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Observational Analysis in Basketball: A literature review

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Abstract

Technological instruments and methods for monitoring, observation, and analysis have become increasingly important for gaining insights into basketball performance. Thus, this literature review aimed to compile information about methods and instruments for observational analysis in Basketball. Previous studies have applied several valid methods for physiological, technical, and tactical analysis in Basketball, specifically: Instrument for evaluating individual technical-tactical performance in Basketball (IAD-BB); Team Sports Assessment Procedure (TSAP); Game Performance Assessment Instrument (GPAI). Also, this type of analysis can be supported by time-motion analysis (TMA) analysis using analysis software with emphasis on Match Vision (software Studio 3.0, International Basketball Federation). In conclusion, the application of observation and analysis instruments in Basketball is valid, and repeatableObservational analysis can be applied in Basketball insights for talent identification; training design and management; technical and tactical performance analysis. Future challenges and research issues will be to compare observation strategies that combine instruments, integrating physical, technical, and tactical factors in Basketball performance analysis.

Keywords: *performance, instruments, methods, monitoring*

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Introduction

Basketball is a team sport defined by complex, dynamic interactions that integrate physical, technical, and tactical elements (Montgomery et al., 2010a). Furthermore, as a multifactorial phenomenon, basketball performance is influenced by contextual and individual factors (Fernández-Leo et al., 2020). Like other team sports, basketball relies significantly on observation as a critical tool for analyzing and improving perfor-

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mance. (Rampinini et al., 2007; Weaving et al., 2014). Currently, this process is facilitated through the utilization of instruments and methods employed in training or competition. Also, observational analysis can be focused on the specific-sports technical and tactical attributes (Knudson, 2013; Weaving et al., 2014) that researchers and practitioners in these specific areas are able to use valid instruments for monitoring technical-tactical processes, enabling the optimization of training processes and a deeper understanding of game performance (Rampinini et al., 2007; Weaving et al., 2014). Additionally, coaches and observers apply data collection methods for observational analysis, such as live observations during games or practices, video analysis, and use of specialized software for tracking and recording data. (Knudson, 2013).

The time-motion analysis (TMA) (Yang et al., 2022) has been described as a valid tool, either through notational analysis or automated artificial intelligence software that is still being refined (Teixeira, Forte, et al., 2022). Several observational analysis instruments have been validated for basketball training and play, including IAD-BB, Game Performance Assessment Instrument (GPAI), Team Sports Assessment Procedure (TSAP), Basketball Learning and Performance Assessment Instrument (BALPAI) (Ben Abdelkrim, Castagna, El Fazaa, et al., 2010; Hulka et al., 2014; Klusemann et al., 2013; Scanlan et al., 2011). Therefore, it is important to describe its application, cost-effectiveness and potential support software such as Match Vision software homologated by International Basketball Federation (FIBA) (Rodrigues & Louro, 2016). On this basis, the performance metrics was identified by technical skills (e.g., shooting percentage, passing accuracy), tactical aspects (defensive rotations, offensive spacing), and physical attributes (speed, vertical leap). Their practical application is only possible through standardized observation protocols to ensure consistency and reliability in data collection. This involves defining clear criteria for assessing different aspects of basketball performance. Strength and conditioning as well as injury prevention are usually analyzed using biomechanical patterns and movement patterns to identify potential injury risk factors (Bond et al., 2019).Observational analysis can be also used to inform about individualized player development, identifying strengths to enhance and weaknesses to address for each player (Knudson, 2013). Previously, eye-tracking technology has been described as a valuable tool for basketball coaches to gain insights into their players' visual patterns and perception strategies, as well as decision-making processes on the pitch during training and game (Damas & Ferreira, 2013).

The pursuit of better sporting outcomes through research has emphasized the need to enhance technical fundamentals and tactical skills . For these reasons, there is a growing demand for tools and methodologies that allow a comprehensive understanding of the dynamics of the game, both at an individual and collective level (Ben Abdelkrim, Castagna, El Fazaa, et al., 2010). Therefore, it is crucial to compile information regarding these observation and analysis methods and instruments. In this sense, coaches and researchers have shown interest in providing themselves with observation and analysis instruments in more depth to understand the game, expanding knowledge about the factors that contribute to enhancing performance (Crandall et al., 2006; Fernandez et al., 2009). Observational and analytical tools in team sports, especially in basketball, play a significant role in indirectly assessing whether the planning and structuring of training content and activities effectively prepare athletes to meet the tactical and technical demands of the sport (Arias & Castejón, 2012; Memmert & Harvey, 2008; Saad, 2012). However, it is noted that there is a dearth of information regarding contextually appropriate instrumentation and observational strategies tested specifically in the basketball context. Currently, there is a gap in the literature regarding the use of time-motion analysis to provide practical recommendations for basketball coaches (D. Branquinho et al., 2022; Ziv & Lidor, 2009).

