# A SYSTEMATIC LITERATURE REVIEW OF BLOCKCHAIN TECHNOLOGY AND THE SPORTS INDUSTRY

## UNA REVISIÓN SISTEMÁTICA DE LA LITERATURA SOBRE LA TECNOLOGÍA BLOCKCHAIN Y LA INDUSTRIA DEL DEPORTE

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## Abstract

This study provides a comprehensive overview of blockchain applications in the sports industry through a systematic literature review (SLR) following PRISMA guidelines. The terms "Blockchain AND Sport" were used to search across databases such as Web of Science, Scopus, ScienceDirect, PubMed, Embase, IEEE, and Dimensions. After the search, 1,571 articles were identified, with 37 primary studies selected for detailed analysis. The review highlights blockchain's potential to transform the management and operation of sports-related activities by addressing challenges faced by stakeholders. The results demonstrated that blockchain enhances stakeholder trust through transparency, decentralization, and immutability. Its ability to automate processes like player transfers and contract management via smart contracts reduces costs and risks, while fan engagement is bolstered through digital tokens and NFTs. The findings underscore blockchain's capacity to revolutionize sports management through digital collectibles, secure transactions, performance optimization, and fan engagement through exclusive digital content. However, significant challenges still need to be addressed, including regulatory uncertainty, technical complexity, high implementation costs, and cultural resistance to decentralization. Despite these obstacles, blockchain presents substantial opportunities for innovation and efficiency in the sports industry. The review concludes that continued technological advancements, regulatory development, and cultural adaptation are essential for the widespread adoption of blockchain in sports.

**Keywords:** Sport management, emerging technology, disruptive technology, technology adoption, team sports.

## Resumen

Este estudio ofrece una visión exhaustiva sobre las aplicaciones de la tecnología cadena de bloques en la industria deportiva a través de una revisión sistemática de la literatura (RSL) siguiendo las directrices de PRISMA. Se utilizaron los términos "Blockchain AND Sport" para realizar la búsqueda en bases de datos como Web of Science, Scopus, ScienceDirect, PubMed, Embase, IEEE y Dimensions. Tras la búsqueda, se identificaron 1,571 artículos, de los cuales 37 estudios primarios fueron seleccionados para un análisis detallado. La revisión pone de manifiesto el potencial de cadena de bloques para transformar la gestión y operación de actividades relacionadas con el deporte al abordar los desafíos que enfrentan los diferentes

actores. Los resultados demostraron que cadena de bloques mejora la confianza de los stakeholders a través de la transparencia, la descentralización y la inmutabilidad. Su capacidad para automatizar procesos como las transferencias de jugadores y la gestión de contratos mediante contratos inteligentes reduce costos y riesgos, mientras que el compromiso de los aficionados se ve potenciado a través de tokens digitales y NFTs. Los hallazgos subrayan la capacidad de blockchain para revolucionar la gestión deportiva mediante coleccionables digitales, transacciones seguras, optimización del rendimiento y la interacción con los aficionados mediante contenido digital exclusivo. No obstante, aún existen desafíos significativos por superar, tales como la incertidumbre regulatoria, la complejidad técnica, los altos costos de implementación y la resistencia cultural a la descentralización. A pesar de estos obstáculos, cadena de bloques presenta oportunidades sustanciales para la innovación y la eficiencia en la industria del deporte. La revisión concluye que los avances tecnológicos continuos, el desarrollo regulatorio y la adaptación cultural son esenciales para la adopción generalizada de cadena de bloques en el ámbito deportivo.

**Palabras clave:** Gestión deportiva, tecnología emergente, tecnología disruptiva, adopción tecnológica, deportes de equipo.

# Introduction

In 2008, Satoshi Nakamoto was the name used by the presumed pseudonymous person or persons who introduced the blockchain concept through Bitcoin, providing a decentralized computing and storage infrastructure (Nakamoto, 2008). Nevertheless, upon realizing the technology's vastly greater potential, blockchain has attracted significant interest from numerous industries and the academic world in recent years (Gökalp et al., 2022). Indeed, blockchain technology has become an essential technological advancement since the advent of the Internet (Casino et al., 2021).

The term "blockchain" derives from the chain of interconnected blocks secured by a cryptographic hash function for information exchange. Each block functions as a digital ledger containing a collection of transaction records. Hence, each network node holds a copy of this digital ledger, and synchronization ensures that each local copy is identical (Bashir, 2020).

The distributed nature of blockchain technology facilitates innovation and efficient reallocation of resources. This environment is highly conducive to creativity, fostering innovative solutions with the potential to revolutionize various industries (Ozcan & Unalan, 2022). Furthermore, blockchain technology can be integrated with other emerging technologies, expanding its applications and capabilities (Deng et al., 2022).

Blockchain technology is a multifaceted field that encompasses a range of technical aspects, such as mathematics, cryptography, internet protocols, and computer programming (Sato, 2021). Despite its complexity, blockchain has shown potential in practical applications, capable of addressing specific technical challenges by applying basic principles to understand complex phenomena (Di Ciccio et al., 2019). The unique properties of blockchain, including a secure transaction environment, decentralized management, consensus mechanisms, security, immutability, distributed ledger technology (DLT), and transparency (Sato, 2021), allow its functionality to vary according to the involved parties, such as users, suppliers, and administrators, highlighting its adaptability to a different function (Park, 2020).

Blockchain can potentially revolutionize industries beyond its initial associations with cryptocurrency (Antonopoulos, 2017) and non-fungible tokens (NFTs) (Zarifis & Cheng, 2022). Blockchain has evolved to offer management solutions across various global industries. Its applications now extend to decentralized finance (Far et al., 2023), healthcare (Andrew et al., 2023), the Internet of Things (IoT) (Abdelmaboud et al., 2022), supply chain management (Al-Rakhami & Al-Mashari, 2021), energy supply (Bürer et al., 2019), tourism (Arif et al., 2023), and education (Bucea-Manea-Tonis et al., 2021). By leveraging blockchain technology, these sectors explore innovative strategies to maintain a competitive edge (Pu & Lam, 2021).

