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Measurement, Control, and Tracking Technologies Used in Soccer Players' Training: A Review

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Abstract: This study addresses the literature concerning the use of technological tools for precise measurement and comprehensive recording of soccer player performance, focusing on indoor soccer. The purpose of this research is to explore the current landscape of technological instruments employed to analyze and quantify soccer players. A systematic search encompassing databases such as Scopus, Science Direct, and Web of Science was conducted between 2014 and 2021 using specific domain keywords. This study follows the PRISMA method for selecting and including articles in the review. From 29 papers meeting the inclusion criteria, it becomes evident that the current literature lacks coverage of technological tools applied to analyze technical actions, particularly among goalkeepers. Despite this, frequently used systems for measurement, control, and monitoring include GPS (42%), GPS + accelerometers (41%), and systems using IMUs (17%). The study underscores the need for further research to enhance the comprehensive understanding of performance across all soccer players, encompassing both field players (86%) and goalkeepers (14%). In its contribution, this literature review lays a foundational basis for future research endeavors in this domain, facilitating advancements in soccer player performance analysis.

Keywords: soccer, tracking, global positioning systems, inertial measurement units, motion capture systems, goalkeeper.

足球运动员训练中使用的测量、控制和跟踪技术：回顾

摘要：本研究涉及有关使用技术工具精确测量和全面记录足球运动员表现的文献，重点关注室内足球。这项研究的目的是探索用于分析和量化足球运动员的技术工具的当前状况。2014年至2021年间，使用特定领域关键词对斯科普斯、Science Direct和科学网等数据库进行了系统检索。本研究遵循棱镜方法来选择和纳入综述中的文章。从符合纳入标准的29篇论文中可以看出，当前的文献显然缺乏用于分析技术动作的技术工具，尤其是守门员的技术动作。尽管如此，常用的测量、控制和监控系统包括全球定位系统(42%)、全球定位系统+加速计(41%)和使用惯性测量单元的系统(17%)。该研究强调需要进一步研究，以增强对所有足球运动员表现的全面了解，包括场上球员（86%）和守门员（14%）。在其贡献中，这篇文献综述为该领域的未来研究工作奠定了基础，促进了足球运动员表

现分析的进步。

关键词：足球、跟踪、全球定位系统、惯性测量装置、动作捕捉系统、守门员。

Introduction

In indoor soccer and other team sports, the preparation of all players is crucial. However, there is a particular position that requires distinct attributes compared to the rest of the team: the goalkeeper.

The goalkeeper's role in the game entails specific functions and demands a range of physical, technical, and psychological aspects [1], which play a decisive role in their performance. The goalkeeper's position requires proficiency in various fundamental skills to fulfill his/her role in the game. These skills include closure, clearance, support, exit, counter-attack, and gaze control during interceptive actions with different spatiotemporal demands [2].

The goalkeeper performs various tasks in specific game situations, including intercepting the ball to prevent goals. Dribbling is a key technique used by goalkeepers to stop the ball from going into their own goal. In executing this action, the goalkeeper relies on their lower body, specifically their lower limbs, to execute this action and protect the goal effectively [3].

Goalkeeper practice or training sessions provide a controlled environment in which the player can invest significant effort to enhance their performance and refine their technique [4, 5]. However, the direction and focus of goalkeeper preparation have often been isolated, poorly supported, and insufficiently researched.

Therefore, there is a need to incorporate additional elements that support the analysis of complementary factors in game situations specific to the goalkeeper [6-8]. In this regard, the integration of technological tools becomes a crucial component in the planning and functional structuring of indoor soccer training programs. These tools play a vital role in improving goalkeeper performance during competitions [9].

On the basis of the aforementioned findings, a gap has been identified in the current literature concerning the analysis of interception sports techniques, specifically regarding the use of technological tools [10]. Furthermore, the majority of studies predominantly concentrate on-field players, often neglecting the inclusion of goalkeepers in their analysis and research [11].

There is a pressing need to broaden the scope and visibility of studies that directly focus on the actions of goalkeepers. This would provide goalkeepers with the necessary recognition and importance in their preparation to enhance performance in competitive and high-performance scenarios.

1. Materials and Methods

The literature review followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) method [12], which guided the selection and inclusion criteria.

