2026 02

ORIGINAL ARTICLE

The effects of Cooperative Circuit Games on fundamental motor skills and social-emotional learning in elementary school students

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Authors' Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection

Abstract

Background and Study Aim Physical education traditionally focuses on the development of motor skills as a core educational objective. At the same time, physical education lessons may also contribute to the development of social-emotional competencies through structured interaction and cooperation among students. Despite the application of various instructional approaches, the relative effectiveness of cooperative circuit games in enhancing both fundamental motor skills and social-emotional learning remains a matter of practical interest. This study examined whether cooperative circuit games could enhance fundamental motor skills and social-emotional learning among upper elementary school students.

Material and Methods A twelve-week cluster-randomized controlled trial was conducted with 192 fourth- and fifth-grade students (aged 9–10 years) from six urban public elementary schools in Yogyakarta, Indonesia. Three schools were randomly assigned to a cooperative circuit training group (n = 96). Three schools received regular physical education instruction (n = 96). The intervention consisted of weekly 55-minute sessions. Each session included five cooperative circuit stations integrating locomotor skills, object control, and structured social interaction. The program also included guided reflection activities. Outcomes were assessed using the Test of Gross Motor Development-2 (TGMD-2) and the Strengths and Difficulties Questionnaire (SDQ).

Results Analysis of covariance (ANCOVA) revealed intervention effects on locomotor skills, object control, prosocial behavior, and reductions in total difficulties (all partial $\eta^2 > 0.34$, $p < 0.001$). The experimental group demonstrated medium-normalized gains across outcomes. The control group showed minimal change. The intervention also shifted social-emotional functioning from the borderline range to the average range.

Conclusions Cooperative circuit games enhance motor competence and social-emotional development. This approach may be used to integrate these domains in educational settings with limited resources.

Keywords: cooperative learning, circuit games, fundamental motor skills, social-emotional learning, physical education

Introduction

Physical education in elementary school is a component of children's overall development within the school environment. Beyond physical fitness, physical education lessons create conditions for learning movement patterns, cooperation, and behavioral regulation through structured activity. Fundamental motor skills form the basis for later participation in physical activity, while social-emotional competencies influence peer interaction, engagement, and classroom behavior. Integrating these domains within physical education presents a complex task that requires instructional approaches capable of addressing both motor and social-emotional aspects simultaneously.

In this context, fundamental motor skills (FMS) and social-emotional learning (SEL) represent key developmental competencies for elementary school students. These competencies provide a basis for participation in physical activity that involves movement execution and interaction with peers. Fundamental motor skills function as building blocks for the acquisition of more complex movement patterns and are associated with health and well-being across the lifespan [1]. At the same time, evidence indicates that a substantial proportion of children and adolescents demonstrate limited motor competence. Systematic reviews report that motor skill levels often fall below age-appropriate expectations, with many children not achieving key developmental milestones in motor proficiency [2]. This condition is commonly associated with limited motor practice and increasingly sedentary lifestyles. As a result, movement repertoires may be constrained, and the protective effects of habitual physical activity may be reduced [3].

doi:10.15561/26649837.2026.0203

Alongside physical skill development, the integration of social-emotional learning into school curricula supports students' emotional regulation and collaborative behavior. School-based SEL interventions are associated with improvements in social competence, peer relationships, and academic performance. They are also associated with reductions in behavioral and emotional problems [4, 5, 6]. These findings indicate a relationship between physical and emotional development in educational settings. They also suggest that pedagogical approaches addressing both domains may differ in their effects from interventions that address them separately.

The interrelationship between motor competence and cognitive-social development has received scientific attention. Empirical evidence indicates that gross motor skills are associated with executive functions in children. This association is more apparent when physical activities are structured, cognitively demanding, and goal-oriented [7]. Physical activity interventions are also associated with improvements in self-regulation, empathy, and cooperative behavior. In addition, collaborative physical education environments are linked to peer relationships and social competence [8, 9]. Sport-based programs are associated with social interaction, self-confidence, and a sense of inclusion among participants [10, 11]. Taken together, these findings indicate that physical education can serve as a setting for the development of motor, cognitive, and social-emotional competencies.

In Indonesia, concerns regarding students' social-emotional development have increased in connection with extensive digital engagement. This engagement may disrupt interpersonal interaction, emotional regulation, and real-world collaboration. High levels of digital dependency are associated with interpersonal conflict, reduced learning motivation, and a higher prevalence of mental health problems, including anxiety and depression [12, 13, 14]. Excessive online gaming is also associated with social withdrawal, sleep disturbances, and declining academic performance [15, 16]. National surveillance data indicate that 68.4% of Indonesian school-aged children exceed the recommended daily screen time threshold of more than two hours per day. This pattern is associated with reduced participation in outdoor physical activity and higher indicators of social isolation [17]. Prolonged screen exposure affects physical and mental well-being and is associated with anxiety, depressive symptoms, and limitations in the development of social interaction skills during key developmental periods [18, 19]. Technology-based interventions show potential for supporting SEL-related knowledge and attitudes [20, 21]. However, a balanced approach is required to reduce risks associated with digital dependency while maintaining direct social engagement [22, 23]. In this context, school-based initiatives that encourage physical activity, structured sports programs, and outdoor play may contribute to reduced social isolation and support the development of social competencies [24, 25].

Despite empirical support for structured physical education as a means of supporting motor and social-emotional development, instructional practices in Indonesian elementary schools often rely on unstructured routines, repetitive drills, and games without explicit FMS and SEL objectives. Observational research indicates that many physical education lessons do not include intentional SEL integration. As a result, opportunities to develop cooperative skills through structured pedagogical models may be limited [26, 27]. Empirical studies also indicate that incorporating SEL within physical education is associated with students' collaboration and social interaction during lessons [28, 29]. In addition, cooperative learning structures are associated with social interaction, emotional regulation, and students' participation in physical activity [27, 30]. Taken together, these findings indicate that explicit integration of SEL within physical education may influence developmental outcomes.

Cooperative Circuit Games represent a pedagogical model that combines principles of circuit training with cooperative learning strategies. This approach uses rotating activity stations that involve varied movement patterns and balance-related tasks. At the same time, the activities encourage group interaction, active listening, and collective reflection. Systematic reviews report that cooperative educational models are associated with social interaction and emotional regulation in physical education settings [31, 32]. Within a cooperative framework, circuit training is associated with student engagement, intrinsic motivation, and teamwork-related behaviors in collaborative learning contexts [33, 34]. Structured cooperative games are also associated with physical fitness outcomes and social-emotional responses. Circuit-based cooperative activities are linked to interpersonal skills and participation-related enjoyment in physical activity [35, 36]. Taken together, these findings indicate that Cooperative Circuit Games may be used to address motor and social-emotional aspects within physical education.

