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COOPERATIVE LEARNING VS. DIRECT INSTRUCTION IN YOUTH SPORT: EFFECTS ON CHILDREN'S MOTOR LEARNING

PRIMERJAVA SODELOVALNEGA UČENJA IN DIREKTNEGA POUČEVANJA V ŠPORTU MLADIH: UČINKI NA GIBALNO UČENJE OTROK

ABSTRACT

Cooperative Learning promotes peer teaching that fosters active learner engagement and better retention and usefulness of knowledge. Research has shown that Cooperative Learning has a positive impact on motor learning in PE students. The aim of this study was to investigate whether Cooperative Learning is a more appropriate teaching approach for use in youth competitive athletics to improve children's motor learning, compared to the Direct Instruction used so far. Using cluster random assignment, twelve Slovenian track and field groups (140 young athletes) were divided into an experimental group that completed three Cooperative Learning units (30 training sessions) and a control group. The children's performances in four track and field skills were recorded and rated by three qualified assessors. A pretest-posttest research design was used. Nested analyses of covariance were conducted to examine whether the model (Cooperative Learning vs. Direct Instruction) affected posttest scores, adjusting for the average age of children and their track and field proficiency at baseline. Significant differences in favour of Cooperative Learning were found for three variables: track and field skills, low skipping, and crouch start. We found that Cooperative Learning is very effective in improving motor learning in youth competitive athletics and even more effective than Direct Instruction. The cooperative nature of the studied pedagogical model promotes peer teaching, giving feedback and taking responsibility, which has a more positive effect on the young athletes' sports skills than the traditional teaching method.

Keywords: teaching method, pedagogical model, young athletes, athletic skills

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IZVLEČEK

Sodelovalno učenje spodbuja medvrstniško poučevanje, ki omogoča aktivno učenje in boljšo zapomnitev ter večjo uporabnost znanja. Raziskave so pokazale, da ima sodelovalno učenje pozitivne učinke na gibalno znanje učencev pri športni vzgoji. Namen naše študije je bil preučiti, če je sodelovalno učenje bolj primerna metoda poučevanja za uporabo v športu mladih z namenom izboljšanja gibalnega učenja, v primerjavi z direktnim poučevanjem, ki se je uporabljalo do sedaj. Dvanajst slovenskih atletskih skupin (140 mladih atletov) smo naključno razdelili v eksperimentalno skupino (ta je opravila tri enote sodelovalnega učenja na 30 treningih) in kontrolno skupino. Otroke smo posneli pri izvajanju štirih atletskih spretnosti. Posnetke so nato ocenili trije usposobljeni ocenjevalci. Uporabili smo raziskovalni načrt s pred- in post-testiranjem. Da bi ugotovili učinke modela (sodelovalno učenje proti direktnemu poučevanju) na končne rezultate in pri tem kontrolirali povprečno starost otrok pred eksperimentom in začetno atletsko znanje, smo uporabili grajeno analizo kovariance. Pomembne razlike v prid sodelovalnemu učenju so se pokazale pri treh spremenljivkah: atletske spretnosti, nizki skiping in nizki štart. Ugotovili smo, da je sodelovalno učenje zelo učinkovito za izboljšanje gibalnega znanja v tekmovalni atletiki mladih in da je učinkovitejše od direktnega poučevanja. Sodelovalna narava preučevanega pedagoškega modela spodbuja medvrstniško poučevanje, dajanje povratnih informacij ter prevzemanje odgovornosti in ima zato bolj pozitiven vpliv na športne spretnosti mladih atletov kot tradicionalna metoda poučevanja.

Ključne besede: metoda poučevanja, pedagoški model, mladi atleti, atletske spretnosti

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INTRODUCTION

According to Fitts and Posner's model, learning a motor skill involves three stages (Magill & Anderson, 2017). In the cognitive stage, learning success relies heavily on demonstration and verbal instruction. In the second, associative stage, a person refines their performance and acquires the ability to recognise and identify performance errors. Continuous improvement of a motor skill and eventual movement automatism are made possible by frequent training, a large number of repetitions, feedback, etc. However, the success of motor learning is influenced by many other factors, such as the personal characteristics of the individual, their motor and intellectual abilities, and also the approach to teaching and learning (Škof, 2016).

Traditional teaching methods are blamed for passive knowledge and poor understanding of the subject matter among learners (Rutar Ilc, 2004). On the other hand, active knowledge acquisition is characteristic of the constructivist paradigm. Learners construct their knowledge independently by using higher-order thinking processes to incorporate new information into existing experiences. Active learning improves retention, understanding, usefulness, and transferability of knowledge (Casey et al., 2009). The basic assumption of constructivism is that each person should create knowledge through their own thinking activity in a productive interaction process or dialogue with others (Marentič Požarnik, 2004). Thus, the teacher cannot inculcate knowledge into the learners, but it is up to them to acquire it themselves.

