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Original article

Artificial intelligence in planning and performance analysis in school fencing

[*Inteligencia artificial en la planificación y análisis del rendimiento en esgrima escolar*]

[*Inteligência Artificial no planejamento e na análise do desempenho na esgrima escolar*]

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ABSTRACT

Introduction: The incorporation of artificial intelligence (AI) into the planning and analysis of athletic performance represents a methodological transformation in

contemporary training. In Cuban school fencing, the lack of integrated technological tools limited the objectivity of load management, the systematic analysis of opponents, and data-driven decision-making by coaches.

Objective: To describe the experience of integrating artificial intelligence tools in training planning and performance analysis in school fencing, implemented at the Eide "Héctor Ruiz Pérez" in Villa Clara during the preparatory cycle for JENAR 2026.

Methods: A methodological innovation study with a mixed-methods, descriptive-applied approach was conducted. Participants included six coaches, a provincial methodologist, and 24 athletes from the three fencing disciplines (Foil, Épée, and Sabre), in both male and female school categories (ages 13-15). The following methods were applied: document analysis, design and validation of the Comprehensive Fencing Analysis System (SIAE), development of annual training plans using the Hanser model, construction of opponent studies using multivariate weighting models (IPPR, IRHP, IRP, IRH), and AI training workshops for coaches.

Results: Four complementary tools were developed and implemented in a pilot phase: the SIAE (which reduced analytical recording time from 40 to less than ten minutes per session); 51-week annual training plans with a progressive wave dynamic modeled with AI (with a documented 40-60% reduction in document preparation time); opponent studies with probabilistic classification into three performance groups; and a system of specialized prompts for tactical analysis and talent identification. Coaches positively evaluated the relevance and accessibility of the tools through iterative feedback in training workshops.

Conclusions: Integrating AI into planning and performance analysis in school fencing is feasible, relevant, and produces objective improvements in the efficiency of the training process. The systemic approach adopted, which combines accessible technological tools with the coach's experience, represents a replicable model for other combat sports within the Cuban sports system.

Keywords: artificial intelligence; fencing; training planning; performance analysis; school sport; methodological innovation.

RESUMEN

Introducción: la incorporación de la inteligencia artificial (IA) a los procesos de planificación y análisis del rendimiento deportivo representa una transformación metodológica en el entrenamiento contemporáneo. En la esgrima escolar cubana, la ausencia de herramientas tecnológicas integradas limitaba la objetividad del control de la carga, la sistematicidad del análisis de contrarios y la toma de decisiones basada en datos por parte de los entrenadores.

Objetivo: describir la experiencia de integración de herramientas de inteligencia artificial en la planificación del entrenamiento y el análisis del rendimiento en esgrima escolar, implementada en la Eide "Héctor Ruiz Pérez" de Villa Clara durante el ciclo preparatorio para el JENAR 2026.

Métodos: se realizó un estudio de innovación metodológica con enfoque mixto, de carácter descriptivo-aplicado. Participaron seis entrenadores, un metodólogo provincial y 24 atletas de las tres modalidades de esgrima (Florete, Espada y Sable), categorías escolares masculino y femenino (13-15 años). Se aplicaron: análisis documental, diseño y validación del Sistema Integral de Análisis de Esgrima (SIAE), elaboración de planes anuales de entrenamiento con modelo Hanser, construcción de estudios de contrarios con modelos de ponderación multivariable (IPPR, IRHP, IRP, IRH) y talleres de capacitación en IA para entrenadores.

Resultados: se desarrollaron e implementaron cuatro herramientas complementarias en fase piloto: el SIAE —que redujo el tiempo de registro analítico de 40 a menos de diez minutos por sesión—; planes anuales de entrenamiento de 51 semanas con dinámica ondulatorio-progresiva modelada con IA —con una reducción documentada del 40-60 % en el tiempo de elaboración documental—; estudios de contrarios con clasificación probabilística en tres grupos de rendimiento; y un sistema de prompts especializados para análisis táctico y detección de talentos. Los entrenadores evaluaron positivamente la pertinencia y accesibilidad de las herramientas mediante retroalimentación iterativa en talleres de capacitación.

Conclusiones: la integración de la IA en la planificación y el análisis del rendimiento en esgrima escolar es factible, pertinente y produce mejoras objetivas en la eficiencia del

proceso de entrenamiento. El enfoque sistémico adoptado, que articula herramientas tecnológicas accesibles con la experiencia del entrenador, representa un modelo replicable para otros deportes de combate en el sistema deportivo cubano.