Nevertheless, game-based and cooperative approaches are increasingly used in physical education. At the same time, experimental studies examining the effects of Cooperative Circuit Games on both fundamental motor skills and social-emotional learning among elementary school students are still limited. Motor competence has been associated with social skill development and group adaptation [37, 38]. Balance competence has been examined less frequently as a factor that may influence intervention outcomes [39, 40]. Studies evaluating cooperative learning models and circuit training report effects on children's motor and social-emotional outcomes [41, 42, 43, 44]. However, these outcomes are often addressed separately rather than within a single instructional framework. As a result, intervention models that combine motor and social-emotional components, particularly in Indonesian elementary school settings, are used infrequently. This separation limits the examination of combined instructional approaches within physical education.

Analysis of research findings has shown that physical education can address motor competence and social-emotional learning when instructional approaches incorporate structured movement and cooperative interaction. Researchers emphasize that integrated pedagogical models may influence motor performance, peer interaction, and behavioral regulation within the same learning context. At the same time, the interaction between specific motor components, such as balance competence, and social-emotional outcomes remains methodologically complex and context-dependent, particularly within elementary school settings. These considerations indicate the relevance of examining instructional formats that combine cooperative structures and circuit-based activities within regular physical education practice.

In addition, analysis of previously reported findings indicates that cooperative and structured physical education approaches are associated with motor and social-emotional outcomes. At the same time, differences in intervention design, the degree of integration between fundamental motor skills and social-emotional learning, and the specificity of instructional guidance are addressed inconsistently across studies. In particular, limited attention has been given to interventions that embed social-emotional objectives directly within motor task structures and provide clearly defined implementation procedures in elementary school settings. In this context, the present study examined whether cooperative circuit games could enhance fundamental motor skills and social-emotional learning among upper elementary school students.

Materials and Methods

Participants

A total of 192 students met the eligibility criteria and provided consent to participate in the study (N = 192). Cluster randomization was applied at the school level. Three schools were assigned to the experimental group (EXP; n = 96; 50 males and 46 females), and three schools were assigned to the control group (CON; n = 96; 45 males and 51 females). All participants were enrolled in grades 4 and 5 and were aged 9–10 years. The mean age was 9.6 years (SD = 0.5). Statistical comparisons showed no differences between the EXP and CON groups in mean age or sex distribution.

Information on prior sports participation was collected using questionnaires completed by parents and verified by physical education teachers. Approximately one-third of the students (32.3%) participated in structured extracurricular sports activities, including soccer, futsal, martial arts, swimming, or gymnastics, at least once per week. The remaining participants (67.7%) engaged in structured physical activity only through school-based physical education classes and unstructured activity at home or within the school environment. The distribution of supplementary sports experience was comparable between groups, reducing potential baseline differences related to physical fitness or motor skill proficiency.

Inclusion criteria were: (1) age 9–10 years; (2) enrollment as an active student with regular attendance in physical education classes; (3) absence of diagnosed physical disabilities or severe developmental disorders limiting participation in group physical activities; and (4) written parental or guardian consent with verbal child assent. Exclusion criteria included chronic medical conditions that restricted participation in moderate-intensity physical activity, such as uncontrolled congenital heart disease, severe unstable asthma, or severe musculoskeletal disorders.

Ethical Considerations and Safeguards

The study protocol was reviewed and approved by the Research Ethics Committee of Yogyakarta State University (No. B/84/UN34.16LT/2025). The study was conducted in accordance with the ethical principles of the Declaration of Helsinki. Written informed consent was obtained from parents or guardians using standardized forms. These forms explained the study objectives, procedures, duration, potential minor physical risks, safety precautions, the voluntary nature of participation, and the right to withdraw at any time without academic consequences. Verbal assent was obtained from each child before participation in assessments and intervention activities.

Safety measures were applied throughout the intervention period. These measures included health readiness checks at the beginning of each session. A supervision ratio of 1:24 was maintained and involved physical education teachers and trained assistants. Training areas were inspected to remove potential hazards, and protective mats were used for activities with a higher risk of injury. Exercise intensity was monitored using the Borg Rating of Perceived Exertion (RPE) scale, with a target range of 11–13. Workload adjustments were applied when signs of excessive fatigue were observed. First-aid kits were available, and access to healthcare services was ensured. All incidents were documented. After completion of post-test assessments, debriefing sessions were conducted to explain the study objectives and summarize the findings for participating schools. Following completion of data collection, the control group was provided access to the Cooperative Circuit Games intervention protocol.

Research Design

The study was conducted in six public elementary schools located in an urban area of Yogyakarta, Indonesia. The schools were characterized by predominantly middle-to-upper socioeconomic conditions. Most parents were employed as civil servants, professionals (e.g., teachers, lecturers, healthcare workers, and accountants), formal-sector employees, or medium-scale entrepreneurs. Households in this population had broad access to digital devices, including smartphones, tablets, and gaming consoles, as well as stable internet connectivity. As a result, children were exposed to relatively high daily screen time for gaming and digital media use. Opportunities for active outdoor play were more limited due to academic schedules and participation in supplementary educational courses.

The study used a cluster-randomized controlled trial design. Baseline measurements were conducted one week before the start of the intervention. These measurements included assessments of fundamental motor skills and social-emotional learning indicators. The intervention was implemented over a 12-week period. Post-test measurements were administered one week after the final intervention session. The same instruments and procedures were used at baseline and post-test. This design was used to reduce the influence of maturation effects, seasonal variation in physical activity, and changes related to academic scheduling. Figure 1 presents the research flow of the study.