Cooperative learning (CL) is a pedagogical model in which children work as active learners in small, heterogeneous groups (Casey & Quennerstedt, 2020; Metzler & Colquitt, 2021). The main idea of CL is that children are responsible for learning in the group and that they depend on their classmates (Casey et al., 2015; Johnson & Johnson, 2009). To pursue group goals, children learn how to teach their peers, which enables them to improve their knowledge as well (Cecchini Estrada et al., 2019; Johnson & Johnson, 2009). Interactions between group members and mutual support encourage learners to critically analyse each other's performance and actively receive feedback from peers (Huang et al., 2017). Feedback is one of the four common instructional strategies that promote active student engagement (Moon, 2022).

Since CL corresponds to the processes of motor learning and control in a way that promotes active learning through peer teaching and feedback, it is not surprising that it improves motor learning in PE students (Darnis & Lafont, 2013; Dyson, 2002; Huang et al., 2017). Physical activity in pre-adolescence needs to focus on learning new sports skills, regardless of the sport context – physical education (PE) or competitive sport (Way et al., 2016). If the main objective

of a lesson/session is based on learning, competitive activities are less appropriate as competition limits learning opportunities in some areas (Grineski, 1996; Johnson & Johnson, 2009). Moreover, competition motivates only those children who have the potential to succeed and does not promote the development of social skills. Although psychosocial and cognitive goals are becoming increasingly important in youth sport, physical goals remain the main effects of the learning process (Bailey et al., 2009). However, the quality of children's physical activity depends on the number of children achieving as many different learning goals as possible (Grineski, 1996). Through cooperation, children can develop multiple psychological and social skills that cannot be fostered by the other goal structures – competitive or individual (Hortigüela Alcalá et al., 2019). CL proved to be more suitable than DI for improving peer relationships, motivational climate and emotional self-concept in young athletes (Železnik Mežan et al., in press). Therefore, it could help reduce high dropout rates among promising athletes (Sheehan et al., 2018). Among other things, CL also enables children to develop critical thinking skills, which are positively associated with motor learning (Chou et al., 2015; Dyson et al., 2010). The aim of our study was to find out whether CL is also suitable for motor learning in youth competitive athletics. Two pedagogical models, namely CL and direct instruction (DI – classical teaching method most commonly used for training young athletes), were empirically investigated to compare their effects on young athletes ' track and field skills.

METHODS

Design

The effects of CL intervention on the track and field skills of young athletes were compared with the effects of the control programme (DI). A cluster random assignment and a pretest-posttest research design were used.

Participants

The Republic of Slovenia is a small country in central-southeast Europe with a population of 2.052 million people. In order to obtain the largest possible sample, we contacted all potential athletics clubs in Slovenia. Twelve of them met certain conditions, the fulfilment of which made it possible to carry out the experiment: at least one group of 8-to 11-year-olds; at least twelve children who train regularly; possibility of using indoor sports facilities in winter; training accessories; trainer with appropriate education (university degree, pedagogy) or qualification

(at least first level and at least seven years of professional experience); trainer is willing to participate in the study; training takes place two or three times a week with the same trainer. All twelve clubs were thus included in the study.

By recruiting twelve trainers for the experiment, all their athletes aged 8-11 years were invited to participate in the study. The twelve track and field groups were randomly divided into an experimental group (EG) (six clubs) and a control group (CG) (six clubs). 140 children participated in both measurements and in at least 70% of the training sessions. EG with CL consisted of 52 girls and 26 boys (mean age: 9.22 ± 0.68 years). CG with the traditional DI consisted of 37 girls and 25 boys (mean age: 9.86 ± 0.76 years). Further demographic data can be found in Appendix A.

Procedure

Table 1 shows the timeline of the experiment.

Table 1. Timeline.

February 2021	March-October 2021	May 2021	October 2021	November 2021 – first two weeks	November 2021-March 2022	April 2022
- approval by the Ethics Committee* - introductory session for trainers and parents	- coach training for CL	- trainers signed a consent form - trainers received the entire intervention programme	- parents and children signed a consent form	- pretest: Recording of children performing track and field skills → assessment (first time point)	- 30 consecutive training sessions with CL/DI (immediately after pretest) - recording of randomly selected sessions – model fidelity	- posttest: Recording children performing the same skills as pretest → assessment (second time point)

Note. *Committee on Ethical Issues in Sport (University of Ljubljana, Faculty of Sport, Ljubljana, Slovenia).

Model Fidelity

The next subsections determine the model fidelity of the intervention. Although each pedagogical model has its own idea and set of specific characteristics, each model is flexible and allows practitioners to design units that are adapted to the specific circumstances of their context (Hastie & Casey, 2014). To ensure appropriate interpretation of the findings, we have described the context of the study in detail in the three elements of model fidelity that should be considered when researching educational approaches (Casey et al., 2015; Hastie & Casey, 2014).

