Journal Pre-proof

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PII: S2666-7649(23)00050-4

DOI: <https://doi.org/10.1016/j.dsm.2023.11.001>

Reference: DSM 79

To appear in: *Data Science and Management*

Received Date: 4 July 2023

Revised Date: 4 November 2023

Accepted Date: 6 November 2023

Please cite this article as: Ati, A., Bouchet, P., Ben Jeddou, R., Using multi-criteria decision-making and machine learning for football player selection and performance prediction: A systematic review, *Data Science and Management* (2023), doi: <https://doi.org/10.1016/j.dsm.2023.11.001>.

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# Using multi-criteria decision-making and machine learning for football player selection and performance prediction: A systematic review

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1

# Using multi-criteria decision-making and machine learning for football player selection and performance prediction: a systematic review

**Abstract**

**Evaluating and selecting players to suit football clubs and decision-makers (coaches, managers, technical, and medical staff) is a difficult process from a managerial-financial and sporting perspective. Football is a highly competitive sport where sponsors and fans are attracted by success. The most successful players, based on their characteristics (criteria and sub-criteria), can influence the outcome of a football game at any given time. Consequently, the D-day of selection should employ a more appropriate approach to human resource management. To effectively address this issue, a detailed study and analysis of the available literature are needed to assist practitioners and professionals in making decisions about football player selection and hiring. Peer-reviewed journalswere selected for collecting published papers between 2018 and 2023. A total of 66 relevant articles (journal articles, conference articles, book sections, and review articles) were selected for evaluation and analysis. The purpose of the study is to present a systematic literature review (SLR) on how to solve this problem and organize the published research papers that answer our four research questions.**

**Keywords: multi-criteria decision-making, machine learning, football player selection, managerial-financial and sporting performance.**

## Introduction

Soccer has been the world’s most influential most and popular sport for over a century. For the past thirty years, it has also become the most gainful industry, with a significant managerial and financial impact on sponsorship, broadcasting, and transfers of players (Müller et al., 2017; Rohde and Breuer, 2017). Many professional football clubs are complex businesses that exclusively deal with financial issues (Morrow and Howieson, 2014). However, Katzenbach (2009) explored the counter- intuitive features comprising high-performing teams, such as selecting team members based on their skills rather than their compatibility. Club success is determined by the score on the field, which depend on the line-up of the chosen players. Therefore, the selection should be based on a more relevant human resource management strategy.

In a football match, in addition to preparing the team to participate in competitions, the role of decision-makers(managers, coaches, technical, and medical staff) is to hire and select players to form the team line-up by relying, technical, and tactical factors (Carmichael et al., 2000). Most importantly, the goal of the player selection process for a particular team is to choose the most suitable player for a particular playing position and role (Dezman et al., 2001; Trninic et al., 2008). Accordingly, decision-makers constantly search for the most efficient technique to identify outstanding players and build e lite teams (Katzenbach and Smith, 1993). One strategic decision decision-makers should made is choosing players for certain football match. The starting line-up comprises 11 players among the 28 available to coaches to play at the beginning of a game. This decision influences the success of a team in achieving financial and sports performance (Szymanski and Smith, 1997; Carmichael et al., 2011; Rohde and Breuer, 2016). This strategic process is part of a conventional approach that does not refer to a thorough scientific method; it is carried out mainly by intuition, common sense, and an uncertain methodology (Boon and Sierksma, 2003; Dadelo et al., 2014; Purwanto et al., 2018; Salles et al., 2019).

This process is complex and challenging to manage because it must consider a large number of qualitative and quantitative criteria and sub-criteria that describe the performance and position of each player (Arnason et al., 2004; Tavana et al., 2013; Nasiri et al., 2018). To solve this issue, decision- makers do not refer to modern methods used in other areas, such as health, software packages, transportation, and environment, which consist of multi-criteria decision-making (MCDM) methods. MCDM approaches could be beneficial and useful in assisting decision-makers, providing more objective decisions, especially when combined with machine learning algorithms. Historical research on football player selection and performance prediction oscillated between the traditional coaching experience and data-driven approaches. MCDM methods have gained traction in recent years because they provide a multi-criteria perspective for informed decision making (Dadelo et al., 2014). Simultaneously, machine learning based on large datasets may provide granular predictions of player performance using models, such as neural networks and random forests (Azeman et al., 2021). The potential fusion of MCDM for selection and machine learning for predictive insights remains underexplored area of research. Addressing this research gap is critical, and motivates this systematic literature review (SLR).

This study provides a research review to improve the evaluation and selection process of football players. Therefore, this study aims to review and organize the literature on decision-making analysis and machine learning by performing an SLR. The remainder of this paper is as organized as follows: The following section presents the research method and details of the

protocol used to plan and conduct the proposed research. Section 3 shows the analysis results to answer the research questions related to the topic. Section 4 and concludes.

## Research method

For the present study follows an SLR protocol based on Kitchenham’s guidelines (Barbara Kitchenham and Charters, 2007). Figure 1 shows three sequentialplans reflecting the components of the SLR: planning, conducting, and reporting the review.

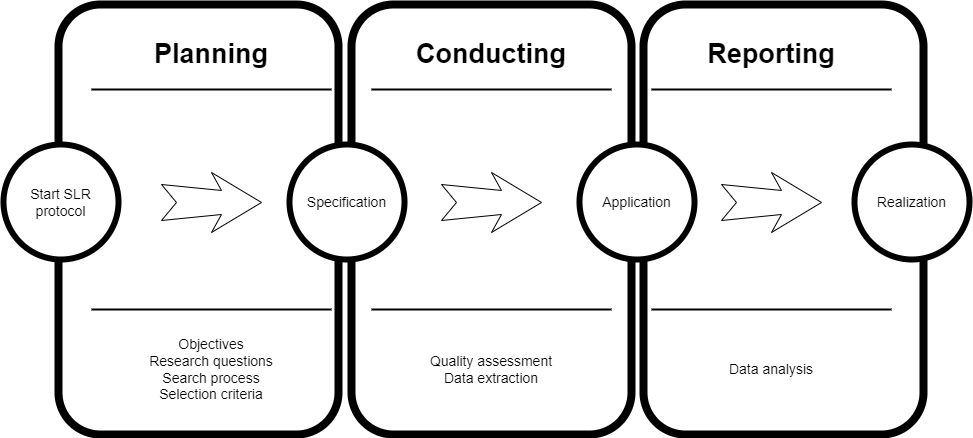


Fig. 1. SLR general process

* 1. Planning the review

The purpose of the planning phase is to specify the following steps: determine the objectives of a review, set the research questions (four research questions are selected), perform a search process using keywords for downloading the relevant papers from the selected digital libraries, and identify the selection criteria.