One example of how blockchain has expanded its utility is using smart contracts, self-executing scripts designed to automate agreements between parties without intermediaries (Sato, 2021). Ethereum, one of the most stimulating blockchain networks, allows the deployment of these smart contracts to facilitate secure, transparent, and automated transactions (Ivanov et al., 2023). Smart Contracts are essential in enabling decentralized applications, including managing non-fungible tokens (NFTs) and fan tokens (Parham & Breitinger, 2022). NFTs, for example, are digital assets that represent unique items such as artwork or in-game collectibles, and their ownership is secured through Ethereum's blockchain (Sakız & Gencer, 2021). On the other hand, fan tokens empower sports and entertainment fans to actively participate in decision-making processes related to their favorite teams or artists (Haque et al., 2022).

The emergence of blockchain as a disruptive technology can provide advantages to the sports industry (Khaund, 2020) because sports constitute a significant element of human life and play an essential societal role (Lombardo, 2012). With

the progressive advancements in technology and its impact on the sports environment, sports management has become increasingly complex and challenging (Ratten, 2019).

In this scenario, blockchain technology has garnered significant attention in recent years, mainly due to the widespread adoption of cryptocurrencies (Antonopoulos, 2017). It has created a promising opportunity to enhance sports management, offering improved efficiency, transparency, and engagement among industry stakeholders (Carlsson-Wall & Newland, 2020). It marks a shift towards a new economy that promises to revolutionize the sports industry and the governance and economic models underlying it (Liu et al., 2021; Wang et al., 2019).

This interconnection with the sports world can revolutionize how fans interact with content and how teams, players, and leagues manage their digital presence and monetization (Baker et al., 2022; Scharnowski et al., 2023). Major sports leagues, including the National Basketball Association (NBA) and National Football League (NFL), increasingly invest in blockchain-based solutions. For instance, NBA Top Shot, a platform developed in partnership with Dapper Labs, allows users to trade "moments" – digital collectibles featuring videos of iconic NBA player performances (Young, 2021). Moreover, startups are developing innovative blockchain-based solutions to address challenges faced by sports organizations, suggesting a promising future for blockchain in sports.

Blockchain applications can extend across many domains, from ticket management (Nugraha et al., 2021; Regner et al., 2019) to the copyright protection of sporting events (Jun-Ming & Jing, 2021). Blockchain can potentially democratize global access to sports, enabling worldwide participation and enjoying its benefits (Carlsson-Wall & Newland, 2020). Furthermore, blockchain could offer greater transparency in resource management and revenue distribution within sports (Raveh, 2020). Additionally, blockchain technology can help create intellectual property and monetization systems, ensuring fans have safe and transparent access to exclusive content (Franceschet & Libera, 2023).

Conducting research in this field can help identify blockchain applications that can offer advantages to sports. Additionally, it can help comprehend blockchain implementation's difficulties in sports, which are crucial to developing solutions that meet the needs of sports users and organizations. By identifying blockchain applications in sports, research can also assist sports managers in understanding how technology can enhance processes and boost the efficiency of organizations. Furthermore, it can identify gaps in existing knowledge and suggest areas for further study, contributing to advancing scientific research and sports management.

This article adopts a novel approach by examining the innovative applications of blockchain technology within the sports context, thus expanding the research scope in this field. From a practical standpoint, integrating blockchain technology into the sports industry is anticipated to drive innovation and development. Therefore, this study aims to provide a comprehensive overview of the potential uses of blockchain in sports through a systematic literature review (SLR).

Beyond identifying key application areas of blockchain in sports, this review also aims to explain the rationale for adopting this technology, analyse the technical approaches employed, and address the challenges faced during the development and implementation of blockchain-based systems. Furthermore, it highlights the barriers to adoption and provides recommendations for overcoming these obstacles, making it a valuable resource for researchers and practitioners.

The main contributions of this paper are threefold: (1) We identify and categorize the primary studies related to blockchain applications in the sports industry, laying a foundation for future research. (2) We offer a detailed synthesis of state-of-the-art blockchain applications in sports through both quantitative (bibliometric analysis) and qualitative (thematic analysis) approaches, providing insights into current trends and gaps in the literature. (3) We explore the technical challenges and barriers to implementing blockchain in the sports industry, offering actionable solutions to facilitate broader adoption.

The remainder of this paper is organized into sections as follows: Section 2 provides the background knowledge of blockchain and discusses related work; Section 3 describes the study methodology and presents the PRISMA approach; Section 4 presents the results; Section 5 discusses blockchain applications in the sports field and study limitations; Section 6 concludes the paper.

## Materials and Methods

### Study Design

This study followed the standard guideline for systematic reviews according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) (Page et al., 2021). A common objective of conducting an SLR is to map the current state of knowledge in a specific field, identify a research inquiry, and contribute to expanding existing knowledge (Tranfield et al., 2003).

### Search Strategy

To conduct a comprehensive SLR, in March 2024, we searched the Cochrane Library for any existing review addressing the use of Blockchain technology in the sports industry, but we found nothing. Thus, we searched the Medical Subject Hea-

dings (MeSH) to identify potential keywords for the present SLR. We then opted for a simple Boolean search phrase encompassing the entire spectrum of the topic for all databases. The search phrase was: Blockchain* AND Sport*. We searched for relevant articles from multiple sources, including the Institute for Scientific Information (ISI) Web of Science (SSCI), Scopus, ScienceDirect, PubMed (MEDLINE), Embase, Institute of Electrical and Electronics Engineers (IEEE) Xplore, and Dimensions. We selected data sources from the two leading databases for bibliometric analyses, with the Dimensions database emerging as a significant competitor to Web of Science and Scopus databases (Singh et al., 2021). We also selected two of the most representative digital libraries for Software Engineering Research (ScienceDirect and IEEE Xplore) (Kitchenham et al., 2007) and relevant databases in the sports area (PubMed and Embase).

Following the initial search, we conducted a forward and backward snowballing process to identify any additional related studies that may have been missed. Backward snowballing involves examining the references of papers, while forward snowballing involves examining the documents that cited the selected studies (Wohlin, 2014).