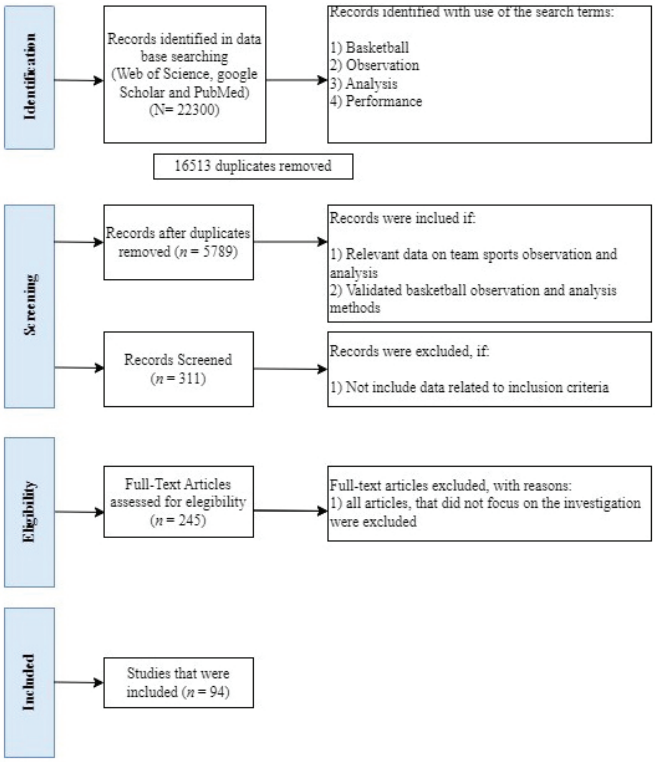

Figure 1. Prisma flowchart illustrating the research strategy

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Thus, the objective of this literature review was to compile the information contained in scientific literature, regarding observation and analysis instruments in basketball, and their applicability to games and/or training, as well as the impact that this type of observation strategies has on individual and collective technical-tactical performance in basketball.

Materials and Methods

Search Strategy

To conduct this review, the available literature was systematically searched using the Web of Science, Google Scholar, and PubMed databases. Articles published between 1990 and the present were included for analysis, and the selection process followed a PRISMA Flowchart. The search strategy combined four primary keywords "basketball," "observation," "analysis," and "performance"—using Boolean operators.

The inclusion criteria for articles were: (1) relevant data on team sports observation and analysis, and (2) validated methods for basketball observation and analysis. Studies were excluded if: (1) they did not meet the inclusion criteria, or (2) they were conference abstracts. Articles were initially screened based on their titles and abstracts, and those not aligned with the research focus were excluded.

A total of 178 articles were identified as relevant for this review. Each article was thoroughly reviewed and assessed for relevance and quality by two senior researchers with expertise and publications in the field. Articles failing to meet the criteria were excluded. Two independent authors (R.F. and L.B.) conducted the literature search between January and November 2023, with a third reviewer (M.C.M.) appointed to resolve any disagreements regarding study selection. Following this process, 94 articles were retained for final analysis (Figure 1).

Results

The Demands of Basketball

Basketball has been extensively studied in terms of physical attributes, physiological characteristics, on-court performance, and nutritional strategies. Key variables such as height, weight, somatotype, body composition, aerobic capacity, strength, anaerobic power, agility, and speed have been widely reported to define the sport's physical and physiological demands. (Ziv & Lidor, 2009). The implementation of techniques to monitor athletes' responses to training stimuli, as well as in a game context, or other events in a competitive context, is relevant for team sports coaches, structuring and adapting technical and tactical processes to optimize sports performance (Fernandez et al., 2009).