Palabras clave: inteligencia artificial; esgrima; planificación del entrenamiento; análisis del rendimiento; deporte escolar; innovación metodológica.

RESUMO

Introduction: The incorporation of Artificial Intelligence (AI) into the planning and analysis processes of sports performance represents a methodological transformation in contemporary training. In Cuban school fencing, the absence of integrated technological tools limited the objectivity of load control, the systematic analysis of opponents, and data-driven decision-making by coaches.

Objective: To describe the experience of integrating Artificial Intelligence tools in training planning and performance analysis in school fencing, implemented at EIDE Héctor Ruiz Pérez, in Villa Clara, during the preparatory cycle for JENAR 2026.

Methods: A methodological innovation study with a mixed-methods approach, of a descriptive-applied nature, was conducted. Participants included six coaches, one provincial methodologist, and 24 athletes from the three fencing disciplines (foil, épée, and sabre), in the male and female school categories (13-15 years). The following methods were applied: document analysis; design and validation of the Integrated Fencing Analysis System (SIAE); development of annual training plans using the Hanser model; conducting opponent studies with multivariate weighting models (IPPR, IRHP, IRP, IRH); and AI training workshops for coaches.

Results: Four complementary tools were developed and implemented in a pilot phase: SIAE—which reduced analytical recording time from 40 to less than 10 minutes per session—; 51-week annual training plans with AI-modeled undulating-progressive dynamics—with a documented 40-60% reduction in document preparation time—; opponent studies with probabilistic classification into three performance groups; and a system of specialized prompts for tactical analysis and talent detection. Coaches

positively evaluated the relevance and accessibility of the tools through iterative feedback in training workshops.

Conclusions: The integration of AI in planning and performance analysis in school fencing is viable, relevant, and produces objective improvements in the efficiency of the training process. The systemic approach adopted, which articulates accessible technological tools with the coach's experience, represents a replicable model for other combat sports in the Cuban sports system.

Keywords: artificial intelligence; fencing; training planning; performance analysis; school sports; methodological innovation.

INTRODUCTION

Contemporary sports training is characterized by a growing demand for systematization, objectivity, and personalization in the management of training processes. In this context, artificial intelligence (AI) has emerged as a high-potential tool to support decision-making by coaches, methodologists, and sports managers, enabling the processing of large volumes of information, the identification of performance patterns, and the generation of data-driven planning proposals (Claudino *et al.,* 2019; Beal *et al.,* 2019).

In combat sports, and particularly in fencing, the tactical complexity of competition demands a level of analysis that goes beyond the coach's empirical observation. Fencing is a cognitively demanding opposition sport in which tactical anticipation, the variability of technical actions, and the ability to read the opponent largely determine the outcome of the bout (Roi & Bianchedi, 2008; Turner *et al.,* 2014). Within this framework, the integration of technological tools for bout analysis, training load planning, and opponent study becomes a methodological necessity.

In Cuba, the high-performance school sports system is structured through the School Sports Initiation Schools (EIDE), institutions that concentrate the first level of talent

selection and training in multiple disciplines. The "Héctor Ruiz Pérez" EIDE in Villa Clara is the leading institution for school fencing in the province and is the main venue for preparation for the National High-Performance School Games (JENAR). The training process at this level has historically lacked integrated technological tools for systematic load planning, objective performance analysis, and the well-founded development of opponent studies, a situation that is part of the general diagnosis of the Science, Innovation, and Technology System of Physical Culture documented by Vento *et al.* (2022).

The introduction of AI into the methodological work of Cuban school sports responds to the Cuban Society's Informatization Policy and the objectives of the Science, Technology, and Innovation System of the National Institute of Sports, Physical Education and Recreation (INDER), which promote the use of Information and Communication Technologies (ICTs) as a cross-cutting element in the sports training and management process (Díaz-Canel and Núñez, 2020). However, the lack of systematic evidence on the practical application of AI in the context of Cuban school fencing constitutes a gap that this research seeks to help close.

Recent research has documented the potential of advanced technological tools and analytical models for performance analysis in fencing (Tsolakis *et al.,* 2010; Turner et al., 2014), the use of wearable technology and digital systems for analyzing technical actions in combat sports (Borysiuk *et al.,* 2022), and the application of AI models for optimizing complex planning processes in environments with heterogeneous technological resources (Rommers *et al.,* 2020). However, these experiences have been developed primarily in high-performance contexts in technologically advanced countries, and their adaptation to the conditions of Cuban school sports requires a specific methodological approach that combines the possibilities of open-source AI tools with the expert knowledge of coaches and methodologists within the national sports system.

