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Application of tactical optimization model and decision-making strategy in football teaching practice

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The primary objective of this scholarly article is to assess the effectiveness of implementing the tactical optimization model and decision-making strategy in the context of football coaching environments. The study involved the participation of 120 boys from a school in China, enrolled in grades 7–9, and actively engaged in a football program, with an average age of 13.8 years (SD = 1.26). Two subscales from the Tactical-technical and Social Competencies of Football Players Scale (TTSCS) and four subscales from the Melbourne Decision-Making Questionnaire (MDMQ) were employed in the research. The study revealed that the tactical optimization model and decision-making strategy in football empirically substantiated their effectiveness. The intervention group demonstrated improvements in attacking tactical-technical competencies (ATTC) by 10.03 and defensive (DTTC) by 11.35 compared to the control group, where statistically significant changes amounted to only 2.16 in the DTTC subscale. In the decision-making domain within the intervention group, a statistically significant increase in vigilance by 2.92 was noted, while other subscales decreased: hypervigilance by 3.75, transfer of responsibility, and procrastination by 3.45, indicating enhancements.

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Introduction

Football, aside from being a globally beloved sport, plays a pivotal role in the educational paradigm, particularly within middle school programs, contributing not only to physical prowess but also honing strategic thinking and decision-making skills (Ndlovu et al., 2020). Traditional football teaching methodologies in schools have undergone significant evolution, adapting to the changing dynamics of both sporting and educational needs. However, the potential for optimizing these methods remains underexplored, especially when considering them through the lens of tactical complexity and strategic decision-making (García-Ceberino et al., 2020a). Worldwide, the approach to football education significantly varies under the influence of cultural, infrastructural, and pedagogical factors (Barrero, 2023; Puente-Maxera et al., 2020). In many Western countries, a pronounced emphasis is placed on the physical aspects of the game, sometimes neglecting tactical components in early training (Kelly and Williams, 2020). In contrast, in Latin American countries, for instance, there exists a distinct approach to mastering tactics and intuition, encompassing a comprehensive approach to football teaching methods (Borges et al., 2019). While numerous diverse methodologies, though effective in isolation, often lack a structured approach to tactical optimization and decision-making strategies (Pill et al., 2024; Teoldo et al., 2021).

The recent surge in the development of football in China serves as a unique example. Due to a systematic approach to sports education, Chinese schools have incorporated a more tactical and reasoned curriculum into football training (Peng et al., 2019; Zhang (2020)). This cognitive-oriented method provides students with a deeper understanding of game tactics and decision-making processes, signifying a significant departure from traditional methods that combine physical training with skill refinement (Liang, 2020). However, in comparison to global practices, the Chinese methodology, although innovative, exhibits certain limitations: despite its tactical orientation, the approach often lacks the flexibility and adaptability observed in more authoritative football nations (Dai, 2022). It has also been noted that the balance between physical and tactical preparation is not always effectively maintained, and these differences create a fertile ground for exploring a more comprehensive approach to football education (Peng et al., 2022). The strengths of existing methodologies lie in their focus on specific aspects of football—physical endurance, technical skills, or tactical awareness (Liu, Ma (2022)). Nevertheless, the weaknesses of various methodologies are vividly expressed in the absence of a comprehensive structure that would seamlessly integrate these elements. This is particularly evident in the insufficient emphasis on real-time decision-making strategy and the adaptive application of tactics in different game situations (Silva et al., 2020).

Identifying existing gaps in knowledge and practice, the current study proposes a model of tactical optimization intricately interwoven with a strategic decision-making system, tailored for football education in middle schools in China. It aims to address current limitations by providing a structured yet flexible approach to football education that equally emphasizes physical skills, tactical knowledge, and decision-making proficiency. The relevance of this research lies in its potential to shift football teaching methodologies, making them more comprehensive, adaptive, and effective in cultivating multifaceted football intelligence among young athletes. The study presents an innovative model of tactical optimization and decision-making strategy in football education, promising significant implications. The integration of tactical and cognitive components in training enhances the effectiveness of player preparation. However, existing models seldom combine these aspects into a unified, structured methodology tailored for adolescents. The present work aims to address this gap by proposing a model that simultaneously develops tactical skills and decision-making abilities, thereby laying the foundation for a more comprehensive approach to training in sports schools. From a scholarly perspective, the article contributes to the literature on sports education, laying the groundwork for future research on integrating cognitive and physical skills into practical sports training. The flexibility of the proposed model is expected to allow its application in various contexts, including middle education, sports academies, and coaching programs. Additionally, the article offers insights into effective pedagogical approaches for developing complex skills relevant to both sports and broader educational contexts.

Literature review

The reform of Chinese football. The reform of Chinese football in 2015 marked a fundamental shift in the country's approach to the sport, propelled by governmental initiatives aimed at elevating national standards in this domain (Peng et al., 2019). The primary objective of the reform is to cultivate a robust football culture and enhance the overall quality and performance of players both at the domestic and international levels (Qi et al., 2023). This ambitious project also encompassed the integration of football into the national educational curriculum to nurture a new generation of players with exceptional skills and tactical understanding. The impact of the reform is evident in the increased participation levels in youth football and the enhanced performance of Chinese players on international stages (Peng et al., 2019). In the context of such reform and the growing interest in football, there is a heightened need for the development or refinement of models that would contribute to the development of the most crucial components of successful football education, particularly tactics and decision-making strategies.