1. Objectives: This study examines research out in decision-making and machine learning when evaluating and selecting players, considering their playing attributes (physical, technical, tactical and behavioral criteria) and how this process influences managerial-financial and sporting performance. Player selection is a significant challenge for all clubs, involving multiple criteria that should be evaluated simultaneously. Therefore, the process of hiring and line-ups must respect many sports and financial considerations. We aim to assess the main criteria by which decision-makers set line-ups and predict the impact of their choice on sport and financial performance. To this end, decision-making methods may help decision-makers recruit and select the best players, and machine learning algorithms would be appropriate for predicting sporting and financial performances following this selection. Therefore, we provide a SLR of books and papers published in journals and conference proceedings related to our research topic.
2. Research questions*:* After determining the purpose and motivation of our research, the SLR proposes a process to answer the following research questions:

**RQ1:** What is the contribution of the literature to the review and study of the relationship between managerial-financial and sports performance? Financial and managerial successes are not the main objective, and football performance remains the primary goal. These two goals are mutually linked, and each determines the other. Football and financial success depend on hiring strategies and players’ lineups.

**RQ2:** What are the main criteria and sub-criteria for football players? In addition to preparing the team to participate in competitions, the coach’s role is to select the starting range among the players in the hired stock, based on factors such as physics, technique, tactics and behavior.

**RQ3:** The effectiveness of sports clubs is influenced by players’ and coaches’ talents. The most crucial elements of a sports organization are the athletic resources that constitute its human capital. MCDM approaches couldbe of interest to support decision makers and provide more objective decisions. This study investigates the applicability and utility of MCDM approaches in the selection process for football players.

**RQ4:** How can we build a hybrid model combining MCDM approaches and machine learning algorithms by integrating all technical and managerial-financial variables to help decision makers select the best players for a game?

1. Search process: For planning the SLR process, an appropriate mechanism must be followed to ensure the retrieval

of rele cles by

vant studies from the selected digital libraries. A systematic mechanism is used to collect the most pertinent arti



formulating a set of specific keywords. These data are then used to search peer-reviewed digital libraries for research articles. In the proposed SLR, several keywords are related to the analysis and applicability of multi-criteria decision models and machine learning in sports, mainly football, based on the above research questions. However, following a search strategy that identifies the most relevant documents is essencial. To ensurethe quality of the articles, the search focused on various electronic databases: IEEExplore, SpringerLink, ScienceDirect, Taylorand Francis, and Wiley Online Library. These are the most frequently used libraries and are known to publish high-quality materials. The authors use specific keywords to search for relevant articles in these libraries. The keywords are selected based on the proposed research questions. A search string ***S*** is formulated to interact with the libraries (Table 1). The first attempt in this search process has yielded the following results: IEEE →802, ScienceDirect →1432, Springer →398, Taylor and Francis →221, and Wiley Online Library →137. To refine the results we assigned a subset of keywords (S1, S2, S3, S4) to each research question. Given the large amount of information generated by different digital libraries, they cannot be included in the proposed SLR. A process for selecting criteria, followed by the analysis and assessment of each article, should be developed.

Table 1 List of keywords selected for search process

**Research questions Keywords for search process**

The whole topic S = (“Multi-criteria Decision Making”) AND (“machine learning”)

AND (“selection”)

RQ1 S1 = (“football” OR “soccer”) AND (“management” OR

“managerial”) AND (“financial sporting performance”)

RQ2 S2 = (“football” OR “soccer”) AND (“player”) AND (“criteria” OR

“attribute”)

RQ3 S3 = (“Multi-criteria Decision Making”) AND (“selection problems”)

RQ4 S4 = (“Multi-criteria Decision Making”) AND (“prediction”) AND

(“machine learning”) AND (“football player selection”)

1. Selection criteria: Selection criteria are specified to refine the search results, namely, the inclusion and exclusion criteria. Given the large volume of published research, it is crucial to establish boundaries for a thorough and detailed literature review. We focus on the period between 2018 and 2023, sufficiently long to observe critical trends related to our research topic. Table 2 summarizes the essential inclusion and exclusion criteria for the proposed SLR.

**Inclusion criteria**

Table 2 Selection criteria of the relevant papers

* + Published between 2018 and 2023
  + English language
  + Provide good knowledge of the formulated research questions
  + Content of the paper provide satisfactory information of the main topic and research questions

**Exclusion criteria**

* + Published outside the 2018-2023 period
  + Other language than English
  + Content of the paper not providing satisfactory information of the main topic and research questions
  + Informal literature surveys
  + Duplicate papers
  1. Conducting the review

Once the research protocol is completed, we may proceed with the review and apply what we have specified in the planning phase. The process is iterative (Fig. 2), and the first primary study is performed on search string S. For greater relevance, we use a search string for each research question (Table 3). Second, the inclusion/exclusion criteria are applied to a subset of primary studies (Table 4). Third, the remaining studies are analyzed in depth and filtered by title and paper keywords, abstracts, and content (Table 5). Each digital library is searched separately. Finally, the articles collected from the five databases are imported into the Zotero reference management software (Zotero\_community, 2023) to check for duplicates. Consequently, only 66 relevant documents (journal articles, conference papers, and book sections) that fit our topics and answer our research questions are identified. Figures 3 and 4 show the research trends in the selected period and the percentage of digital libraries, respectively.