Team sports such as basketball present a wide variety of actions, requiring the player to constantly make decisions in different contexts of action and performance (Fernandez et al., 2009). Basketball performance depends on multiple qualities, including functional capabilities, tactical concepts, and psychological attributes (Drinkwater et al., 2008; Rodrigues & Louro, 2016). In this sense, it is important to have instruments that allow evaluating athletes' performance in different situations, whether in the context of teaching-learning, training, or competition (Memmert & Harvey, 2008).

Measurement of athletes' time-motion data indicates that the intermittent, high-intensity nature of the game of basketball, combined with the need to perform sport-specific activities such as dribbling, positioning, and cutting maneuvers, imposes a unique set of demands to players (Abdelkrim et al., 2007; Scanlan et al., 2011). Consequently, it is important that the effectiveness of established training load models is evaluated during basketball training so that appropriate training load monitoring practices can be adopted (Saad, 2012). Defensive and offensive training during basketball practice presents similar physiological responses and physical demands, with the game being substantially more demanding than training (Montgomery et al., 2010b). In team sports, the game evaluation instruments have been revealed as essential means to assess the characterization of the specific demands required of players in a competitive situation. In the literature, this type of study is found using different nomenclatures, such as game observation, notational analysis and game analysis (Ben Abdelkrim, Castagna, El Fazaa, et al., 2010; Garganta, 2001). In basketball, the game can be analyzed from the technical point of view (i.e., performance of one or more players, determining the level of actions – efficiency and effectiveness of the execution of its fundamentals) and the tactical point of view (i.e., decision making and adaptations made according to the situation imposed by the game) (Aoki et al., 2017; Arede, Fernandes, et al., 2020). Both analyzes can be carried out objectively (i.e., quantification of a given action) or subjectively (i.e,. qualitative observation of technical executions or joint actions performed by the athletes involved) (McLaren et al., 2018) However, for any analysis process to have reliability and validity, it is necessary to develop observation systems and methods that make it possible to record all relevant facts of the game, thus producing objective, quantifiable, consistent and reliable information (Aoki et al., 2017; Arede, Fernandes, et al., 2020).

Research focused on game analysis has made significant contributions to understanding the characteristics, patterns, and unique aspects of team behaviors in general, as well as individual player behaviors specifically (Marcelino et al., 2011), enabling considerable advances both conceptually and methodologically. The first recorded analyzes were carried out without any theoretical support, with a predominance of rudimentary techniques (paper and pencil) to obtain information, noting only the frequencies of success or failure on certain grounds, during the matches themselves (Vázquez-Guerrero et al., 2019; Vázquez-Guerrero & Garcia, 2021)In this way, the need and demand for observation and analysis methods and instruments have emerged, progressively, and Sports Science researchers have emerged, looking for more robust analyzes of data collected in different contexts. (Barros et al., 2002; Marcelino et al., 2011). Therefore, it is important to understand the best basketball observational analysis methods and instruments to collect evidence about overall performance in training and play that can be used in the development of individual basketball players (Knudson, 2013).

The Importance of Methods and Instruments for Observation and Analysis

The instrumental evaluation in sports games allows observing and measuring the performance of athletes in a laboratory context and in a real teaching and learning situation (dos Santos et al., 2016). Professional intervention in the process of performance analysis in the context of training and competition/game, requires in-depth knowledge of the activity/task and the athlete, with the application of highly rigorous processes, resulting from the collection of information through instruments, technologies or information collection methodologies through observation and direct analysis (Rodrigues & Louro, 2016).

In the last decade, several instruments have been designed with the aim of evaluating athletes' technical and tactical skills (dos Santos et al., 2016) and so it is not surprising that techni-

cal-tactical observation and analysis is increasingly common in sport (Taylor et al., 2008). It is not only intended for diagnosing motor behaviors, but also for identifying and evaluating the technique and its control parameters, with the aim of understanding and modifying the target behavior (Rodrigues & Louro, 2016). The process of analyzing sports performance is therefore a fundamental factor in regulating training and competitions, allowing the collection of relevant information to improve sports performance (Garganta, 2001).