## Eligibility Criteria

We established rigorous selection criteria for papers, which three researchers later reviewed to finalize the eligibility criteria. The inclusion criteria were papers proposing blockchain technology applications in the sports industry and papers that obtained scores classifying their quality as good or fair in the assessment process. The exclusion criteria were papers unrelated to the sports industry, papers focusing on gambling or sports betting, papers not employing blockchain technology, superseded versions of studies with more comprehensive updates, inaccessible papers, books, book chapters, theses, preprints, editorials, conference proceedings, retracted papers and surveys, reviews, and SLR papers, which were categorized separately to outline the state-of-the-art in blockchain within sports. Data from these studies were not extracted or synthesized, as they are considered related work for this study.

## Data Extraction and Synthesis

The results were exported from our electronic search to the Rayyan web platform for organization, duplicate removal, and to conduct the inclusion and exclusion process through double-anonymized validation by two reviewers, who performed the process independently to avoid interference in decision-making. A third reviewer was available to resolve discrepancies after completing the individual screening (Ouzzani et al., 2016). For study quality assessment and the snowballing method, we used Zotero 6.0.19, a user-friendly, open-source software, along with Google Sheets for continuum double-anonymized verification.

## Quality Assessment

We assessed the quality of selected papers using established systematic review guidelines to determine their inclusion eligibility (Kitchenham & Brereton, 2013; Petersen et al., 2015; Wohlin et al., 2020). We developed Five quality criteria (QC) to evaluate whether the criterion was entirely, partially, or failed. The total scores of the five QC were calculated, and the papers were ranked into three categories: good, fair, and fail. Documents in the good and fair groups were included, while those in the failure group were excluded. During the quality assessment, we also reviewed the reference lists of the selected studies to identify additional peer-reviewed studies. All papers selected for this review scored above two, indicating fair or good quality. The QC are as follows:

**Table 1**
*Papers Quality Criteria*

| QC | Question | Description |
|---|---|---|
| QC1 | Does the study have a clearly defined research purpose? | A primary study must have a clear objective for using blockchain technology in sports. A study that fails to meet this criterion will not be included in the subsequent data extraction and synthesis process. |
| QC2 | Does the study clearly define the blockchain concept and its application in sports? | A clear definition is necessary for developing a comprehensive understanding of the use of blockchain technology in the context of sports institutions. |
| QC3 | Does the study describe its methodology clearly? | The applied methodology is crucial in determining the article's relevance to this research. |
| QC4 | Does the study propose practical solutions and provide a way to evaluate them? | The feasibility of a study's proposed solutions is essential in designing functional, available, and applicable methods. |
| QC5 | Does the study discuss its limitations? | Discussion of the current limitations of blockchain governance can reveal the direction of future studies on this research. |

*Note.* A quality criterion (QC) is used to evaluate the papers.

## Bibliometric Analysis

The data extraction process began with downloading selected articles to compose the SLR and recording their basic information (e.g., title, year of publication, authors, publication journal, and affiliation) to evaluate the impact of these publications. The impact analysis of the articles in this SLR assesses the impact in the following ways: a) Author impact (Egghe & Rousseau, 2008; Hu et al., 2021); b) Journal ranking methods (Canales & Sanz Valero, 2020; Vairavan et al., 2020). Google Scholar was used to search for the researcher's h-index. The scientific structure is essential for understanding a specific research field. Therefore, it becomes necessary to analyze the structure of the works and how authors organize themselves in this context (Horta et al., 2018). This bibliometric analysis composition used during a systematic review can be observed in Principe et al. (2022).

## Data Selection

Our SLR protocol employs the 5W1H approach (i.e., what, why, where, when, who, and how) to formulate research questions (RQ), followed by Liu et al. (2023), providing a comprehensive examination of blockchain adoption and application in the sports industry, as detailed in Table 2.

**Table 2**
*Research Questions With the 5W1H Approach*

| RQ | 5W1H | Research question | Motivation |
|---|---|---|---|
| 1 | What | What is blockchain technology? | To observe how primary studies define the concept of blockchain. |
| 2 | Why | Why has blockchain technology been adopted in the sports industry? | To understand the forces to adopt blockchain technology in sports. |
| 3 | Where | Where is blockchain technology enforced in sports? | To distinguish the key objects that can be used in the blockchain ecosystem in sports. |
| 4 | When | When is blockchain technology applied in the sports environment? | To understand where blockchain fits in the development process of the sports environment. |
| 5 | Who | Who is involved in blockchain technology in the sports context? | To identify the different roles and their authorities, capabilities, and responsibilities |
| 6 | How | How is blockchain technology designed for sports? | To explore actionable mechanisms for implementing blockchain technology in sports |

*Note.* Research question (RQ) and 5W1H. Five questions start with the letter W (What, Why, Where, When, Who), and 1 question starts with H (How).

In RQ1, our goal is to extract the definition of blockchain from primary studies, which will provide us with insights into the fundamental dimensions of this technology. RQ2 aims to identify critical issues that require appropriate solutions. This research question will enable us to comprehend the strengths and consequences of the mechanisms for using blockchain technology analyzed in RQ6. RQ3 aims to expand the sports ecosystem by identifying key objects for blockchain technology use. By doing so, we will be able to understand how these objects are interconnected and determine when sports can apply blockchain technology for their development, as explored in RQ4. RQ5 focuses on comprehending the stakeholders involved in adopting blockchain technology in sports. Lastly, RQ6 explores the mechanisms and best practices for implementing blockchain technology in the context of sports.

## Results

This section outlines the SLR framework workflow, detailing the study selection, quality assessment, and quantitative (bibliometric) and qualitative (research questions) analyses.

## SLR Framework

Initially, 1,571 articles were identified. After removing duplicates, retracted papers, and those outside the scope, we reviewed the full text of 55 studies. Then, 32 articles underwent snowballing to identify additional relevant articles not retrieved by keyword search. We included four studies from the snowballing process and added five known studies not previously identified. After quality analysis, we excluded four studies that failed to meet the criteria, leaving 37 articles for quantitative and qualitative analysis (see figure 1).