Fig. 2. Review process

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | | | | | | Table 3 Search process based on research questions |
| **Digital libraries** | **S1** | **S2** | **S3** | **S4** | **Total** |  |
| **IEEE** | 52 | 33 | 3 | 13 | 101 |  |
| **ScienceDirect** | 614 | 64 | 29 | 6 | 713 |  |
| **Springer** | 233 | 94 | 50 | 19 | 396 |  |
| **Taylor and Francis** | 147 | 86 | 3 | 33 | 269 |  |
| **Wiley Online Library** | 288 | 14 | 2 | 29 | 333 |  |
|  |  |  |  |  |  | Table 4 Search process with inclusion/exclusion criteria |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Digital libraries** | **Journal papers** | **Conference papers** | **Book section** | **Total** |
| **IEEE** | 1 | 21 | - | 22 |
| **ScienceDirect** | 54 | - | 3 | 58 |
| **Springer** | 36 | 4 | 7 | 47 |
| **Taylor and Francis** | 32 | - | - | 32 |
| **Wiley Online Library** | 22 | - | 1 | 23 |

Table 5 Filtering papers by title and paper keywords, abstract, and contents

|  |  |  |  |
| --- | --- | --- | --- |
| **Digital libraries** | **Title and paper keywords** | **Abstract** | **Content** |
| **IEEE** | 30 | 28 | 22 |
| **ScienceDirect** | 31 | 28 | 20 |
| **Springer** | 10 | 8 | 7 |
| **Taylor and Francis** | 11 | 11 | 9 |
| **Wiley Online Library** | 10 | 10 | 8 |
| **Total** | 92 | 85 | **66** |

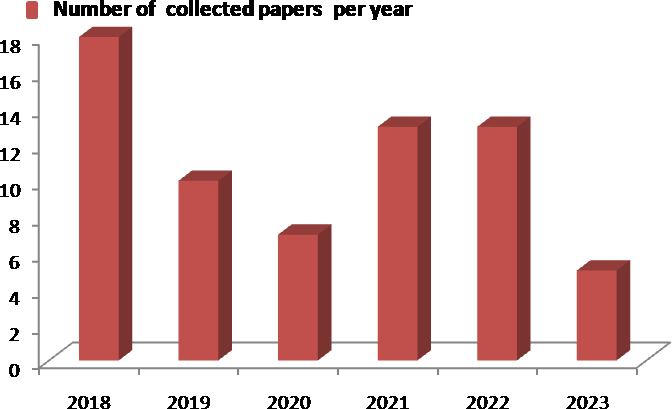


Fig. 3. Research trends 2018–2023

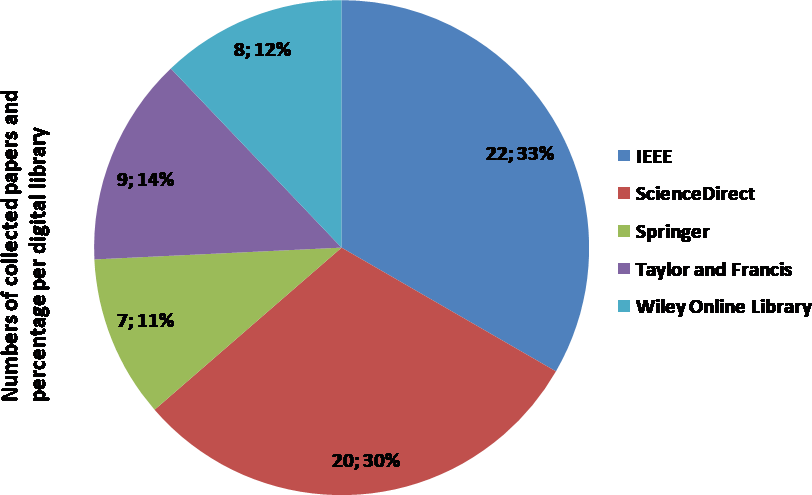


Fig. 4. Contribution share of each database

1. Study quality assessment: The study quality phase aims to assess the quality of the primary studies. Each article is evaluated separately to ensure that it targets the research objective. We refer to the data analysis, figures, tables, and appendixes for analyzing and collecting data from each paper.
2. Data extraction: The data extraction process extracts items from the 66 included studies and collects all information required to answer the research questions related to our topics. An extracted data form (Table 6) is developed to collect data items from each primary study. This process is the object of a meticulous examination by the authors to verify the consistency of the inclusion/exclusion decisions and ensure the quality of the selected studies (Table 7).

We also consider books and book sections on sports management and decision- making: (Saaty and Vargas, 1982; Katzenbach and Smith, 1993; Saaty, 1996; J. Katzenbach, 2009; Dobson and Goddard, 2001; Tzeng and Huang, 2011; Ishizaka and Nemery, 2013). We thoroughly review articles that answer three or more research questions. However, by focusing on these articles, we delve into studies with higher levels of complexity and depth. It is essential to note that our approach does not diminish the importance of articles that address fewer research questions. Such studies can be valuable and insightful and often shed light on certain aspects of the topic. We also try to find articleson subjects not from the period selected for the proposed SLR, to avoid omitting any relevant and useful articles. To this end, we use the Connected Papers website (Tarnavsky Eitan et al., 2023), a visual tool that helps researchers.

Table 6 Data extraction form

**Data item Description**

Ref. Reference ID/Number of the paper under Studyyear year of publication

RQ1 Does the paper relate to our RQ1? RQ2 Does the paper relate to our RQ2? RQ3 Does the paper relate to our RQ3? RQ4 Does the paper address RQ4?

Case Study Does the Study Apply any Case?

DataBase Does the paper include dataset from any DataBase?

We identify academic articles relevant to our research areas. Some of these documents are considered in the reporting phase even if they do not fall within theselected period.

## Results: Reporting the literature review

The reporting phase is designed to analyze and implement a literature review that addresses the research questions related to our topics. This phase addresses 66 studies from the conducting process and other works related to the main papers. Section 1 reports the contribution of the literature to the study of the relationship between managerial and financial performance and sports performance (RQ1). Section 2 describes the main criteria and sub-criteria related to the football players involvedin the selection problem (RQ2). Section 3 presents the decision-making methods used to assist decision-makers in solving selection problems, referring to player criteria and sub-criteria (RQ3). Section 4 highlights hybrid models that integrate all technical and economic variables to help decision makers select the best players for a game (RQ4).