Recently, there has been a surge in publications addressing training load, with reviews and meta-analyses in team sports increasingly focusing on evaluating the relationship between load and performance. (Fox et al., 2018; McLaren et al., 2018), intensity (McLaren et al., 2018), training results (Ferreira Nunes da Silva et al., 2017), acute/residual fatigue (Drew & Finch, 2016; Hader et al., 2019), injuries, illnesses and pain (Drew & Finch, 2016). The literature has shown some examples of technologies to determine the physical profiles of players in relation to factors such as the position of the player (Di Salvo et al., 2007, 2010), fatigue or rhythmed (Bradley & Noakes, 2013), variation of indicators during the halftime of the game (Rampinini et al., 2007), the competitive level (Lago, 2009; Rampinini et al., 2007) as well as the impact of contextual variables, including match location, opponent quality, and game state. (Castellano et al., 2011; Taylor et al., 2008). All these variables seem to influence not only the way the game is played, but also the physical demands (Lago, 2009; Rampinini et al., 2007), its technical performance (Taylor et al., 2008), the game effectiveness (Castellano et al., 2011), and the percentage of ball possession for each team (Lago, 2009).

It is essential to collect data that should measure what it is intended to measure (i.e., validity), with as little error as possible (i.e., reliability), regardless of the assessment of who measures it (i.e., objectivity) (Garganta, 2001). After data collection, it is necessary to interpret the information produced, giving it an appropriate meaning, that is, transforming the information into knowledge (Garganta, 2001). Coaches have always observed and analyzed the performance of athletes subjectively, making important decisions based on this subjectivity (Taylor et al., 2008). In this sense, there is a need to resort to organized data analysis systems, capable of improving the quality of training and play (Muyor et al., 2018). The improvement of technical fundamentals and tactical ability, in the search for better sports results has underscored the necessity of employing tools that provide deeper insights into game dynamics., both at the individual and collective level (Ben Abdelkrim, Castagna, El Fazaa, et al., 2010; J.-F. Gréhaigne & Godbout, 1998).

Observation methods and instruments and analysis

The definition of the crucial variables to be observed and analyzed in the context of a game is fundamental for understanding the processes that take place during a game, and for optimizing the technical and tactical processes associated with the performance of athletes throughout the game (Pino-Ortega et al., 2021). With the fast advancement of technology in team sports and the resulting surge in available data, the need for effective data mining has driven the adoption of data reduction techniques, such as Principal Component Analysis (PCA), machine learning, and other similar methods. (Forte et al., 2023; Rojas-Valverde et al., 2021; Teixeira, Forte, et al., 2022).

As previously mentioned, team sports performance relies on multiple dimensions (e.g., technical, tactical, and physical), necessitating multivariate data analysis structured around three key areas: conducting efficient game analysis, designing training tasks aligned with the most critical efforts, and identifying the most significant variables for talent detection. (Pino-Ortega et al., 2021). For the basketball, the above-referenced article highlights the following dimensions (McInnes et al., 1995; Narazaki et al., 2009) (Figure 2).

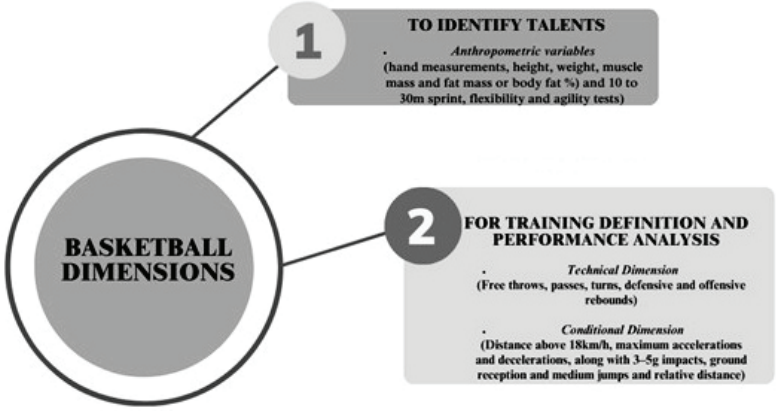

Figure 2. Basketball Dimensions

For the evaluation of parameters in the context described above, over the years, several data analysis and observation methods have emerged in the literature. The following points present a summary of the most relevant ones.