**Figure 1**
*The Overview Process of the Literature Review*
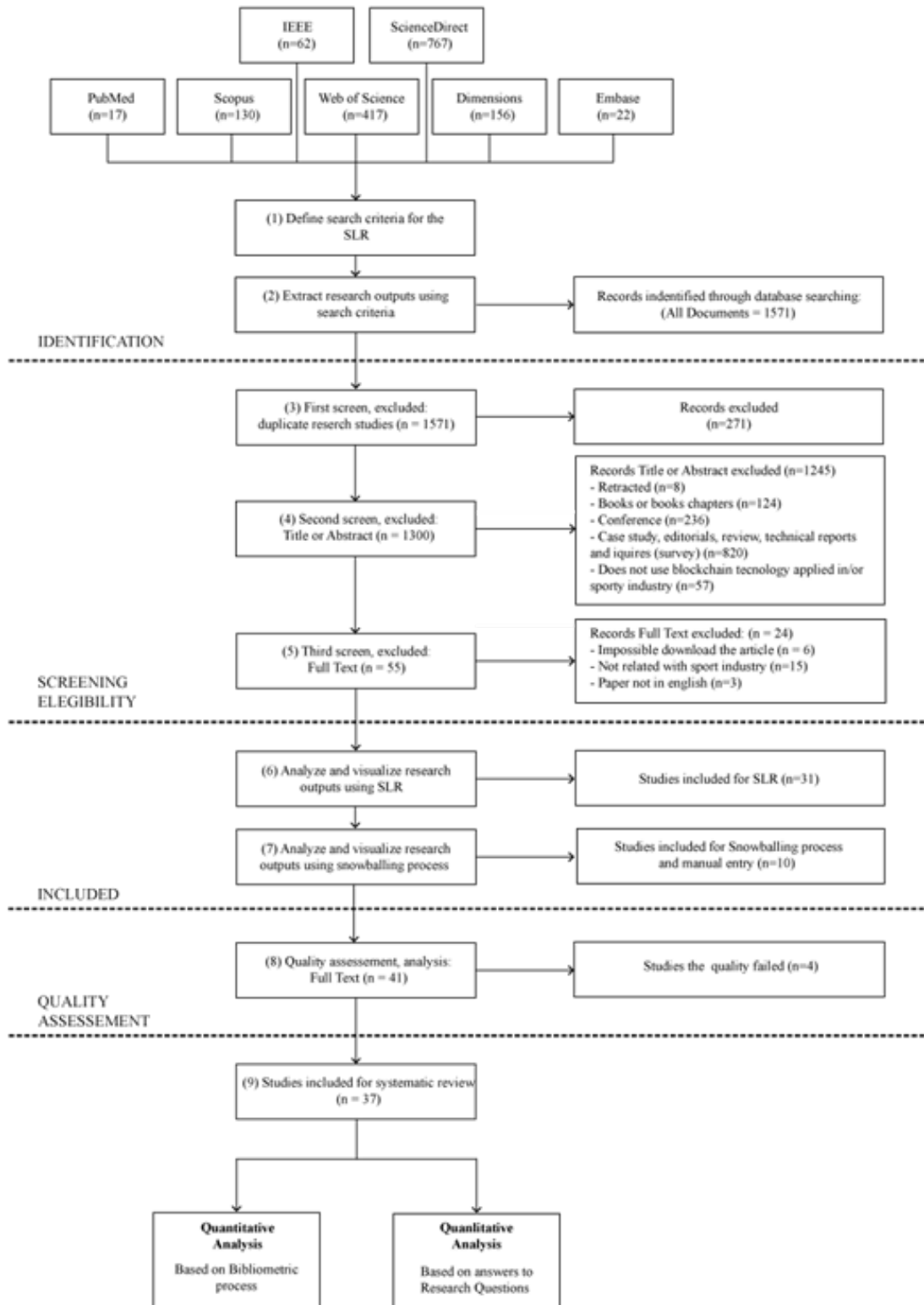


*Note.* This figure demonstrates the PRISMA process (Page et al., 2021). IEEE: Institute of Electrical and Electronics Engineers and SLR: systematic literature review.

Using the snowball strategy (table 3), identified 41 articles: 32 were from the initial database, and nine met all research criteria and were manually included. This process resulted in the inclusion of additional studies, as illustrated in table 1.

**Table 3**
*Snowballing Process Paper Insertions*

| Seed paper | Snowballed paper |
|---|---|
| Vidal-Tomás (2023) | Ersan et al. (2022) |
| Scharnowski et al. (2023) | Mazur and Vega (2023) |
| Alaminos et al. (2024) | Solntsev et al. (2022) |
| Ante et al. (2023) | Bernstein (2018) |

*Note.* The insertion of articles was found through the snowballing process, where it is possible to see the source article and which document was found based on this study.