A Rich Description of the Curricular Elements of the Unit

The intervention programme consisted of 30 training sessions divided into three CL units. The first unit (Introduction to CL) started with cooperation games (icebreakers) that did not yet contain all the key elements of CL (see Appendix B). The trainers added them gradually as they first had to get used to the new teaching and learning method (Casey et al., 2015). In the second and third units, the content focused on athletics. Different track and field skills were taught, although the children only had to perform four of them during the measurements. The trainers had to form fixed, heterogeneous groups of four (±1), taking into account gender, abilities, knowledge, psychosocial characteristics, friendships, etc. The children were presented with different cooperative structures that determined how they worked together and what their learning objectives were (Appendix B). Pairs-Check-Perform (Grineski, 1996; based on Kagan (1992)) was introduced first because peer teaching in pairs is much easier than working in larger groups. Peer teaching was also promoted through Learning Teams (Johnson & Johnson, 1994). Trainers had to assign specific roles to children (e.g. performer, trainer, timekeeper, referee, etc.) so that they learned to take responsibility for part of a group task. Jigsaw (Grineski, 1996) was also widely used for learning basic track and field skills that were broken down into parts (subtasks). With PACER (Kane & Kane Jr, 2004) we focused on improving running technique. Student Teams-Achievement Divisions (STAD; Slavin, 1995) was the most complicated of all the structures used. Learners tried to make the most progress as a group, so they taught the other group members the correct technique. Collective Score (Orlick, 1982) was mainly used to develop movement skills for learning sports skills (Kane and Kane Jr 2004). Most of the cooperative structures were chosen because they enable children to learn sports skills independently. This should be the main learning objective of training plans for young athletes (Way et al., 2016). The criterion for selecting the cooperative structures was also the achievement of affective goals. Each structure was adapted to the 8-11 year olds and used several times with different track and field skills. Only six different structures were used because the learners had to get to know each of them well before a new one was added (Grineski, 1996).

The cooperative structures promoted peer teaching and all five CL non-negotiables. The children were provided with learning materials, e.g. special flashcards with coordination exercises (PACER), so that face-to-face promotive interaction was encouraged. Positive interdependence and individual accountability were promoted by giving each member of a jigsaw group only one piece of information needed to complete a group task. PACER also

emphasised positive interdependence, by requiring all members to reach a certain level of competence in coordination exercises before the group (consisting of two pairs) could play a game. Individual accountability was also promoted by publicly presenting both the group's progress and individual results (posters). As part of the affective goals, the interpersonal and small group skills were defined separately for each training session (Appendix B). The trainers presented each skill to the children and they wrote it together on a special poster that accompanied them throughout the experiment. Group processing took place at the end of each session. It evolved from a whole group discussion led by the trainer to an independent debate in fixed groups.

The control programme corresponded to the intervention programme in terms of content. Regardless of the model used, the children worked on the same physical goals. However, there were differences in psycho-social learning, while DI does not allow for all types of goal achievement, as is typical for CL. In the CG, the trainers continued to use DI. They were the only ones who set tasks, determined the course and pace of learning, assessed goal achievement and monitored the group's interactions (Metzler & Colquitt, 2021). The work was organised frontally so that the children had the same tasks at the same time. The goal structure was either individual or competitive.

A Detailed Validation of Model Implementation

To determine model fidelity, i.e. whether reported learning outcomes could be attributed to the pedagogical model, we recorded four randomly selected training sessions from each athletics group in EG (Zach et al., 2020). Data were collected through systematic event coding of the 17 categories of the Cooperative Learning Validation Tool (CLVT) (see Appendix D). It was developed by Dyson (2010) and tested and modified by Casey and colleagues (2015). Observations were conducted by the first author. Average percentages for each coded category were calculated. The Post Lesson Teacher Analysis Tool (PLTA) was used to report on children's learning and the actions of the trainers from the trainers' perspective (Bodsworth & Goodyear, 2017). They were asked to write structured reflections after each training session.

The CLVT results showed that we achieved a satisfactory degree of CL model fidelity (Appendix D). All critical elements of CL were used in 75% of the sessions, but group processing was done in all sessions. Other key concepts beyond the five non-negotiables (categories 2-6 in Appendix D) were also observed in about three-quarters of the recorded

training sessions. We found that the percentage of observed CL key elements would be even higher if the structures and non-negotiables were not added gradually (Appendix B).

Student learning was assessed in each session and improvements were made in 92% of the sessions, indicating high student engagement (Appendix D). The number of learning assessments and observed improvements were highest in the social or emotional domain. The CLVT revealed that physical goals were observed in every training session, while cognitive goals were observed in three-quarters of the recorded sessions (Appendix D). Consistent with the CLVT results, trainers reported improvements primarily in the areas of social/emotional and sports skills (PLTA). Trainers noted that the children showed an understanding of the track and field technical elements and that they learned to recognise major mistakes that they and their peers were making.