Technical-Tactical Basketball Performance Assessment Instrument (IAD-BB)

Folle et al. (2014a) validated an instrument calledI-AD-BB, where the evaluation of each of the actions (offensive and defensive) occurred based on three specific indicators, which depend on the component to be analyzed, i.e., efficiency. In seeking to contribute to the advancement of systems for analyzing the game, the IAD-BB observation indicators were developed based on the technical-tactical fundamentals and the characteristics of the players in the training categories of the basketball. Similarly, the game components were designed considering the dimensions of technical-tactical performance, such as movements without the ball – Adaptation (Saad, 2012), selection of the way of acting, according to the circumstances of the game - Decision making (Oliveira & Paes, 2004) and the result of the motor action – Effectiveness (Rink, 2014).

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Table 1. Technical-tactical performance in basketball (IAD-BB)
(Adapted from Folle et al., 2014a; Torres-Ronda et al., 2015)2014a; Torres-Ronda et al., 2015)

Action	Component	Indicators
Pass	Decision-making	a) Pass the ball to the marked teammate. b) Pass the ball to an unmarked teammate (conservation). c) Pass the ball to a teammate in a position to advance and/or finish (advancing or finishing).
	Efficacy	a) Passing error. b) Pass intercepted by opponent. c) Passes the ball to a teammate.
Reception	Efficacy	a) Cannot control the ball. b) Receives the ball but loses possession to the opponent. c) Receives the ball and maintains its control.
Dribble	Decision-making	a) Dribbles in an inappropriate place with pressured marking and/or defensive coverage. b) Dribbles without offensive action and/or maintain possession of the ball (conservation). c) Dribbles to continue the offensive action and/or to obtain finishing conditions (advancing or finishing)
	Efficacy	a) Loses possession of the ball alone or commits a violation. b) Losing the ball to the opponent. c) Keeps possession of the ball.
Throwing	Decision-making	a) Throwing with pressed marking and/or in an inappropriate place. b) Throws with easy marking by opponent. c) Throwing free, in adequate space.
	Efficacy	a) Unconverted throw. b) Throw intersected. c) Throw converted.
Lightshield	Adaptation	a) Position yourself in a suitable location to block the defender's trajectory (Location). b) Adopts adequate posture to interfere in the defender's trajectory (Posture) c) Places himself at the adequate time to perform the light cutter (Synchronization).
	Efficacy	a) Does not make it difficult for the opponent to score. b) It makes it difficult for the opponent to score. c) Frees or avoids opponent's marking.
Deselection	Adaptation	a) Occupies adequate space (pass line) to receivthe ball (Place). b) Positions himself with body protection to receive the ball (Posture). c) Alternates speed and direction to get rid of the opponent (Speed).
	Decision-making	a) Does not come forward to receive the ball (does not create a pass line). b) Looks for free space (creates pass line), in an inadequate place for offensive sequence (Conservation). c) Looks for free space (creates pass line) in adequate place for offensive action (Advance or Finishing).
	Efficacy	a) Does not react to marking. b) Cannot unmark himself. c) Can get unmarked.
Blocking the offensive rebound	Adaptation	a) Places himself in a suitable location to block the opponent (Location). b) Assumes basic posture for blocking (Posture). c) Anticipates blocking and prevents the opponent's action (Anticipation).
	Efficacy	a) Does not assume a locked position. b) Takes up a blocking position but does not prevent the opponent's action. c) Takes up a blocking position and prevents the opponent's action.
Offensive rebound	Efficacy	a) Loses the bounce. b) Gets the rebound but does not retain possession. c) Gains the rebound and retains possession.
Marking without the ball	Adaptation	a) Places himself in a location that makes it difficult for the opponent to progress and/or receive the ball (Location). b) Assumes basic marking position, seeking to have a view of the opponent and the ball (Posture). c) He adapts to the speed imposed by the opponent (Speed).
	Decision-making	Individual a) Do not try to inhibit the opponent's progression and reception of the ball. b) Try to inhibit the opponent's progression or the reception of the ball (Containment). c) Seek to prevent the opponent's progression and reception of the ball (Protection or Recovery). Zone a) Mark outside the pass line and does not perform coverage. b) Mark only on the pass line or only performs coverage (Containment). c) Mark on the line of scrimmage and cover teammates (Protection or Recovery).
	Efficacy	a) Does not make it difficult for the opponent to progress and/or receive the ball. b) Difficult the opponent to progress and/or receive the ball. c) Prevents the opponent from progressing and/or receiving the ball.