**Table 4**
*Study Quality Assessment Results*

| Studies | QC1 | QC2 | QC3 | QC4 | QC5 | Decision |
|---|---|---|---|---|---|---|
| Alaminos et al. (2024) | Entirely | Partially | Entirely | Entirely | Partially | Good |
| Ante et al. (2023) | Entirely | Entirely | Entirely | Entirely | Entirely | Good |
| Baker et al. (2022) | Entirely | Entirely | Failed | Entirely | Failed | Fair |
| Bernstein (2018) | Failed | Entirely | Failed | Entirely | Failed | Fail |
| Cao et al. (2021) | Entirely | Partially | Entirely | Entirely | Failed | Fair |
| Chen (2024) | Entirely | Entirely | Partially | Failed | Failed | Fail |
| Chen et al. (2022) | Entirely | Partially | Entirely | Entirely | Failed | Fair |
| Demir et al. (2022) | Entirely | Partially | Entirely | Partially | Failed | Fair |
| Ersan et al. (2022) | Entirely | Partially | Entirely | Partially | Failed | Fair |
| Foglia et al. (2024) | Entirely | Partially | Entirely | Entirely | Entirely | Good |
| Fukuzawa et al. (2023) | Entirely | Entirely | Entirely | Entirely | Entirely | Good |
| Hong and Park (2020) | Entirely | Partially | Entirely | Entirely | Failed | Fair |
| Jiang et al. (2023) | Entirely | Entirely | Entirely | Entirely | Entirely | Good |
| Jin et al. (2021) | Failed | Partially | Failed | Entirely | Failed | Fail |
| Jun et al. (2024) | Entirely | Entirely | Entirely | Entirely | Entirely | Good |
| Karakaya and Akleylek (2021) | Entirely | Partially | Entirely | Entirely | Entirely | Good |
| Li and Zhu (2023) | Partially | Entirely | Partially | Entirely | Failed | Fair |
| Li et al. (2021) | Entirely | Entirely | Entirely | Entirely | Failed | Good |
| Liu et al. (2018) | Entirely | Partially | Entirely | Entirely | Failed | Fair |
| Lv et al. (2022) | Entirely | Entirely | Entirely | Entirely | Entirely | Good |
| Ma (2021) | Entirely | Entirely | Partially | Entirely | Failed | Fair |
| Mazur and Vega (2023) | Entirely | Partially | Partially | Entirely | Failed | Fair |
| Mohammad et al. (2023) | Entirely | Partially | Entirely | Entirely | Failed | Fair |
| Naraine (2019) | Entirely | Entirely | Partially | Entirely | Entirely | Good |
| Nugraha et al. (2021) | Partially | Entirely | Entirely | Entirely | Failed | Fair |
| Pinto et al. (2022) | Entirely | Entirely | Entirely | Entirely | Entirely | Good |
| Pu et al. (2023) | Entirely | Entirely | Entirely | Entirely | Failed | Good |
| Sabarigirisan et al. (2021) | Entirely | Entirely | Partially | Entirely | Entirely | Good |
| Sang and Wang (2022) | Entirely | Entirely | Entirely | Entirely | Partially | Good |
| Scharnowski et al. (2023) | Entirely | Partially | Entirely | Entirely | Failed | Fair |
| Shan and Mai (2020) | Entirely | Entirely | Entirely | Entirely | Failed | Good |
| Sharma (2021) | Entirely | Entirely | Entirely | Entirely | Failed | Good |
| Singhal et al. (2023) | Failed | Partially | Entirely | Entirely | Failed | Fail |
| Solntsev et al. (2022) | Partially | Entirely | Partially | Entirely | Entirely | Good |
| Song and Tuo (2022) | Entirely | Entirely | Entirely | Entirely | Failed | Good |
| Vidal-Tomás (2023) | Entirely | Partially | Entirely | Partially | Failed | Fair |
| Wang and Liu (2022) | Partially | Entirely | Entirely | Entirely | Failed | Fair |
| Wilson et al. (2022) | Entirely | Entirely | Partially | Entirely | Entirely | Good |
| Yang et al. (2023) | Entirely | Entirely | Failed | Entirely | Failed | Fair |
| Yin et al. (2023) | Entirely | Partially | Entirely | Entirely | Failed | Fair |
| Yu (2021) | Entirely | Partially | Entirely | Entirely | Entirely | Good |

*Note.* This table demonstrates the quality assessment for the studies.

Following the SLR guidelines, the review process may introduce validity threats that could affect the entirety of the study. Consequently, following the selection of studies shown in Section 3 and the framework depicted in figure 1, we devised strategies to mitigate the influence of these studies based on their quality. The construct validity might be jeopardized by the potential incompleteness of the search strings and the ambiguity of the terms used. Therefore, we intended to include synonyms for "blockchain", such as "web3" and "Distributed Ledger Technology", in our search queries. However, the ambiguity of these terms led us to define our search terms conservatively, mitigated by strict inclusion and exclusion criteria and detailed screenings of titles, abstracts, and full texts.

Bias during data extraction was addressed by having two researchers independently extract data from assigned studies and validate each other's findings using a predefined quality protocol. Studies scoring below 3, based on five critical questions (table 4), were considered inadequate and excluded, resulting in 37 selected studies.

Figure 2 illustrates the relationship between blockchain technology and its main characteristics, its applications in the sports industry, and which stakeholders benefit from its use. The reviewed articles indicate that using blockchain technology within the sports industry stems from the characteristics outlined in figure 2, making blockchain a potential solution for the observed gaps. Thus, from the included studies, it was possible to observe that various segments with specific needs already utilize blockchain technology.

**Figure 2**
*The Sports Blockchain Overview*
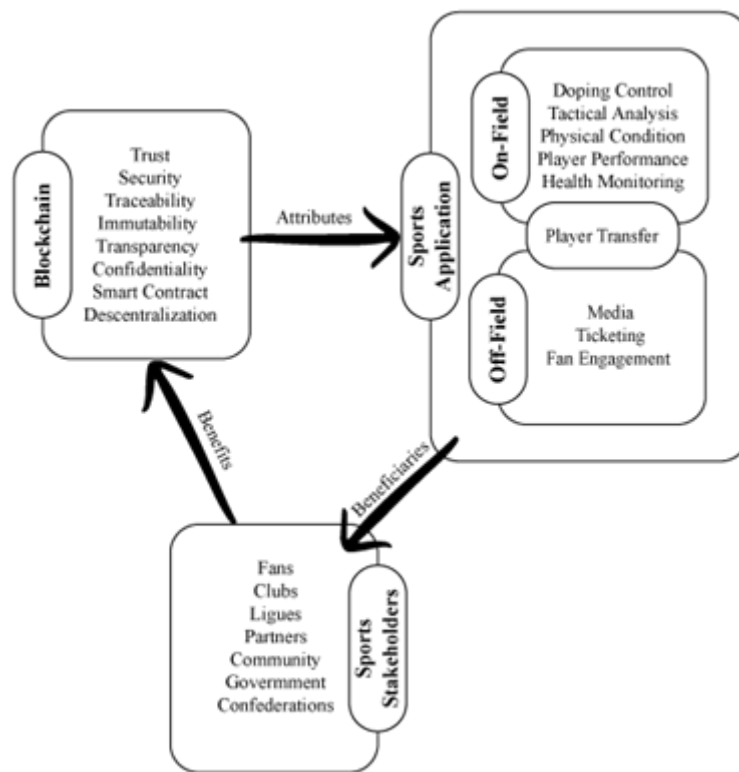


*Note.* This figure summarizes blockchain's attributes, the areas where studies show that this technology is applied in sports, and the main stakeholders in the sports industry.

The provided image represents a preliminary conceptual sketch of the studies selected in this review, aimed at exploring the potential impact of blockchain technology in the sports industry. The central element is sports applications, where blockchain technology is applied holistically, covering a wide range of operations and processes in the industry. The direct connection between blockchain and sports applications suggests a facilitative role for blockchain, acting as an enabler in this context. This relationship highlights the potential of blockchain's inherent features – decentralization, transparency, and security – to enhance sports applications.