1. *RQ1: What is the contribution of the literature to the review and study of the relationship between managerial-financial andsporting performance?* A team’s success may be defined by its results and how managers organize and manage a football club. Several parameters must be considered during the decision-making analysis. According to Rohde and Breuer (2018), the managerial-financial process is an investment activity in a club organization where footballers represent a major asset. Furthermore, Flegl et al. (2018) highlights that selecting personnel in an organizations is usually tricky . The process becomes even more complicated when selection occurs in complex organizations where different areas can work toward multiple conflicting objectives. Contradictions between a higher income, promoting sports, and providing a good show can be targets. As many areas may be involved in the selection process, it can become complexand challenging. Therefore, Samur (2018) suggests that football organizations can be broken down into critical processes thatcan be managed easily. The study underlines the importance of financial transfers generated by sporting success to all club activity areas in a balanced manner.

Gonçalves et al. (2020) measures economic-financial performance using net revenue and other revenue sources such as broadcasting, matchday,commercial, and player sales. Using panel data analysis, they find that team performance positively and significantly affects the clubs’ economic and financial performance in the subsequent year. Similarly, Barros (2006) examines the relationship between football success, financial management, and performance of clubs. The study concludes that the financial crisis in the Portuguese first division may be imputed to mismanagement. Ribeiro and Lima (2012) analyzes the relationship between the distribution of players’ salaries and the effectiveness of clubs, and how sports performance and financial performance can mutually impact each other. Clubs should structure salaries to achieve optimal salary ranking to induce player effort. Alaminos et al. (2020) emphasizes that the financial success of football clubs has become essential in ensuring their long-term solvency and viability. Therefore, theoretical and practical considerations reveal that financial, sporting, and business elements must be included to properly manage the club’s finances and analyze potential revenues. They use neural networks to study the financial success of European football clubs. Their results show that a club’s financial performance is influenced by its liquidity, leverage, and sports performance.

Seungbum and Ross (2012) identifies the decision-making factors affecting sports sponsorship in a global market context. Sports teams with star players or coaches increase the club’s attractiveness. Trequattrini et al. (2012) proposes a method to determine the economic value of professional football players in the event of a purchase or sale. Dimitropoulos and Scafarto(2021) examines the relationship between the athletic and financial performance of Greek football clubs. They deduce that sports and financial performance are linked through investments in players. Frick and Simmons (2008) establishes a positive correlation between spending on team payroll (managerial compensation) and team performance. Using stochastic analysis, they demonstrated that coaching and playing inputs contribute to team success in the league. Boon and Sierksma (2003) discusses in their model how to support the design of optimal teams and assesses the value-added of a team’s potential.