We cannot say that full fidelity was achieved in every session. However, this moderate to high degree of model fidelity allows us to assume that the children's response to the units was the result of CL (Bjørke & Mordal Moen, 2020; Casey et al., 2015).

A Detailed Description of the Programme Context that Includes the Previous Experiences of the Trainer and Children with the Model

All the trainers (except me – the first author) had only the traditional approach (DI) before the study. CL caught my attention a year before the study, so I first did a literature review and then started using it in practice, as I work as an athletic trainer for children. The impact of CL on children's learning is also the topic of my PhD (in progress). I have conducted a coach training for CL for the trainers in EG. We met five times from March to October and conducted two lectures and three workshops, which lasted a total of 20 hours (Table 1). In the lectures, the trainers were theoretically introduced to CL with its non-negotiables and structures. In the workshops, the trainers were given a first insight into the intervention programme. The cooperative structures with athletic content were presented in practise. To check whether learning had taken place, the trainers tried their hand at teaching according to CL. During the experiment, we were in constant contact with the trainers. We met regularly remotely and communicated by phone and email to solve various dilemmas, deepen the trainers' knowledge of CL and adapt the plan according to the circumstances.

Details of the participating children can be found in the subchapter Participants and in Appendix A. They had no previous experience with CL.

Data Collection

The children were recorded on camera during pre- and posttest as they performed the same four track and field skills that represent sets of basic athletic disciplines: low skipping and bounding (running), crouch start (sprinting), and vortex throw (throwing). Each task was first demonstrated by the principal investigator. The children's performances were observed and evaluated by three qualified assessors who teach athletics at the Faculty of Sports, University of Ljubljana. In order to evaluate the children's progress in athletics, the assessors evaluated the recordings at two points in time – first the baseline condition (of the children's athletics practical knowledge) and also the final condition after the experiment (see Table 1). The children's performances were scored from 1 to 5, based on the descriptive criteria for each task. The average scores were then calculated and compared between the models (CL vs. DI). A protocol based on the integral rating model was followed (Majerič, 2004). Validation of the rating scales was conducted by Železnik Mežan and Škof (2022) and confirmed the variability of the scores as well as external and internal consistency. Factor analysis confirmed that the selected tests represent the same concept or single construct. To obtain a composite score (track and field skills), we estimated the coefficients of the factor scores using the Anderson-Rubin method. For the purposes of this study, we calculated test-retest reliability by having assessors rate the performance of 30 randomly selected children after some time (see Results section).

Data Analysis

The data were analysed using IBM SPSS Statistics for Windows, version 26. Descriptive statistics were first compiled and pretest differences between groups were tested the independent samples T-test or its nonparametric alternative (Mann-Whitney U-test) (see Table 2). In order to apply the analysis of covariance (ANCOVA), the data had to meet certain assumptions. We conducted exploratory analyses to confirm that there were no significant outliers; our residuals were approximately normally distributed for each category of the independent variable; Levene's test confirmed homogeneity of variances; the covariate (initial knowledge) was linearly related to the dependent variables at each level of the independent variable; Scatter plots representing the standardised residuals and the predicted values (Z-scores) of each dependent variable confirmed homoscedasticity; no interaction was found between the covariate (initial knowledge) and the independent variable (i.e. the homogeneity of the regression slopes). Nested ANCOVAs were used to examine whether the posttest results of the dependent variables differed between the models (CL vs. DI) when controlling for pretest

results and the average age of the children at baseline. Athletics clubs were nested within the EG and the CG. At the end, we reported the effect sizes. Reliability was calculated using the Pearson correlation coefficient. For all statistical analyses, the significance level was set at $p \leq 0.05$.

Table 2. Descriptive Statistics and Pretest Differences Between Groups.

Variable	Pretest					Posttest	
	M ± SD EG	CG	Test statistic	p	Cohen's d	M ± SD EG	CG
Low skipping	2.46 ± 0.90	2.57 ± 0.77	-0.73	0.47	-0.12	2.58 ± 0.70	2.38 ± 0.73
Bounding	2.15 ± 1.06	2.33 ± 1.02	2768*	0.19	*-0.18*	2.47 ± 1.03	2.47 ± 0.92
Crouch start	2.09 ± 0.66	2.23 ± 0.70	2780.50*	0.23	*-0.20*	2.60 ± 0.88	2.22 ± 0.63
Vortex throw	2.54 ± 0.79	2.60 ± 0.87	-0.45	0.66	-0.08	2.60 ± 0.57	2.57 ± 0.78
Track and field skills	-0.07 ± 1.01	0.11 ± 0.97	-1.10	0.27	-0.19	0.14 ± 1.05	-0.17 ± 0.91

Note. To analyse pretest differences between the groups, the independent samples T-test was used for dependent variables that met the normality assumption. *For other variables, the Mann-Whitney U-test was used.