Tactical optimization in football. Tactics in football encompass the strategies and game plans utilized by a team to secure victories, involving team formation, player roles, and in-game adjustments (Teoldo et al., 2021). It involves planned actions and strategies employed by a team to win matches: formations, player roles, playing styles, and in-game adjustments, all of which are crucial for creating goal-scoring opportunities while minimizing the opponent's chances (García-Ceberino et al., 2020b; González-Rodenas et al., 2023). Simultaneously, tactical optimization in football is the process of refining these strategies to maximize team efficiency, often involving in-depth data analysis and player-specific tactics (Wang, 2023). To enhance tactical optimization, teams employ sophisticated data analytics to understand performance and identify areas for improvement. Regular training focused on tactical drills, and scenario-based learning is essential to improve decision-making processes and enhance adaptability (Beal et al., (2020); Teoldo et al., 2017). The flexibility in tactics is of paramount importance, enabling adaptation to different opponents and game situations. Additionally, continuous coach training and feedback systems for players and staff are crucial for refining and developing tactical approaches in the dynamic world of football (Caicedo-Parada et al., 2020; Karpa et al., 2021).

Decision-making strategies. Decision-making strategy in football is the process through which players determine their actions on the field, such as passing, shooting, or choosing a position, which is crucial for influencing the game's outcome (Roca and Ford, 2020). Improving this skill involves a combination of teaching methods and cognitive development, and specific exercises replicating match conditions are pivotal in training as they enhance a player's ability to make quick and effective decisions

under pressure (Silva et al., 2020). Video analysis of games provides valuable information about decision-making during matches, helping players and coaches understand and draw lessons from past decisions (Natsuhara et al., 2020). Cognitive exercises aimed at improving perception, concentration, and anticipation can significantly enhance the speed and accuracy of decision-making. A deep understanding of team tactics and individual roles is also vital as it provides the necessary context for making informed decisions (Silva et al., 2020; Staiano et al., 2022). Furthermore, regular gameplay experience combined with constructive feedback and effective team communication is foundational for refining these player abilities (Kent et al., 2022).

Thus, the application of the tactical optimization model and decision-making strategy in football education, including at the middle school level, holds profound implications for the development of skilled and tactically prepared players (Beal et al., (2020)). There is evidence suggesting that introducing tactical models at a young age helps deepen the understanding of the game, leading to more intuitive and strategic play (Machado et al., 2020). Moreover, the model proposed in this study is not solely focused on improving physical skills but also emphasizes cognitive aspects. This dual approach is supported by research asserting that teaching tactics alongside physical skills results in more comprehensive development of young players, whereas a focus solely on technical skills may lead to a loss of players' interest (Slaidins and Fernate, 2021; Thompson et al., 2022). Furthermore, the integration of decision-making strategies into training significantly enhances on-field performance, as players become better prepared to navigate real-game scenarios (Miller-Dicks and Upton, 2016). It is assumed that the implementation of models similar to the current one in a structured educational environment could create favorable conditions for nurturing talent overall, potentially leading to future successes both domestically and internationally in the realm of football.

The existing literature on tactical optimization and decision-making strategies in sports education demonstrates a significant interest in these topics; however, notable gaps remain. Most studies examine tactical optimization and decision-making strategies in isolation, failing to integrate these components into a cohesive model. This study aims to address this gap by proposing a comprehensive model that enhances the training of football players (Teoldo et al., 2021; Silva et al., 2020; Korniichuk et al., 2021). Contemporary research predominantly focuses on professional or semi-professional athletes, leaving the area of adolescent football education underexplored (Peng et al., 2019; García-Ceberino et al., 2020a). This work addresses this gap by presenting an adapted model for training adolescents, which is crucial for the development of future football talents. The methodological foundation of this research also diverges from previous studies. The use of quantitative analytical methods allows for an objective assessment of the model's effectiveness, contrasting with the qualitative or mixed methods employed in most prior research (Dai, 2022; Pill et al., 2024; Spaska et al., 2021).

Gaps in the literature and innovation of the study. The existing literature on tactical optimization and decision-making strategies in sports education demonstrates significant interest in these topics; however, there remain notable gaps. Most studies examine tactical optimization and decision-making strategies separately, without integrating these components into a unified model (Silva et al., 2020; Teoldo et al., 2021). This study aims to address these aspects by proposing a comprehensive model that enhances the training of football players. Contemporary research (García-Ceberino et al., 2020a; Peng et al., 2019) predominantly focuses on professional or semi-professional athletes, leaving the area of adolescent football education underexplored. This work addresses this gap by presenting an adapted model for training adolescents, which is crucial for the development of future football talents. The methodological foundation of this research also distinguishes itself from previous studies, as the use of quantitative analytical methods allows for an objective assessment of the model's effectiveness, in contrast to the qualitative or mixed methods employed in most prior research (Dai, 2022; Pill et al., 2024). The innovation of this article lies in its practical significance. The theoretical justification of the model is combined with its practical implementation, enabling an evaluation of the model's impact on actual training processes and athlete outcomes. This provides coaches and educators with specific tools and methodologies for improving the educational process.