Procedure

Experimental Group (EXP): Learning Program Intervention

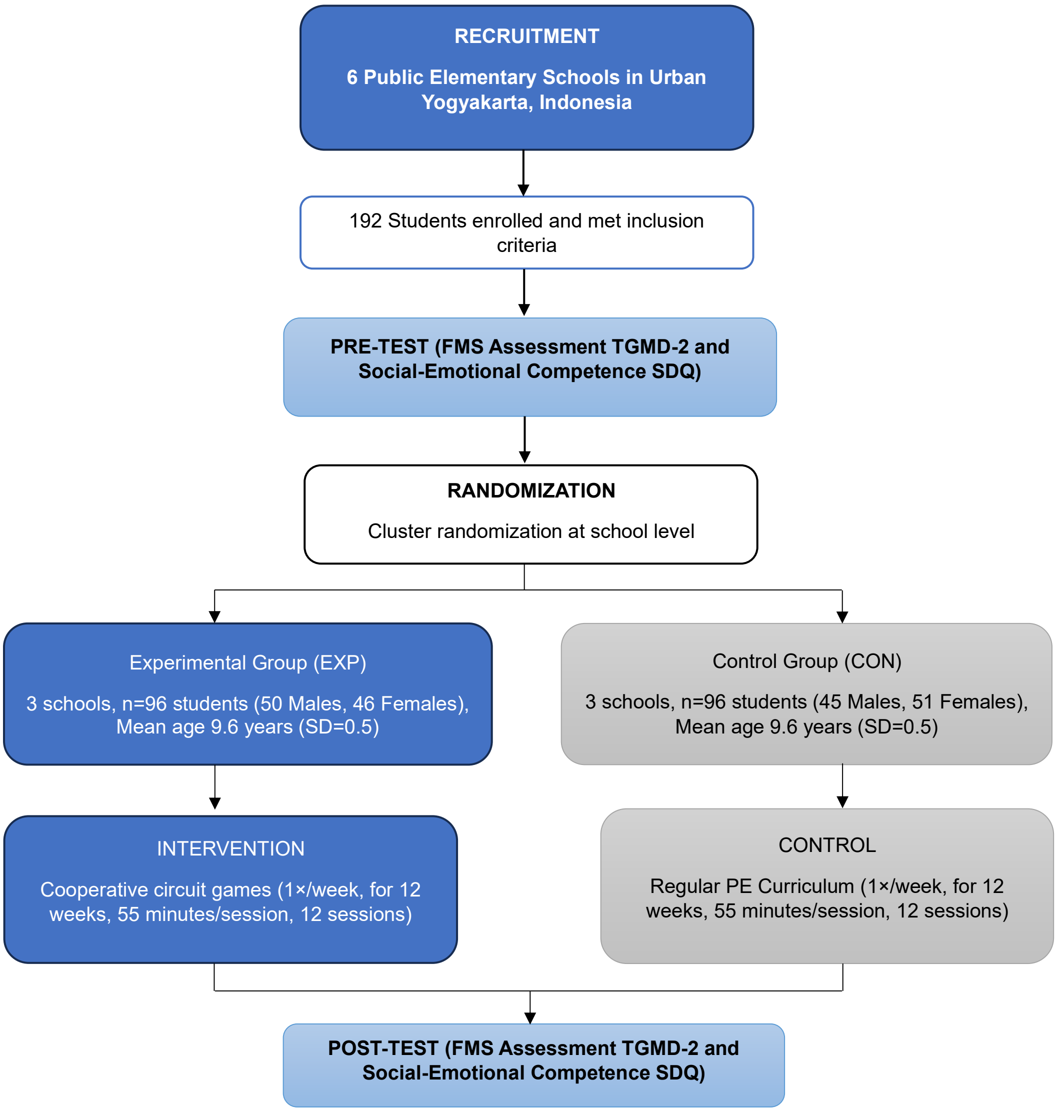

Figure 1. Research flow

Participants in the experimental group received the Cooperative Circuit Games intervention as part of their regular physical education lessons over a 12-week period. The program included 12 instructional sessions conducted once per week. Each session lasted approximately 55 minutes (range: 50–60 minutes). The intervention was designed to address fundamental motor skills and social-emotional competencies through structured cooperative learning within a circuit-based activity format. An overview of program dose parameters is presented in Table 1.

Table 1. Program Dose Parameters

Parameter	Specification
Program duration	12 weeks
Session frequency	1 session per week
Total sessions	12
Duration per session	55 minutes (range: 50–60 minutes)
Stations per session	5
Time per station	6–8 minutes
Transition time	30–60 seconds between stations
Work-to-rest ratio	Phase 1: 1:1 to 1:1.5 Phase 2: 1:0.8 to 1:1 Phase 3: 1:0.7 to 1:1
Sets per station	4–6 sets (or equivalent trials)
Repetitions per drill	Approximately 8–15 repetitions, depending on activity
Work duration per set	25–60 seconds
Rest between sets	15–60 seconds
Target intensity	Borg Rating of Perceived Exertion (RPE): 11–13
RPE monitoring	Every 8–10 minutes in approximately 20% of participants
Teacher feedback frequency	Every 2–3 sets or trials
Group size	4–5 students per group

Each intervention session followed a standardized four-phase structure, with progression across phases described in Table 2. The warm-up phase lasted approximately 10–15 minutes and included dynamic stretching and low-intensity locomotor activities conducted in cooperative formats. This phase was intended to prepare students physically and facilitate initial social interaction. The main circuit activity phase lasted approximately 30–35 minutes and consisted of five activity stations. Each station integrated locomotor skills (e.g., running, jumping, galloping) and object control skills (e.g., kicking, catching, dribbling). Activities were performed in pairs or small groups to support cooperation and shared task responsibility. Work duration ranged from approximately 25 to 40 seconds per set, with 4–6 sets completed at each station. Rest intervals of approximately 30–60 seconds were provided between sets, and exercise intensity was maintained within a target range of Borg RPE 11–13.

The cooperative challenge phase lasted approximately 5 minutes and involved small-group tasks requiring planning, coordinated execution of motor skills, and collective decision-making. The final cool-down and reflection phase lasted approximately 10 minutes. This phase included static stretching for 5 minutes, followed by guided group reflection focused on teamwork, emotional awareness, and regulation during cooperative activities for an additional 5 minutes. The equipment used during intervention sessions is illustrated in Figure 2.

Facilitators, Training, and Fidelity Monitoring

Intervention delivery was conducted by four certified physical education teachers. Each teacher held at least a Bachelor's degree in Physical Education and had a minimum of five years of teaching experience. Before implementation, all instructors completed a training program totaling 16 hours. The training program covered the following components: (1) principles underlying the design and implementation of Cooperative Circuit Games; (2) instructional strategies for fundamental motor skill development, including demonstration, scaffolding, and corrective feedback; (3) techniques for facilitating social-emotional learning within physical activity contexts, such as reflective questioning and reinforcement of prosocial behaviors; and (4) standardized procedures for assessment and documentation, including monitoring of RPE, attendance, and observational recording of cooperative behaviors.

The training program was structured into four modules and delivered through a combination of lectures, discussions, hands-on practice, and teaching simulations. Each module focused on: (1) cooperative learning theory and its application; (2) instructional strategies for motor skill development and assessment; (3) techniques for facilitating social-emotional learning; and (4) documentation and safety procedures. Teachers' competency was evaluated using a written test, teaching simulations, and written reflections. A minimum score of 80% was required in all modules. Teachers who successfully completed the program received a Trained Facilitator Certificate.