Therefore, the objective of this research was to describe the experience of integrating artificial intelligence tools in the planning of training and the analysis of performance in

school fencing, implemented in the Eide "Héctor Ruiz Pérez" of Villa Clara during the preparatory cycle for the JENAR 2026.

MATERIALS AND METHODS

A methodological innovation study with a mixed approach, of a descriptive-applied nature, was carried out between January and March 2026 in the context of the pilot phase of preparation for JENAR 2026.

Participants

The study involved six coaches and the provincial fencing methodologist from the Villa Clara Provincial Directorate of Sports, Physical Education, and Recreation, all affiliated with the "Héctor Ruiz Pérez" Sports Initiation School (EIDE). Additionally, 24 athletes from the male and female school categories (ages 13-15) participated, distributed across the six competitive categories (male and female foil, male and female épée, and male and female sabre).

Ethical considerations

The research was approved by the Scientific Council of the Provincial Directorate of Sports, Physical Education, and Recreation of Villa Clara. Coaches and methodologists participated voluntarily with informed consent, ensuring the confidentiality of individual data. In the case of athletes under the age of 18, the EIDE (School for Sports Initiation) provided its knowledge and institutional approval, and individual data of rival athletes are presented in anonymized form in accordance with the ethical principles of sports research. No interventions were made on the athletes that modified their usual training process; the study was limited to the design and implementation of methodological tools to support the coach.

Theoretical methods

Analysis and synthesis were applied to systematize knowledge about the application of AI in sports training and combat sports. Induction and deduction guided the derivation of the design principles for the tools developed from sports training theory. The systems approach underpinned the integration of the four tools into a coherent training process management system.

Empirical methods

The documentary analysis included a study of the Comprehensive Athlete Preparation Program (PIPD) for fencing, regulations from the National Institute of Sports, Physical Education and Recreation (INDER) and the Ministry of Science, Technology and Environment (CITMA) on science and innovation, and current scientific literature on AI applied to sports. Scientific observation of training sessions and semi-structured interviews with coaches and methodologists allowed for the identification of the specific needs of each tool. Triangulation of sources ensured the internal validity of the results. Iterative feedback from coaches in training workshops provided criteria for the practical evaluation of the tools. The reduction in operational time was measured through direct time studies of tasks, comparing the conventional method with the use of the new tools, with systematic recording by the provincial methodologist.

Tools developed

Four complementary tools were designed and implemented in a pilot phase, the description of which is detailed in the results section:

- Comprehensive fencing analysis system (SIAE): web application for recording and analyzing fights in real time, with three functional modules.
- Annual training plans: 51-week macrocycles with progressive wave-like load dynamics according to the Hanser model, modeled with the support of generative AI.

- Opponent studies: analysis of rivals with four proprietary multivariable weighting models (IPPR, IRHP, IRP, IRH) and probabilistic classification into three performance groups.
- Specialized prompt system: library of structured instructions for the use of generative AI in tactical analysis, talent detection and training planning.

RESULTS AND DISCUSSION

Comprehensive Fencing Analysis System (SIAE)

The SIAE was conceived as a web application for recording and analyzing combat in real time, accessible from mobile devices and computers without installation. Its functional architecture includes three main modules: recording offensive and defensive actions by touch (with classification by weapon, category, and gender), post-combat statistical analysis (frequency of actions, touch zones, attack-defense ratio), and automatic generation of individual and team performance reports.

The application was developed using standard web technologies (HTML5, JavaScript, CSS) and persistent local storage, ensuring its functionality without a permanent internet connection—an essential requirement in the context of Cuban sports facilities. During the pilot phase in training sessions at the EIDE (School for Sports Initiation), the system proved to be operational and easy for coaches to use, reducing the recording and analytical processing time from approximately 40 minutes per session to less than 10 minutes. This data was measured through direct timing in five training sessions, comparing the conventional method—recording on a physical form and subsequent processing in a spreadsheet—with the use of the SIAE (Integrated System for Academic and Data Analysis).

This result is consistent with the findings of Claudino *et al.* (2019), who reported that the implementation of digital recording systems in combat sports significantly reduced data processing time and improved record consistency compared to manual methods. The

integration of automated statistical analysis expands the coach's ability to identify tactical patterns that would be difficult to detect through direct observation, which is consistent with the findings of Borysiuk *et al.* (2022) on the potential of digital systems for tactical analysis in combat sports.