RESULTS

Descriptive statistics and pretest differences between the two groups are presented in Table 2. Non-significant differences and small effect sizes (which can be considered trivial) were found for all dependent variables.

Nested ANCOVAs revealed significant differences between EG and CG at posttest in the areas of general track and field skills, low skipping, and crouch start (Table 3). We proved that CL was more effective than DI in improving low skipping, crouch start, and track and field skills of young athletes. In fact, the children of CG performed worse on the posttest than on the pretest in all tests except bounding (Table 2). We found no statistically significant differences between EG and CG at posttest in bounding and vortex throw. The effect sizes showed large effects in track and field skills, crouch start, and low skipping.

Table 3. Nested ANCOVA for Posttest Differences between Experimental and Control Group.

Variable	Estimated marginal mean		Nested ANCOVA		Partial eta squared	Observed power
	EG	CG	F	*p*		
Low skipping	2.67	2.34	5.58	0,03*	0.27	0.60
Bounding	2.56	2.37	0.79	0.39	0.06	0.13
Crouch start	2.65	2.13	7.87	0.01*	0.36	0.74
Vortex throw	2.64	2.53	0.93	0.35	0.05	0.15
Track and field skills	0.25	-0.28	13.37	0.00*	0.44	0.93

*$p < 0.05$.

Using Person Correlation Coefficient and Intraclass Correlation Coefficients we found that the test-retest reliability was good in vortex throw and excellent in all other dependent variables (see Table 4).

Table 4. Test-Retest Reliability.

Variable	Pearson correlation coefficient	ICC (consistency)	ICC (absolute agreement)
Low skipping	0.91	0.95	0.94
Bounding	0.94	0.97	0.96
Crouch start	0.96	0.98	0.98
Vortex throw	0.81	0.89	0.89
Track and field skills	0.88	0.94	0.94

Note. ICC = Intraclass correlation coefficient.

DISCUSSION

The results of the present study support the hypothesis that CL produces greater improvement in the track and field skills of young athletes compared to DI. The results are consistent with those of previous studies showing that PE students improve more in motor learning when they work collaboratively than when traditional teaching methods are used (Altınkök, 2017; Velazquez-Callado, 2012; Casey et al., 2009; Darnis & Lafont, 2013; Dyson, 2002; Guzmán & Payá, 2020; Huang et al., 2017). Several studies have already confirmed the effectiveness of CL for teaching PE, but none of them has yet tested it under competitive conditions. The novelty and significance of our study is also related to data collection and analysis. Altınkök (2017) did not control for baseline condition and other potential confounding variables. Velazquez-Callado (2012) did not describe the data collection and quantitative analysis in detail, so the replicability

of the experiment is not possible. Casey and colleagues (2009) conducted only a qualitative analysis of interviews, reflective journal, reflections, non-standardised questionnaires, observations, etc., which do not allow for an objective assessment of the relationships between variables.

The main goal of our study was to objectively compare the effects of CL and DI on motor learning in youth competitive athletics. The results showed significant differences in the areas of general track and field skills, low skipping, and crouch start between EG and CG. The results may suggest that CL is an effective pedagogical model for developing athletic skills in youth competitive sports. The improvement in track and field skills in EG could be due to the children's active engagement in learning. Children were encouraged to give verbal instructions, demonstrate, observe peers and analyse their partner's movement. In the cognitive motor learning stage, learning success is highly dependent on verbal instructions and demonstrations (Magill & Anderson, 2017). Although the theoretical background and empirical evidence suggest that it is better for beginners to observe skilled demonstrators, there is evidence that beginners can also gain learning benefits by observing unskilled demonstrators (peers). It is unlikely that a particular way of performing a skill (by a teacher/trainer) will suit every learner. It is also beneficial to demonstrate a skill not only before the learner starts to practise it, but also while practising – as often as possible. In CL, giving instructions, feedback, and encouragement is not just the domain of the teacher/trainer, as is characteristic of DI. CL therefore allows for more frequent feedback and encouragement, leading to greater improvements in motor skills (Dyson et al., 2010). The results of previous studies have shown that verbal discussions between peers about technical characteristics, learning objectives, and playing strategies enable the development of technical and tactical skills (Darnis & Lafont, 2013).