Implementation fidelity was monitored using a daily observation checklist assessing adherence to the protocol, interaction quality, and completeness of documentation. The checklist included key fidelity indicators, such as ensuring that the warm-up lasted

Table 2. Phase Progression with Activity Examples

Phase	Phase 1 (Sessions 1–4): Basic Routines and Skill Acquisition	Phase 2 (Sessions 5–8): Increased Complexity and Skill Consolidation	Phase 3 (Sessions 9–12): Skill Integration and Student Leadership
Example session	First session: balance tasks (e.g., walking on a balance beam with a partner)	Fifth session: use of equipment (e.g., jump ropes) to develop coordination and agility	Tenth session: students design games and teach skills to group members
Core activity duration	Approximately 33 minutes	Approximately 33 minutes	Approximately 35 minutes
Station example	Station 1 – River Crossing (locomotor and balance skills)	Station 2 – Twin Jumpers (synchronized jumping)	Station 1 – Coach's Corner (students teach skills)
Equipment	Balance beam (3 m length, 10 cm width, 20 cm height)	Five obstacles (10–20 cm height)	Various equipment selected by student coach
Format	Pairs	Pairs	Small groups (1 student coach, 3–4 learners)
Task instructions	Hold hands and walk slowly on the beam; communicate to maintain balance; restart and discuss strategy if balance is lost	Perform synchronized jumps over obstacles; communicate timing for coordination	Student coach demonstrates and explains skills; learners practice and provide feedback
Work duration	30 seconds per trial; 8 trials	25 seconds per set; 6 sets	7 minutes per station
Rest duration	30 seconds between trials (work-to-rest ratio 1:1)	35 seconds between sets (work-to-rest ratio approximately 1:1.4)	Rotation between stations every 7 minutes
Distance / repetitions	3 m per crossing	Not applicable	Not applicable
Progression	Trials 1–4: no obstacles (focus on communication); Trials 5–8: two cones as stepping stones	Sets 1–2: jumps without obstacles; Sets 3–4: jumps over 15 cm obstacles; Sets 5–6: jumps over 20 cm obstacles	Student-led progression based on group needs
Total time per station	Approximately 7 minutes (4 minutes work, 3 minutes rest)	Approximately 6 minutes	Approximately 35 minutes

Figure 2. Equipment Used

10–15 minutes and included dynamic stretching and cooperative activities; conducting RPE monitoring every 8–10 minutes; providing specific and positive corrective feedback during activities; and ensuring that safety procedures were followed, including the use of mats and maintenance of safe distances. When fidelity compliance fell below 90%, corrective actions were implemented. These actions included feedback sessions with teachers and additional monitoring during subsequent sessions.

To support implementation fidelity, 25% of intervention sessions were observed by two independent observers to assess reliability. These sessions were evaluated using an Implementation Fidelity Observation Form that recorded adherence to session structure, time allocation, and safety protocols. Fidelity compliance was monitored across schools. A compliance level of at least 90% was required for the intervention to be considered implemented as planned.

Inter-rater reliability procedures were applied to assess consistency between observers. For each session selected for dual observation, two trained observers independently completed the fidelity observation forms. Data from both observers were compared using the Intraclass Correlation Coefficient (ICC). An ICC value of at least 0.75 was used as the reliability criterion. Agreement was observed across assessed components, including overall protocol compliance (ICC = 0.91), session structure (ICC = 0.89), instruction and feedback quality (ICC = 0.86), and RPE monitoring (ICC = 0.88).

Ongoing monitoring was conducted to ensure adherence to established fidelity criteria. Compliance reports were generated after every four sessions, corresponding to the end of each intervention phase. When compliance fell below 90%, corrective actions were applied, including feedback to teachers and additional monitoring during subsequent sessions. Retraining was required if compliance remained below 75% for two consecutive sessions.

Compliance was tracked separately for each school and summarized in standardized reports. A compliance percentage was calculated for each session, and any corrective actions were documented. Overall compliance status was categorized as high, moderate, or low. When required, corrective actions were scheduled based on this classification. An aggregate fidelity report summarized compliance across all participating schools. Average compliance values were examined at the school level to confirm overall fidelity. Schools classified with low compliance received additional support and monitoring to meet the required criteria.

Control Group (CON)

Students assigned to the control group participated in conventional physical education instruction aligned with the national *Kurikulum Merdeka*. Instruction was delivered with the same frequency and duration as in the experimental condition, consisting of one 55-minute session per week. The pedagogical approach in control schools was predominantly characterized by teacher-centered direct instruction, repetitive and individually oriented skill drills, and competitive games emphasizing individual or team performance without explicit cooperative structures. Integration of social-emotional learning components was limited and unsystematic. An overview of the conventional physical education session format used in the control group is presented in Table 3. Detailed session planning elements are provided in Table 4. This structured format ensured consistency across sessions while allowing flexibility to adapt

Table 3. Conventional Physical Education Session Format for Control Group

Session Segment	Duration	Activities	Teacher's Role	Student Focus
Warm-up	10 minutes	- Dynamic stretching - Light movements (walking, running, jumping, rotation)	Guide and lead warm-up activities	Prepare body for physical activity
Core Activity	35 minutes	- Basic skill drills (locomotor, manipulative, stabilization) - Modified games (large ball, small ball, athletics) - Physical fitness exercises (strength, endurance, flexibility, coordination)	- Provide brief demonstrations - Give instructions on technique and safety - Monitor student performance	- Practice fundamental motor skills - Participate in modified games - Apply techniques safely
Cool-down	10 minutes	- Static stretching - Brief group reflection	Facilitate reflection discussion with guiding questions (e.g., "What did you learn today?")	- Stretch muscles - Reflect on learning experience - Share insights with peers

Table 4. Session Planning Details

Component	Description
Session Plan	Detailed plan provided for each activity
Instructions	Specific instructions for each segment
Focus Areas	- Drills focused on technique and safety - Modifications to game rules based on students' abilities
Control Group	- No additional training related to Cooperative Circuit Games - Maintained usual teaching practices - Reflected typical physical education instruction in urban elementary schools in Yogyakarta

activities based on students' needs and abilities.