The innovation of this article lies in its practical significance. The theoretical justification of the model is complemented by its practical implementation, enabling an evaluation of the model's impact on actual training processes and athlete outcomes (Beal et al., (2020); Wang, 2023). This provides coaches and educators with specific tools and methodologies for enhancing the educational process.

Research tasks

The primary objective of this scientific article is to assess the effectiveness of implementing a model of tactical optimization and decision-making strategy within the context of a football coaching environment. This goal is centered on the introduction and evaluation of a novel integrated coaching framework that combines tactical awareness and strategic decision-making skills among young athletes. The primary objectives of the research include:

1. Evaluating the effectiveness of the intervention program by comparing the results of pre-tests and post-tests between the experimental and control groups.
2. Analyzing intragroup differences to assess the impact of the intervention on tactical knowledge and decision-making strategies.
3. Confirming or refuting the hypothesis that the tactical optimization model and decision-making strategy contribute to improved performance outcomes compared to the control group.

Focusing specifically on a particular middle school in China, the article aims to provide a detailed illustration of how these models can be applied in a real educational setting. A crucial aspect involves highlighting the benefits of the tactical optimization model and decision-making strategy, encompassing the demonstration of how these methods enhance players' tactical understanding, their ability to make decisions on the field, and overall football performance. Moreover, it is essential to contribute valuable insights to the field of sports education and coaching by presenting scientifically substantiated conclusions that confirm the effectiveness of integrating tactical optimization and decision-making strategies into football teaching practices. The outcomes of this research are intended to serve as a model for similar educational institutions and coaching environments, both in China and internationally.

Methods and materials

Instruments used in the study. The study employed two subscales from the Tactical-technical and Social Competencies of Football Players Scale (TTSCS) (Ivanišević et al., 2017). The first subscale assessed attacking tactical-technical competencies (ATTC), comprising 17 items (e.g., "I receive and control the ball

under opponent pressure"). The second subscale evaluated defensive tactical-technical competencies (DTTC), consisting of 14 items (e.g., "I recognize the moment to intercept the ball and react accordingly"). Participants were required to self-assess their skill levels for each item on a scale ranging from 1 to 7 (where 1 indicated poor performance and 7 denoted excellent task execution). The results were calculated by summing the responses to each item on the scale. The derived overall score was utilized to evaluate the proficiency level of competencies such as attacking or defensive tactical-technical skills within the TTSCS framework. This instrument is suitable for football players across various age groups, including adolescents and young adults (Ivanišević et al., 2017).

In the current study, the Melbourne Decision-Making Questionnaire (MDMQ) was utilized to measure decision-making skills (Mann et al., 1997), a tool previously employed in the context of football, including with adolescents (Cardona Isaza et al., 2021; Gülle et al., 2017; Ishak et al., 2023). The MDMQ delineates the decision-making process into four approaches: Vigilance—assessing the process of effective decision-making, encompassing goal identification, information gathering, alternative weighing, and alternative checking, comprising six items (e.g., "I consider how best to make a decision"); Hypervigilance—focusing on sensing strong pressure during decision-making, consisting of five items (e.g., "I feel as though I am under immense pressure when making decisions"); Buck-passing—related to avoiding decision-making, incorporating six items (e.g., "I avoid making decisions"); Procrastination—evaluating the procrastination of decision-making, including five items (e.g., "I postpone decision-making"). Respondents answer football-related questions using one of three options: "True for me" (2 points), "Sometimes true" (1 point), and "Not true for me" (0 points). Scores for each item are separately summed for each subscale to assess respondents' attitudes toward different aspects of decision-making. A higher score indicates a more pronounced expression of a particular subscale. The MDMQ is applicable across a wide range of age groups, encompassing adults and older adolescents, as it evaluates general decision-making skills relevant to various age categories (Cardona Isaza et al., 2021; Gülle et al., 2017; Ishak et al., 2023), rendering it a suitable instrument.

Adaptation of instruments to the Chinese context. To adapt the two subscales, TTSCS and MDMQ, to the conditions of a Chinese secondary school, a comprehensive process was undertaken, commencing with the translation of the instruments into the Chinese language. The school is located in one of the southern provinces, in its capital, and features modern sports facilities, including football fields and training halls. It educates ~3000 students, of whom about 200 are actively involved in football as part of the sports program. The school actively supports sports education by integrating it into the overall curriculum and providing students with opportunities to participate in various competitions. Professional translators familiar with psychological and sports terminology performed this translation. Subsequently, an independent translator unfamiliar with the original version translated the text into English. This procedure ensured the accuracy of the translation while preserving the initial meaning of the instruments. Following the translation, experts in psychometrics and specialists in football and sports psychology analyzed the adapted versions. This step helped ascertain that the instruments aligned with the cultural context and specificities of the target audience. Next, pilot testing was conducted with a small group of participants ($n = 25$) from the target audience to provide an initial assessment of the comprehensibility and acceptability of the instruments.

