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Effects of an implicit-explicit hybrid learning model on handball tactical knowledge

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ABSTRACT

Purpose. This study aimed to analyse the effect of an implicit-explicit hybrid learning model on declarative and procedural tactical knowledge of young school handball players.

Methods. Overall, 30 female handball players (mean age: 13.03 ± 0.75 years) from 2 school teams participated in 25 handball training sessions involving activities focused on both implicit and explicit learning. Declarative knowledge was assessed by using the players' analyses of 15 handball video scenes, while procedural knowledge was assessed by analysing the players' actions during a 3 vs. 3 ball possession game.

Results. The results showed a significant increase in declarative knowledge ($t(23) = -4.228$; $p < 0.001$; $d = 0.863$) but not in procedural knowledge ($p > 0.05$).

Conclusions. We concluded that the Iniciação Esportiva Universal model improved the declarative knowledge of school handball athletes.

Key words: Iniciação Esportiva Universal, instructional model, decision making, small-sided games

Introduction

Team handball is a complex and multi-factorial team sport [1] influenced by physical capacities, as well as technical and tactical skills [2]. During a match, multiple skills are performed, such as displacements, jumps, and throws, in a constantly changing environment with teammates and opponents. Athletes' sport-specific background influences the performance of these skills [3], helping to sustain strength and power during game actions [4]. Nevertheless, skilled performance in team sports requires more than implementing adequate skills, since these skills must be employed to solve multiple problems that emerge from game situations (e.g. overcoming the defence to score a goal). Therefore, tactical knowledge is essential for team sports performance since it affects decision-making during different game situations [5].

The assessment of declarative and procedural tactical knowledge can help understand the decision-making process in sport [5–7], evaluate players' level of expertise, and analyse the impact of teaching models in sport [8]. Current teaching models of sport and physical education such as Teaching Games for Understanding (TGfU) [8] and Sport Education [9] focus on the development of tactical knowledge, providing coaches and teachers with a theoretical support for teaching [10]. TGfU is mainly based on explicit learning because it stimulates the acquisition of declarative knowledge through the tactical analysis of different game situations ('what to do?' and 'why to do?'). The practice of skills (sports techniques – 'how to do?') is implemented when students/athletes need motor improvement to be able to play the game. Several studies showed significantly higher improvements in tactical knowledge by using both TGfU and Sport Education

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compared with traditional (technique-centred) approaches in different sports [11], including handball [12].

Other teaching models, such as the Iniciação Esportiva Universal (IEU; Universal Sports Formation) [13], also focus on the development of tactical knowledge but emphasize implicit learning at the beginning of the teaching-learning-training process, through the development of procedural tactical knowledge during game experimentation. Implicit learning can improve decision-making in less complex sports situations [14], which are more suitable for novices. Therefore, the acquisition of tactical knowledge by novices can be favoured by the teaching models of sport that focus on implicit learning because it requires fewer attention resources, occurs regardless of conscious perception [15], shows higher performance under pressure (e.g. fatigue and dual tasks) [16], and is more time-resistant [17]. With the increase in task complexity, emphasis on explicit learning of game logic should also increase, as declarative knowledge about the action ('if-then') rules can contribute to adequate decision-making during different game situations. Therefore, IEU is a hybrid approach because it is based on the principles of both implicit and explicit learning.

IEU constitutes an extension of the Ball School (Ballschule) implicit learning model [18]. The conceptual framework of IEU was first published in 1998, and it has been discussed and extended since then, with different publications [13, 19]. However, little information is available on the impact of this model on students'/athletes' tactical knowledge. Although Le Noury et al. [20] recommend the use of implicit learning for novices, Raab [7] implies that hybrid models can be better at improving decision-making in comparison with models that focus only on implicit or explicit learning. Fasold et al. [21] also suggest studying the effects of hybrid implicit-explicit models since no studies have investigated the impact of hybrid models on tactical knowledge. The exploration of hybrid teaching models in different sports is crucial to better understand their impact on the learning/training process in specific sports, such as handball. This knowledge can help teachers and coaches plan the teaching-learning-training process.

With the consideration of the abovementioned issues, this study aimed to analyse the effects of handball training programs applying IEU on declarative and procedural tactical knowledge in young school athletes. We hypothesized that both declarative and procedural tactical knowledge would improve.