The trainers in EG noted that the children learned to recognise major mistakes made by their peers and showed an understanding of the track and field technical elements (PLTA). This is consistent with the findings of previous (qualitative) research (Casey et al., 2009; Dyson, 2002; Dyson et al., 2010). Some research has even shown that beginners who observe peers perform better than performers (observed beginners) (Magill & Anderson, 2017). When providing feedback to peers, children in EG relied on learning cues – sentences of three or four words describing the basic characteristics of a sports skill (Dyson, 2002). Instructions and learning cues were readily available to them in the learning materials (see Appendix C). Because they allow children to provide qualitative corrective feedback (Casey et al., 2009; Dyson et al.,

2010), learning cues have been shown to be a key factor in improving motor learning (Wisniewski et al., 2020).

Our findings confirm the study by Huang and colleagues (2017), who found that CL has greater effects on children's sports skills than DI. They also found that the impact of CL on critical thinking was greater than that of DI. Several other studies confirmed that working together can improve children's critical thinking (Brennan et al., 2012; Dyson, 2002; Dyson et al., 2010; Gorucu, 2016; Lodewyk, 2009). While problem-solving abilities such as organising and analysing problems, planning and adjusting work progress, and sensitivity in making observations are essential for the development of critical thinking skills, the latter can help children correct misconceptions about motor skills (Lodewyk, 2009). Three important factors for the development of critical thinking skills and progress in motor performance are group processing, decision making, and cooperative problem solving, all of which should be present (Brennan et al., 2012; Huang et al., 2017) and were present in our CL intervention (see Appendix D). To improve problem solving, children should use interpersonal and small group skills and spend a lot of time in face-to-face promotive interaction (Chen, 2001). Appendix D shows that the above categories were coded as being observed very frequently in our study. Social interactions among peers enable them to look at problems from different perspectives and develop critical thinking skills (Dyson, 2002). The learner is also more active in problem solving while pursuing a physical goal when he/she observes and learns from peers (Magill & Anderson, 2017), which our participants did most of the time (Appendix D). When trainers create a cooperative learning environment, young athletes develop psychosocial skills to a greater extent and are thus more successful in motor performance (Chou et al., 2015; Dyson et al., 2010). Our study supports these conclusions. Results reported by Železnik Mežan and colleagues (in press) on the same sample of young track and field athletes confirmed that CL promotes better peer relationships, higher levels of mastery motivational climate, lower levels of performance climate, and better emotional self-concept in young track and field athletes compared to DI. According to the current literature (Brennan et al., 2012; Dyson, 2002; Huang et al., 2017), improving these social and affective variables has an impact on the improvement of learners' sports skills and could also reduce dropout rates in young athletes (Sheehan et al., 2018; Železnik Mežan et al., in press).

CONCLUSION

Given the child's biological development, physical activity in prepuberty needs to focus on learning sports skills (Way et al., 2016). We examined two pedagogical models to determine, which had a greater positive impact on young athletes' track and field skills. We found that CL is more effective than the traditional DI for improving motor learning in youth competitive sport. The positive impact of CL on young athletes' track and field skills is likely to be due to its key features of ensuring children's active involvement in learning and problem solving. The use of interpersonal and small group skills enables young athletes to develop critical thinking skills that are positively associated with the improvement of motor learning (Chou et al., 2015). Peer teaching allows for more verbal instruction, demonstration, more frequent feedback and encouragement, which has a more positive impact on young athletes' sports skills than the traditional teaching method.

First limitation of our study could be its duration. Since the intervention programme was only 30 sessions, not all children reached the second stage of motor learning, although most of the skills were not completely new to them. We assume that retention would not be satisfactory unless the duration of the experiment was longer. For future studies on improving sports skills, we therefore recommend extending the duration of the intervention. It would also be useful to record the children on the same tests some time after the end of the experiment to check retention and compare it between the two models.

In terms of the level of motor learning achieved, we found that the motor tests were not equally demanding for the children. At the pretest, the young athletes had the most difficulty with bounding and crouch start. At the posttest, the EG improved the crouch start significantly, but the mean score of bounding was still much worse than in the other tests. Too high a difficulty level for children of this age could therefore be the reason for the statistically non-significant differences between the groups in bounding. In contrast, the vortex throw seemed to be the easiest of the selected motor tests, so that neither the children in the EG nor the participants from the CG were able to make significant progress. We also found poorer test-retest reliability (Table 4) and interobserver reliability for the vortex throw (Železnik Mežan & Škof, 2022). The descriptors for this test should have been improved when used for future research in this area.

A limitation could also be too small a sample, as shown by the observed power for some of the dependent variables (see Table 3). Small samples could compromise the extrapolation of

research findings to the population as a whole. Generalisation might also be limited as only track and field athletes aged 8-11 years were included in the study. To generalise the results to other sports, future studies should include different groups of participants from different sports in one sample. In our opinion, generalisation to different age groups would not be very useful, as sports training in children and adolescents should differ not only in terms of teaching and learning approach, but also in terms of content. We selected children before the onset of puberty, while the main goal of training at this age should be learning sports skills. Future studies of CL in other age groups are certainly welcome, but we do not support this kind of generalisation of results.