Subsequent steps involved the verification and validation of the instruments, which included an assessment of criterion validity and construct validity. Additionally, an evaluation of the reliability of the instruments was conducted, assessing the stability of results and analyzing internal consistency using Cronbach's alpha, yielding favorable results ranging from 0.86 to 0.91. Exploratory and confirmatory factor analyses were performed to scrutinize the structure of the measured constructs in the context of Chinese culture and the educational system. Based on the obtained data, adjustments to the instruments were anticipated to address any mismatches or ambiguities, but none were found. The entire multi-stage process ensured that the adapted instruments precisely and effectively measured the relevant variables.

Development of a tactical optimization model and decision-making strategy. To successfully implement the research, a new and integrated model of tactical optimization and decision-making strategy was developed, aimed at enhancing the football training process. In the current study, it is viewed as an approach to enhance the quality of training through the structured incorporation of tactical and cognitive elements into the training process. However, it is important to clarify that this model does not constitute a mathematical optimization model in the strict sense, as it does not include objective functions or constraints, which are characteristic of optimization models in mathematics and statistics. Here, "optimization" refers to the improvement and adaptation of training methodologies to achieve higher levels of tactical and technical preparation, as well as the enhancement of decision-making skills among participants. Rather than employing mathematical optimization techniques, the model emphasizes the integration of various training and analytical methods that facilitate the improvement of tactical skills and decision-making abilities. In this context, "optimization" is understood within the framework of pedagogy and sports training, focusing on creating more effective learning conditions rather than finding optimal solutions through quantitative methods. This model is based on existing theoretical concepts and practical approaches to football training. The key aspects were selected based on a review of literature and consultations with experts in sports education. These aspects include:

1. Analysis of game behavior.
   Incorporating an analysis of players' game behavior allows for the identification of typical tactical errors and areas for improvement. This component was selected based on studies indicating that understanding common mistakes contributes to more targeted training (Dunton et al., 2020; Ferguson et al., 2023).
2. Assessment of decision-making.
   The importance of assessing decision-making in football is emphasized by numerous studies highlighting the need for training in quick and effective decision-making during gameplay (Calle-Jaramillo et al., 2023). This aspect was included in the model to enhance players' cognitive skills.
3. Development of training scenarios.
   Drawing on best practices in sports training, the development of training scenarios allows for the simulation of game situations and the practice of tactical actions in conditions similar to real-life scenarios. This component was chosen due to its high effectiveness in player preparation (Nicholson et al., 2022).
4. Monitoring and feedback.

Continuous monitoring of players' progress and providing feedback are key elements of successful training. The inclusion of

this aspect in the model is based on evidence that regular feedback enhances training outcomes (Ryan et al., 2020).

The development of the model involved several stages. Initially, a comprehensive review of existing literature and practical approaches was conducted to identify the key components of the model. Both theoretical and practical research were examined, and consultations were held with coaches and experts in football education. Based on the collected data, the primary components of the model were selected. The selection process involved evaluating the relevance of each component and its potential contribution to improving the training process. A framework for integrating the selected components into a unified model was developed. Interconnections between the components were identified, and methods for their combined use to achieve maximum effect were determined. The model was tested under real training conditions to assess its effectiveness and make necessary adjustments. Additionally, the testing process included quantitative data analysis and feedback collection from participants and coaches. Each component of the model was carefully justified and integrated into the overall training process, resulting in a comprehensive and effective training system. The framework of the model is illustrated below to visualize the relationships between its elements and to better explain their interaction (Fig. 1).

Participants

The study involved 120 boys from a school in China, enrolled in grades 7 to 9 and participating in the school's football section, with an average age of 13.8 years (SD = 1.26). All students in this secondary school football section were invited to participate, and those children who expressed voluntary interest were included. Additionally, written consent was obtained from their parents. Throughout the study, there were no indications from any participants expressing a wish to discontinue their participation prematurely. Additional comprehensive details regarding participants from the three classes are presented in Table 1.

The majority of participants already had specializations in football positions, including defenders, midfielders, forwards, and goalkeepers. However, there was still some flexibility in positions; coaches could determine where students could best demonstrate their abilities and, accordingly, assign them to specialized roles.

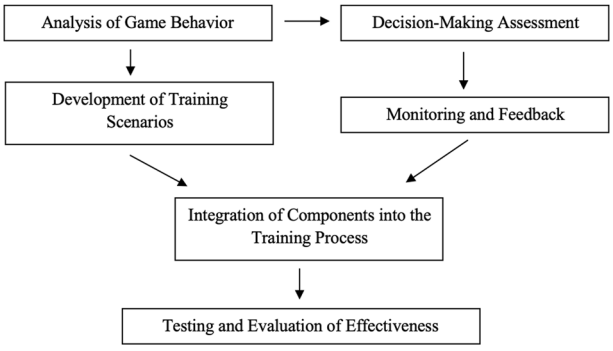

Fig. 1 Structure of the current model.

Therefore, in the current study, participants were not divided based on the criterion of "positions." All participants were randomly assigned to control and intervention groups in equal proportions based on the number of participants in their respective classes.