The review process consisted of four essential steps: 1) Conducting a comprehensive search in specialized databases to gather information on the various types of instruments or technological tools implemented in training preparation between 2014 and 2021; 2) Applying a systematic process to include relevant articles based on predefined criteria; 3) Extracting data and assessing the quality of the information obtained from the included articles; 4) Analyzing and presenting the results derived from the reviewed articles.

1.1. Searches in Specialized Databases

The databases used were Scopus, Web of Science, and PubMed. The terms included in the queries were: ((soccer OR football) AND ((inertial AND sensors) OR IMU OR MEMS OR MOCAP OR (Motion AND Capture AND System) OR GPS) AND GOALKEEPER. This produces 90 results after limiting the information to the date range between 2014 and 2021.

1.2. Selection and Inclusion Criteria

The inclusion of articles in the review was determined by the following criteria: 1) Published in English; 2) Search period: January 2014 to December 2021; 3) Focus on technological instruments incorporating inertial sensors, inertial measurement units (IMU), micro-electro-mechanical systems (MEMS), motion capture systems (MOCAP), and global positioning systems (GPS); 4) About soccer players, specifically related to goalkeepers.

Articles were excluded if they did not establish a connection between technological instruments and the measurement and/or analysis of any variable related to the physical performance of soccer players. These criteria ensured that the selected articles were relevant to the research topic and provided valuable insights into the use of technological tools in measuring and analyzing the physical performance of soccer players, with a specific emphasis on goalkeepers.

1.3. Data Extraction and Evaluation Criteria

The process of data extraction and evaluation

followed the results obtained from the aforementioned query. The information was organized and classified accordingly. A total of 29 articles were compiled, each of which mentioned the use of a technological instrument to measure a physical performance variable and/or track the movements of soccer athletes.

Of these 29 articles, 25 specifically discussed the use of instruments to measure physical performance factors in field players, while only four focused on analyzing variables associated with the role of goalkeepers.

2. Results

This section provides an overview of the results obtained from the search and selection of articles that met the inclusion criteria for this study.

2.1. Selection of the Studies

During the search across various databases, 90 articles were initially identified. Among these, 29 records were filtered and subsequently removed following the selection criteria, and 32 duplicated records were deleted, resulting in a final set of 29 articles that met the inclusion criteria for analysis in this research. A concise summary of the entire process is presented in Fig. 1, which provides a visual representation of the selection and inclusion process.

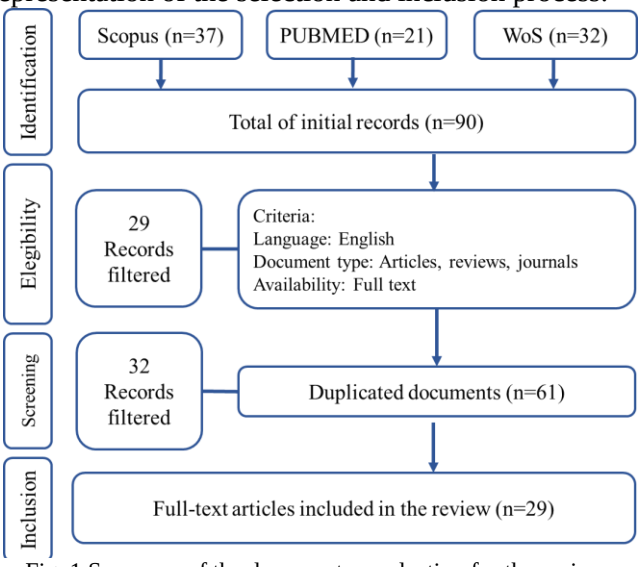

Fig. 1 Summary of the documentary selection for the review implementing the PRISMA methodology (The authors)

2.2. Overview of the Literature Analysis

The 29 articles included in this study were systematically classified on the basis of two key criteria: 1) Technology used: Each article was analyzed and categorized according to the specific technological tools or instruments employed in the research; 2) Player position on the field: the articles were carefully examined and classified on the basis of the positions of the players involved in the study, encompassing goalkeepers, defenders, midfielders, and forwards.

By applying this dual classification approach, a comprehensive analysis was conducted on the articles, considering both the technology employed and the specific positions of the players.