Material and methods

Participants

A total of 30 female handball players from 2 school teams initially participated in the study (age: 13.03 ± 0.75 years; handball practising experience: 2.00 ± 1.15 years; handball competing experience: 1.69 ± 1.12 years). Five players moved to another school (and therefore left the handball team), and one player dropped out of the study before follow-up owing to an injury. Thus, 24 participants were included in the final analyses. Both squads participated in handball competitions at regional and national levels. All participants only played handball within the school team. One of them was also engaged in the volleyball school team (twice a week).

The coaches of the handball squads had at least 10 years of handball coaching experience and had worked with the participating teams for at least 2 years. Both coaches knew the IEU model and had experience in applying it during training. They also held weekly meetings with the main researcher to discuss the IEU model.

All the procedures, risks, and benefits of participating in the study were explained to the participants and their parents.

Procedures

All the research procedures took place separately within each school, although the same procedures were replicated between the institutions. First, the participants' declarative knowledge was assessed through the analysis of 15 handball game scenes. After each scene, the players were to express the best decision (e.g. passing or shooting) for the player with the ball and justify that decision. This procedure occurred in a quiet room of the school and was supervised by the main researcher.

After 20 days, the subjects underwent the Procedural Tactical Knowledge Test for Sport Orientation (PTKT) [22]. The 3-a-side teams that participated in PTKT were balanced as for the results of the declarative knowledge test. The 6 players with the highest scores in the declarative test were arranged in 2 teams that played against each other, and the 6 players with the lowest scores were arranged in 2 teams that played against each other. A few adjustments were proposed by the coaches with regard to the players' physical characteristics, tactical-technical skills, and playing experience. The PTKT was filmed with a digital cam-

era for further analysis of the participants' procedural tactical knowledge.

The 25 handball training sessions took place 2 or 3 times a week (duration of 120–150 minutes) over the following 12 weeks in accordance with the IEU model. All training interventions were carried out within each squad training facility at their regular training time. At the end of the training intervention, the participants repeated both tests for the assessment of procedural and declarative knowledge. The order of the scenes in the evaluation of declarative knowledge was randomly changed to avoid recognition. For PTKT, the 3-player teams and opponents were kept the same to avoid the influence of opponents on the tactical response [23]. In the PTKT post-intervention test, the participants excluded from the study were substituted by others with similar declarative knowledge who had already completed the post-intervention test.

The IEU model and training sessions

Previous research on teaching models that showed significant changes in tactical knowledge included 17–35 sessions [24, 25], although Miller [26] suggested 10 training sessions for improving tactical knowledge. We held 25 training sessions to assure the inclusion of data of all athletes, despite sporadic absences due to injury or school activities. The coaches of the squads and the main researcher of this study planned the training sessions in accordance with the IEU model. Although the coaches had previous experience with IEU, they were instructed to study the model by assessing available books [19] and articles [13] on this topic. Subsequently, the coaches and the researcher studied and discussed the model before the training intervention. In addition, the researcher supported the coaches throughout the whole data collection process in questions related to the IEU model. The sessions were filmed for further analysis of the training content (3 sessions could not be recorded owing to technical problems with the digital camera).

The IEU model proposes the use of games for developing intelligence and creativity (GICs), general and specific small-sided games (SSGs), and motor coordination and general technical skills training. For tactical training, this model defines SSGs as game situations that decrease the tactical complexity but keep the formal game logic [13]. General SSGs in the model include numerical equality (e.g. 1 vs. 1), numerical superiority (e.g. 2 vs. 1), and situations with floater players (e.g. 1 vs. 1 + 1). The floater is used to help players in offence but cannot score to keep the possibility that the defending team adopts a man-marking strategy. These general SSGs are similar to the game structures used by children during play and may be associated with the 'deliberate play' proposed by Côté and Hancock [27]. These SSGs can be modified by the coach (e.g. pitch size, rules) to emphasize the implicit learning of general tactical principles of team sports. The model also recommends the use of specific SSGs for 12-year-old or older players, as they represent sport-specific game situations (e.g. game positions in handball: wings, centre back) that focus on individual and group tactical actions (in both defence and offence). Finally, GICs also resemble popular games and contain general elements of team sports (offence, defence, fast breaks), but they increase the distribution of attentional resources and stimulate the use of creativity to solve tactical problems.