Study design

Model integration. In the current study, a model of tactical optimization and decision-making strategy was employed in the practice of teaching football. This model was developed by the contributing researchers based on their knowledge and experiences and further refined through consultations with numerous experts in the field. The creation of a comprehensive model for tactical optimization and decision-making strategy in school football coaching demanded meticulous planning and organization. Additionally, the Hudl Replay program was utilized, enabling coaches and analysts to analyze key game situations and make real-time decisions, as well as revisit game scenarios later on (Butterworth, 2023). It was incorporated as part of the coaching strategy in school football, aiming to assist coaches, their assistants, and players in implementing the current model. Various aspects of the coaching process, including programs, tools, and player information retrieval means, along with more detailed information describing the model (albeit not its complete version, due to character constraints in this article), are presented in Table 2.

Study duration and participant procedures. The study was conducted from October 2022 to May 2023. Participants completed the TTSCS and MDMQ, provided to them electronically, and were instructed to respond to the questions according to the instructions. The allotted time for completion was 20 min. At the end of the study, all participants refilled the TTSCS and MDMQ in the same electronic forms. The presented model was implemented in the influence group, while the control group continued practicing the traditional approach to football. This involved studying various game strategies, tactics, and proper positioning on the field. Physical training included developing endurance, speed, and flexibility, with regular control and friendly matches allowing students to apply knowledge in real game situations, enhancing their practical skills and team interaction.

Implementation stages. The specific procedures for implementing the model involved several stages. In the preparatory phase, training was conducted for coaches and assistant coaches: three coaches and three assistant coaches, as well as two sports psychologists and two technicians responsible for organizing work with the Hudl Replay program, were engaged in the implementation of the model. All participants underwent specialized training and received certification to validate their qualifications. Technical preparation was also carried out, which included the setup of equipment and software necessary for conducting training sessions and measurements. During the model implementation, daily training sessions were held: each intervention group had nearly daily practices after regular classes, except on weekends or holidays. The training sessions followed the tactical

Table 1 Participant data in the current study.

Grade	Total	Control group	Experimental group	Average age	SD
Students in 7th Grade	38	19	19	12.87	0.79
Students in 8th Grade	42	21	21	13.58	0.63
Students in 9th Grade	40	20	20	14.96	0.92
Total	120	60	60	13.80	1.26

Table 2 Key aspects of the intervention program based on the model of tactical optimization and decision-making strategy in the practice of teaching football in a Chinese middle school.

Model component	Description and purpose	Key activities	Frequency
Tactical assessment	Assessment of players' current tactical knowledge and decision-making	Application of small-sided games (SSG), game analysis	Once per season
Tactical goals	Identification of specific tactical goals for the season	Establishment of clear team goals, breaking them down into individual goals	Annually
Tactical training	Enhancement of players' understanding of various tactics and strategies	Conducting tactical drills, position-specific training	Weekly
Decision-making exercises	Improvement of players' ability to make quick and effective decisions	Organization of small-sided games (SSG), conducting scrimmages	Weekly
Game analysis	Review of match recordings to identify tactical strengths and weaknesses	Video analysis implementation	After each game
Tactical adjustments	Implementation of necessary tactical adjustments based on game analysis	Adaptation of the game plan, gathering player feedback	As needed
Communication with players	Facilitation of effective communication among players on the field	Execution of communication exercises	Weekly
Teambuilding	Promotion of team cohesion and trust to enhance the decision-making process	Team-building activities, development of leadership qualities	Periodically
Mental training	Enhancement of players' mental resilience and ability to make decisions under pressure	Utilization of visualization exercises, mindfulness, and attention concentration exercises	Weekly
Competitions	Providing players with opportunities to apply tactical knowledge	Organization of intra-team scrimmages, friendly matches	Regularly
Evaluation	Assessment of players' progress in tactical skills and decision-making	Conducting periodic player assessments, end-of-season evaluations	Regularly
Performance enhancement software	Utilization of performance analysis software to track player data	Use of sports analytics software (Hudl Replay)	Throughout the entire season
Fitness tracking tools	Monitoring players' physical condition and workload	Application of wearable fitness trackers, including heart rate monitors	Throughout the entire season
Injury prevention	Implementation of injury prevention programs to maintain players' physical fitness	Implementation of strength and physical training programs, injury risk assessment	Throughout the entire season
Injury prevention sports scientific research	The need to stay updated on the latest research in football tactics	Review of scientific publications and literature on football coaching, attendance at coaching seminars and conferences	Continuously
Player feedback	Gathering player feedback to assess their needs and issues	Conducting individual meetings with players	Throughout the entire season

optimization and decision-making strategy model described earlier. Participants in each intervention group also received support from sports psychologists, who assisted them in developing cognitive and emotional skills essential for decision-making in game situations. Each team consisted of 20 members during training, with the number of participants in solo, pair, or group drills varying accordingly.

Data analysis

The data analysis was conducted using the Statistical Package for the Social Sciences (SPSS) software, version 28. To compare pre- and post-intervention results within each group, a paired *t*-test was employed, which allowed for the determination of significant changes in TTSCS and MDMQ scores. For independent samples, an unpaired *t*-test was used to compare results between the control and experimental groups after the intervention, facilitating the identification of differences in the effectiveness of the traditional approach versus the new model. Additionally, analysis of variance (ANOVA) was applied to assess differences in results among several subgroups within the experimental group, enabling the evaluation of the impact of various factors on outcomes. Pearson correlation analysis was utilized to examine correlations between different indicators, revealing relationships between improvements in various aspects of the training process and participants' cognitive skills.