Instruments

Test of Gross Motor Development-2 (TGMD-2)

Fundamental motor skills were assessed using the Test of Gross Motor Development–Second Edition (TGMD-2). The TGMD-2 is a standardized instrument designed to assess gross motor skill proficiency in children aged 3–10 years [45]. The instrument consists of two subtests: Locomotor Skills and Object Control Skills. The Locomotor Skills subtest includes six movement tasks: run, gallop, hop, horizontal jump, vertical jump, and slide. The Object Control Skills subtest includes six tasks: striking a stationary ball, dribbling with the feet, catching, kicking, overhand throwing, and underhand rolling. Each skill is evaluated using specific performance criteria, with three to five components per skill. Participants performed two trials for each task. A score of 1 was assigned when a component was performed correctly and 0 when performed incorrectly. Component scores were summed to generate raw subtest scores for locomotor skills (0–48) and object control skills (0–48), as well as a Gross Motor Quotient (GMQ) adjusted for age and sex (mean = 100, SD = 15).

To assess measurement consistency in the present study, 20% of the sample was independently scored on-site by two trained raters blinded to group allocation and assessment time. Inter-rater reliability for TGMD-2 total scores showed an Intraclass Correlation Coefficient (two-way random effects model, absolute agreement) of 0.88 (95% CI: 0.83–0.92), indicating agreement between raters.

Strengths and Difficulties Questionnaire (SDQ) – Indonesian Version

Social-emotional competence was measured using the Indonesian version of the Strengths and Difficulties Questionnaire (SDQ). The Teacher Report (TR) form was used. This form is intended for children aged 6–10 years. The SDQ-TR is a screening instrument used to assess psychosocial functioning in school-aged children. The questionnaire consists of 25 items distributed across five subscales that represent dimensions of social-emotional functioning. The Prosocial Behavior subscale includes five items and assesses helping, sharing, and caring behaviors. The Emotional Problems subscale includes five items and assesses symptoms related to anxiety, depression, and somatic complaints. The Conduct Problems subscale includes five items and assesses aggressive behavior, defiance, and rule violations. The Hyperactivity/Inattention subscale includes five items and assesses restlessness, impulsivity, and difficulties with concentration. The Peer Relationship Problems subscale includes five items and assesses social withdrawal, peer rejection, and experiences of bullying.

Each item was rated using a 3-point Likert scale (0 = not accurate, 1 = somewhat true, 2 = undoubtedly true). Subscale scores ranged from 0 to 10. The Total Difficulties Score (TDS) was calculated by summing four problem subscales: emotional problems, conduct problems, hyperactivity/inattention, and peer relationship problems. The total score ranged from 0 to 40, with the prosocial behavior subscale excluded from the TDS calculation. Higher prosocial scores reflected stronger social competence, whereas higher problem scores reflected greater psychosocial difficulties.

Based on established cut-off values, SDQ scores were categorized as follows: close to average (TDS 0–13), slightly raised (TDS 14–16), and high (TDS 17–40).

Administration procedure. The SDQ-TR was completed by classroom teachers for each participating student during pre-test and post-test assessment periods. Teachers received standardized written instructions before data collection and completed the questionnaires independently. To reduce potential assessment bias, teachers were blinded to students' group allocation and to the specific research hypotheses.

In this study, a subsample comprising 20% of participants was independently rated by two classroom teachers to estimate inter-rater agreement. Inter-rater reliability for the SDQ-TR Total Difficulties Score was assessed using the Intraclass Correlation Coefficient (two-way random effects model, absolute agreement). The ICC value was 0.82 (95% CI: 0.77–0.87), indicating consistency between raters.

Statistical Analysis

Statistical analysis was performed using IBM SPSS Statistics (version 26.0). Prior to inferential testing, all datasets were screened for completeness and accuracy. Descriptive statistics were calculated for all motor skill and social-emotional variables at pre-test and post-test. These statistics included means, standard deviations, minimum values, and maximum values.

The content validity of the Cooperative Circuit Games program was examined using Aiken's V coefficient based on expert judgments across predefined evaluation aspects. Aiken's V values exceeding the established threshold were interpreted as indicating acceptable content validity. Internal consistency reliability of the validation instrument was assessed using Cronbach's alpha coefficient. Values above 0.70 were used as the reliability criterion. Homogeneity of variance between the experimental and control groups was tested using Levene's test for all pre-test and post-test variables. A non-significant Levene's test result ($p > 0.05$) indicated that the assumption of equal variances was met. This supported the use of covariance-based analyses. Analysis of covariance (ANCOVA) was used to examine intervention effects on post-test scores, with pre-test scores entered as covariates. Effect sizes were calculated using Cohen's d. The level of statistical significance was set at $\alpha = 0.05$.

Results

Content validity was assessed using Aiken's V based on evaluations provided by four experts in physical education pedagogy and training across 20 indicators. The mean Aiken's V value was 0.94, with values ranging from 0.90 to 1.00. Internal consistency reliability of the validation instrument was assessed using Cronbach's alpha. The alpha coefficient was 0.713. Detailed results of the content validity analysis are presented in Table 5.

Internal consistency reliability of the Cooperative Circuit Games program validation instrument was assessed using Cronbach's alpha. The analysis yielded a Cronbach's alpha coefficient of 0.713 based on 20 items, indicating internal consistency

Table 5. Validation of the Cooperative Circuit Games Program

No.	Rated Aspect	Σs	V	Description
Content/Material Alignment				
1	Alignment of Cooperative Circuit Games program with Physical Education learning objectives and *Kurikulum Merdeka* for grades 4-5 elementary students (ages 9-10 years)	20	1	Accepted
2	Integration of fundamental motor skill development (locomotor, object control, stability) in program design	19	0.95	Accepted
3	Inclusion of social-emotional learning components (prosocial behavior, emotion regulation, communication, problem-solving) appropriate to students' developmental stages	19	0.95	Accepted
4	Appropriateness of cooperative activity selection (paired tasks, small-group challenges, reflective discussion) for upper elementary students	19	0.95	Accepted
5	Potential of the program to enhance locomotor skills (running, jumping, galloping, hopping, sliding) through structured circuit activities	18	0.9	Accepted
6	Potential of the program to enhance object control skills (kicking, catching, throwing, dribbling, striking) through cooperative stations	19	0.95	Accepted
7	Potential of the program to enhance prosocial behavior (cooperation, helping, sharing) through structured group activities	20	1	Accepted
8	Potential of the program to enhance verbal and non-verbal communication skills in group physical activity contexts	18	0.9	Accepted
9	Potential of the program to enhance cooperative problem-solving skills through specially designed circuit challenges	19	0.95	Accepted
10	Potential of the program to enhance emotion regulation and frustration management in group physical activity situations	18	0.9	Accepted
Program Construction				
11	Appropriateness of session structure (10-15 min warm-up, 30-35 min main circuit, 10 min cool-down and reflection) for Grades 4-5 students	20	1	Accepted