2.3. Literature Analysis According to the Technology Used in the Study

The section dedicated to analyzing the 29 articles included in this study focuses on a crucial criterion: the technology employed in the research. Each article was subjected to a meticulous examination and subsequently categorized on the basis of the specific technological tools or instruments used by the researchers.

Through this comprehensive analysis, this section aims to provide a deeper understanding of the diverse range of technological approaches employed by researchers, highlighting their impact on advancing our knowledge of soccer player performance evaluation.

The main distribution of technologies used for motion capture in the target population is illustrated in Fig. 2. This distribution will be further explored and discussed in detail in the following subsections to provide a comprehensive understanding of the specific technological tools employed in capturing and analyzing motion within the study's context.

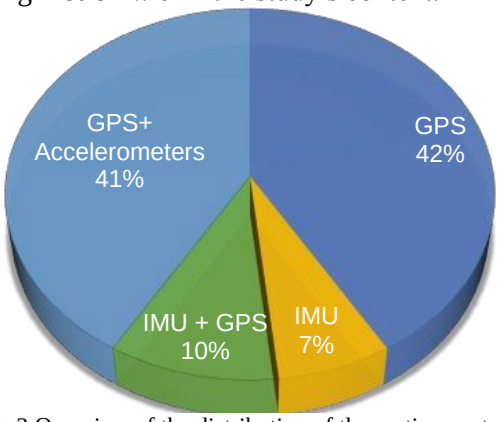

Fig. 2 Overview of the distribution of the motion capture technologies used (The authors)

2.3.1. Global Positioning System (GPS)

In the context of soccer player performance analysis, the use of global positioning systems (GPS) as a motion capture system has gained significant prominence. GPS technology offers a valuable means to capture and track the movements of soccer players during training and matches.

By incorporating GPS devices into player equipment or wearable devices, precise location data can be collected, providing valuable insights into player positioning, speed, distance covered, and movement patterns. The integration of GPS technology into soccer player monitoring has revolutionized the way coaches, trainers, and sports scientists assess and optimize player performance.

According to [13], the authors used various technological instruments, including global positioning systems, photocells, a jumping platform, and digital

video cameras, to assess the movement characteristics of soccer players under different game conditions during training sessions.

A study focusing on physical and movement variables in different formats of reduced games in professional soccer players from the first league of Qatar was conducted by [14]. This approach employed global positioning devices to collect data during training sessions.

Mitrotasios et al. [15] analyzed physical performance and mobility factors of soccer players across different play areas. They used FIFA GPS trackers to collect data during official seasonal matches of the Greek league. This approach allowed for a comprehensive understanding of the player's movements and performance in various game scenarios.

Similarly, Izzo et al. [16] focused on evaluating performance variables of soccer players. The physical profiles of the players were monitored using portable GPS global positioning systems and heart rate monitors. These monitoring devices were employed during training sessions, the development of physical tests, and official competitions. By using these technologies, the researchers gained valuable insights into the players' physical capabilities and performance across different contexts.

[17] compared the physical performance of youth and professional soccer players in the Italian Premier League. The data collection involved the use of GPS devices during official league matches for the youth players, while information on professional players was obtained through video analysis from existing literature. This comparison allowed for an examination of movement variables and performance differences between the two groups.

Several studies in the field have emphasized the direct application of global positioning systems for analyzing movement characteristics in soccer players. For instance, [18] analyzed the activity profile of soccer players during training sessions and competition matches, considering their respective positions. This study used GPS as a tool for data collection.

Similarly, Travassos et al. [19] employed GPS devices to collect the data from senior professional soccer players to determine positional movement indices under different game conditions during the training.

Furthermore, Corvino et al. [20] used a global positioning system along with video cameras to record movement information in handball players. Specifically, they conducted a time-motion analysis on eight players from an Italian Serie A1 league team, capturing both cyclic and acyclic movements.

In [21], the physical responses of soccer players during various game situations were analyzed. The research employed GPS devices to collect movement data during training sessions, and Polar heart rate monitoring systems were used during the applied tests. This comprehensive approach allowed for a detailed examination of physical responses in different game scenarios.

Furthermore, another study focused on the metabolic demands of reduced game match actions during training sessions [22]. In this study, a GPS global positioning system was implemented as the primary technological instrument. The study involved 16 sub-elite soccer players, and the GPS provided valuable data on the players' movements and positioning.