Table 7 Summary of the reviewed literature

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Authors** | **Year** | **RQ 1** | **RQ 2** | **RQ 3** | **RQ 4** | **Case study** | **Data Source** | N° |
| Xia et al. (2018) | 2018 | ✓ | - | - | - | ✓ | National Football League & National Basketball Association | 1 |
| Blanco et al. (2018) | 2018 | ✓ | - | ✓ | ✓ | ✓ | Spanish ACB Basketball League | 2 |
| Lepschy et al. (2018) | 2018 | ✓ | - | - | - | - | - | 3 |
| Flegl et al. (2018) | 2018 | ✓ | ✓ | ✓ | ✓ | ✓ | sofifa | 4 |
| Danisik et al. (2018) | 2018 | ✓ | ✓ | ✓ | - | - | - | 5 |
| Purwanto et al. (2018) | 2018 | - | ✓ | ✓ | ✓ | ✓ | interviews | 6 |
| Parida et al. (2022) | 2018 | ✓ | ✓ | - | - | - | - | 7 |
| Rohde and Breuer (2018) | 2018 | ✓ | - | - | - | ✓ | Big five clubs owners from 2003 to 2014 | 8 |
| Samur (2018) | 2018 | ✓ | - | - | - | - | - | 9 |
| Hervert-Escobar et al. (2018) | 2018 | ✓ | ✓ | - | - | ✓ | FIFA world cup 2018 | 10 |
| Wadjdi et al. (2018) | 2018 | - | - | ✓ | - | - | - | 11 |
| Buhagiar et al. (2018) | 2018 | ✓ | - | - | - | - | - | 12 |
| Galariotis et al. (2018) | 2018 | - | - | ✓ | ✓ | - | - | 13 |
| Chatterjee et al. (2018) | 2018 | - | - | ✓ | ✓ | ✓ | ABP (Media company in india) | 15 |
| Farshidi et al. (2018) | 2018 | - | - | ✓ | ✓ | ✓ | Software companies | 16 |
| Nasiri et al. (2018) | 2018 | ✓ | ✓ | ✓ | ✓ | ✓ | Questionnaire | 17 |
| Chen et al. (2018) | 2018 | - | - | ✓ | ✓ | ✓ | Location Selection | 18 |
| Lepschy et al. (2018) | 2018 | - | ✓ | ✓ | ✓ | ✓ | American/Canadian basketball league NBA | 19 |
| Bhat et al. (2019) | 2019 | ✓ | - | - | ✓ | - | - | 20 |
| Shahriar et al. (2019) | 2019 | - | ✓ | ✓ | ✓ | ✓ | Bangladesh Soccer Team | 21 |
| Mohanta et al. (2019) | 2019 | - | - | ✓ | ✓ | - | - | 22 |
| Nsolo et al. (2019) | 2019 | - | - | - | ✓ | ✓ | WhoScored - Opta | 23 |
| Ouahli and Cherkaoui (2019) | 2019 | - | - | ✓ | ✓ | ✓ | - | 24 |
| Purwanto et al. (2018) | 2019 | - | - | - | ✓ | - | Wysout (soccer-logs) | 25 |
| Patnaik et al. (2019) | 2019 | - | ✓ | - | - | ✓ | OPTA | 26 |
| Saeed et al. (2019) | 2019 | - | - | ✓ | - | - | - | 27 |
| Gu et al. (2019) | 2019 | ✓ | - |  | - | ✓ | Major League Soccer from 2004 to 2015 | 28 |
| Gomez-Gonzalez et al. (2019) | 2019 | - | - | ✓ | ✓ | - | - | 29 |
| Alaminos et al. (2020) | 2020 | ✓ | - | - | - | - | - | 30 |
| Cacho-Elizondo (2020) | 2020 | - | ✓ | - | - | - | - | 31 |
| Gonçalves et al. (2020) | 2020 | ✓ | - | - | - | ✓ | Brazilian sports clubs from 2013 to 2017 | 32 |
| Yang et al. (2020) | 2020 | - | ✓ | ✓ | ✓ | - | - | 33 |
| Valenti et al. (2020) | 2020 | ✓ | - | - | - | ✓ | Data from 55 UEFA members from 2011-2017 | 34 |
| Salih et al. (2020) | 2020 | - | ✓ | ✓ | ✓ | ✓ | Data from (Raheela et al., 2016) | 35 |
| Di Simone and Zanardi (2020) | 2020 | ✓ | - | - | - | ✓ | European football companies (59 firms from 2013 to 2018). | 36 |
| Romero et al. (2021) | 2021 | - | ✓ | ✓ | ✓ | ✓ | 2018 European Men’s Handball Championship | 37 |
| Bai and Bai (2021) | 2021 | - | ✓ | - | - | - | - | 38 |
| Manish. et al. (2021) | 2021 | ✓ | ✓ | - | - | - | - | 39 |
| Azeman et al. (2021) | 2021 | - | ✓ | ✓ | ✓ | ✓ | English Premier League Season 2005-2006 | 40 |
| Rahman and Asadujjaman (2021) | 2021 | - | - | ✓ | ✓ | - | - | 41 |
| Wieckowski and Watróbski (2021) | 2021 | - | - | ✓ | ✓ | ✓ | Formula 1 | 42 |
| Zhao et al. (2021) | 2021 | - | - | - | ✓ | ✓ | Sofifa | 43 |
| Aydemir et al. (2021) | 2021 | ✓ | ✓ | ✓ | - | - | - | 44 |
| Li et al. (2021) | 2021 | ✓ | ✓ | - | - | ✓ | National Basketball Association 2012 to 2015 | 45 |
| Fry et al. (2021) | 2021 | ✓ | - | - | - | - | - | 46 |
| Kaczynska et al. (2021) | 2021 | - | - | ✓ | ✓ | ✓ | ratings.fide.com (chess) | 47 |
| Dimitropoulos and Scafarto (2021) | 2021 | ✓ | - | - | - | - | - | 48 |
| Garcia‐delBarrio and Agnese (2022) | 2022 | ✓ | - | - | - | ✓ | Premier League, La Liga, Serie A, and Ligue 1, 201- 2019 | 49 |
| Steve Arrul et al. (2022) | 2022 | ✓ | - | - | - | ✓ | FIFA 2019 | 50 |
| Morciano et al. (2022) | 2022 | ✓ | ✓ | - | - | - | - | 51 |
| Rose et al. (2022) | 2022 | ✓ | - | - | - | - | - | 52 |
| Jenifer and Sundarrajan. (2022) | 2022 | - | - | ✓ | ✓ | - | - | 53 |
| Datta and Rudra (2022) | 2022 | ✓ | ✓ | ✓ | - | - | - | 54 |
| Parida et al. (2022) | 2022 | ✓ | ✓ | ✓ | - | ✓ | Football Club Barcelona | 55 |
| Hu and Fu, (2022) | 2022 | - | - | - | ✓ | ✓ | Premier League & La Liga data | 56 |
| Karakaya et al. (2022) | 2022 | - | ✓ | ✓ | - | - | - | 57 |
| Mahmood et al. (2021) | 2022 | ✓ | - | - | - | ✓ | National Basketball Association | 59 |
| Wieckowski and Watróbski (2021) | 2022 | - | - | ✓ | ✓ | ✓ | Randomly generated decision matrix | 60 |
| Ribeiro et al. (2022) | 2022 | ✓ | ✓ | - | - | ✓ | Portuguese First League from 2016 to 2018 | 61 |
| Manju and Philip (2023) | 2023 | - | - | ✓ | ✓ | ✓ | Dataset of cricket matches 2008-2022 | 62 |
| Peddii and Jain (2023) | 2023 | - | ✓ | ✓ | ✓ | ✓ | Historical data | 63 |
| Athish V et al. (2023) | 2023 | - | - | ✓ | ✓ | ✓ | kaggle.com & Sofifa.com. | 64 |
| Joe Anand et al. (2023) | 2023 | - | - | ✓ | - | - | - | 65 |
| McHale and Holmes (2023) | 2023 | ✓ | ✓ | ✓ | - | ✓ | transfermarkt.com, Instat, sofifa. com | 66 |

New team members in football and volleyball support the idea that hiring new players to improve a team’s quality is one of the difficulties in sports and human resources management.

Based on these studies, we conclude that financial and sporting performances are two major factors in club success; hence, several playing and non-playing criteria should be analyzed to improve the player selection process.

1. *RQ2: What are the main criteria and sub-criteria for selecting football players?* The selection of a football player includes many performance attributes, also known as criteria, such as technical, physical, mental, and behavioral attributes that have emerged from Big Data technologies. Due to the increasing amount and different types of sports data, Big Data has become a challenge (Bai and Bai, 2021). Specialized companies such as OPTA, FIFA, and the websites of the official leagues provide an exponential number of datasets for Big Data research related to football analytics, focusing on individual player characteristics (Raheela et al., 2016; Cacho-Elizondo, 2020). In selecting the best player, Nikjo et al. (2015) defines six criteria after questioning ten experts and three decision-makers. These criteria include technical and tactical skills, experience of professional play, average number of goals scored per game, ability to coordinate with the team, moral and behavioral features, and social prestige.