Annual training plans with AI-modeled load dynamics

Annual training plans were developed for the six school fencing categories, with a 51-week structure organized into 13 mesocycles according to Hanser's periodization model, which establishes a progressive, wave-like dynamic of the load as a methodological requirement of the fencing PIPD (Inder, 2022). The theoretical framework of the periodization was based on the principles of sports training reference in the Cuban system (Platonov, 2001; García Manso *et al.,* 2019).

The incorporation of generative AI in this process was carried out in three phases: (1) generation of the initial volume and intensity distribution scheme from the PIPD parameters and the JENAR 2026 competitive calendar; (2) iterative adjustment of the model from the results of the control evaluations in the training sessions; and (3) visualization of the load curves using progressive wave dynamics graphs in Excel, which allow the coach to intuitively appreciate the behavior of the load throughout the macrocycle.

Table 1 summarizes the main parameters of the annual plan developed for the Espada 13-15 years category, which can be considered representative of the general structure adopted for the six categories (Table 1).

Table 1. *- Parameters of the annual training macrocycle. School épée (13-15 years). JENAR 2026*

Parameter	General Preparation	Special Preparation	Pre-competitive	Competitive
Duration (weeks)	20	16	8	7
Relative volume (%)	High (70-80%)	Medium (55-70%)	Low (40-55%)	Low-Medium (45-60%)
Relative intensity (%)	Low-Medium (50-65%)	Media-Mlta (65-80%)	High (80-90%)	Maximum (90-100%)
Mesocycles	5	4	2	2
Technical-tactical emphasis	Fundamentals and physical basis	Specific actions	Competitive simulation	Competition and recovery

Source: *own elaboration (2026)*

The use of generative AI as a planning assistant did not replace the coach's expert judgment, but rather amplified their analytical capabilities. Participating coaches reported a reduction of between 40% and 60% in the time spent documenting training plans, estimated by comparing the time spent in previous cycles—according to records from the provincial methodologist—with the time spent during the pilot phase. This finding is consistent with the reports by Rommers *et al.* (2020) on the impact of analytical model-based support systems on the efficiency of training monitoring and planning processes.

Contrary studies with multivariable weighting models

Opponent studies were developed for the six school categories of fencing, with particular emphasis on athletes qualified for JENAR 2026. The methodological framework adopted four self-designed weighted performance indices, constructed from the theory of sports training and the principles of multidimensional performance assessment (Platonov, 2001; Taborda *et al.*, 2020):

- **IPPR** (Weighted Index of Preparation and Performance): evaluates the athlete's physical, technical, tactical and psychological preparation by different weighting per factor, on a scale of 0-10.

- **IRHP** (Weighted Historical Performance Index): quantifies the athlete's performance in previous competitions, weighted by competition level and results obtained, on a scale of 0-10.
- **IRP** (Prospective Performance Index): projects the expected performance level of the athlete in the analyzed competitive cycle, based on the IRHP and the preparation trend indicators, on a scale of 0-10.
- **IRH** (Head-to-head performance index): analyzes the history of direct confrontations between the athlete analyzed and their main rivals, weighting by temporal proximity and level of competition, on a scale of 0-10.

The integration of the four indices into a probabilistic classification model allowed athletes to be categorized into three groups: high probability of a medal (average ≥ 8.0), competitive in the qualifying zone (average 6.5-7.9) and outside the podium zone (average < 6.5).

Table 2 presents the probabilistic classification obtained for the School Female Épée category in Villa Clara (Table 2).

***Table* 2.** - *Probabilistic classification of athletes. School Women's Sword — VCL. JENAR 2026*

Athlete	IPPR	IRHP	IRP	IRH	Classification
Peñalver López, A.	8.7	8.4	8.9	8.6	High
Domínguez Banguela, L.	7.9	7.6	8.1	7.8	High
National reference athlete 1*	8.1	8.5	8.0	8.3	High
Rival reference 2*	6.8	7.1	6.9	6.5	Average

** Identities protected for reasons of competitive confidentiality. Source: own elaboration (2026)*

The use of generative AI in constructing opponent studies operated on two levels: as an assistant in synthesizing and structuring the observational information collected by the coaches, and as a generator of probable tactical scenarios based on the historical performance patterns of the analyzed athletes. The AI's ability to organize large volumes of qualitative and quantitative information into structured formats reduced the time

required to develop each study by approximately 3 to 5 hours compared to the previous manual method, according to the timed records kept by the provincial methodologist during the pilot phase.