The technical skills training in this model is based on the development of motor coordination (especially for players aged 6–12 years), which provides the basis for learning sport-specific techniques [13] and is essential for sports performance [28]. Therefore, the development of motor coordination should occur before skill specialization through activities that involve general sports skills (passing, receiving, and shooting) in contexts with sport-related pressures such as time, precision, and simultaneity.

Table 1 describes a typical training session including the types of activities proposed by the IEU model.

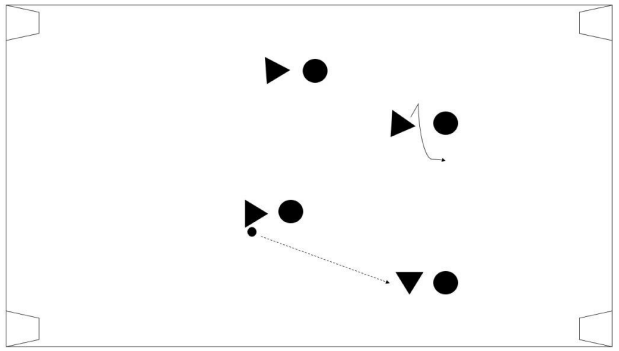
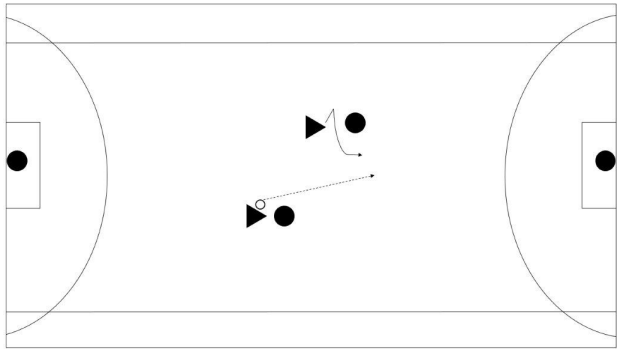
During the intervention period, both coaches focused mainly on specific SSGs with explicit learning of action rules because the athletes already had experience in handball. The 3 vs. 3 SSG was frequently used by both coaches because it was the smallest format that allowed performing all handball group tactical actions, such as screening, crossing, and successive penetrations. These tactical actions were also the main contents to be developed during the season. Figure 1 shows the distribution of contents over the training sessions using the IEU model.

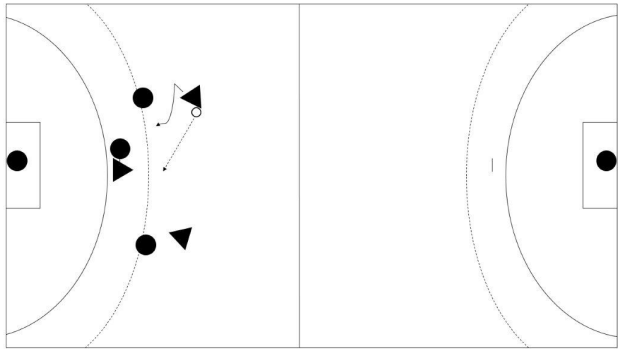
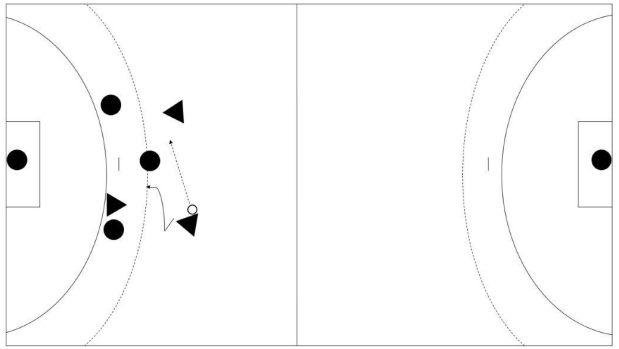
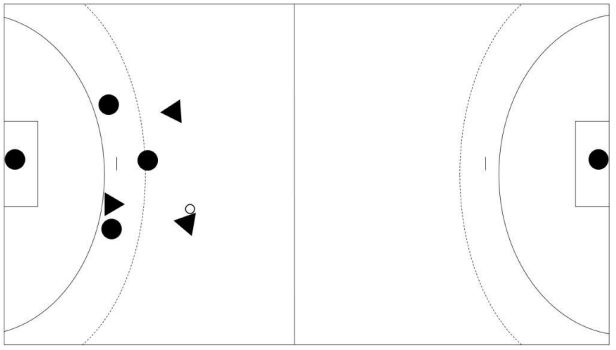
Instruments