Because of the small number of young track and field athletes in Slovenia, we also had to randomise by natural groups. Due to the specific context, we could not use the matched groups technique. In addition, the clubs had very different training conditions (see Appendix A), although the selection process was based on certain selection criteria. Another limitation arose from the coronavirus pandemic. The closures resulted in a lower average attendance of children, so the standard for exclusion from the study had to be adjusted (it is normally 80%). There were two limitations in determining model fidelity. If we were to study CL another time, we would record all the training sessions to get a more realistic picture of the model implementation. If there was another CL expert in Slovenia, we would ask him to assess model fidelity using the CLVT so that we could calculate the reliability of the first author's observations.

According to the CLVT results and the trainer's reports of improvements in the cognitive domain (PLTA), future research should focus on the cognitive development of young athletes as an effect of CL.

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Conflicts of Interest

The authors report there are no competing interests to declare.

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Appendix A

Table A1. Demographic Information of the Clubs, Coaches and Youth Participants in Experimental Group.

Club	E	F	G	I	J	N
Facilities	Good	Good	Poor	Very good	Good	Very good
Number of sessions per week	2	2	3	3	2	2
Length of a session [min.]	90	60	60	90	90	75
Coach's gender	F	F	F	F	F	F
Coach's age	39	44	29	49	36	27
Coach's education/ qualification	PE teacher[a]	2. level	Sports coaching graduate[a]	2. level	1. level	PE teacher[a]
Coach – professional/amateur	A	P	A	A	A	A
Coach's experience coaching athletics	13	18	7	13	10	9
Male athletes	7	5	3	7	1	3
Female athletes	11	3	9	7	10	12
Athletes' age [M]	9.44	8.38	9.17	9.29	9.40	9.29
Athletes – years in sport	1.5	0.7	1.2	2.0	1.4	2.1

Note. Facilities: Poor – little gymnasium, track and field stadium (200-400m); Good – gymnasium, track and field stadium (300/400m); Very good – track and field hall and stadium.

[a] Educated personnel (PE teachers, sports coaches) does not need a qualification to coach.

Table A2. Demographic Information of the Clubs, Coaches and Youth Participants in Control Group.

Club	A	B	C	K	L	M
Facilities	Good	Good	Good	Poor	Poor	Very good
Number of sessions per week	2	2	2	3	2	3
Length of a session [min.]	60	90	90	75	90	60
Coach's gender	M	F	M	F	F	M
Coach's age	23	27	30	24	36	28
Coach's education/ qualification	Student, Sports coaching; 1. level	Preschool teacher; 2. level	PE Student[a]	PE Student[a]	1. level	2. level
Coach – professional/amateur	A	A	A	A	A	A
Coach's experience coaching athletics	1	7	5	4	15	7
Male athletes	3	4	7	6	1	4
Female athletes	5	3	8	4	9	8
Athletes' age [M]	9.75	10.43	9.17	9.50	10.22	10.36
Athletes – years in sport	1.4	2.1	1.3	1.7	2.0	1.9

Note. Facilities: Poor – little gymnasium, track and field stadium (200-400m); Good – gymnasium, track and field stadium (300/400m); Very good – track and field hall and stadium.

[a] Educated personnel (PE teachers, sports coaches) does not need a qualification to coach.

Appendix B - Description of Cooperative Learning Units

Unit	Session	Structures	Non-negotiables	Learning goals
1. – Introduction to CL	1.	/	Cooperative skills	Physical: - coordination, reaction speed Affective: - active cooperation of all - proper communication
1. – Introduction to CL	2.	/	Cooperative skills	Physical: - natural human movement - running technique - precision Affective: - active cooperation of all
1. – Introduction to CL	3.	/	Cooperative skills, group processing	Physical: - natural human movement - endurance, speed, precision Affective: - proper communication
1. – Introduction to CL	4.	/	Cooperative skills, group processing	Physical: - running technique - coordination Affective: - active cooperation of all
1. – Introduction to CL	5.	/	Cooperative skills, group processing	Physical: - speed, agility, precision Affective: - everyone included - cooperation – communication, help
1. – Introduction to CL	6.	Pairs-check-perform	Cooperative skills, group processing, face-to-face promotive interaction (worksheet)	Physical: - running technique - dynamic balance Affective: - mutual help - giving feedback
1. – Introduction to CL	7.	Collective Score	Cooperative skills, group processing, positive interdependence	Physical: - repetitive strength Affective: - listening to others carefully
1. – Introduction to CL	8.	/	Cooperative skills, group processing, face-to-face promotive interaction	Physical: - running technique - speed, agility Affective: - sharing ideas - giving feedback
1. – Introduction to CL	9.	Jigsaw	Cooperative skills, group processing, face-to-face promotive interaction, individual accountability	Physical: - endurance, coordination - precision Affective: - cooperation – communication, help
1. – Introduction to CL	10.	/	all five	Physical: - natural human movement - endurance Affective: - everyone included - proper communication
2. – Jumping and throwing	11.	Jigsaw, Collective score	all five	Physical: - place vortex throw - standing long jump - explosive strength Affective: - mutual respect and help
2. – Jumping and throwing	12.	STAD	all five	Physical: - running technique - place vortex throw - precision, strength Affective: - encouraging others - giving praise
2. – Jumping and throwing	13.	Jigsaw	all five	Physical: - long jump - explosive strength (legs) Affective: - focus on task - mutual help
2. – Jumping and throwing	14.	Jigsaw, Learning Teams	all five	Physical: - long jump - strength (technique) Affective: - listening to others carefully - encouraging active involvement