Table 5. Continued

No.	Rated Aspect	Σs	V	Description
12	Design of five circuit stations with appropriate station duration (6-8 min), work-rest ratio (1:1 to 1:1.5), and structured transitions based on child training principles	19	0.95	Accepted
13	Systematic program progression from foundation (Weeks 1-4), consolidation (Weeks 5-8), to integration-autonomy (Weeks 9-12) phases	19	0.95	Accepted
14	Suitability of the implementation guide (activity instructions, group management strategies, RPE monitoring) for elementary PE teachers	18	0.9	Accepted
15	Provision of opportunities for students to observe demonstrations of motor skills and cooperative strategies at each station	19	0.95	Accepted
16	Provision of opportunities for student questioning and discussion during reflection phases and inter-station transitions	19	0.95	Accepted
17	Provision of opportunities for students to actively practice motor skills within cooperative contexts	18	0.9	Accepted
Program Ergonomics/Practicality				
18	Use of equipment (e.g., balance beams, balls, cones, agility ladders, mats, ropes) that is easily obtainable or adaptable to school conditions	18	0.9	Accepted
19	Safety of equipment and activities, including mat use, safety zones, supervision procedures, and RPE 11-13 intensity monitoring	20	1	Accepted
20	Attractiveness and motivational quality of cooperative circuit activities for active participation among Grades 4-5 students	20	1	Accepted
	Mean	**18.8**	**0.94**	**Accepted**

of the instrument.

Baseline measurements indicated that the experimental and control groups were comparable across motor skill and social-emotional variables. Descriptive statistics for all variables at pre-test and post-test are presented in Table 6. Following the intervention period, mean values for locomotor skills, object control skills, Gross Motor Quotient (GMQ), and prosocial behavior were higher in the experimental group than in the control group. Mean values for total difficulties scores were lower in the experimental group compared with the control group.

As shown in Table 6, baseline measurements indicated comparable levels of locomotor and object control skills between the experimental and control groups. Following the intervention period, higher post-test values for both locomotor and object control skills were observed in the experimental group, whereas changes in the control group were smaller.

With respect to social-emotional outcomes, total difficulties scores decreased from pre-test to post-test in the experimental group, while only minor changes were observed in the control group. Prosocial behavior scores increased in both groups over time, with a more pronounced increase observed in the experimental group.

Normality of ANCOVA model residuals was examined using the Shapiro–Wilk test. For all dependent variables, the test results were non-significant ($p > 0.05$), indicating that the normality assumption was met. Residuals for post-test locomotor skills, object control skills, Gross Motor Quotient (GMQ), total difficulties, and prosocial behavior met this criterion. Normality test results are presented in Table 7. Complementary Kolmogorov–Smirnov tests produced p-values of 0.200 for all variables. In IBM SPSS Statistics, this value represents the upper reporting limit, indicating that the observed p-values exceeded this threshold.

Homogeneity of variance between the experimental and control groups was examined using Levene's test for all pre-test and post-test variables. For all measures, Levene's test results were non-significant ($p > 0.05$), indicating that the assumption of equal variances was met. The results of the homogeneity tests are presented in Table 8. Homogeneity of variance was observed for all motor skill and social-emotional variables at both pre-test and post-test assessments. Variance estimates were comparable between the experimental and control groups across measurement occasions.

Normalized gain analysis was used to examine changes from pre-test to post-test across outcome variables. Mean N-gain values for each variable and group are presented in Table 9. The experimental

Table 6. Descriptive Statistics of Pre-test and Post-test

Variable	Group	N	Mean	SD	Min	Max
Pre Loco	1(EXP)	96	27.33	5.534	12	39
	2(CON)	96	27.70	5.435	17	42
Post Loco	1(EXP)	96	37.98	5.183	26	46
	2(CON)	96	29.24	6.426	14	44
Pre Obj	1(EXP)	96	30.36	5.689	18	46
	2(CON)	96	30.28	5.538	16	44
Post Obj	1(EXP)	96	39.02	4.652	28	48
	2(CON)	96	31.22	5.437	18	46
Pre GMQ	1(EXP)	96	59.85	21.886	46	152
	2(CON)	96	60.84	23.345	46	130
Post GMQ	1(EXP)	96	73.76	27.777	46	152
	2(CON)	96	65.82	25.868	46	145
Pre Diff	1(EXP)	96	15.20	2.976	7	21
	2(CON)	96	15.24	3.565	8	25
Post Diff	1(EXP)	96	9.58	3.131	0	20
	2(CON)	96	14.92	3.323	6	23
Pre Pros	1(EXP)	96	6.57	1.665	3	10
	2(CON)	96	6.01	1.815	2	10
Post Pros	1(EXP)	96	8.57	1.013	6	10
	2(CON)	96	6.50	1.753	3	10

Note. EXP = experimental group; CON = control group; Loco = locomotor skills; Obj = object control skills; GMQ = Gross Motor Quotient; Diff = Total Difficulties Score (SDQ); Pros = Prosocial behavior (SDQ).

Table 7. Normality Test Results for ANCOVA Model Residuals

Variable	Sig. Kolmogorov-Smirnov	Sig. Shapiro-Wilk	Interpretation
Residual Post Loco	0.200	0.267	Normal
Residual Post Obj	0.200	0.806	Normal
Residual Post GMQ	0.200	0.200	Normal
Residual Post Diff	0.200	0.790	Normal
Residual Post Pros	0.200	0.216	Normal

Note. Loco = locomotor skills; Obj = object control skills; GMQ = Gross Motor Quotient; Diff = Total Difficulties Score; Pros = Prosocial behavior. Values of 0.200 for the Kolmogorov–Smirnov test indicate the upper limit reported by SPSS, reflecting p-values greater than this threshold.

Table 8. Homogeneity Test Results

Variable	F Levene	Sig.	Interpretation
Pre Loco	0.000	0.994	Homogeneous
Pre Obj	0.090	0.764	Homogeneous
Post Loco	3.448	0.065	Homogeneous
Post Obj	0.755	0.386	Homogeneous
Pre GMQ	1.375	0.242	Homogeneous
Post GMQ	0.544	0.462	Homogeneous
Pre Diff	3.213	0.075	Homogeneous
Post Diff	0.096	0.757	Homogeneous
Pre Pros	0.110	0.741	Homogeneous
Post Pros	0.714	0.563	Homogeneous

Note. Loco = locomotor skills; Obj = object control skills; GMQ = Gross Motor Quotient; Diff = Total Difficulties Score; Pros = Prosocial behavior. Homogeneity of variance was assessed using Levene's test; non-significant p-values ($p > 0.05$) indicate equal variances between groups.