Ozceylan (2016) provides a set of criteria based on the position of players within a football team: Goalkeeper, Fullback, Central Defense, Central Midfield, Winger and Forward Center. The study describes a set of specific criteria for goalkeepers, such as one-on-ones and aerial abilities, and general criteria for all positions, such as anticipation, agility, and first touch. Purwanto et al. (2018) discusses a selection method for starting a line-up based on the physical, technical, tactical, and mental criteria. Sub-criteria such as agility, dribbling, ball control, and positional play, have also been studied to develop a system for line-up selection, where technical ability and physical strength are two most significant factors. Qader et al. (2017) presents a methodology for evaluating and ranking football players basedon anthropometric, fitness, and ability tests. Tavana et al. (2013) proposes 18 evaluation criteria (e.g. heading, jumping, and reading the game) that are usually considered by coaches when making team selections. The selection process includes four defenders, four midfielders, and two forwards. Nasiri et al. (2018) examines several criteria and sub-criteria considered necessary by experts and the literature for evaluating football players. The study also describes the existing relationships between different sub-criteria. For independent criteria such as passing, dependent criteria exist, such as creativity, reading the game, reaction, speed, and both feet. It is worth noting that the talents of players and coaches influence the effectiveness of sports clubs. The essential elements for a sports organization are the athletic resources that constitute its human capital. Therefore, many authors place players at the center of their studies. Therefore, b o t h player recruitment and team line-up selection are critical for maximizing profits and victory (Charnes et al., 1978; Carmichael et al., 2000, 2011). Consequently, sports management requires decision-making based on scientific research that supports and informs decision-makers of the most effective strategies to improve team performance and profitability.

1. *RQ3: What are the existing decision- making methods in which sports decision makers compare the usefulness, results, and validity of several MCDM methods?* Several MCDM methods have been reported in the literature. Following (Ishizaka and Nemery, 2013), these methods are classified into three main categories:
   * Full aggregation approach: this method assumes compensable scores. The analytic hierarchy process (AHP) implemented by (Saaty and Vargas, 1982) and the analytic network process (ANP) extended from the AHP to consider the interdependent relationships between criteria and sub-criteria belong to this approach (Saaty, 1996).
   * Outranking approach: this method assumes that a good score cannot compensate for a bad score. Methods belonging to this approach include The elimination Et choix traduisant la réalité (ELECTRE) (Roy, 1968) and the Preference ranking organization method for enrichment evaluations (PROMETHEE) (Mareschal et al., 1984).
   * Goal or reference level approach: this method defines a goal for each criterion, and then identifies the options closest to the ideal reference level or goal. This approach includes the technique for order preferences by similarity to an ideal solution (TOPSIS) proposed by (Hwang and Yoon, 1981) to identify the best alternative based on the concept of the compromise solution, and data envelopment analysis (DEA) formulated by (Charnes et al., 1978) to measure the performance of decision-making units (DMUs) that convert multiple inputs into multiple outputs.

This research aims to review articles demonstrating the use of multiple criteria decision-making methods in sports, particularly in football player selection (Table 8). Mavi et al. (2012) measures the sporting performance of 18 professional football teams in the German Bandesliga by collecting data for the season 1999/2000. Seungbum and Ross (2012) ranks the criteria and sub-criteria to identify the decision making factors in sports sponsorship in the global market context. (Blanco et al., 2018) applies a multi-criteria outranking methodology to the Spanish ACB Basketball League, using as alternatives the potential players and as criteria different efficiency indices. According to Ozceylan (2016), the top-performing players in Turkish football clubs are selected for inclusion in the team. In the first phase, the Analytic Hierarchic Process attributes weight to each criterion based on the player’s position. In the second phase,a scalar is established from zero to one, and an integer linear programming model is developed using the former weights of the player attributes. Dey et al. (2011) contents that the performance of fast-bowlers and spinners of Cricket Indian Premier League is based on their economy rate, bowling average, and bowling strike rate, using AHP-TOPSIS and AHP-COPRAS (complex proportional assessment) approaches. Bozbura et al.

(2008) ranks six national basketball association (NBA) players according to their proximity to the ideal solution given by the TOPSIS method. Dadelo et al. (2014) develops an integrated model of TOPSIS and expert judgment to ensure greater efficiencyin the assessment, rating, and selection of 18 basketball players. Nasiri et al. (2018) proposes an integrated approach combining MCDM analysis and mathematical programming to support decision-makers through the process of building a football team. Nikjo et al. (2015) selects the best players from a sports team. AHP prioritizes each criterion, and extended TOPSIS is applied for weighing decision-makers and ranking alternatives. Purwanto et al. (2018) develops a system to select the starting line-up of football players based on the AHP method, in which technical ability and physical strength are the two critical factors for line-up selection. Raheela et al. (2016) proposes a method for evaluating and ranking 24 football players in the same team using MCDM, where players are selected according to several physical fitness indicators, such as 30-meter speed running. Ballı and Korukoğlu (2014) applies a fuzzy multi-attribute decision-making algorithm based on the fuzzy-AHP and TOPSIS methods to develop a decision support framework for selecting eligible basketball players in Turkey. The findings of this SLR contribute to a deeper understanding of several MCDM methods used in sports.