[23] showed the physical characteristics of soccer players according to their playing positions using different physical fitness tests. Photodetection units were one of the technological instruments employed in this research, while the remaining variables were evaluated using validated test protocols. This study determined specific values associated with the physical attributes of players based on their positions.

Finally, in [24], the movement and positioning of soccer players were analyzed using GPS technological instruments. These devices captured information on each player's movements during various soccer exercises and modified game scenarios during the training practices. The use of GPS technology allowed for a comprehensive understanding of player movements and positioning dynamics in different training contexts.

2.3.2. Inertial Measurement Unit (IMU)

In addition to GPS, inertial measurement units (IMUs) have emerged as another valuable electronic device for capturing and analyzing movement data in sports. IMUs as motion capture systems have revolutionized soccer player analysis. These wearable devices equipped with accelerometers, gyroscopes, and magnetometers capture players' acceleration, angular velocity, and orientation in 3D space. Offering portability and real-time data collection, IMUs provide valuable insights into dynamic movements, agility, and biomechanical parameters, optimizing performance understanding and training programs.

For instance, [25] assessed movement demands and rates during training and competitive matches of soccer players. The researchers monitored eight Premier League soccer players, focusing on a specific playing position. Micromechanical electrical systems (MEMS) integrated within IMUs were used to accurately capture the players' movements. This analysis provides valuable insights into the physical demands experienced by players in high-level soccer.

Another study analyzed performance factors and training load in soccer players [26]. This study monitored the activity of soccer players during matches and training sessions using K-Track/IMU devices. This

system used three-dimensional data to measure and provide information on the players' exertion levels, offering a comprehensive understanding of their efforts during various game situations and training activities.

Utilization of IMUs and related technologies allows for a more detailed and nuanced analysis of athletes' movements and physical performance. These devices provide precise and real-time data, enabling researchers and practitioners to gain deeper insights into athletes' effort levels, movement patterns, and training loads. Such insights can inform training programs, aid in injury prevention, and enhance overall performance optimization strategies in sports.

2.3.3. Hybrid Systems Based on GPS and IMU

Hybrid systems integrating GPS and IMU technologies have revolutionized soccer player analysis. These integrated systems offer a powerful combination of precise positioning data from GPS devices and detailed motion capture capabilities from IMUs, providing comprehensive insights into player movement and performance. This integration enables the optimization of training programs and the enhancement of player performance in soccer.

[27] analyzed the physical demands of female soccer players based on their specific playing positions during official matches. Position data were collected using GPS units equipped with triaxial accelerometers, gyroscopes, and magnetometers. Heart rate monitors were also used to measure heart rate responses. The study included 94 players from eight teams in the Danish league, shedding light on the physical demands experienced by female soccer players across different positions.

[28] focused on analyzing external load variables in different formats and game conditions to determine the physical profile of professional soccer players. GPS technology integrated with triaxial inertial sensors, accelerometers, gyroscopes, and magnetometers was used to capture data during all training sessions of 22 professional soccer players from a Portuguese team. This comprehensive analysis allowed for a deeper understanding of the external load demands placed on the players in various training scenarios.

These studies demonstrate the increasing use of hybrid systems that combine GPS and IMU technologies in soccer player analysis. By integrating precise positioning data from GPS with detailed motion capture from IMUs, these systems offer valuable insights into player movement patterns, physical demands, and performance. The collected data can be used to inform training programs, optimize player development strategies, and improve overall performance outcomes in soccer.

2.3.4. Hybrid Systems Based on GPS and Accelerometers

Hybrid systems that integrate GPS and accelerometers offer a valuable motion capture solution for soccer player analysis. These systems combine accurate position and speed data from GPS with measurements of linear acceleration provided by accelerometers. This integration allows for a comprehensive assessment of players' spatial movement, physical dynamics, and positional awareness on the soccer field. The collected data can be used to optimize training programs, inform decision-making by coaches, trainers, and sports scientists, and enhance player movement patterns and physical exertion.

Continuing with the analysis of physical variables of soccer players, [29] used a GPS integrated with a triaxial accelerometer to collect information on the positioning of soccer players during different soccer exercises in reduced space. This study further demonstrates the utility of GPS and accelerometer technology in capturing valuable data on player movement and performance during training tasks.