Table 9. Mean N-Gain Pre-Post for Each Variable

Variable	Group	N	Mean N-Gain	Category*
TGMD-2 Locomotor	1(EXP)	96	0.4614	Medium
	2(CON)	96	-0.0387	Low
TGMD-2 Object Control	1(EXP)	96	0.3717	Medium
	2(CON)	96	-0.0766	Low
TGMD-2 GMQ	1(EXP)	96	0.0263	Low
	2(CON)	96	-0.0459	Low
SDQ Total Difficulties	1(EXP)	96	-0.3370	Medium**
	2(CON)	96	0.0458	Low
SDQ Prosocial	1(EXP)	96	0.5186	Medium
	2(CON)	96	-0.0716	Low

Note. * Hake Category: $g < 0.30$ = low; $0.30 \leqslant g < 0.70$ = medium; $g \geqslant 0.70$ = high. ** For Total Difficulties, negative N-gain indicates greater problem reduction, though numerically still categorized as "medium."

Table 10. Summary of ANCOVA Results for Motor and Psychosocial Outcomes

Panel	Outcome (Scale)	Source	Dependent Variable	F	Sig.	Partial η^2	Interpretation
A	TGMD-2 Locomotor	Pre Loco	Post Loco	3.096	0.080	0.016	Covariate not significant, small effect
		Group	Post Loco	107.418	0.000	0.362	Significant difference, large effect
B	TGMD-2 Object Control	Pre Obj	Post Obj	0.086	0.769	0.000	Covariate not significant, negligible effect
		Group	Post Obj	113.526	0.000	0.375	Significant difference, large effect
C	TGMD-2 GMQ Total	Pre GMQ	Post GMQ	0.242	0.623	0.001	Covariate not significant, negligible effect
		Group	Post GMQ	4.224	0.041	0.022	Significant difference, small effect
D	SDQ Total Difficulties	Pre Diff	Post Diff	2.544	0.112	0.013	Covariate not significant, small effect
		Group	Post Diff	132.266	0.000	0.412	Significant difference, large effect
E	SDQ Prosocial	Pre Pros	Post Pros	0.084	0.772	0.000	Covariate not significant, negligible effect
		Group	Post Pros	98.481	0.000	0.343	Significant difference, large effect

Note. TGMD-2 = Test of Gross Motor Development–2; GMQ = Gross Motor Quotient; SDQ = Strengths and Difficulties Questionnaire. ANCOVA was conducted with corresponding pre-test scores entered as covariates. Partial η^2 indicates effect size. Non-significant covariate effects ($p > 0.05$) indicate that baseline scores did not account for post-test group differences.

group showed positive N-gain values for locomotor skills, object control skills, and prosocial behavior, whereas the control group showed low or negative values for these variables. For total difficulties scores, negative N-gain values were observed in the experimental group, reflecting a reduction in reported difficulties, while values in the control group were close to zero. Changes in Gross Motor Quotient (GMQ) scores were small in both groups.

After controlling for pre-test locomotor scores, analysis of covariance indicated a statistically significant group effect on post-test locomotor performance (Table 10A). The pre-test locomotor score entered as a covariate was not statistically significant, indicating that post-test differences were not explained by baseline values.

After controlling for pre-test object control scores, analysis of covariance indicated a statistically significant group effect on post-test object control performance (Table 10B). The pre-test object control score entered as a covariate was not statistically significant, indicating that baseline values did not account for post-test differences between groups.

After controlling for pre-test Gross Motor Quotient (GMQ) scores, analysis of covariance indicated a group effect on post-test GMQ scores (Table 10C). The effect was statistically significant, while the associated effect size was small. The pre-test GMQ score entered as a covariate was not statistically significant, indicating that baseline GMQ values did not account for post-test differences between groups.

After controlling for pre-test total difficulties scores, analysis of covariance indicated a statistically significant group effect on post-test total difficulties (Table 10D). The associated effect size was large. The pre-test total difficulties score entered as a covariate was not statistically significant, indicating that baseline differences did not account for post-test group differences.

After controlling for pre-test prosocial behavior scores, analysis of covariance indicated a statistically significant group effect on post-test prosocial behavior (Table 10E). The associated effect size was large. The pre-test prosocial score entered as a covariate was not statistically significant, indicating that baseline prosocial behavior did not account for post-test differences between groups.

Discussion

This study examined whether cooperative circuit games could enhance fundamental motor skills and social-emotional learning among upper elementary school students. The results showed that a 12-week cooperative circuit games intervention was associated with improvements in both fundamental motor skills and social-emotional competencies. Baseline equivalence between the experimental and control groups across motor variables confirms that post-intervention differences were not related to pre-existing disparities. After the intervention, the experimental group demonstrated higher levels of locomotor skills, object control skills, and Gross Motor Quotient scores compared with the control group. Large effect sizes were observed for locomotor skills, object control, prosocial behavior, and total difficulties. These results indicate that cooperative structures embedded within circuit-based physical activities can address motor and social-emotional domains within a single instructional approach.

The present results are consistent with previous findings indicating that fundamental motor skill interventions incorporating cooperative and interactive elements are associated with changes in motor performance. Reviews of movement-based programs that include group interaction report differences in gross motor development, particularly in locomotor skills [46]. Cooperative games are also associated with interpersonal interaction and peer communication, which relate to physical skill acquisition and the development of social competencies [36, 47]. In comparison with teacher-centered instructional formats, cooperative learning environments have been linked to differences in engagement and outcomes across several developmental domains [46, 48].

The effects of the cooperative approach on fundamental motor skill development can be explained through several interconnected mechanisms. First, positive interdependence within cooperative circuit activities creates conditions for peer instruction and reciprocal feedback, which support technical refinement [49]. In contrast to drill-based practice that emphasizes individual repetition, cooperative tasks such as synchronized jumping or paired balance beam activities require continuous communication and mutual adjustment. This structure promotes repeated practice with contextual variation, which is relevant for motor learning consolidation [50]. Second, the circuit-based rotation system distributes practice across locomotor and object control skills. This distribution reduces skill stagnation that may occur in single-skill interventions. This approach is consistent with contextual interference theory, which indicates that varied and alternating practice schedules support skill retention and transfer compared with blocked practice formats [19]. In addition, the prescribed work-to-rest ratios (1:1–1:1.5) and moderate intensity levels (RPE 11–13) support a balance between training volume and recovery. This balance helps maintain participation without fatigue-related reductions in performance quality. Third, cooperative goal structures create a supportive learning environment that may reduce performance-related anxiety, particularly among students with lower initial competence. This environment is associated with intrinsic motivation and willingness to participate in activities [51].