Table 8 Summary of studies related to our RQ3

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Methods**  **References** | **Category** | **Application** | **Goal** |  | **Criteria (Sub-criteria)** |
| Fuzzy- | * Goal or reference | Predicting the chances of | Predicting | the | Drivers’ gap; Tyres; Distance; |
| COMET | level | overtaking during pit stops | chances | of | Pit stop; Driver experience; team |
| Wieckowski and Watróbski (2021) |  | in Formula 1 races by us- ing fuzzy COmbined Mea- surement Techniques | overtaking |  | ranking |

Fuzzy-AHP • Full aggregation Selecting team performance Team Individual performance

Ouahli and Cherkaoui (2019)

in industrial and safety criti- cal systems

performance (Personal factors, skills,

vigilance, Motivations); Job attributes (Criticality, Activity impact, Safety Impact); Team attruibutes (Communication, Pattern of distribution,Team experience, Global synergy) distribution)

Fuzzy-ANP- • Full aggregation An integrated approach that Status of the Technical ability - Mental ability PROMETHEE • Outranking combines MCDM analysis players owned - Physical ability ( Study the re- II-DEA • Goal or reference and mathematical program- by the club lationship between sub-criteria)

Nasiri et al. (2018)

level ming to support the deci- sion maker during the football transfer season

(sale, stay)

AHP • Full aggregation Selection starting lineup of Starting line- Physical, technical, tactical,

Purwanto et al. (2018)

football players based on their position

up selection mental

PROMETHEE • Outranking Applying a multi-criteria Ranking 6 efficiency indices (such as Ra- I- outranking methodology on basketball tio of points scored by the player

PROMETHEE the Spanish ACB Basketball players with respect to the number of

II League using as alternatives minutes played)

Blanco et al. (2018)

the potential players and as criteria different efficiency indices

AHP- • Full aggregation Selecting football players Team selection several attributes are given by TOPSIS • Goal or reference based on Multi-criteria player’s position such as: Finish-

Flegl et al. (2018)

level Decision Analysis with the integration of qualitative and quantitative data

ing, Crossing, Agility, ball con trol, Acceleration, Vision, Sprint, speed, Dribbling. . .

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Methods**  **References** | **Category** | **Application** | **Goal** | **Criteria (Sub-criteria)** |
| TOPSIS | * Goal or reference | Assessing 24 football players | Ranking foot- | Anthropometric, fitness, skills |
| Raheela et al. (2016) | level | belonging in the same team using a MCDM | ball players |  |

AHP-linear • Full aggregation Determining top performers Selection of Criteria for goalkeepers, defen- program- • Goal or reference players for inclusion in the top performers sive centres, midfielder centres, ming model level team wings, forward centers Ozceylan

(2016)

AHP- • Full aggregation Selecting best player in a Ranking best 6 criteria among them: The av- TOPSIS • Goal or reference sport team. player erage number of goals scored

Nikjo et al. (2015)

level per game (due to the Post) and

Social prestige (popularity)

TOPSIS • Goal or reference Ranking 18 basketball players Players starting 23 physical criteria , classified

Dadelo et al. (2014)

level from the best to the worst the game into 4 groups of competences

(Body Size and Composition, Speed and Quickness, Power, Aerobic Endurance)

Fuzzy Infer- • Full aggregation Selecting player for a football Football player Heading, jumping, Shoot, Short, ence System team by position: defenders, selection by passing, Crossing, Ball con-

Tavana et al. (2013)

midfielders, forwards position trol, Dribbling, Finishing, Speed,

Creativity, Create goal, scor- ing, position, Tackling, Both feet, stamina, Height, providing through (long) pass, Technical ability, Create attacking opportunities, Read the game

AHP- • Full aggregation Mesuring the sporting per- Best team Players’ annual wages, Coach’s TOPSIS • Goal or reference formance of 18 professional monthly wage, Points, Specta-

Mavi et al. (2012)

level football teams. tors, Stadium utilization, Total revenues)

AHP • Full aggregation Ranking criteria and sub- Evaluating Sport team factors (Media expo-

Seungbum and Ross (2012)

criteria to Identify the deci- sion making factors of sport

Weights of factors

sure opportunity, Sponsorship fit, Team image, Fan base strength,

sponsorship in the global mar- affecting sport performance, Hospitality oppor- ket context. sponsorship tunity, Facility average atten-

decision dance), Country factors (Interest

level in sport, Political and eco- nomic state), Environment fac- tors (Competitors Ambush mar- keting, League authority over sponsorship)

AHP- • Full aggregation Measuring the performance Ranking of Economy rate, bowling average, TOPSIS • Goal or reference of Fast-bowlers and Spinners faster-bowlers bowling strike rate

AHP- level of Criket. and spinners COPRAS

Dey et al.

(2011)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Methods**  **References** | **Category** | **Application** | **Goal** | **Criteria (Sub-criteria)** |
| TOPSIS | * Goal or reference | Ranking the six NBA (Na- | Ranking player | Rebounds per game, Points per |
| Bozbura et al. (2008) | level | tional Basketball Association) players according to their | to transfer | game, Blocks per game, Age, Player Salary, Assists per game |
|  |  | proximities to ideal solution |  |  |
|  |  | given by TOPSIS method. |  |  |

1. *RQ4: How can we create a hybrid MCDM model that incorporates all technical and economic variables to help decision- makers select the best players for a game?* Our model uses machine learning algorithms to predict players’ (sporting and financial) performances based on historical data collected from official club websites set of criteria and sub-criteria is then weighted using an MCDM method such as AHP, and football players required for the line-ups are ranked using an appropriate MCDM approach. This hybrid model allows for a complete analysis by integrating the strength of machine learning algorithms to predict criteria and sub-criteria for decision-making models.

This research question focuses on studies (samples) that construct a model to select or rank the best players (Table 9).

Table 9 A samples of studies related to RQ4

### References Model/System Application

Feng et al. (2010) Multi-objective 0–1 Proposed method to select the members of a cross-functional programming model team. They considered both the individual performance of can- and an improved didates and the collaborative performance between candidates.

NSGA-II algorithm They developed a multi-objective 0–1 programming model and improved the nondominated sorting genetic algorithm II (INSGA- II) to solve The member selection problem.

Tavana et al. (2013) Two-phase Proposed a two-stage framework for player selection and team framework formation in football: first a fuzzy ranking method, then evalua- tion of alternative combinations of selected layers using a fuzzy

inference system (FIS).

This framework is illustrated with a case study using real data from a professional football team.

Ballı and Korukoğlu (2014)

Fuzzy decision support framework

Developed a fuzzy multi-attribute decision-making algorithm for the selection problem of basketball players. The model used

port framework FAHP method to identify the weights of criteria, and the TOPSIS method for the final ranking alternatives.