The flowchart categorizes activities into 'On-Field' and 'Off-Field' domains, suggesting a separation between activities directly related to sports performance and those that are part of the infrastructure and administration that sustain sports. The inclusion of 'Player Transfer' under the 'Off-Field' domain with a direct link to the 'On-Field' domain alludes explicitly to the potential role of blockchain in facilitating player transfers, a process that traditionally involves complex negotiations, contracts, and sig-

nificant asset exchange. The use of blockchain could introduce new methods of contracting based on smart contracts, which can automate and legally protect player transfers, thereby improving transaction efficiency and reliability.

The reference to sports stakeholders acknowledges the diverse entities and individuals interested in this sector. The impact of blockchain adoption is likely to be heterogeneous, affecting different stakeholders in distinct ways. For example, fans may experience greater integration and engagement with their favorite teams and athletes through blockchain applications that offer increased transparency and interaction. Similarly, regulators and sports organizations may use blockchain as an effective means to track and validate the integrity of results and regulatory compliance. The inclusive nature of the diagram suggests that the scope of blockchain's impact on sports is broad, potentially altering the landscape for all participants, from players to governmental organizations and spectators.

## SLR Framework

Impact assessment was based on the annual number of articles published from 2019 to 2024, as shown in figure 3.

**Figure 3**
*Annual Publication Volume (2019–2024)*
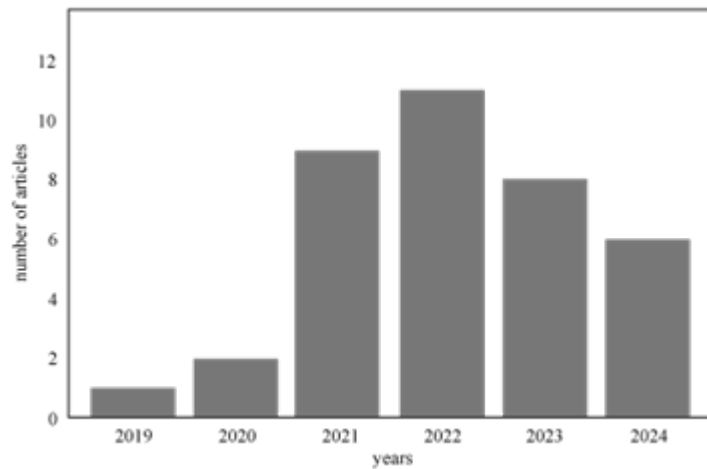


*Note.* This figure demonstrates the evolution of publications over the years.

Publications on blockchain in the sports industry have risen. Specifically, nine and 11 papers on this topic were published in 2021 and 2022, respectively. This highlights this topic's growing interest and relevance in the academic community. Notably, the earliest article selected from our comprehensive search dates to 2019, 11 years after Nakamoto's paper introducing the technology (Nakamoto, 2008).

Twenty-nine different scientific journals published the articles reviewed in this research. IEEE Access (Cao et al., 2021; Liu et al., 2021; Mohammad et al., 2023) and Mobile Information Systems (Song & Tuo, 2022; Wang & Liu, 2022; Yu, 2021) had the highest number of publications, with three articles each. Research in International Business and Finance had two publications each (Ersan et al., 2022; Foglia et al., 2024). Additionally, 29 other journals were identified, with only one publication each.

Table 5 provides a comprehensive overview of the most relevant journals extracted from the databases using the search term(s), classified by the number of articles published in these databases. While all journal counts are recorded in a spreadsheet for further analysis, this table highlights journals with more than one publication during the study period. It also includes other vital metrics such as impact (Journal Citation Reports and H-index), prestige (SCImago Journal Rank and Eigenfactor Score), and the number of articles found in the search.

**Table 5**
*The Impact of the Most Relevant Journals*

| Journals | NA | JCR | HI | SJR | ES |
|---|---|---|---|---|---|
| IEEE Access | 3 | 3.4 | 204 | Q1 (0.93) | 0.002 |
| Mobile Information Systems | 3 | 1.8 | 42 | Q3 (0.66) | <0.001 |
| Research in International Business and Finance | 2 | 6.3 | 63 | Q1 (1.27) | None |
| EURASIP Journal on Wireless Communications and Networking | 2 | 2.3 | 74 | Q2 (0.66) | 0.006 |

*Note*. This table shows the impact of journals with more than one publication in the database used. NA: Number of articles, JCR: Journal Citation Reports, HI: H-index, SJR: SCImago Journal Rank, ES: Eigenfactor Score, CIT: Total number of journal citations, and None: There are no records for the search criteria you entered.

Regarding impact, especially in terms of the Journal Impact Factor, the journal Research in International Business and Finance performed better, most likely due to the relevance of its publications in the business and finance field since 2018. Notably, none of the most published journals are in the sports field, suggesting possible disinterest in technology-related topics or reluctance among researchers who publish in this area to submit their work to these journals. Research in International Business and Finance journals was not found in the Eigenfactor Score database (eigenfactor.org), which ranks only specific ISI-listed journals by category, journal, and publisher.

In the subsequent step, the articles were condensed to determine which researchers had the most significant impact. All the authors in the database had only one article in this study, implying that no author stood out in the number of publications. Consequently, we used the criterion to analyze the lead authors of the six papers published in 2024 since the database of studies found did not present any author with more than one study published. Table 6 presents the researchers ranked by total number of citations and h-index in the Google Scholar database.

**Table 6**
*The 2024 Authors' Impact*

| Authors | CIT | HI | Institution |
|---|---|---|---|
| Alaminos, David | 363 | 8 | University of Barcelona, Spain |
| Ante, Lennart | 2126 | 19 | Blockchain Research Lab |
| Foglia, Matteo | 640 | 14 | University of Bari, Italy |
| Fukuzawa, Mathew | 8 | 2 | North Carolina State University, USA |
| Jun, Wang | None | None | Anhui Xinhua University, China |
| Vidal-Tomás, David | 1333 | 16 | University College London, UK |

*Note.* CIT: Number of author citations on Google Scholar; HI: H-Index; USA: United States of America; UK: United Kingdom.