Similarly, Rago et al. [30] focused on measuring the individual movement patterns of soccer players during training exercises in reduced space. GPS units with triaxial accelerometers were employed to capture movement data in this study, which involved 20 soccer players from a professional team. The use of GPS and accelerometer technology allowed for a detailed analysis of players' movement patterns and performance in confined training spaces.

In [31], the analysis and measurement of physical load during the training and competition of a soccer player, specifically a professional goalkeeper from the English Premier League, were conducted. GPS devices, along with a triaxial accelerometer unit, were used to obtain data on the players' movements throughout the season. This comprehensive analysis of physical load and movement patterns offers valuable insights into the demands placed on a professional goalkeeper during training and competitive matches.

In the research by Rojas-Inda [32], the focus was on analyzing the internal and external load of youth soccer players during games in reduced space. The study used GPS global positioning instruments along with a triaxial accelerometer to gather data on the position and movement of soccer players during the training.

In addition, a polar band was used to measure the heart rate, providing insights into the physiological responses of the players.

Similarly, an analysis of load quantification during training and official matches throughout the season was performed in [33]. This study involved professional soccer players from the Netherlands' league. The data were collected using GPS and a triaxial accelerometer. These instruments measured the characteristics of players' movements, offering valuable information on their physical demands and performance.

Furthermore, [34] analyzed the physical responses and time-movement characteristics of soccer players during game actions under different conditions in reduced space. This study used GPS incorporating a triaxial accelerometer to capture data. The research included 14 soccer players from a Polish professional club, and the data collected provided insights into their physical responses and movement patterns during training sessions.

In the research by Praça [35], a combination of GPS global positioning technology and a triaxial accelerometer was employed to determine physical factors related to game exercises in reduced game situations. In addition, physiological conditions were analyzed using heart rate monitors. This study involved 18 youth soccer players from a professional club in Brazil, providing insights into their physical and physiological responses during game-related exercises.

Similarly, [36] analyzed physical variables related to the development of reduced game actions and alterations in the dimensions of the game space during training sessions. This study used GPS devices and a triaxial accelerometer to measure body movements. The participants were 28 players from lower categories of a professional children's club in the Spanish league. The findings shed light on the physical demands and movement patterns of young soccer players in response to changes in game situations.

Physical performance factors and movement patterns during different formats of reduced games in soccer players were analyzed using various technological tools [37]. In this study, portable GPS units were used to measure movement characteristics, accelerometers were employed to measure acceleration and deceleration, and speed tests were conducted using photocells. The study included 18 soccer players from different local clubs. This research provided valuable insights into the physical demands and movement patterns exhibited by players during reduced game formats.

In a study by Gaudino et al. [38], the influence of different game contexts in confined spaces on the physical demands of soccer exercises was analyzed. The activity data of soccer players were collected during each training session and monitored using GPS global positioning technology and a triaxial accelerometer. The study included 26 soccer players who participated in the Premier League and Champions League. The findings shed light on the physical demands placed on players during various game contexts in confined spaces, providing valuable insights for training program optimization.

Similarly, Castellano et al. [39] measured the physical profiles of soccer players in different game situations. The collection of movement data was performed during training sessions using portable GPS technological instruments. In addition, accelerometers were used to measure the load on the soccer players in three different planes of movement. This comprehensive analysis provided a deeper understanding of the physical demands and movement patterns exhibited by soccer players across various game formats.

Finally, in [40], positional and movement data of soccer players were analyzed during reduced space game tasks. Data collection occurred during all training sessions, and measurements were obtained using GPS technology with a built-in triaxial accelerometer. The research included 24 high-level U17 soccer players, providing insights into their positional and movement patterns in confined game situations.

These studies demonstrate the use of GPS global positioning technology and triaxial accelerometers to analyze the physical demands, movement patterns, and positional data of soccer players. By collecting comprehensive data during training sessions and game situations, researchers can gain valuable insights into the physical performance characteristics of players. These insights contribute to the optimization of training programs, tactical strategies, and player development in soccer.