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Table 1. Technical-tactical performance in basketball (IAD-BB)
(Adapted from Folle et al., 2014a; Torres-Ronda et al., 2015)2014a; Torres-Ronda et al., 2015)

Action	Component	Indicators
Marking with the ball	Adaptation	a) Position yourself at a distance that allows you to remain marking the opponent (Location). b) Assumes basic marking position (Posture). c) Adapts to the speed imposed by the opponent (Speed).
	Decision-making	a) He tries to mark the opponent, without offering resistance or disputes the ball hastily. b) Seeking to impede the progression or completion of the opponent (Containment). c) Seeks to pressure the opponent to regain possession or induce the opponent into error (Protection or Recovery).
	Efficacy	a) Does not impede the opponent's action. b) Hinders the opponent's action but does not regain possession. c) Regains possession or provokes the opponent's mistake.
Defensive rebound blocking	Adaptation	a) Places yourself in a suitable location to block the opponent (Location). b) Assumes basic posture for blocking (Posture). c) Anticipates the opponent's action (Anticipation).
	Efficacy	a) Does not assume a locked position. b) Takes up a blocking position but does not prevent the opponent's action. c) Takes up a blocking position and prevents the opponent's action.
Defensive rebound	Efficacy	a) Ask for the rebound. b) Gets the rebound but does not retain possession. c) Gets the rebound and retains possession.

In determining the general performance level of two athletes, the analysis of all components of the instrument was used. The instrument also allows the analysis of each component or each year individually, also providing important information regarding the identification of the player's specific performance level. (Folle et al., 2014b).

The IAD-BB was developed with the objective of evaluating the level of technical-tactical performance in basketball youth athletes, considering the fundamentals and game components of this modality. In addition, the interest was to contribute to the improvement of the means and techniques of analysis of the game, in real situations experienced by the players during the games (Hatem et al., 2020; Rösch et al., 2022).

Game Performance Assessment Instrument (GPAI)

In view of the above, several instruments have been developed with the aim of enabling the technical and tactical assessment of athletes. Thus, instruments such as the Game Performance Assessment Instrument (GPAI) allow the analysis of the result of the action (e.g., product of the movement) and the variables of the motor execution process related to game actions (e.g., technique and tactics) (Tallir et al., 2003). The GPAI was developed to assess behaviors associated with game performance, especially those of a tactical nature, as well as the player's ability to solve tactical problems in an ecological context (Harvey et al., 2010). It is, effectively, a flexible observation tool that can be used to assess the real performance of players, through direct observation, or using video (indirect observation). Furthermore, the GPAI can be used to follow the evolution of athletes' performance and measure their motor performance in several contexts (J.-F. Gréhaigne & Godbout, 1998). However, it should be noted that the GPAI has some limitations in its application. For example, this instrument does not indicate the performance level of the athletes, since the performance indices only allow comparisons between athletes, thus there is not a criterion that allows, in the observed game, to place the player at a determined level of performance.

Over time, several authors have praised the relevance of GPAI for analyzing results and the process of executing game actions (technique and tactics) considering the components of sporting performance (Da Costa et al., 2011; Mitchell, 2016; Wright et al., 2005).

That said, considering the relevance of the instrument in recent literature, it is important to analyze and interpret it in more detail. The GPAI allows evaluating seven components in the context of basketball performance, namely: 1) support: appropriate return of the player to his position or recovery after performing the actions); 2) adjustment: ability to read the game and elements that involve it, acting in order to establish the best action); 3) decision- making: making best decision regarding ball possession); 4) skill execution: efficient performance of selected skills); 5) support action or support: movement of the player without the ball to receive a pass or launch); 6) coverage: defensive support to the player with the ball or moving towards it); 7) protect/mark: defending an opponent who has or does not have the ball (Memmert & Harvey, 2008).

In the literature, although there is a reduced number of studies that use the GPAI to analyze the performance in the basketball game, due to the excess of subjects to be analyzed, cohesion between the evaluators, among other aspects capable of determining the efficiency of a good evaluation, the studies presented demonstrate the relevance and importance of the instrument in the analysis and evaluation of sports performance in basketball.