Assessment of procedural tactical knowledge

PTKT is a test performed in a game-based context in which two 3-player teams play on a 9 × 9 m area (half volleyball court); it lasts for 4 minutes [22]. The team in offence aims to maintain ball possession by passing the ball among teammates; dribbling is allowed but discouraged. The other rules were the same as the basic handball rules (e.g. only 3 steps allowed without

Table 1. Example of a typical training session of intervention using the Iniciação Esportiva Universal model

Activity	Description	Illustration of activity on the handball court
GIC: endzone	The team in the offence should take the ball to the opponents' end line (limited by the cones) and put it on the ground. Passes should be made with both hands and above the head (as in the 'throw in' in soccer). Tactical aim: create/obstruct passing lines, overcome/defend the direct opponent (with and without the ball), progress/avoid progressing rapidly to the target.	
Skills and coordination	1. Players should hold a ball at their back and throw it towards their front (above head) while walking straight. 2. Players should pass the ball between hands under one raised leg while alternating the leg that is raised. 3. Zig-zag displacement in a defensive position while dribbling the ball. Must switch the direction and the dribbling hand every 2 steps.	Pressure conditions: 1. simultaneity, precision 2. simultaneity 3. simultaneity, sequence precision
General SSGs: 2 vs. 2	Two players in offence play against 2 players in defence within the space indicated by the lines. If the defenders recover ball possession or after a shot on goal, the team in defence should perform a fast break (without opposition) and shoot on goal on the opposite side. Tactical aim: create/obstruct passing lines, overcome/defend the direct opponent (with and without the ball), progress/avoid progressing rapidly to the target.	

Specific SSGs: 3 vs. 3 without goalkeepers	One defender in the first defensive line and 2 defenders in the second defensive line. The team in offence plays with 2 back players and 1 pivot. If the defenders recover ball possession or after a shot on goal, the team in defence must perform a fast break without opposition and shoot on goal on the opposite side. Tactical aim: attack against modified 3–3 defence, create momentary numerical superiority with the pivot. Relevant cues: screen side and movement of the pivot, the distance between the defender and the attacker, the distance between the defender and the goal area, and teammates overcome by the opponent (defensive covering/supporting).	
Specific SSGs: 3 vs. 3 without goalkeepers	Two defenders in the first defensive line and 1 defender in the second defensive line. The team in offence plays with 2 back players and 1 pivot. If the defenders recover ball possession or after a shot on goal, the team in defence must perform a fast break without opposition and shoot on goal on the opposite side. Tactical aim: attack against a 5–1 defence, create momentary numerical superiority with the pivot. Relevant cues: screen side and movement of the pivot, the position of the pivot's defender (back, front), the distance between the defender and the attacker, the distance between the defender and the goal area, and teammates overcome by the opponent (defensive covering/supporting).	
Specific SSGs: 3 vs. 3 with goalkeepers	Similar to the formal game, but the throw-off is performed by the goalkeepers after a scored goal. Players can change game positions to 3 back players. Tactical aim: practice the relation between back players and pivot in a situation similar to the formal game, anticipate the fast break. Relevant cues: screen side and movement of the pivot, the position of the pivot's defender (back, front), the moment of the attack shots, the distance between the defender and the attacker, the distance between the defender and the goal area, and teammates overcome by the opponent (defensive covering/supporting).	

GIC – game for developing intelligence and creativity, SSGs – small-sided games, triangles – players in offence, full circles – players in defence or goalkeeper, black and white circles – ball, dashed line – ball trajectory, full line – player trajectory

