects and the rules, while procedural knowledge refers to decisions (cooperation) made in concrete game situations [85]. Chatzipanteli et al. (2016) noted that students need sufficient declarative knowledge to develop procedural knowledge. Declarative knowledge should precede problem-solving and decision-making [86]. García-Ceberino et al. (2020) stated that declarative and procedural knowledge are acquired through sports practices and that the structured memory and specific knowledge acquired through sports practices differentiate expert students from novices [84]. Therefore, MacPhail et al. (2008) emphasized the importance of teaching sports with CL rather than focusing on teaching technical skills [87]. During sports practices, students make decisions based on their existing knowledge structures and ability to process new information [88]. Considering the effects on decision-making and learning transfer, cooperative teachings are of greater importance for VMI and SA factors [89].

Limitation

This study had several strengths and limitations. The sample was well-balanced in terms of age, height, weight, and academic achievement, representing a substantial child population suitable for FMS application. This study is among those that examine the impact of FMS-based PA on CL within BE courses. Additionally, it is the first intervention study evaluating the effects of this pedagogical model on students' VMI and SA. The significant increases previously emphasized in the study's content have been validated. Therefore, the findings from this study can be considered a substantial contribution to scientific and pedagogical knowledge concerning behavioral outcomes related to CL usage. However, interpreting the results of this study requires consideration of certain limitations. Due to internal validity concerns, only 10-11-year-old male children were targeted as participants, limiting generalizability to other age groups and genders benefiting from FSM and cognitive functions. Another limitation is that all children were from the same school. The study was conducted only in two groups, further restricting its generalizability. Therefore, future research should aim to confirm these results using more diverse samples across different schools, larger groups, and employing more contemporary and comprehensive longitudinal methods for comparison. Teacher efficacy could have been calculated in the study. Future researchers may consider adding third-level variables (e.g., teacher motivation, exercise types) to their studies.

Conclusion

The results indicate improvement in VMI and SA skills in both CM and CL intervention programs involving FMS activities. Hence, teachers should consider developing and designing structured FMS-based programs incorporating goal-setting strategies to support children's psychomotor, cognitive, and affective learning outcomes. Importantly, administrators should recognize the importance of enhancing FMS proficiency in children, as it forms the foundation for physical development. There was a difference in outcomes between groups based on teaching method. CL applied in BE classes increased students' VMI and SA more than the CM approach. This can be considered a significant contribution to the scientific and pedagogical literature, potentially leading to adaptive motivation patterns among children. Through the development of VMI and SA, children can enhance their ability to form quality relationships, enjoy activities, learn stress management, and develop as a group [90]. Therefore, we call upon policymakers in the education sector to recognize the benefits of CL. We recommend informing teachers about the positive effects of CL and integrating CL into education and instruction.

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Authors' contributions
MA and BT conceptualised this study; MA and BT contributed to methodology of this study; MA and BT carried out formal analysis; MA and MGG contributed to data curation; MA carried out original draft preparation; MA, BT, MGG contributed to writing-review and editing; MA and BT looked after project administration. All authors have read andagreed to the published version of the manuscript.

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Availability of data and materials
No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate
The study was in accordance with the principles as outlined in the Declaration of Helsinki. The experimental protocol was approved by the The Second Uşak University institutional review board and written informed consent was obtained from all participants.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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