App development in a team sports: A Systematic Literature Review

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Abstract. This study aims to conduct a systematic review and a survey in an exemplary academic setting to assess the present state of app development in a sports game along with the following research questions: (Q1) Are software engineering principles well understood in sports game app development? (Q2) Is the function of skill tests on sports games in app development adequately understood? A systematic search was undertaken in Google Scholar, PubMed, Science-Direct, and Atlantis Press electronic databases up to July 2023. The keywords 'application' and 'sports games' were used. A multidisciplinary team created the survey, which had four key themes: development process, technology, functional requirements, and dissemination. Out of 2.709 matches, 53 were included in the review. We conclude that the context for developing sports game apps contains a range of software engineering skills (Q1). Additionally, we discovered that the function of sports game coaches inside app development requires adequate definition (Q2). We offer suggestions for enhancing the likelihood of app development success and sustainability and guidance on the possible subject expertise of sports games. The reporting of the app development process and the generalizability of these findings should be the main areas of future research.

Keywords: application, sport games, team sports

1 Introduction

Enhancing an athlete's performance is the primary goal of sports equipment development, and there are two ways to do it [1]. The first technical strategy focuses on enhancing certain sporting goods features, such as increasing rigidity, lowering weight, enhancing aerodynamics, etc. By utilizing biomechanical effects and enhancing the usability and ergonomics of the sports equipment, the second strategy aims to enhance the interaction between the athlete, the particular piece of sporting equipment, and the surroundings.

The advancement of computer technology has led to significant enhancements in artificial intelligence technology, resulting in its increasingly prevalent application in sporting events [2]. The proliferation of the Internet has profoundly influenced various domains of contemporary society, encompassing business, education,

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government, the entertainment sector, and individual spheres. The utilization of the Internet for software development offers several notable advantages. Firstly, it eliminates the need for any installation charges. Additionally, all users are granted automatic upgrades that come with enhanced functionalities. These benefits have been highlighted in previous research [3]. Mobile programs, commonly called apps, have profoundly influenced various aspects of our lives, including communication, consumption, daily routines, and planning [4]. These apps are designed to operate on smartphones and tablets. The adaptive applied software undergoes continuous enhancements and serves as the central component of the computer [5]. The mobile app market is snowballing, with projected revenue to increase threefold from 365 billion US dollars in 2018 to 935 billion US dollars in 2023 [6]. In 2021, individuals utilizing iOS and Android smartphones will have access to a vast selection of 5.5 million applications. Based on current trends, it can be observed that a significant majority of firms have recognized the significance of mobile applications in terms of customer retention and expansion [7]. Sport-specific testing is a valuable tool primarily employed to assess and cultivate the skills of young athletes' skills and identify the strengths and weaknesses of both young and elite athletes to optimize their training [8][9].

From an academic standpoint, the growth of team sports in a technological environment that is continually changing is difficult. The obstacles above and the cross-disciplinary character of app development need to be sufficiently considered. No study examines the academic growth process from a domain expert's perspective. In order to design team sport test apps, it is necessary to take a closer look at university development processes and potential success factors.

This study aims to provide an overview of the app development process in a setting of academic sports science and to examine the role of sports scientists as subject-matter experts in the process. We began a systematic assessment to look at the state of app development today in team sports. Examining the current state of app development by a systematic literature review and a survey within an exemplary setting, we further aimed to derive recommendations for structuring the app development process in academic sports, especially team sports.

The remaining part of this essay is broken out as follows. In Section 2, the associated research is reviewed. Our study strategy and research questions are described in Section 3. The SLR's findings are presented in Section 4. The key conclusions are covered in Section 5. The paper is concluded in Section 6.