Results

The primary objective of this study was to assess the efficacy of the intervention program through the implementation of a developed and integrated model. This was achieved by comparing pre-test and post-test results between the experimental and control groups. The outcomes of the tactical training and skills competence scale (TTSCS), encompassing both the tactical-attack and tactical-defense competencies of the participants, are presented in Table 3.

Average values of pre-test and post-test indicators for both groups experienced changes: for the control group, the difference in ATTC was 0.64, and in DTTC 2.16, while for the intervention group, the values were significantly higher: the difference in ATTC was 10.03 and in DTTC 11.35. The results of the four subscales of MDMQ, which assessed the decision-making skills of the respondents, are presented in Table 4.

The average values of pre-test and post-test scores for both groups in the MDMQ subscales also exhibited changes. For the control group, the dynamics of the indicators were minimal: ranging from a decrease of 0.42 in buck-passing to an increase of 0.22 in the vigilance subscale. In contrast, for the intervention group, the vigilance subscale increased by 2.92, while the scores for the other subscales decreased: hypervigilance by 3.75, buck-passing and procrastination by 3.45. The second objective was to assess the effectiveness of the intervention on variables of tactical knowledge and decision-making strategies by examining

Table 3 Pre-test and post-test results of two subscales of TTSCS among respondents in control and experimental groups.

		Pre-test tactical-technical attack competencies (ATTC)	Post-test tactical-technical attack competencies (ATTC)	Pre-test tactical-technical defense competencies (DTTC)	Post-test tactical-technical defense competencies (DTTC)
Control group	Mean	46.43	47.07	59.17	61.33
	Standard deviation	4.081	3.498	3.131	2.152
	Standard error of the mean	0.527	0.452	0.404	0.278
	Variance	16.656	12.233	9.802	4.633
	Excess kurtosis	−1.073	−1.295	−1.194	−0.849
	Skewness	−0.025	0.132	−0.002	0.236
Experimental group	Mean	46.07	56.10	59.17	70.52
	Standard deviation	4.178	3.611	2.713	3.427
	Standard error of the mean	0.539	0.466	0.350	0.442
	Variance	17.453	13.041	7.362	11.745
	Excess kurtosis	−1.156	−0.824	−0.750	−1.154
	Skewness	0.201	0.383	−0.056	0.070

Table 4 Pre-test and post-test results of four subscales of MDMQ among respondents in control and intervention groups.

		Pre-test vigilance	Post-test vigilance	Pre-test hypervigilance	Post-test hypervigilance	Pre-test buck-passing	Post-test buck-passing	Pre-test procrastination	Post-test Procrastination
Control group	Mean	8.55	8.77	11.68	11.32	13.25	12.83	11.78	12.05
	Standard deviation	1.141	1.047	1.142	0.770	1.348	1.064	1.508	1.523
	Standard error of the mean	0.147	0.135	0.147	0.099	0.174	0.137	0.195	0.197
	Variance	1.303	1.097	1.305	0.593	1.818	1.131	2.274	2.319
	Excess kurtosis	−1.399	−1.167	−1.300	−1.035	−1.018	−1.222	−1.396	−1.458
	Skewness	−0.092	−0.243	−0.329	−0.620	−0.303	0.005	0.229	−0.117
Experimental group	Mean	8.65	11.57	11.67	7.92	12.88	9.43	11.90	8.45
	Standard deviation	1.022	1.184	1.130	1.406	1.303	0.963	1.374	1.126
	Standard Error of the mean	0.132	0.153	0.146	0.181	0.168	0.124	0.177	0.145
	Variance	1.045	1.402	1.277	1.976	1.698	0.928	1.888	1.269
	Excess kurtosis	−1.096	−1.513	−1.366	−1.245	−1.100	−0.905	−1.233	−1.369
	Skewness	−0.126	−0.038	−0.176	0.191	0.128	0.078	0.145	0.055

Table 5 Assessment of the statistical significance of intragroup differences in pre-test and post-test scores of TTSCS and MDMQ Subscales among respondents in control and intervention groups (Wilcoxon rank-sum test).

TTSCS

		Tactical-technical attack competencies (ATTC)	Tactical-technical defense competencies (DTTC)
Control group	Z	−0.882	−3.788
	p value	0.378	**0.000**
Experimental group	Z	−6.740	−6.741
	p value	**0.000**	**0.000**

MDMQ

		Vigilance	Hypervigilance	Buck-passing	Procrastination
Control group	Z	−1.005	−1.875	−3.075	−0.998
	p value	0.315	0.061	0.011	0.318
Experimental group	Z	−6.686	−6.703	−6.655	−6.648
	p value	**0.000**	**0.000**	**0.000**	**0.000**

Bold values identify statistical significance ($p < 0.05$).

intragroup differences in the results. The data are presented in Table 5.

In the control group, statistically significant improvement is observed only in the tactical-technical defense Competencies (DTTC) subscale, whereas differences in the intervention group are statistically significant in all investigated subscales. Therefore, one can infer that the intervention program has significantly and positively contributed to the enhancement of both attacking and defensive tactical-technical competencies among the participants in the study. Furthermore, vigilance among respondents in the intervention group increased, while hypervigilance, buck-passing, and procrastination decreased, suggesting an enhancement in their decision-making skills.