Analyzing the author's impact in a research area reveals how each researcher seeks to establish their ideas in their field of expertise. Therefore, journal impact analysis favored the selection of high-quality journals and determined study visibility. The six articles published in 2024 highlight expertise in financial and economic research, with Alaminos, Ante, Matteo, and Vidal-Tomás holding PhDs in economics. Fukuzawa, a doctoral student in Operations Research, has fewer citations and a lower h-index. Information on Jun was unavailable in the Google Scholar database.

## Discussion

In this section, we present the qualitative stage of the analysis: a discussion of the answers we identified for each of our research questions. We then describe this study's limitations and implications for future research.

### RQ1: What is Blockchain Technology?

Within this context, several definitions of blockchain technology have emerged. However, from a technical perspective, blockchain is a distributed peer-to-peer digital ledger that uses cryptography to ensure its security while recording transactions (Jiang et al., 2023; Nugraha et al., 2021). At the same time, it allows the addition of new data through a commonly agreed consensus mechanism, ensuring that previous data records cannot be altered or deleted (Lv et al., 2022). Thus, it becomes a decentralized and transparent record-keeping system. However, according to (Naraine, 2019), this definition of blockchain may be too abstract for professionals in the sports industry if they do not have a background in technology.

The main characteristic of blockchain technology is decentralization. Instead of a single point of control, multiple participants in the network possess a copy of the complete database, known as the ledger. These participants, also known as nodes, validate and record transactions, ensuring the integrity and security of the data (Ma, 2021; Song & Tuo, 2022; Wang & Liu, 2022).

In the database analyzed in this study, we can find a global definition to explain blockchain: "A blockchain consists of blocks and chains. Blocks are linked together in chronological order by the previous block's hash value, making the blockchain difficult to change" (Sang & Wang, 2022).

### RQ2: Why has Blockchain Technology Been Adopted in the Sports Industry?

Blockchain technology is adopted in the sports industry for several reasons, including its ability to enhance transparency, security, and efficiency in various processes. One significant application is the use of smart contracts for the automated management of athlete transfers and contracts, which ensures transparency and reduces reliance on intermediaries (Fukuzawa et al., 2024). Furthermore, blockchain enables secure data management and traceability, allowing the collection

of health and performance data, which can be utilized to monitor athletes' physical conditions and improve their training regimes (Yu, 2021). The decentralized nature of blockchain is also beneficial in managing large-scale sports events by improving credential management and security for participants and sponsors, as seen in events like the Olympic Games (Naraine, 2019; Wang & Liu, 2022; Yu, 2021). Additionally, blockchain contributes to the innovation of business models in sports, allowing for better monetization of fan engagement and athlete interactions. For example, platforms like vSport utilize blockchain to issue tokens that can be exchanged for fan engagement experiences, connecting millions of sports fans globally (Lv et al., 2022).

## RQ3: Where is Blockchain Technology Enforced in Sports?

Blockchain technology is applied across various sports sectors, including digital collectibles, contract management, athlete transfers, access control and digital tickets, performance monitoring, health and injury management, and fan engagement, among many others. As the technology continues to evolve, new applications and use cases are being explored, mainly to increase transparency, security, and efficiency in different aspects of the sports industry.

Technology is used to ensure new sources of income through digital collectibles, such as tokens, to represent digital assets such as tickets (Alaminos et al., 2024). NBA Top Shot is a platform where iconic game moments are tokenized and sold as digital collectibles (Baker et al., 2022). Blockchain-based systems for tracking the authenticity of digital collectibles (Chen et al., 2022), fan tokens used by football clubs to generate revenue through exclusive voting rights and benefits (Demir et al., 2022), the financial connectivity between fan tokens and football club stocks (Ersan et al., 2022), and platforms like Socios.com for fan engagement and exclusive rewards (Foglia et al., 2024).

The integration of cryptocurrencies and tokens for football club financing and fan interaction (Mazur & Vega, 2023), blockchain platforms that allow users to acquire digital assets in sports games (Naraine, 2019), fan tokens, and NFTs as tools for both fan engagement and financial speculation (Solntsev et al., 2022)., and the use of blockchain to monetize fan engagement in sports through tokens (Vidal-Tomás, 2023). Platforms like NBA Top Shot have also been highlighted for selling iconic basketball game moments as digital collectibles (Wilson et al., 2022). At the same time, blockchain and big data are leveraged to create new economic models in sports with NFTs (Yang et al., 2023).

The use of blockchain for automated and decentralized contract management includes smart contracts that facilitate the acquisition or transfer of athletes by automatically executing the terms of contracts without intermediaries (Fukuzawa et al., 2024). Moreover, blockchain ensures transparent and secure transactions in the athlete transfer process, allowing for real-time tracking and immutable records of contracts, as highlighted by (Liu et al., 2021).

Blockchain can monitor health by securely collecting and recording data on the blockchain, such as IoT sensors for real-time monitoring of athletes' physical conditions and rehabilitation (Karakaya & Akleylek, 2021). Blockchain and IoT technologies are applied to sports injury rehabilitation systems, ensuring data integrity and enabling precise analysis of injury locations (Li & Zhu, 2023). A hybrid blockchain model is used for secure medical data storage and diagnosis, allowing seamless access and sharing (Mohammad et al., 2023). In the context of doping control, blockchain is leveraged to securely store and track athletes' health and injury data, ensuring privacy and transparency (Pinto et al., 2022). Blockchain's decentralized nature facilitates full-cycle management of athlete injuries, allowing for secure health data recording (Pu et al., 2023). Furthermore, blockchain-based health data collection systems can ensure the secure transmission of athletes' health information during training, minimizing risks and optimizing performance tracking (Yu, 2021).

Blockchain technology can analyze, improve, and control sports performance through decentralized platforms that predict sports performance using blockchain-enabled models (Cao et al., 2021). It also helps monitor physical fitness through IoT sensors integrated with blockchain for real-time data collection, ensuring privacy and accuracy in data analysis (Hong & Park, 2020; Sang & Wang, 2022). Similarly, blockchain enables innovative applications by combining with the Internet of Things to manage fitness and sports performance dynamically (Shan & Mai, 2020). Additionally, blockchain's integration with sports-related industries promotes innovation, better data management, and transparency, as seen in decentralized tracking and contracts for athletes and data dissemination in the sports industry (Jiang et al., 2023; Naraine, 2019). Blockchain improves sports platforms' development and interaction with fans, ensuring security and data integrity in various processes (Wang & Liu, 2022; Yin et al., 2023).