2 Method

2.1. Systematic review

This study utilized the systematic literature review (SLR) research approach to look at, analyze, and then interpret how youngsters learn to play sports. The SLR's objectives are to locate pertinent articles, gather the required data, analyze it, and synthesize it to fully understand the article's main review [10][11]. The Systematic Literature Review (SLR) process consists of six parts, including (1) analyzing research objectives, (2) establishing inclusion and exclusion guidelines, (3)

discovering literature, (4) sorting literature, (5) validating literature, and (6) synthesizing and interpreting literature [12].
During the literature search, the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) statement was adhered to [13]. Three significant electronic databases were used in the search (PubMed, ScopusTM, and IEEE), and the period of time covered from January 1, 2017, to September 1, 2023. The AND and OR operators were used in a Boolean search approach [14]. The apriori-specified inclusion criteria covered the following search syntax following the primary issue of the present study: ("software" AND "team sports").

3 Result

The systematic search's screening process is depicted in Figure 1. After removing duplicate entries, a total of 2,104 articles were subjected to screening based on their title and abstracts. Based on the established inclusion criteria, 110 articles were selected and included in the subsequent full-text screening process. Among the selected studies, twelve were omitted due to the unavailability of complete text. Additionally, 31 studies were excluded as they did not involve the development of a mobile application. Furthermore, 45 studies were excluded as they did not specifically address the utilization of mobile applications in the context of team sports. The 22 papers included in this analysis were subject to qualitative evaluation to determine the extent to which the primary subjects were addressed within each study. Table 1 provides a concise overview of the findings derived from the analysis of the 22 papers included in this study. Of the articles, 14 were classified as original, while the remaining eight were categorized as conference papers. The publication period was limited to January 2017 to September 2023. The objectives of the applications can be categorized into three main areas: performance analysis, sports injury prevention, and talent identification procedures.

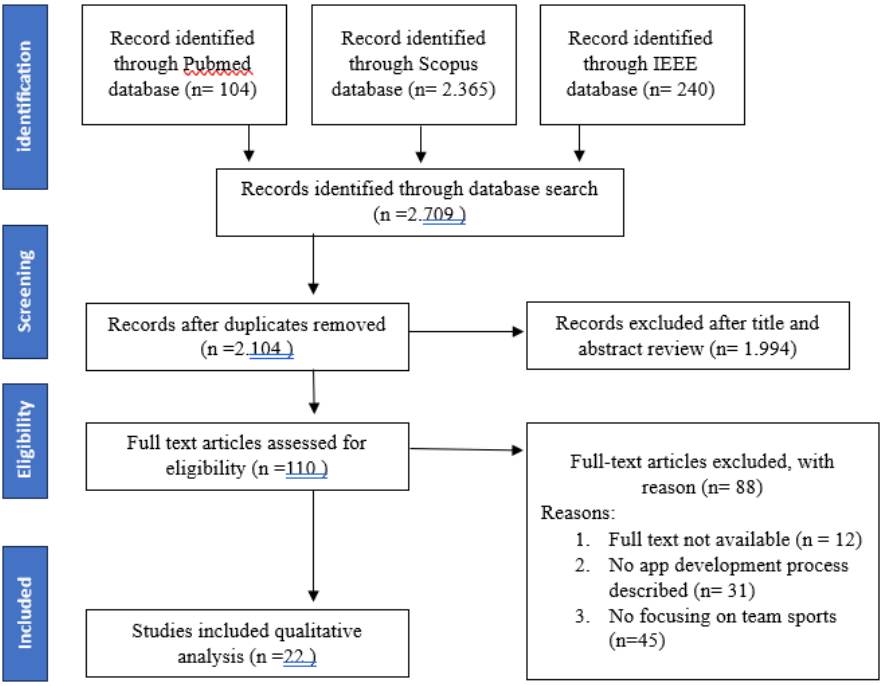

Fig 1. PRISMA diagram

Table 1. Findings of the systematic literature review

Outcome	**Findings *(n)***
Type of Article	Original article (14)
	Conference paper (8)
Year of publication	2017 (1), 2018 (1), 2019 (5), 2020 (2), 2021 (4), 2022 (4), 2023 (5)
Aim of the app	Performance analysis (20), talent identification (1), sport injury (1)

Table 2. Exploratory papers published on application development in team sports

Author	Title	Desain	Method	Results
Talent identification				
Bani and Yamamoto, 2017[15]	Development of an R-Shiny-based Shooting Area Visualization Application for Use in	Research and Development	The information given by these sites is quite useful, and they give teams a straightforward way to submit	The creation of an R-Shiny application is the visualization technique. Thus, we aim to describe each team's