The social-emotional outcomes observed in this study followed a similar pattern. The experimental group showed a reduction in total difficulties scores from pre-test to post-test, whereas only minor changes were observed in the control group. According to SDQ classification criteria, this change corresponded to a shift from the borderline range toward the average range of functioning. At the same time, prosocial behavior scores increased in the experimental group, while changes in the control group were smaller. The effect sizes observed for prosocial behavior and total difficulties are comparable to patterns reported in structured social-emotional learning interventions [52]. These results indicate that cooperative physical education formats may support social-emotional learning processes, particularly in educational contexts where structured SEL programs are limited and behavioral challenges are associated with increased screen exposure and urban living conditions [53].

The integration of social-emotional learning into school curricula has been examined in previous research. Meta-analytic evidence indicates that school-based SEL programs are associated with social competence, emotional regulation, and behavioral adjustment across developmental stages [52]. Within physical education, cooperative learning strategies promote social interaction and shared responsibility. These features are aligned with SEL-related processes and support prosocial behavior during instructional activities [54, 55]. The present findings correspond to key components of cooperative learning, including positive interdependence, individual accountability, promotive interaction, explicit instruction of social skills, and structured group reflection [56, 57, 58, 59, 60].

Compared with previously described pedagogical models, the present study applied a structured integration of fundamental motor skills and social-emotional learning within a single instructional format. This integration was supported by defined implementation procedures, teacher training requirements, and fidelity monitoring protocols, as described in earlier methodological sections. The intervention combined motor and social-emotional components within each activity station and followed predefined guidelines for instruction and observation, which allowed consistent delivery across sessions [41, 42, 43, 44]. In addition, the program included standardized instructional materials, observation formats, and facilitator competency checks intended to support uniform implementation. These features provide a basis for examining integrated physical education approaches within school settings.

In the context of increased digital media exposure, which has been associated with reduced social interaction and behavioral risks among children [61, 62], the present findings indicate that cooperative circuit games may function as a compensatory approach. Descriptive data showed that a large proportion of participants reported daily screen time exceeding two hours, and many did not participate in structured sports activities outside school. High levels of digital media use limit physical activity and reduce opportunities for developing social competencies through direct interaction. In this study, total difficulties scores decreased in the experimental group following the intervention. This pattern suggests that cooperative circuit games may be relevant for preventive efforts addressing social-emotional difficulties during childhood. Social-emotional difficulties that persist during childhood have been associated with later psychological and behavioral problems. In this context, the inclusion of cooperative circuit games within regular physical education lessons may support student well-being over time.

These findings are consistent with the conceptualization of physical literacy as a multidimensional construct that includes motor, affective, and social components. In contrast to interventions that examine motor competence or social-emotional outcomes separately, the present study assessed both domains concurrently using validated instruments, including the TGMD-2 and the Indonesian version of the SDQ. The study used a cluster-randomized controlled trial design, which reduced risks related to selection bias and contamination. The sample size was 192 participants. Pre-test covariate effects across ANCOVA models were non-significant, indicating baseline equivalence between groups. Under these conditions, post-intervention differences were not explained by baseline individual differences.

Limitations of the Study

Several limitations of this study should be acknowledged. First, the 12-week intervention period provides evidence of short-term effects but does not address long-term retention or transfer of motor and social-emotional skills. Follow-up assessments at later time points would be required to examine the durability of the observed outcomes. Second, the sample was drawn from urban schools with predominantly middle-to-upper socioeconomic backgrounds. This sampling frame may limit the applicability of the findings to rural or lower-resource settings.

Additional methodological considerations should be noted. Teachers and students were not blinded to group allocation, which may have introduced expectancy effects. Potential mediating factors underlying the observed changes, such as perceived competence, motivation, or peer support, were not directly measured. Social-emotional outcomes were assessed using teacher reports only. This approach, while commonly applied, may be influenced by subjective perceptions and classroom context.

Future research may employ longitudinal designs to examine skill retention and transfer. Studies conducted in diverse educational contexts could further examine implementation conditions. Economic evaluations may also inform feasibility at scale. Qualitative approaches involving students, teachers, and parents could provide insight into participant experiences and contextual influences. Mediation analyses may help clarify pathways linking cooperative activities with motor and social-emotional outcomes. Comparative studies involving other pedagogical models, such as Sport Education, Teaching Games for Understanding, and Teaching Personal and Social Responsibility, could examine differences across instructional approaches. Longer-term investigations addressing academic outcomes, mental health, physical activity behaviors, and cardiometabolic indicators may extend understanding of integrated physical education interventions.

Conclusions

This study indicates that cooperative circuit games can be applied as a pedagogical approach to support the development of fundamental motor skills and social-emotional competencies among upper elementary school students. The intervention was associated with effects across the measured motor and social-emotional domains, showing that motor learning and social-emotional learning can be addressed within a single instructional framework.

The findings have practical implications for educational contexts in which opportunities for structured physical activity outside school are limited. The program can be implemented within regular physical education lessons and does not require specialized facilities or equipment. Improvements observed in social-emotional functioning indicate that cooperative circuit games may be relevant for preventive approaches addressing behavioral and emotional difficulties in childhood. Taking into account the limitations related to intervention duration and sample characteristics, the results support the use of cooperative circuit games as an instructional approach aligned with the aims of physical literacy and integrated child development in elementary physical education.

Acknowledgments

The authors express their gratitude to Yogyakarta State University and to the school principals, physical education teachers, and students from elementary schools in Yogyakarta City, Indonesia, for their cooperation during the study.

Conflict of Interest

The authors declare no conflicts of interest.

AI Tools Usage

During manuscript preparation, Perplexity AI was used to support sentence structuring, language editing, and the preparation of visual figures. All content was reviewed and verified by the authors, who take full responsibility for the accuracy and integrity of the manuscript.

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Cite this article as:

Kuspratiwi FW, Suherman SW, Komari A, Nevitaningrum N. The effects of Cooperative Circuit Games on fundamental motor skills and social-emotional learning in elementary school students. *Pedagogy of Physical Culture and Sports,* 2026;30(2):93–110.
https://doi.org/10.15561/26649837.2026.0203

Received: 29.11.2025
Accepted: 31.12.2025; Published: 30.04.2026