Unit	Session	Structures	Non-negotiables	Learning goals
2. – Jumping and throwing	15.	Collective Score	all five	Physical: - medicine ball throw - explosive strength (upper extremities), endurance Affective: - mutual trust - asking for help
2. – Jumping and throwing	16.	/	Cooperative skills, group processing	Physical: - long jump - explosive strength, endurance Affective: - sharing ideas - listening to others carefully - encouraging others
2. – Jumping and throwing	17.	Pairs-Check-Perform, Jigsaw	all five	Physical: - high jump (scissors) - running technique (scissors) Affective: - proper communication - mutual help, giving feedback
2. – Jumping and throwing	18.	STAD	all five	Physical: - medicine ball throw - explosive strength, speed Affective: - giving praise (when deserved)
2. – Jumping and throwing	19.	Pairs-Check-Perform	all five	Physical: - place vortex throw - relays (rules) - speed, agility Affective: - giving feedback - focus on task
2. – Jumping and throwing	20.	PACER	all five	Physical: - running technique - coordination Affective: - insistence, supporting others - giving feedback
3. – Sprinting and running	21.	Pairs-Check-Perform, Learning Teams	all five	Physical: - standing start - running technique - endurance Affective: - proper communication - encouraging others
3. – Sprinting and running	22.	Jigsaw	all five	Physical: - block start - speed (frequency, start acceleration) Affective: - sharing ideas - criticizing ideas, not individuals
3. – Sprinting and running	23.	/	Cooperative skills, group processing, face-to-face promotive interaction (worksheet)	Physical: - block start - explosive strength, stabilization Affective: - active cooperation - solving problems together
3. – Sprinting and running	24.	Collective Score	all five	Physical: - relays - speed endurance Affective: - insistence, encouraging others
3. – Sprinting and running	25.	PACER	all five	Physical: - running technique - coordination Affective: - insistence, supporting others - active cooperation
3. – Sprinting and running	26.	Learning Teams	all five	Physical: - block start - stride frequency, explosive strength (legs), precision Affective: - focus on task - giving feedback
3. – Sprinting and running	27.	STAD, Collective Score	all five	Physical: - block start - acceleration speed, stabilization Affective: - encouraging others - giving feedback and praise

Unit	Session	Structures	Non-negotiables	Learning goals
3. – Sprinting and running	28.	Jigsaw	all five	Physical: - balance, coordination, agility, strength Affective: - proper communication - sharing ideas - criticizing ideas, not individuals
3. – Sprinting and running	29.	Learning Teams	all five	Physical: - place vortex throw, block start, long jump (refreshing) - explosive strength Affective: - independent individuals - active cooperation - mutual help and support
3. – Sprinting and running	30.	/	all five	Physical: - place vortex throw, block start, long jump (refreshing) - explosive strength, speed Affective: - mutual support - giving praise

Appendix C - Results of the Systematic Event Coding on Cooperative Learning Validation Tool

Category number	Description of category	Percentage of sessions category coded as observed		
1a	Social/emotional goals	75		
1b	Physical/skill goals	100		
1c	Cognitive goals	75		
2	Equitable heterogeneous groups	92		
3	Student centered instruction	75		
4	Teacher facilitator	75		
5	Cooperative learning structure	75		
6	Students have shared ownership	67		
7	Face-to-face promotive interaction	92		
8	Positive interdependence	75		
9	Small group and interpersonal skills	83		
10	Individual accountability	75		
11a	Physical assessment	75		
11b	Cognitive assessment	67		
11c	Social or emotional assessment	100		
12a	Physical improvement	92		
12b	Cognitive improvement	75		
12c	Social or emotional improvement	92		
13	Self, group or peer assessment	100		
14	Students encouraging one another	42		
15a	Group processing – what happened?	100		
15b	Group processing – so what?	100		
15c	Group processing – now what?	100		
		Low	Moderate	High
16	High academically focused time	17	42	42
17	High level of student attention/interest/engagement	0	25	75