	Basketball		feedback. This project uses the visualization of such data to present quantitative information intuitively.	shooting location data and talk about how to apply it to scouting and actual games.
Muracki et al, 2019 [16]	Practical Use of the Navigate Pain Application for the Assessment of the Area, Location, and Frequency of the Pain Location in Young Soccer Goalkeepers.	experiment	Twenty-four healthy male goalkeepers with at least four years of training experience currently competing in Poland's top junior divisions were included in the study (age: 16.7 0.67 years, body height: 175.6 5.4 cm, body mass: 65 5 kg).	Between the three categories of pain, there was a significant difference in the area (p 0.001). According to the post hoc analysis, there are statistically significant differences between the pixel areas of IP and JP, IP and MP, and JP and MP (p 0.001). There was no significant difference for any of the three pain locations between the front and back of the body for the IP area between 1 and 5 days of training (p = 0.610), the MP area (p = 0.118), or the JP area (p = 0.797).
Silva et al, 2017 [17]	A new tool for network analysis on team sports the ultimate performance analysis tool	Research and Developme nt	It will also discuss building specific network metrics to explain the centralities and general	The Ultimate Performance Analysis Tool (uPATO) enables the data collection from witnessed games through

			characteristics of unweighted and weighted graphs and digraphs. The procedures to visualize and import data will be demonstrated.	observation, codification, import, visualization, computation of metrics, and export. The user may only use one program to visualize and analyze the match while considering the network that develops during play.
Beato et al, 2018 [18]	The Reliability of Technical and Tactical Tagging Analysis Conducted by a Semi-Automatic VTS in Soccer.	experiment	During a friendly game in the 2016 season, two professional soccer teams with 30 male players (age 23 5 years, body mass 78.3 6.9 kg, height 1.81 0.06 m) were observed. Data analysis was done right away after the game. Then, a week later, a similar procedure was carried out (4 operators analyzed the data each week).	According to this study, Match and its Replication have an almost perfect relationship. For each of the technical variables considered, R2 coefficients (relationships between Match and Replication) were very significant (p 0.001). An important interclass correlation score and a low coefficient of variance were reported in particular. Insignificant discrepancies between Match and its Replication (intra-day reliability) are

				reported in this study. We concluded that the Digital.Stadium® VTS's semi-automatic method was more than capable of accurately recording technical tagging data.
Claudino et al, 2019 [19]	Current Approaches to the Use of Artificial Intelligence for Injury Risk Assessment and Performance Prediction in Team Sports: a Systematic Review.	systematic review	The review comprised 58 papers, and 11 AI approaches or methods were used in 12 team sports. The pooled sample included 6456 participants, 76% of whom were professional athletes (male, 97%, 25–8 years old; female, 3%, 21–10 years old).	Artificial neural networks, decision tree classifiers, support vector machines, and Markov processes were the AI approaches or methodologies that were most frequently employed, and all of them had good performance metrics. Soccer, basketball, handball, and volleyball were the team sports with the most AI applications.
Roell et al, 2019 [20]	Validation of Wearable Sensors during Team Sport-Specific Movements in Indoor Environments.	Research and Developme nt	KF data overstated MA resultant acceleration throughout all trials (n = 1093) by 0.42 0.31 m/s2 for the mean and 4.18 3.68 m/s2 for peak values, whereas CF	The results of this study indicate that inertial measurement units (IMUs) have the potential to assess accelerations in the context of indoor team sports accurately. It is recommended to employ a comb