2.4. Literature Analysis According to the Game Techniques and Player Position on the Field

This review identified a range of game techniques used in the included articles. These techniques were categorized into three main types: training, official matches, and reduced games. Among the identified techniques, 14% of the articles focused on training scenarios in which players undergo structured practice sessions to develop their skills and tactics. In contrast, 21% of the articles examined player performance in official matches, providing insights into their abilities during competitive play.

Interestingly, most articles (65%) explored player performance in reduced games, which are modified versions of the sport played with fewer players or in smaller playing areas. This emphasis on reduced games highlights their significance as an effective means of evaluating soccer players' abilities and performance in a more controlled and specific context. Fig. 3 visually represents the distribution of game techniques identified in the review.

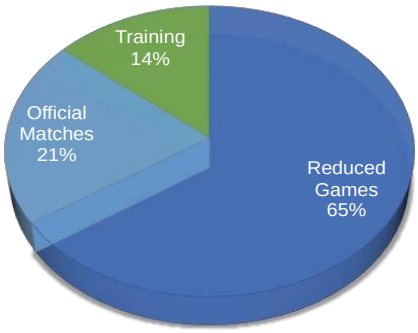

Fig. 3 Distribution of the game techniques for soccer player performance analysis (The authors)

In addition, through a comprehensive analysis, the following subsections provide a deeper understanding of how research on soccer player performance varies across different positions. By examining the specific focus on goalkeepers and other field players (defenders, midfielders, and forwards), as summarized in Fig. 4, valuable insights are gained regarding the unique demands and considerations for player positions concerning technological tools and performance analysis.

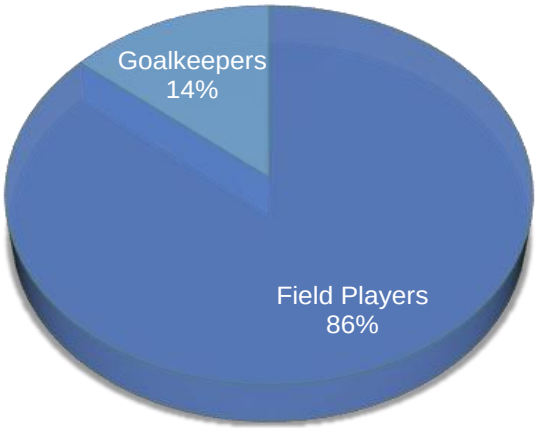

Fig. 4 Distribution of the soccer player positions in the reviewed papers (The authors)

2.4.1. Field Players

Several studies have examined the physical demands of soccer players during various game conditions and exercises. Panduro et al. [27] researched physical demands based on players' positions during official matches. They collected data on heart rate, distance covered, speed, and acceleration. In addition, load profiles were analyzed during reduced game formats, including metrics such as total distance, high-speed running, mechanics, acceleration, and deceleration efforts [14].

In [34], physical and movement factors during the execution of conditioned soccer and reduced game exercises were analyzed in professional players. This study focused on several physical variables, including player load, effort index, maximum speed, total distance, and time spent at different intensities. The sample for this study consisted of 14 players from a professional club in Poland.

As in previous studies, goalkeepers were excluded from the sample.

[35, 38, 39] have analyzed physical and movement factors in conditioned soccer and reduced game exercises in professional players. They considered variables such as player load, effort index, maximum speed, total distance, and time at different intensities. The sample included 14 players from a professional club in Poland.

Another approach was used in [29], where physical responses during reduced games were evaluated, recording data such as average speed, distance covered in different speed zones, and acceleration distances.

Some studies have reported physical performance variables in previous training and games, monitoring metrics such as distance covered at high speed, distance at very high intensity, accelerations, decelerations, metabolic power, and heart rate [16, 36].

Several studies have focused on determining movement characteristics during medium game exercises. In [30], movement characteristics were determined in medium game exercises by analyzing variables such as total distance, distance covered at high intensity, high-speed running, acceleration distance, maximum acceleration, total deceleration, and maximum deceleration. In addition, an analysis of physical performance during official games was conducted in [15, 26, 37], measuring parameters such as total distance, distance per minute, distance at high intensity, metabolic power, acceleration, and deceleration.