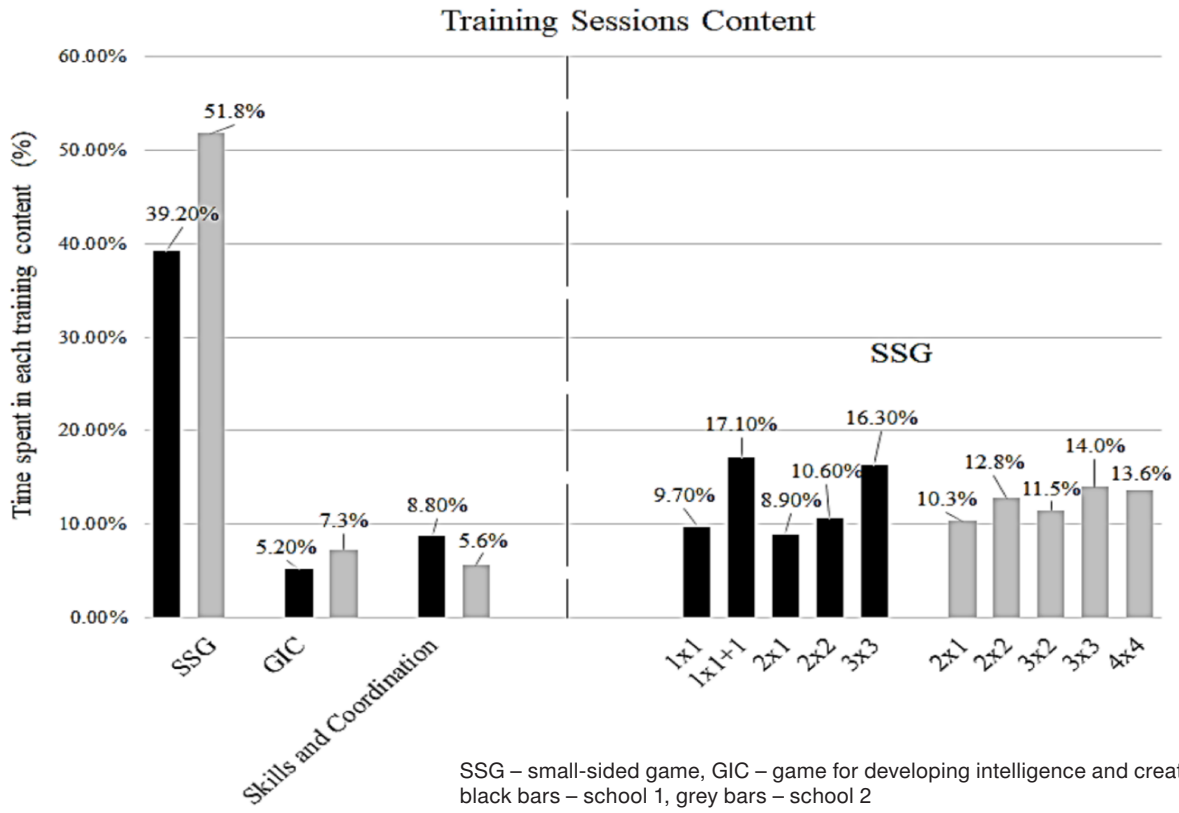


Figure 1. Distribution of training contents over the training interventions

dribbling, not pushing/pulling the opponent). When the ball went out of the game area, it was quickly put back into play from the sidelines. The passes for returning the ball into play were not allowed to be intercepted by the defence. If the team in defence recovered ball possession (intercepting passes or stealing the ball during dribbling), they immediately started the offence. No technical or tactical instructions were provided during the test. The players were encouraged to count the number of passes performed to maintain a high level of motivation.

The tests were filmed with a digital camera for further analysis of the frequencies of tactical actions that characterized the procedural tactical knowledge: (1) 'Player moves around the playing area to receive the ball'; (2) 'Player passes the ball to a free teammate and prepares to receive the ball again'; (3) 'Player supports her teammates in defence (defensive covering) when they are overcome by the opponent'; (4) 'Player supports a teammate in defence when the opponent has difficulty controlling the ball'; (5) 'Player follows and disturbs the opponent'; and (6) 'Player induces the opponent to the corners of the playing area'. The individual scores for each tactical action were determined by 2 observers who analysed the videos of the test.