			processing revealed inaccuracies of up to 0.57 0.41 m/s2 and -2.31 2.25 m/s2, respectively. The absolute error was reduced by around 14% for mean values and 56% for peak values by resampling to 5 Hz. Nevertheless, larger acceleration magnitudes resulted in a significant rise in inaccuracy.	filter and downsample the data to a sampling rate of 5 Hz. Significant reductions in validity are observed when high magnitudes of acceleration are present, necessitating cautious interpretation.
Liang et al, 2019 [21]	Team Formation Mapping and Sequential Ball Motion State Based Event Recognition for Automatic Data Volley	experiment	The present study analyzes game videos from the Semifinal and Final Game of the 2014 Japan Inter High School Games of Men's Volleyball, which took place at the Tokyo Metropolitan Gymnasium.	The experiments on the suggested approach yielded an average accuracy of 98.51%, showcasing a notable improvement of 10.34% compared to the conventional way. Additionally, the average recall was 98.94%, exhibiting a substantial improvement of 18.5%. Furthermore, the precision attained was 97.85%,

				demonstrating a significant improvement of 13.12% compared to the conventional method.
Wang et al, 2019 [22]	Tac-Simur: Tactic-based Simulative Visual Analytics of Table Tennis	Research and Developme nt	The Tac-Simur platform facilitates user navigation across various players and tactics by leveraging their match performance. This allows users to select interesting players and tactics for further investigation. Subsequently, individuals can employ the system to actively engage with various simulation tasks and graphically elucidate the outcomes of those simulations.	This study's efficacy and utility are exemplified by examining two case studies wherein subject matter experts employ Tac-Simur to uncover intriguing and relevant insights.
Panchuk et al, 2020 [23]	Application of Mobile Computer Digital Devise for Current Medical and Biological Control in Futsal	Research and Developme nt	The successful application of the technique significantly reduced sports-related injuries within the team, with a notable decrease of	This study demonstrated the indispensability of using information and computer technology within the context of futsal as an integral

			30%. Furthermore, the team's performance in tournaments exhibited noticeable improvement as a direct consequence of this implementation.	component of the training regimen.
Lin et al, 2020 [24]	The Application of Artificial Intelligence Video Feedback System in Tennis Teaching in Colleges and Universities	experiment	A total of 64 male and female students from the tennis team at XX University were allocated into two groups, namely the experimental group (n=32) and the control group (n=32), using a random assignment method. The experimental and control groups underwent an eight-week tennis instruction program with identical learning content. However, the experimental group received an additional intervention through a video feedback	Results: 1) The experimental group exhibited considerable improvement in the scores of forehand and backhand batting skills), as well as the evaluation of movement technique, compared to their pre-experiment performance ($p< 0.05$). 2) The experimental group exhibited statistically significant improvement compared to the control group ($p < 0.05$). Following the completion of the trial, it was observed that the test group exhibited a statistically significant improvement compared to the

			system.	control group ($p < 0.05$).
Teune et al, 2021 [25]	Application of a continuous pressure metric for Australian football.	experiment	The study examined the impact of training design changes on density by measuring two environmental constraints: area per participant and number of players. The density comparison was also conducted concerning established pressure measurements in notational analysis.	The study's findings revealed a positive correlation between a greater concentration of abilities and the successful execution of these talents. A negative correlation was observed between the application of notational analysis pressure measurement and the level of skill efficacy. The study revealed a robust negative correlation between manipulating environmental constraints and density. Specifically, increasing the field area and the number of players resulted in a drop in the density of skill involvement.
Z. Hu, 2021 [26]	Research on American Professional Basketball League based on big data technology	Research and Developme nt		Utilizing the Vu data analysis system, fine-grained high-order statistical analysis system, and visual data information system inside the American Professional

				Basketball League can offer valuable insights for advancing professional basketball in China.
Gleeson and Kelly, 2021 [27]	Putting the player first: A method to analyse and develop expert players performance in professional soccer.	experiment	The data were obtained using a designed performance analysis approach and conducting subsequent unstructured interviews to investigate the participants' perceptions of the used methodology. The study had a cohort of thirty professional football players with a range of professional playing experience from 2 to 19 years. These participants were selected from three distinct professional clubs.	The results indicate that implementing a player-centric approach to performance analysis in professional soccer contributes to a deeper comprehension of the overall performance of skilled players and has the potential to enhance long-term learning opportunities.
Peng et al, 2021 [28]	The Development and Implementation of a Smartphone Based Archery	Research and Developme nt	One notable feature of our application, compared to the already available archery	The findings of this study provide evidence of the efficacy of implementing our proposed approach within the context