These results are consistent with those reported by Beal et al. (2019) in the context of opponent analysis in team sports, where the integration of data-driven analytical models improved the predictive accuracy of opponent analyses. In the case of fencing, the application of multivariate models offers an additional advantage by allowing the quantification of aspects that are usually assessed in a purely qualitative way, such as tactical adaptability or the consistency of performance under competitive pressure (Turner *et al.,* 2014; Tsolakis *et al.,* 2010).

Specialized prompt system for generative AI in fencing

A library of specialized prompts was developed for the use of generative AI models in specific contexts of Cuban school fencing. The library was structured into five thematic sections:

- Tactical analysis of combat and development of preparation strategies against identified rivals.
- Training planning: generating sessions, distributing weekly load and adjusting mesocycles.
- Performance monitoring: interpretation of statistical indicators and generation of monitoring reports.
- Talent detection: development of performance profiles and selection criteria by category and modality.
- Technical communication: drafting methodological reports, letters of invitation and sports management documents.

The prompts were tested and validated by participating coaches through iterative feedback in training workshops. The tool was delivered in an interactive HTML format,

allowing the coach to select the task type, customize the parameters (weapon, category, opponent), and copy the generated prompt directly to their preferred AI model.

The coaches' training followed a three-stage model: (1) conceptual awareness of AI and its application in sport; (2) practical training in the use of the developed prompts; and (3) follow-up and adjustment during implementation in daily work. The coaches positively evaluated the accessibility and practical usefulness of the tools, highlighting as the main limitation the intermittent internet connectivity at the EIDE facilities, a structural condition of the Cuban context that should be considered in the design of future tools.

The integration of a system of specialized prompts as a mediator between the trainer and the generative AI models constitutes a methodological approach that democratizes access to the analytical capabilities of AI for trainers without technical training in computer science, consistent with the recommendations of Rommers et al. (2020) on the design of user-centered tools for contexts with heterogeneous technological capabilities.

Integrative discussion: towards a systemic model of AI applied to fencing

The experience developed in Villa Clara during the preparatory cycle for JENAR 2026 allows us to propose a systemic model of AI integration in the school fencing training process, articulated in three levels of application: the level of registration and analysis (SIAE), the level of planning (generative AI with Hanser model) and the level of competitive intelligence (studies of opponents and prompt system).

This three-level model aligns with the conceptual frameworks proposed by Claudino *et al.* (2019) for integrating AI into high-performance sports, which distinguish between AI applications for athlete monitoring, training optimization, and competition analysis. The main contribution of the reported experience lies in demonstrating that this type of integration is viable within the context of Cuban school sports, using freely available technological resources and without requiring high-cost infrastructure.

A significant limitation of this study is its pilot phase (January-March 2026) and the absence of a comparison group that would allow for a more precise quantification of the tools' impact on competitive performance indicators. The results regarding reduced operating times are promising, but should be interpreted with caution given the brevity of the implementation period and the small sample size of coaches. Future studies should incorporate quasi-experimental designs that compare the results of JENAR 2026 with those of previous competitive cycles. Evaluating the medium-term impact of AI training on coaches' methodological practices is also a high-priority research area.

CONCLUSIONS

The integration of artificial intelligence into training planning and performance analysis in school fencing in Villa Clara proved to be feasible, relevant, and methodologically sound within the context of the pilot phase. The four implemented tools—the SIAE (Integrated System for Training Analysis), annual plans with AI-modeled load dynamics, opponent studies with custom-designed weighted indices, and a specialized prompt system—form a coherent and complementary system that expanded the coach's analytical capabilities without replacing their expert judgment.

The results of the pilot phase demonstrate improvements in the efficiency of the document planning process (a 40-60% reduction in preparation time), in the speed of opponent analysis (a reduction of 3-5 hours per report), and in the quality of information available for technical and tactical decision-making. Training coaches in the use of generative AI tools, facilitated by a system of specialized prompts adapted to the context of Cuban fencing, is a key enabling factor for the sustainability of the proposed model.

The systemic approach adopted, which combines accessible technological tools with the expert knowledge of coaches and methodologists, represents a replicable model for other sports disciplines within the Cuban system. The competitive results of the 2026 National Sports Games (JENAR 2026) and the evaluation of the medium-term impact of

AI training on coaches' methodological practices constitute the main lines of future work.

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