Assessment of declarative tactical knowledge

Declarative tactical knowledge was assessed through the analysis of 15 handball game scenes extracted from professional male and female international competitions, similarly as performed by Ribeiro et al. [29]. These scenes went through content validation procedures by the evaluation by 3 experts. The validation of the scenes included 4 components: content validity (content validity coefficient), language clarity, and theoretical and practical relevance. The results for each component showed scores above 0.80. The video scenes allowed viewing all players from the top and referred to an offensive situation. They lasted for 4–9 seconds and froze for 3 seconds. The participants were familiarized with the test by analysing 3 sample scenes. At this moment, they could clarify any doubts regarding the test. After the scene froze, the participant had to (as quickly as possible) verbally express the best decision (e.g. passing or shooting) for the player with the ball and provide reasons for her choice. The answers were recorded with a digital recorder and compared with an answer key built by 3 experts (handball coaches with more than 10 years of experience). The score in each scene varied between 0 and 5, totalling 75 points, in accordance with the following criteria: 0 points, if the decision

and the reasons were inadequate; 1 point, if the decision was adequate but the reasons were inadequate; 2 points, if the decision was inadequate but the reasons were partially adequate; 3 points, if the decision was adequate and the reasons were partially adequate; 4 points, if the decision was inadequate but the reasons were adequate; and 5 points, if both the decision and the reasons were adequate.

Statistical analysis

Data from both teams were treated together. The scores related to declarative tactical knowledge are described as mean and standard deviation. The frequency of actions performed in PTKT is described as median and interquartile range. The parametric assumption of data related to declarative and procedural knowledge was tested by using the Shapiro-Wilk (normality) test. Data from the declarative knowledge test followed a normal distribution and pre- and post-intervention test scores were compared by using paired *t*-tests and Cohen's *d* effect size. The *d* effect sizes were classified as small (d = 0.2), medium (d = 0.5), or large (d = 0.8) [30]. The PTKT data did not meet parametric assumptions and the frequencies of actions related to procedural knowledge were compared between pre- and post-intervention tests by using the Wilcoxon signed-rank test and Pearson's *r* effect size, classified as small (r = 0.1), medium (r = 0.3), or large (r = 0.5) [30]. Statistical analyses were performed with the SPSS 19.0 software, except for effect sizes, which were calculated by using the Excel 2013 software. The level of statistical significance was set at 5%.

The between-observer reliability and within-observer reliability of the frequencies of tactical actions during PTKT were verified with the intraclass correlation coefficient ($ICC_{2,1}$). For within-observer reliability, the main observer repeated 10% of the analyses 21 days after the first analysis. For between-observer reliability, 2 observers performed all analyses. The ICC values of both analyses were 0.94.

Ethical approval

The research related to human use has complied with all the relevant national regulations and institutional policies, has followed the tenets of the Declaration of Helsinki, and has been approved by the Universidade Federal de Minas Gerais ethics committee (CAAE: 86435518.6.0000.5149).

Informed consent

Informed consent has been obtained from all individuals included in this study and their legal guardians.

Results

Table 2 shows the comparisons between pre- and post-intervention test results for declarative and procedural tactical knowledge. The scores related to declarative knowledge and the frequency of actions of defensive support when a teammate was overcome by

Table 2. Declarative and procedural tactical knowledge before and after the training intervention using the Iniciação Esportiva Universal model

Variable	Before	After	$t(23)$	p	Effect size
Score in declarative knowledge (points)	29.25 ± 9.65	36.29 ± 8.61	–4.228	< 0.001	d = 0.863
Frequency of tactical actions characterizing procedural knowledge					
1. 'Player moves around the playing area to receive the ball'	14.00 (10.12–18.00)	14.25 (11.00–19.37)	–0.872	0.383	r = 0.125
2. 'Player passes the ball to a free teammate and prepares to receive the ball again'	3.50 (1.00–6.00)	3.50 (1.12–6.37)	–0.331	0.741	r = 0.047
3. 'Player supports her teammates in defence (defensive covering) when they are overcome by the opponent'	0.00 (0.00–0.50)	0.50 (0.00–1.00)	–2.040	0.041	r = 0.294
4. 'Player supports a teammate in defence when the opponent has difficulty controlling the ball'	0.00 (0.00–0.50)	0.00 (0.00–0.50)	–0.262	0.788	r = 0.179
5. 'Player follows and disturbs the opponent'	5.25 (2.75–6.85)	5.25 (4.00–8.12)	–1.245	0.213	r = 0.038
6. 'Player induces the opponent to the corners of the playing area'	1.00 (0.50–2.00)	0.75 (0.50–1.37)	–1.173	0.075	r = 0.257

d – Cohen's *d* effect size, *r* – Pearson's *r* effect size

the opponent (item 3 of PTKT) significantly increased between the pre- and the post-intervention test. The frequency of the other actions related to procedural tactical knowledge did not change significantly.