	Analysis System		applications, is its ability to automatically calculate the archery score without requiring any manual input.	of archery training.
Bampouras and Thomas, 2022 [29]	Validation of a LiDAR-based player tracking system during football-specific tasks	Research and Development	Two football players in direct competition with each other, aged 18 years, with a height of 1.74 ± 0.01 m and a mass of 66.5 ± 7.8 kg, participated in a study. These players had accumulated three years of experience playing at this level. During the study, each player underwent a series of nine trials consisting of six sport-specific motions, which included straight-line sprints, cuts, and curved runs.	The velocity root mean square error (RMSE) values exhibited a range of 0.04 to 0.14 m·s−1 for all movements, whereas the acceleration RMSE values ranged from 0.16 to 0.7 m·s−2. The disparities in the various methods for allocating time within each essential performance indicator category were predominantly inconsequential. This study's findings demonstrate that using a LiDAR-based system yields reliable measurements of velocity and acceleration during

				football-specific activities. Consequently, this technology enables precise tracking of players and the computation of pertinent key performance indicators.
Vu et al, 2022 [30]	Visual tracking assessment in a soccer-specific virtual environment: A web-based study.	Observation	The present study required participants to monitor and track many players in a simulated soccer field. The virtual players exhibited movement patterns determined by actual or simulated random trajectories. The study was carried out via an online platform utilizing a web-based program.	The distribution of virtual players in space was observed to have a notable impact on visual tracking performance, particularly concerning soccer-specific motions.
He, 2022 [31]	Research on Application of Computer Virtual Reality Technology in Sports	Experiment	Utilizing computer-based virtual reality technology to precisely depict the anatomical	The study's findings demonstrate that the system can efficiently generate diverse

	Simulation Training		attributes of the athlete's physique and the three-dimensional representation of a volleyball. Simultaneously, the human body model was imported from Pro/ENGINEER into Visual Studio, and OpenGL animation simulation was employed to manipulate the three-dimensional entity model, therefore simulating diverse blocking motions executed by volleyball players.	human models through parameter modifications. This enables the simulation of players with distinct movement characteristics, effectively supporting the volleyball team's blocking training endeavors.
Shushan et al, 2023 [32]	A Worldwide Survey on the Practices and Perceptions of Submaximal Fitness Tests in Team Sports.	Systematic review	The survey was completed by 66 practitioners (74 discrete protocols) from 24 countries. The most crucial implementation qualities were their speed and lack of exhaustion. Although doctors recommended a variety of	

			SMFTs, most of which were given on a monthly or weekly basis, scheduling tactics vary within SMFT categories.	
Rico-Gonzalez et al, 2023 [33]	Machine learning application in soccer: a systematic review.	Systematic review	Outcome measures from 32 of the 145 initially selected studies were retrieved and analyzed.	All of the articles were grouped into three categories, including injury (n = 7) and performance (n = 21), which included match/league results predicting, physical/physiological forecasting, technical/tactical forecasting, and talent forecasting (n = 5). Technology advancements and the resulting abundance of data have made machine learning (ML) a crucial method for assisting team staff members in decision-making and decreasing the chaotic aspect of this team sport.
Marquina et al, 2023 [34]	Development and Validation of an Observational Game Analysis Tool	Research and Development	Validation of the instrument was done first by a group of experts. Ten experts	Cohen's kappa index (k) = 0.889 demonstrated that the instrument's validity among experts had a high

	with Artificial Intelligence for Handball: Handball.ai		responded to a questionnaire regarding the appropriateness and relevance of each presented variable. Two observers hired to assess a Champions League game verified the statistics and had 1.5 and 2 years of handball observational analysis expertise.	degree of agreement. For both automatic and manual variables, a very good intra-((automatic: Cronbach's alpha (α) = 0.984; intra-class correlation coefficient (ICC) = 0.970; k = 0.917) (manual: α = 0.959; ICC = 0.923; k = 0.858)) and inter-observer ((automatic: α = 0.976; ICC = 0.961; k = 0.874) (manual: α = 0.959; ICC = 0.923; k = 0.831) consistency and reliability was found. These findings demonstrate a high level of instrument validity, reliability, and accuracy, offering coaches, analysts, and researchers in handball a brand-new tool to enhance handball performance.
Chen et al, 2023 [35]	iBall: Augmenting Basketball Videos with Gaze-moderated Embedded	Research and Developme nt	Eight uncommitted basketball lovers (P1-P8; M=3, F =5; Age: 18–35) who only knew "basic rules of	