Other studies [18, 40] determined physical demands according to players' positions on the field, analyzing metrics such as traveled and covered distance, sprint distance, high-intensity acceleration and deceleration, metabolic load, and metabolic power. Rojas-Inda [32] conducted research to determine the physical variables of external load, recording measures such as total and average distances traveled, acceleration, and deceleration in different zones. Volume and intensity data of acceleration in the three axes of movement for each player were also recorded.

In addition to the analysis of physical variables, some studies have addressed technical variables in different situations and game conditions during training sessions [21]. Some researchers performed initial sprinting and jumping tests to determine the maximum speed of each player, analyzing technical components such as short and long passes, dribbling, shots on goal, tackles, and interceptions during reduced games [13].

Corvino et al. [20] analyzed physical and movement factors, including total distance, percentages of time spent in different speed zones, and technical variables such as shots on goal, piston movements, passes, jumps, tackles, changes of direction, and team actions. Sinclair et al. [41] analyzed soccer players' lower limb performance in kicking situations, obtaining 3D kinematic data on the lower limbs, ball launch velocity, kicking postures of the hip, knee, and ankle, and angles of the lower limbs.

Other studies focused on the positional characteristics and physical profiles of soccer players. For instance, positional characteristics were analyzed in various game formats, dividing the field into left, right, central corridor, and defensive sector zones [19]. An analysis of the physical profiles of soccer players according to their positional roles was performed in [23, 28], evaluating tests such as linear speed running, agility, repeated sprinting, and aerobic capacity during

training sessions. In [22], an analysis of metabolic demands in different reduced game formats was conducted, collecting data related to metabolic factors such as power, load, average metabolic power, high load distance, and equivalent distance.

Finally, an analysis of the positional characteristics of soccer players in reduced game situations was conducted in [24], collecting data on the latitude, longitude, and geometric center of the team in different sectors of the field, as well as speed, dispersion rate, and angles.

2.4.2. Goalkeepers

Among the studies reviewed, the focus was on analyzing the specific actions performed by soccer goalkeepers in training sessions and competition matches, using technological instruments as measurement tools.

For example, in the study by White et al. [25], the objective was to determine various rates of movement, such as dives, jumps (high, medium, low), changes of direction, explosive efforts, and distance traveled. This study included 16 professional goalkeepers from a high-level premier league soccer club.

Similarly, [17] analyzed the physical characteristics of elite soccer goalkeepers. The measured parameters included training load, average strength, lateral imbalance, vertical jumps, acceleration in vertical jumps, and lateral dives. The study collected data from both training sessions and official competition matches, providing valuable insights into the specific movement actions of goalkeepers in practice and real games.

Another study related to measuring goalkeeper variables was conducted by [31]. The researchers evaluated the daily training and competition loads over a period of seven days, focusing on various actions such as distance traveled, average speed, standing, walking, jogging, running, high-speed running, and sprinting. The data were collected from a professional goalkeeper in the premier league. Finally, in [33], the physical and movement factors performed by soccer goalkeepers are addressed.

The research involved analyzing training sessions and official matches throughout the season, with a focus on measuring the total distance, average speed, acceleration, deceleration, and player load. This study included one professional soccer goalkeeper competing in the Netherlands league.

These studies provide valuable insights into the specific actions and physical demands experienced by soccer goalkeepers during training and competition. By using technological instruments, researchers can measure and analyze various performance variables, thereby enhancing our understanding of goalkeeper performance and assisting in the development of targeted training programs for this specialized position.

3. Discussion

The above literature review provides valuable insights into the current landscape of technologies incorporated in sports. The review focused on studies conducted between 2014 and 2021, encompassing 29 articles that examined body motion capture and tracking devices for analyzing specific variables in athletes across different positions and sports.

A key finding from this review highlights the significance of GPS global positioning systems as an essential tool for analyzing physical performance in sports [13]. The integration of GPS technology allows researchers and practitioners to gather precise data on athletes' movements, distances covered, and speeds achieved during training and competition [15]. By combining GPS with other instruments such as heart rate monitors, accelerometers, magnetometers, and gyroscopes, a comprehensive understanding of athletes' performances and their physiological responses is gained [33, 36, 39].

There is a notable gap in research tailored to the requirements and characteristics of goalkeepers [17]. Given their unique role in team sports, future research should focus on uncovering the intricate movement patterns, technical nuances, and distinct physical demands of goalkeepers using appropriate technological tools.