The third objective was to confirm or refute whether the model of tactical optimization and decision-making strategy in football teaching practice could improve the investigated variables of tactics and decision-making. The results of the Kolmogorov–Smirnov non-parametric test are presented in Tables 6, 7.

During the pre-tests, the *p* values for the control and intervention groups were similar, while the post-test scores for the ATTC and DTTC subscales did not exceed the threshold, confirming that the differences are statistically significant (Table 6). Thus, the results affirm that after the implementation of the current intervention, the intervention group demonstrated statistically higher scores on the ATTC and DTTC subscales compared to the control group, indicating a positive impact of the program on the enhancement of tactical skills and decision-making abilities among the respondents.

Table 7 presents the results of assessing the statistical significance of differences between the control and intervention groups in the MDMQ subscales, revealing a similar pattern: homogeneity at the pre-test and statistical significance of differences between the control and intervention groups at the post-

Table 6 Assessment of the statistical significance of differences in TTSCS subscales among respondents in control and intervention groups (Kolmogorov–Smirnov criterion).

		Pre-test tactical-technical attack competencies (ATTC)	Post-test tactical-technical attack competencies (ATTC)	Pre-test tactical-technical defense competencies (DTTC)	Post-test tactical-technical defense competencies (DTTC)
Greatest	Absolute	0.100	1.000	0.133	0.933
Extreme	Positive	0.033	1.000	0.133	0.933
Discrepancies	Negative	−0.100	0.000	−0.083	0.000
Kolmogorov–Smirnov Z		0.548	5.477	0.730	5.112
p value		0.925	**0.000**	0.660	**0.000**

Bold values identify statistical significance ($p < 0.05$).

Table 7 Assessment of the statistical significance of differences in MDMQ subscales among respondents in control and intervention groups (Kolmogorov–Smirnov criterion).

		Pre-test vigilance	Post-test vigilance	Pre-test hypervigilance	Post-test hypervigilance	Pre-test buck-passing	Post-test buck-passing	Pre-test procrastination	Post-test Procrastination
Greatest Extreme	Absolute	0.100	0.983	0.067	0.817	0.150	0.850	0.100	0.767
Discrepancies	Positive	0.100	0.983	0.033	0.000	0.000	0.000	0.100	0.000
	Negative	−0.017	0.000	−0.067	−0.817	−0.150	−0.850	−0.033	−0.767
Kolmogorov–Smirnov Z		0.548	5.386	0.365	4.473	0.822	4.656	0.548	4.199
p value		0.925	**0.000**	0.999	**0.000**	0.509	**0.000**	0.925	**0.000**

Bold values identify statistical significance ($p < 0.05$).

test. These results further confirm that the model of tactical optimization and decision-making strategy in football teaching practice has demonstrated its effectiveness in the investigated variables.

Discussion

In the current study, the use of the tactical optimization model and decision-making strategy in football instruction has led to significant improvement in both attacking and defensive tactical-technical competencies within the intervention group. This improvement can be attributed to two key factors. Firstly, there was a focus on developing comprehensive gameplay skills. Secondly, decision-making strategies were integrated into the training process. This approach collectively contributed to a comprehensive understanding and response to in-game situations. In contrast to traditional methods primarily focused on physical and fundamental technical skills, the proposed approach prioritized tactical flexibility and psychological preparedness, potentially resulting in more pronounced improvements in decision-making, particularly in aspects such as reducing hypervigilance, which focuses on mitigating perceived pressure during decision-making. One study by Slaidins and Fernate (2021) suggested that a holistic approach is the most optimal method for the technical development of young adolescent football players, contributing to both the growth of technical mastery in young players and the holistic development of talent.

The findings from Slaidins and Fernate (2021) illustrate the advantages of a holistic approach compared to an analytical approach, where the acquisition and development of technical skills take on a monotonous and standardized nature. This monotony may result in a loss of interest in the training process for young players, emphasizing the necessity for the modernization of training processes. Another study by Barrero (2023) investigated whether the use of traditional methodology yields the same level of satisfaction among goalkeepers as a methodology focused on enhancing a player's adaptability. The results revealed a higher level of satisfaction and a lower level, affirming that improved programs contribute to player education and commitment to the sport (Barrero, 2023), aligning with the findings of the present study.

One article by García-Ceberino et al. (2020) aimed to investigate and compare the differences in football education using two different teaching methodologies. The results demonstrated improvements in both intervention programs; however, the tactical program yielded a higher level of education than the technical program between the assessment tests, correlating with findings from the current study. Another study by Pill et al. (2024) emphasizes that the concept of teaching styles differs from the concept of the pedagogical model. Still, both can be valuable for physical education teachers to understand specific aspects of instructional episodes and, consequently, enhance teaching and learning practices. This aids in aligning pedagogy with desired learning outcomes, affirming the potential application and integration of new models into training processes, as explored in the current research.

Additionally, the current model incorporated an application allowing the analysis of key game situations and improvement of training, consequently enhancing player performance. The integration of modern technologies is highly pertinent and essential in the training process. This aligns with the goal of another study by Wang (2023), which sought to determine the impact of network technologies on players' ability to collaborate, engage, and exhibit a creative approach to learning football tactics. Covariate analyses indicated that network technologies may exert a minor or moderate influence on enhancing collaboration among players in football tactical training (Wang, 2023), explaining the feasibility of integrating such technologies into training sessions.