	Visualizations		basketball" and watched "1–10 games per year" were categorized as "casual fans." We further recruited eight devoted fans (P9 - P16; M=8; Age: 18 - 55) who were familiar with "basketball tactics and the advantages and disadvantages of specific players" and who watched "at least one game per week" in order to understand better the problems that are unique to casual viewers.	
Lan et al, 2023 [36]	SimuExplorer: Visual Exploration of Game Simulation in Table Tennis	Research and Development	For the immediate and long-term effects of certain behaviors, the SimuExplorer system incorporates a Markov chain model. The user can then use flow and matrix views to see and understand these impacts.	Case studies and expert interviews demonstrate the system's utility. The technique is highly regarded by professionals, who have used it to gain an understanding of player behavior.

4 Discussions

4.1. Discussion of the main topics

The field of applied software is continuously undergoing optimization efforts, as it plays a crucial role in the functioning of computers and serves a wide range of purposes. For instance, the utilization of office and financial processing software is prevalent in company operations, while computer-assisted instruction (CAI) software significantly contributes to the facilitation of coaching [2]. The significance of sports prowess has garnered much attention in contemporary times since it provides valuable insights into the physical attributes of the entire populace. Software is thus referenced as a means to enhance the training and performance of athletes. In the 100-meter dash, there are instances where the athletes' finishing times are so closely matched that it becomes challenging for the referee to determine the winner [3]. There will be no issues encountered in the implementation of the software.

The thorough investigation revealed that team sport application development aimed at talent identification and performance analysis. The systematic review revealed that 22 articles discuss application development in team sports with the goals of performance analysis, talent identification, and sports injury. Most featured articles did not go into great length about app development. The creation of team sports-focused apps must consider functional specifications and features. Functional specifications and features are crucial in creating apps emphasizing physical exercise. However, these were only specifically reported in some systematic review studies. Twenty-two articles discuss identification and sports injuries. Most featured articles did not go into great length about app development. Features and functional criteria are crucial in the creation of apps focusing on.

Performance analysis is still a major topic in the trend of sports application development, so many applications have been developed to analyze a match or track training progress. However, applications based on talent identification, both in terms of biomotor and technical indicators of the game, still need to be improved.

4.2. Strengths and limitations

One notable aspect of this study is the methodology employed and the subsequent formulation of actionable suggestions to facilitate effective app development and ensure its sustained viability. Moreover, the perspective of domain specialists regarding app development holds significant value, as they are frequently the driving forces behind or are sought after for digital solutions tailored to specific use cases. The literature study needs to accurately represent the actual quantity of applications available within the domain of sports science. The survey's shortcomings encompass sample selection, reliance on self-reported data, and a restricted recruiting reach. The tiny sample size is a significant constraint. Moreover, the study must thoroughly examine the crucial aspect of user experience throughout the development process. The consideration of user requirements and feedback is crucial in creating

applications, necessitating its incorporation throughout the development process [37]. (Zhou et al, 2019).

5 Conclusion

Upon reviewing the existing literature about studies on app development models aimed at enhancing the quality of training, it becomes evident that the data provides unequivocal proof. The data utilized for analyzing the research variables can be duly accounted for. It is imperative to emphasize that the selection of team sports methods for athlete development applications should be tailored to the individual qualities of the athletes. The creation of team sports-focused apps must consider functional specifications and features. Functional specifications and features are crucial in creating apps emphasizing physical exercise. However, these were only specifically reported in some systematic review studies. Twenty-two articles discuss identification and sports injuries. Most featured articles did not go into great length about app development. Features and functional criteria are crucial in the creation of apps focusing on.

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