The score related to declarative tactical knowledge is described as means and standard deviations. The frequencies of actions performed in the Procedural Tactical Knowledge Test are described as medians and interquartile ranges.

Discussion

This study aimed to verify the effect of handball training programs using the IEU model on the declarative and procedural tactical knowledge of young school handball athletes. We expected both declarative and procedural knowledge to increase after the training program. The results partially confirmed our hypotheses since declarative knowledge significantly increased, but only one tactical action related to procedural knowledge improved.

The increase in declarative knowledge found in this study is in line with the results of previous research on the effects of training programs that focused on the development of tactical knowledge in team sports [25]. In this study, the regular use of specific SSGs may support the increase in declarative knowledge, since this type of game emphasizes explicit learning and deliberate decision-making [7]. The coach directs players' attention to the relevant cues for adequate decision-making, depending on the different game situations experienced through specific SSGs. This helped players to create the action rules for the game (e.g. 'if-then' rules, if the defender of the pivot stops marking the pivot to support the defender of the centre back, then pass to the pivot). The explicit stimulus to observe and create solutions to tactical problems helps players to attach or add significance to each game situation [25, 31] and make adequate tactical decisions.

Only one action related to procedural tactical knowledge significantly improved after the training programs using the IEU model ('Player supports her teammates in defence (defensive covering) when they are overcome by the opponent'). However, we believe that this improvement does not represent a practical significance (pre-intervention test median frequency = 0.0; post-intervention test median frequency = 0.5). We expected procedural tactical knowledge to be mainly stimulated by tasks that involved implicit learning of action rules, such as GIC and general SSGs. This type of activity presents situations with high unpredictability and variability [13, 32], which may favour intuitive decision-making. The small percentage of training time spent in general SSGs, as well as in GIC (5.20% and 7.3% in teams 1 and 2, respectively), and most of the training time spent in specific SSGs may explain the small improvement in procedural tactical knowledge. The results of the present study are different from previous results that showed increases in procedural tactical knowledge in team sports after training programs [31, 33]. Práxedes et al. [31] emphasize the importance of providing implicit learning to players. In addition, it is suggested that excessive stimulation of explicit learning may impair the improvement of tactical knowledge [33]. It is possible that a higher percentage of tasks (GIC and general SSGs) that stimulated the development of procedural tactical knowledge could have led to greater improvements, but this hypothesis needs to be tested.

In the present study, the participants were older (mean age: 13 years) than those in previous studies (mean age: 10–12 years) [11, 31, 34] and sometimes more experienced [11], possibly presenting a higher level of procedural tactical knowledge. Although we used a longer training period compared with other studies in the literature, an even longer intervention may be necessary to improve the procedural tactical knowledge of players with higher levels of knowledge (i.e. turn declarative into procedural knowledge).

In general, our results suggest that the IEU model can improve the declarative tactical knowledge of school athletes. Considering the advantages of implicit learning such as robustness [16] and durability [17], the transition from implicit to explicit learning of action rules by using specific SSGs should be made with caution by coaches, especially at an early age, when the game situations are less complex and players can develop their tactical creativity. Therefore, as a practical implication, we recommend coaches to emphasize GIC and general SSGs to stimulate implicit decision-making in the youth handball teaching-learning process.

One limitation of this study is the absence of a retention test, which could indicate the durability of the improvements in declarative tactical knowledge after the training programs. Future studies should include a retention test and apply the IEU model over a longer period. Another limitation of the present study is the sample size. In addition to the 6 players that dropped out of the study, the small sample is associated with the characteristics of local school teams, in which few athletes represent schools in competitions. Further studies should also apply IEU to a larger number of participants, and with different ages and levels of expe-

rience. Finally, future research should develop specific tests for handball tactical knowledge, as has been done in other team sports, such as soccer [35]. Testing the effects of spending different amounts of time on activities focused on implicit and explicit tactical learning could also bring new insights into the distribution of training contents during the teaching-learning-training process of team sports and their contribution to the development of each type of tactical knowledge.

Conclusions

IEU, a teaching model based on hybridizing the implicit and explicit learning processes, improves the declarative knowledge of school handball athletes. Further investigation is needed to verify the impact of the model on procedural knowledge depending on age and level of experience.

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Disclosure statement

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Conflict of interest

The authors state no conflict of interest.

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