The studies reviewed show a higher but balanced focus on blockchain technology applications focusing on sports management, with 32% (n=12) addressing on-field perspective and 49% (n=18) examining off-field aspects. This indicates a homogeneous application of blockchain technology across the sports industry.

## RQ4: When is Blockchain Technology Applied in the Sports Environment

As noted, the applicability of blockchain technology in the sports industry is diverse. Studies show significant homogeneity regarding the technology's application. The studies explore applications that are not limited to specific moments,

such as training or games. Still, they are more connected to the sports management process and different applications to understand the dynamics of technology use in the sports industry. We can highlight actions related to fans during sporting events, in the context of COVID-19 control or access control measures (Nugraha et al., 2021; Sabarigirisan et al., 2021) and in the digital realm, where several authors have explored the application of blockchain from the perspective of fan tokens and their various uses, ranging from fan engagement (Demir et al., 2022) to the appreciation of digital assets (Solntsev et al., 2022; Vidal-Tomás, 2023) based on team victories in championships (Ante et al., 2024) and their financial relationship (Ersan et al., 2022; Foglia et al., 2024; Mazur & Vega, 2023) as an attractive form of resources.

### RQ5: Who is Involved in Blockchain Technology in the Sports Context?

From the analysis of these studies, we can identify various actors in this scenario, including government, sports entities, clubs, athletes, fans, sports organizations, leagues, and companies, among others, working and innovating in using blockchain technology in sports. This can be confirmed by some citations, such as: "Players, spectators, technical team, and club doctors are involved, with blockchain technology ensuring the integrity of the data" (Karakaya & Akleylek, 2021); "The system has three unique roles: coach, team doctor, and athlete, each with its functional modules" (Li & Zhu, 2023); "Who is involved: sports clubs, the fans, blockchain developers, and platforms like 'Socios' that facilitate the engagement between these entities" (Alaminos et al., 2024); or "Sports industry enterprises, government, and regulatory bodies involved in blockchain technology in the sports context" (Li et al., 2021).

### RQ6: How is Blockchain Technology Designed for Sports?

Providing a recipe or manual on how blockchain technology is or can be designed for the sports industry is impossible. Each institution has its own reality and distinct problems to solve depending on its level of managerial maturity. As blockchain technology advances, numerous other studies on this topic and its applicability in sports will emerge in the coming years. Thus, we are still dealing with an emerging technology that requires more time for in-depth exploration of its uses and applications.

However, we can frame blockchain technology as a shift in focus from algorithms and computer science to management and operationalization. Furthermore, it guides how this new system differs from the current paradigm and gains acceptance in the sports industry. Blockchain can be conceptualized in sports organizations not only as a new technology that can bring about changes but as a paradigm that, due to its decentralized and transparent nature, sets it apart from other studies and applications in sports that are focused on centralization as a critical factor in this industry.

### Study Limitations

The study's limitations stem from the need for clear indications about the applicability of blockchain technology in the sports industry, as this is a relatively new area, and there is a need for more articles in exercise and sports science journals. Much of the research is published in technology-focused journals with a financial bias, particularly concerning fan tokens. The search process was also constrained by the absence of synonyms like "Web3" and "Distributed Ledger Technology" in the Medical Subject Headings (MeSH), which limited their use as search terms. Although we tested these terms, they were excluded and did not add value to the research. Similarly, the synonym "block chain" (with a space) appeared in MeSH but proved ineffective when used as a search term.

Additionally, many articles in conference proceedings needed peer review, a criterion for inclusion in this study, further restricting the available sources. Therefore, more peer-reviewed studies, especially those that examine the broader applications of blockchain technology in sports beyond the technical and financial aspects, are recommended. These should focus on understanding blockchain's role in fan engagement and organizational governance within the sports sector.

## Conclusions

This study systematically reviewed the potential applications of blockchain technology in the sports industry. Blockchain's core features (decentralization, transparency, security, and immutability) offer solutions to stakeholders such as athletes, clubs, fans, and regulators. One significant benefit is its capacity to enhance trust through transparent, auditable transactions. Blockchain also enables automation via smart contracts, streamlining processes like player transfers and contract management while reducing fraud and costs. For fans, digital tokens and NFTs foster direct engagement with clubs and offer decision-making participation, creating trust and new monetization opportunities.

Despite its promise, blockchain adoption faces significant challenges. Major barriers include a standardized regulatory framework, legal uncertainties, technical complexity, and high implementation costs, particularly for smaller clubs. Resistance to decentralized systems and scalability and energy efficiency issues, especially in Proof of Work (PoW) networks, further hinder adoption. However, more sustainable alternatives like Proof of Stake (PoS) are emerging. Interoperability between different blockchain platforms also complicates the development of a unified digital ecosystem.

While these challenges are considerable, blockchain can transform the sports industry, improving efficiency and trust. Addressing these barriers will require technological, regulatory, and cultural shifts within sports organizations. This review provides a foundation for future research, focusing on governance, stakeholder decision rights, and legal and ethical frameworks to better understand blockchain's role in sports.

## Ethics Committee Statement

It's not applicable because the study is a systematic literature review.

## Conflict of Interest Statement

We confirm no conflicts of interest are associated with the information and findings presented in this manuscript.

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## Authors' Contribution

Vitor Ayres Principe: Writing – original draft, conceptualization, project administration; Giullio César Pereira Salustiano Mallen da Silva: Writing – original draft, methodology, visualization; Juliana Brandão Pinto de Castro: Writing – review & editing, formal analysis, supervision; Diego Gama Linhares: data curation, methodology, visualization; Wecisley Ribeiro Espírito Santo: data curation, formal analysis, supervision; Rodrigo Gomes de Souza Vale: Writing – review & editing, formal analysis, project administration, validation; Rodolfo de Alkmim Moreira Nunes: Writing – review & editing, conceptualization, supervision, validation. All authors have read and agreed to the published version of the manuscript.

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