Another article by Beal et al., (2020) investigated the method of predicting the probability of game outcomes and winning based on team actions, resulting in the development of an algorithm for optimizing team formation and gameplay tactics with various objectives. The empirical evaluation of this approach demonstrated that employing optimized Bayesian and stochastic game tactics can enhance a team's chances of victory (Beal et al., (2020)), adding relevance to the development of other tactical-technical models. In addition, another scholarly work by Silva et al. (2020) indicates that the effects of decision-making training programs in football imply a positive impact from the use of practical scenarios, primarily improving decision-making and its

execution. However, the benefits of interventions using video remain unclear. The current model included video analysis, and although in the work by Silva et al. (2020), the authors did not find a video effect, another article suggests the opposite (Natsuhara et al., 2020), providing grounds for further exploration of the effectiveness of video analysis in training. This exploration is warranted given the various methods, programs, and qualifications of personnel involved in this practice.

In conclusion, it can be stated that, unlike traditional methods, which primarily focus on physical and technical skills, the approach proposed in this article prioritizes tactical flexibility and psychological preparedness. This results in more pronounced improvements in decision-making, particularly in reducing hypervigilance. The theoretical contribution of this study lies in affirming the importance of integrating tactical optimization and decision-making strategies into the football training process. The research adds to the existing literature by combining components that were previously considered separately and demonstrating their effectiveness within a comprehensive model (Silva et al., 2020; Teoldo et al., 2021). Furthermore, the study enhances the understanding of applying these models in adolescence, an area that has been insufficiently explored (García-Ceberino, et al., 2020a; Peng et al., 2019). The practical contribution of the research is in providing specific tools and methodologies for coaches and educators, enabling a more effective organization of the training process. The article reveals how the proposed model enhances both physical and cognitive skills of players, which is crucial for their overall development and motivation (Beal et al., (2020); Wang, 2023).

Conclusions

The study revealed that the tactical optimization model and decision-making strategy in football empirically confirmed its effectiveness. The intervention group demonstrated improvements in attacking tactical-technical competencies (ATTC) by 10.03 and defensive (DTTC) by 11.35 compared to the control group, where a statistically significant change was observed only in the DTTC subscale with a value of 2.16. In the realm of decision-making within the intervention group, a statistically significant increase in vigilance by 2.92 was noted, while other subscales decreased: hypervigilance by 3.75, and buck-passing and procrastination by 3.45, indicating enhancements. Non-parametric calculations conducted for the control and intervention groups confirm that the intervention positively influenced the development of competencies in attacking and defensive tactical-technical actions, as well as decision-making skills among participants.

The study demonstrates the practical value of the tactical optimization model and decision-making strategy in the realm of football education and training. The efficacy of this model in enhancing attacking and defensive skills opens up new possibilities for coaches and sports educators to improve players' game competencies. The scientific significance lies in the empirical confirmation that an integrated and strategic approach to education can have a substantial impact on the tactical development of athletes. The findings can be applied in schools, youth sports academies, and clubs to develop more effective training programs. Additionally, they may contribute to the formulation of individualized learning plans based on tactical flexibility and decision-making strategies. In a scholarly context, this research may stimulate further investigations in the fields of sports psychology and pedagogy.

Limitations

The current study relied on a sample from a single high school, which complicates the generalization of results to a broader population of football players. The 1-year nature of the study does not permit the observation of long-term intervention effects, and the absence of prolonged monitoring after program completion limits understanding of sustainability. External factors, such as individual physiological and psychological characteristics of participants, which could theoretically influence outcomes, were not taken into account. Self-report measures may also carry certain limitations. Additionally, contextual constraints related to China's geographical and cultural factors may restrict the applicability of the results in different conditions. Additionally, family and demographic data, such as parents' employment, income, and education level, were not considered in this study, which constitutes a limitation. Future research should aim to expand the sample size and incorporate long-term monitoring for a better understanding of the sustainability of developed skills and the program's impact on various player groups. It is also crucial to investigate the influence of participants' differences on the effectiveness of the current model.

Data availability

All data generated or analysed during this study are included in this published article.

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Author contributions

CW—Conceptualization; Data curation; Resources; Software; Writing—review & editing. FL—Investigation; Methodology; Project administration; Visualization; Writing—original draft. YW—Formal analysis; Funding acquisition; Supervision; Validation; Writing—review & editing.

Competing interests

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Ethical approval

All methods were performed in accordance with the principles of the Declaration of Helsinki. The study was approved by the Local Ethics Committees of Chongqing University (Protocol № 6 of 13.08.2023). The approval covers all aspects of the study, including participant recruitment, data collection, and data analysis, conducted within the study in a school in China.

Informed consent

Before the study began, participants and their legal guardians were informed about the study's aim and scope, how the data would be used, and their right to withdraw from the study at any time. Informed consent was obtained from their legal guardians before their participation in the study. There were no indications from any participants expressing a wish to discontinue their participation prematurely. Consent covered participation, data use, and publication. The consent process and all procedures adhered to ethical guidelines to ensure participant rights and data integrity. No payment was included.

Additional information

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