Nikjo et al. (2015) WeFA (Weighted Presented a new model for clubs’ head coaches and managers Factors Analysis) by considering experts’ votes. This approach is based on the framework AHP- analytical hierarchy method (AHP) which is used to determine Extended TOPSIS the weight of each criterion and the extended TOPSIS method for weighting to decision makers (DM) and ranking of alternatives.

A numerical example is given with 10 experts, 3 decision makers, 4 players, and 6 criteria.

### References Model/System Application

Ozceylan (2016) A mathematical

model for player selection

Blanco et al. (2018) Quantitative tool

based on the PROMETHEE

Flegl et al. (2018) New methodology

for personnel selection (AHP- TOPSIS)

Purwanto et al. (2018) System for

Line-upSelection

Ouahli and Cherkaoui (2019) Team

performance model using the Fuzzy- AHP

Nasiri et al. (2018) A bi-objective in-

teger programming model

Nsolo et al. (2019) Machine learning

algorithms

Pappalardo et al. (2019)

PlayeRank - Machine Learning

Yang et al. (2020)Deep learning algo-

rithms (MCDM)

Zhao et al. (2021) Multi-objective op-

timization - genetic algorithm

Study proposes a two-phase approach for selecting football players. In the first phase, the attributes of each player at each position were prioritized using AHP. In the second phase, a 0-1 integer linear programming model was developed using the weights of player attributes and the best players were determined for inclusion in the team. The proposed solution was applied to a Turkish football club to demonstrate its applicability and performance.

A quantitative ranking system was constructed to aggregate basketball players using the PROMETHEE methodology. A case study of 191 players who participated in the Spanish ACB basketballleague during the 2014-2015 season.

proposed a new methodology for personnel selection based on MCDA and integrated qualitative and quantitative data to select Mexican football teams for the 2018 W orld Cup in Russia.

A system was developed to select the starting lineup of football playersbased on the AHP method.

Three performance teams in industrial and safety critical systems were developed based on individual performance, job attributes and teamattributes using the fuzzy-Ahp method.

proposed an integrated approach that combines a multi-criteria decision-making analysis (FANP-PROMETHEE II-DEA) and mathematical programming to assist decision-makers in their selection process.

Compared which attributes and skills best predict the success of individual players in their positions in five top European football leagues and evaluate different machine learning algorithms in terms of their predictive performance.

Developed a data-driven framework to help professional football scouts evaluate, search, rank, and recommend football players. This tool, called PlayeRank, is based on a machine learning approach. It uses a large dataset of football records consisting of millions of match events from four seasons of 18 well-known football competitions.

It has been argued that when faced with a set of alternatives, multi-criteria decision making is one of the most appropriate decision-making tools. Combining deep learning algorithms with multi-criteria decision making has proven beneficial for Big Data.

The team composition issue was formulated as a multi-objective optimization problem and, a variant of the genetic algorithm was proposed that can automatically output and recommend a football team with a high win rate by quantifying the players’ abilities under a givenbudget constraint.

### References Model/System Application

Wieckowski and

Watróbski (2021) Complex MCDM

model based on COMET method and fuzzy COs

built a complex MCDM model based on the Characteristic Objects Method (COMET) Method, which was used to predict the chances of overtaking during pit stops in Formula 1 races. This model can reduce the number of characteristic objects (COs) pair comparisons that must be performed by an expert (from 1111 to 111), while maintaining its efficiency.

## Discussion and conclusion

This SLR allowed us to delve deeper into the proposed study area and analyze the literature concerning four research questions. This analysis focused on the following:

* First, we examined the relationship between player performance and football clubs’ managerial and financial performance.
* Second, the main criteria and sub-criteria related to football players’ positions on the pitch were included in the selection process. In this step, we noticed a lack of publications on this topic. In addition, previous articles did not address all criteria, sub-criteria, and the correlations except for (Tavana et al., 2013).
* Third, decision-making methods that could be available to decision-makers for solving the player selection problem were identified.
* Finally, studies dealing with the construction of models, case studies, and databases for solving the selection of football players were examined.

The proposed study used the systematic literature protocol and guidelines by Kitchenham et al. (Barbara Kitchenham and Charters, 2007). Data published between 2018 and 2023 were collected from digital libraries (IEEE, ScienceDirect, Springer, Taylor and Francis and Wiley). Other relevant articles were retrieved from the digital library of the University of Burgundy, although they were not included in the selected period of the SLR. To successfully perform the proposed SLR, all resources listed in Tables 7, 8, and 9 were carefully analyzed: Title, Keywords, Abstract, and T ext. These findings led us to conclude that of the 66 papers identified by the SLR process, only a few articles addressed our four research questions (Blanco et al., 2018; Flegl et al., 2018; Nasiri et al., 2018; Purwanto et al., 2018; Shahriar et al., 2019; Kizielewicz and Dobryakova, 2020; Romero et al., 2021). We could conclude that line-up selection using MCDM methods was a relevant research area and topical subject, especially when combined with machine learning algorithms. This study identified new ways to develop a decision support system for player selection problems using multiple and conflicting criteria. This study’s results may help the research community in this area to better understand and design models, decision support systems based on several criteria, and integrated machine learning algorithms.

Selecting a line-up of teams for a decisive competition is complex because many qualitative and quantitative criteria and sub-criteria must be considered. However, this process tends to be subjectively interpreted, depending on the experience of coaches and managers (Dadelo et al., 2014; Purwanto et al., 2018; Salles et al., 2019). MCDM approaches may assist decision-makers in making more objective decisions. In this context, the current research aims to produce a comprehensive report on the relationship between managerial- financial and sporting performance, and the application of MCDMand machine learning algorithms in football team formation.

**Future research directions:** Although this highlighted the combined use of MCDM and machine learning for football player selection and performance prediction, future studies should incorporate more biometric and psychological data to refine these predictions. In addition, with rapid advancements in technology, the exploration of Artificial Intelligence (AI) techniques will ensure increased transparency in selection decisions. Finally, the proposed methodology deserves to be studied in other sports contexts, paving the way for broader applications and interdisciplinary results.

### Data availability

There are no data available.

### Conflicts of interest

There are no conflicts of interest related to this article.

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## Declaration of interests

☒The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

* The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: