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ORIGINAL ARTICLE

Optimizing Critical Decision-Making in Elite Sports Organizations: A Human-AI Hybrid Framework for Dynamic Environments

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EXTENDED A B S T R A C T

Introduction
Decision-making in critical and high-pressure situations represents one of the most challenging aspects of management within elite sports organizations. In the competitive landscape of professional leagues, characterized by high uncertainty and immediate consequences, the quality of decisions made by managers and coaches can determine the fate of teams and entire organizations. While traditional decision-making in sports has often relied on human intuition, experience, and heuristic judgment, the contemporary sports environment generates vast amounts of complex, real-time data, necessitating more sophisticated analytical approaches. Recent advancements in Artificial Intelligence (AI), particularly in deep learning and machine learning, offer unprecedented capabilities for data analysis, pattern recognition, and predictive modeling. However, the inherently dynamic, unpredictable, and high-stakes nature of elite sports creates a unique paradox: purely algorithmic approaches may lack the contextual understanding and adaptability of human experts, while purely intuitive human judgment may be overwhelmed by complexity and cognitive biases under pressure. This gap highlights the pressing need for integrative frameworks that optimally leverage the complementary strengths of human cognition and computational intelligence. This study, therefore, aims to develop and validate a human-AI hybrid framework specifically designed to optimize critical decision-making in the dynamic environments of elite sports. It seeks to move beyond the human-versus-machine debate by proposing a synergistic model where intelligent decision-support systems augment and enhance human expertise. The research is guided by three primary questions: 1) How can AI systems be effectively integrated with human judgment in critical sports decision-making scenarios? 2) What individual and situational factors influence the effectiveness of this hybrid framework? 3) How can the findings be applied to design intelligent training systems for coaches and real-time decision-support tools?

Mothodology
This research employed a comprehensive mixed-methods approach (qualitative-quantitative) to ensure a holistic and in-depth investigation of the decision-making phenomenon. The methodological design was systematically structured to balance the exploratory depth of qualitative analysis with the predictive precision of quantitative and biometric measurements. The study population consisted of coaches, technical managers, and team supervisors active in national-level professional sports leagues. A purposeful mixed sampling strategy ensured diversity across sports disciplines (team and individual) and managerial levels. The final sample included 120 participants who met strict criteria, including a minimum of three years of professional experience at the national level.
Data collection utilized a multi-instrument strategy. Qualitative data were gathered through in-depth, semi-structured interviews using a researcher-developed protocol, designed to explore experiences, challenges, and strategies in critical decision-making. Quantitative data

were collected via a validated researcher-constructed questionnaire using Likert-scale items, measuring individual characteristics, situational factors, cognitive processes, and decision outcomes. A key innovative component was the use of advanced biometric assessments to record objective physiological and ocular responses during simulated critical decision-making scenarios. Specifically, an eye-tracking system (EyeLink) measured parameters such as fixation duration, number of fixations, pupil dilation, and scan paths, while a physiological monitoring system (AcqKnowledge) recorded electrodermal activity, heart rate, and heart rate variability.

Data analysis was conducted in multiple layers. Qualitative interview data were analyzed using thematic analysis with specialized software. Quantitative data from questionnaires and biometrics were analyzed using advanced statistical techniques, including Confirmatory Factor Analysis (CFA) and Structural Equation Modeling (SEM) in AMOS to test the conceptual model, Artificial Neural Network (ANN) analysis in MATLAB for outcome prediction, and Multivariate Analysis of Variance (MANOVA) in SPSS for group comparisons. The integration of findings from all three data streams (qualitative, quantitative, and biometric) allowed for the development of a robust and nuanced model. Rigorous ethical protocols, including informed consent and confidentiality assurances, were adhered to throughout the research process.

Findings

The integrated analysis yielded significant insights into the factors and processes governing critical decision-making in elite sports. The thematic analysis of interviews identified five core themes: "Time Pressure as a Pivotal Factor," "Complex Interplay between Objective Analysis and Intuition," "Accountability and Responsibility," "Cognitive Flexibility," and "Emotion Regulation." Time pressure was consistently cited as the most salient challenge, forcing rapid information processing under constraints.

Quantitative analyses substantiated and quantified these themes. Regression analysis revealed that time pressure ($\beta = -0.42$, $p < 0.01$), experience level ($\beta = 0.37$, $p < 0.01$), and cognitive ability ($\beta = 0.29$, $p < 0.01$) were the most significant predictors of decision accuracy. Crucially, an interaction effect was found between experience and time pressure, indicating that experienced decision-makers were less negatively impacted by time constraints ($r = -0.28$) compared to their less-experienced counterparts ($r = -0.51$), highlighting experience's role as a protective moderator. Biometric data provided objective evidence of the cognitive and physiological underpinnings of effective decision-making. Eye-tracking results showed that successful decision-makers exhibited longer fixation durations on key information (280 ms vs. 180 ms) and fewer total fixations (4.2 vs. 6.8), indicating superior focus and efficient information filtering. Physiological data revealed that while all participants showed increased electrodermal activity under pressure, successful decision-makers maintained this arousal within an optimal range (+2.5 µS vs. +4.8 µS), demonstrating better emotion regulation and stress management. The most pivotal finding was the performance evaluation of the proposed human-AI hybrid framework. When compared to purely human-based or purely algorithm-based decision-making in simulated high-pressure scenarios, the hybrid approach demonstrated a remarkable increase in decision accuracy of up to 92%. This superior performance was attributed to the framework's ability to leverage AI for rapid data synthesis, pattern identification, and option generation, while reserving for the human expert the final judgment, contextual interpretation, and intuitive weighting of factors that are difficult to quantify. The synthesis of all data led to the development of a comprehensive model. This model posits that optimal decision-making in critical sports environments is a dynamic function of the interaction between: 1) Individual Factors (experience, cognitive ability, emotion regulation skills), 2) Situational Factors (time pressure, uncertainty, stakes), and 3) Organizational/Technological Factors (access to decision-support systems, quality of data infrastructure). The hybrid AI system acts as a force multiplier, particularly enhancing performance under high situational constraints like extreme time pressure.

Discussion and Conclusion

The research results indicated that the performance of sports venues and facilities has 7 main components: enhancing the quality of sports services, effective administrative processes, effective planning, facilities and hardware, customer satisfaction, social relations development, and finally safety and security. Furthermore, it was found that privatization has a significant positive impact on all 7 aforementioned components from the respondents' perspective. The findings of this research, regarding the impact of privatization on enhancing service quality, are consistent with the studies by Ahmadi et al. (2020), Houlihan (2005), and Mirsadeghi & Sadeghi Boroujerdi (2014). Moreover, in terms of improving effective administrative processes, it aligns with the research by Seyed Ali (2023), Razavi et al. (2018), and Moharramzadeh et al. (2015). Regarding the improvement of effective

planning, it is in line with the research by Kamroozman et al. (2010) and Naderian et al. (2015). The component of improving facilities and hardware is consistent with the findings of Mirsadeghi & Sadeghi Boroujerdi (2014) and Hinderson (2016). Also, the customer satisfaction component is aligned with the research by Zhang (2009) and Jafari (2014). The component of developing social relations is consistent with the research by Ruow (2015), Moharramzadeh et al. (2015), and Javanmard & Navabakhsh (2014). Finally, the safety and security component of sports venues is consistent with the research by Hall et al. (2018), Hinderson (2016), and Razavi et al. (2018).

In interpreting the above findings, it can be concluded that given the existence of numerous obstacles and challenges in the public sports facilities and venues sector, undergoing the privatization process presents an economic opportunity for investors. However, for success, investors must guarantee the high performance of privatized facilities and venues. Based on the research results, as a first step, the performance of sports facilities and venues can be improved by promoting a culture and enhancing public participation in sports among the community. This will convert potential applicants for sports goods and services into actual consumers, enabling revenue generation by meeting their needs.

KEYWORDS

Sport Management, Critical Decision-Making, Human-AI Collaboration, Elite Sports, Biometric Data, Deep Learning.