Another concern highlighted in the literature pertains to the prevailing emphasis on acquiring upper body data (head, arms, chest, abdomen) [42]. While these upper body regions provide valuable insights into specific performance aspects, it is crucial to expand the focus to include other crucial anatomical segments, especially in sports where lower limb movements play a significant role [43]. Thus, upcoming research should strive to incorporate technologies that allow a comprehensive exploration of lower limb dynamics, given their pivotal role in overall athletic performance and injury prevention.

Additionally, a discernible trend in the reviewed literature underscores a tendency to quantify physical attributes and evaluate performance during training sessions, including modified training approaches [18]. While these studies provide important insights into general conditioning and physical exertion [18, 21, 32, 40], a gap exists in linking technological instrumentation directly to performance determinants in actual game situations. Understanding how athletes' readiness translates from training to competitive settings is crucial for optimizing training methods and enhancing performance outcomes [44].

The literature review strongly emphasizes the vital role of technological integration in sports analysis. While the utility of GPS and related tools in analyzing physical performance is unquestionable, there is a pressing need for focused research addressing the distinct needs of goalkeepers, encompassing lower

limb movements, and elucidating the interplay between technological analyses and real-game dynamics. Addressing these gaps not only enhances athlete performance but also advances training methodologies across various sports.

Another important aspect to mention concerns the analysis of the technical body movements of soccer players within training scenarios simulating real-game situations. The intricacies of actual gameplay extend beyond physical exertion, an aspect often overlooked in existing studies and potentially limited by technological constraints [45]. These variables including actions such as free kicks, penalties, or corners executed by players or goalkeepers require in-depth analysis. Exploring these dimensions alongside reliable and objective measurement instruments would contribute to the overarching research objective: optimizing athlete performance using refining techniques.

Moreover, a significant portion of the reviewed studies primarily focused on soccer as the main sport of investigation. While soccer certainly holds a prominent place in research, a limitation arises when transferring such analytical technologies to a broader range of sports [45]. Expanding the application of technological tools to encompass diverse sports disciplines would provide a more comprehensive understanding of factors, attributes, and variables influencing athlete performance in various training and competition scenarios.

A noteworthy pattern emerging from the reviewed literature underscores the comprehensive analysis of training scenarios, particularly through simulated games that replicate actual competitive actions [29]. These simulations, which mirror real-game demands, have been instrumental in understanding the behavior and performance of soccer players in their designated roles [30]. However, it is important to recognize that these analyses often exclude goalkeepers, an essential position with distinct responsibilities. To rectify this gap, further efforts are required to broaden research exploring goalkeeper behavior, accounting for diverse game situations and protocols that can be incorporated into training routines. This expansion should be supported by measurement technology tailored to address their unique tasks, both in the physical and technical realms.

4. Conclusion

The integration of technological instruments into training sessions represents a significant advancement in the quest to improve athletes' performance.

The use of inertial sensors, motion capture systems, and GPS provides valuable data for analyzing techniques, determining variables, and enhancing athletes' preparation.

The growing trend of implementing these tools highlights continuous efforts to optimize athletic performance in specific functions across different sports modalities. By leveraging technological advancements, coaches, trainers, and sports scientists are better equipped to understand and address the intricate nuances of athletes' movements.

However, it is important to acknowledge the limitations and gaps in the existing literature. A notable observation is an insufficient focus on the use of technological instruments that specifically measure parameters and analyze characteristics and techniques in the lower limbs of athletes, particularly concerning specific sporting gestures. This signifies a potential area for future research and development.

In addition, it is crucial to consider the adaptability of these instruments to athletes' unique requirements. Many current tools primarily concentrate on measuring and analyzing aspects of physical performance according to the specific demands of the sport. However, there is a need to explore and refine instruments that can effectively assess and improve athletes' performance in specific movements and gestures, with a particular emphasis on the lower limbs.

Advancements in technology offer promising opportunities for enhancing athletic performance. By expanding the scope of research and development and addressing the limitations identified in the literature, it is possible to unlock new insights and strategies to optimize athletes' performance.

Ultimately, the integration of technological instruments tailored to specific movements and gestures will contribute to a more comprehensive understanding of athletic performance and facilitate targeted interventions in training and preparation programs.

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