Team Sports Assessment Procedure (TSAP)

Team Sports Assessment Procedure (TSAP) has been applied in invasive and non-invasive sports (e.g., individual and team sports) (J. F. Gréhaigne et al., 1997). That instrument is based at frequency of the several events occurred during the game, that reflect the technical and tactical aspects, and this evaluation is based on information that quantifies the overall individual offensive performance, that is, in invasion and network games (Tallir et al., 2003). In this context, some studies indicate that this instrument can be an effective tool in the teaching-learning process of motor skills (J. F. Gréhaigne et

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al., 1997; Richard et al., 2002). The TSAP allows obtaining information about the performance of students or athletes, quantifying the technical and tactical aspects in the context of training and game (Gréhaigne et al., 1997). The TSAP features six different observation variables that reflect global offensive performance in invasion games (Table 2).

Table 2. TSAP variables that reflect global offensive performance basketball.

Variable	Offensive performance indicator
Gain of ownership ball	a) Balls won – intercepted and recovered after attempted completion.
	b) Received balls – received from a teammate without losing it right away then.
Flow of ball	a) Lost balls – when you lose control of the ball without having finished.
	b) Lost balls – when you lose control of the ball without having finished.
Pass	a) Which contributes to taking the ball towards the goal or backboard opponent.
Pitch with success	a) Marked basket points, or if keeps the possession of the ball.

As a formative evaluation, the TSAP was applied in soccer, ice hockey and basketball, only two studies were identified (J. F. Gréhaigne et al., 1997; Richard et al., 2002), noting that like this the scarcity in research was carried out about the use of TSAP in that team sport. The primary limitation of TSAP is its focus on player actions with the ball during offense, while neglecting detailed analysis of ball movement. Thus, the contact time with the ball tends to be very limited in basketball invasion games (R. Santos et al., 2016). The results throughout the studies indicated moderate levels of precision and reliability in the use of this instrument as a means of evaluating performance.

Basketball Learning and Performance Assessment Instrument (BALPAI)

The Basketball Learning and Performance Assessment Instrument (BALPAI) is a holistic tool developed to evaluate basketball players' skills, tactical understanding, and overall performance. (Table 2). It is often used in research and coaching settings to evaluate players' abilities and progress over time. The BALPAI typically consists of various components, each focusing on different aspects of basketball performance (Table 3 and Table 4).

Table 3. Common components used in BALPAI (Chen et al., 2013; Szwarc & Lekner, 2022)(Chen et al., 2013; Szwarc & Lekner, 2022)

Technical Skills Assessment	This component evaluates players' proficiency in fundamental basketball skills such as shooting, dribbling, passing, and defensive techniques. Coaches or evaluators may use specific criteria to score players' execution and accuracy in each skill.
Tactical Decision-Making	This component assesses players' understanding of game situations and their ability to make strategic decisions on the court. Evaluators might analyze players' choices in offense and defense, as well as their court awareness and ability to read the game.
Physical Abilities	The BALPAI often includes an assessment of players' physical attributes such as speed, agility, strength, vertical leap, and endurance. These factors play a crucial role in a player's overall performance on the court.
Game Performance	Observational data is often collected during actual games or simulations to evaluate players' performance under realistic conditions. This allows coaches to understand how players apply their skills and tactics in real-game situations.
Scoring and Interpretation	The scores and data collected from the various components of the BALPAI are compiled and analyzed. Coaches can then interpret the results to identify players' strengths, weaknesses, and areas for improvement.
Player Development	The BALPAI can be used to track players' progress over time. By conducting regular assessments, coaches can monitor individual development and tailor training programs to address specific needs.

Table 4. Example of offensive and defensive action coded using the Basketball Learning and Performance Assessment Instrument (BALPAI) (Adapted from Szwarc & Kekner (Szwarc & Lekner, 2022)(Szwarc & Lekner, 2022)).

Action	Component	Indicators
Offensive actions	1) Actions gaining the play field with a ball	a) Dribbling the ball to move from the backcourt to the frontcourt by a player with the ball (with or without the opponent). b) Dribbling pivots with the ball to change the direction of dribbling and to pass an opponent, changes in the pace of dribbling
	2) Actions preparing a situation to score points and creating a situation to score them	a) Offensive activities with the ball while facing the basket - they involve moving a player with the ball in the frontcourt towards the basket, with or without an opponent, in order to score points or create circumstances that will allow for scoring, using the methods of action mentioned in point a); b) Offensive actions with the ball with the back to the basket - these involve moving a player with the ball who is positioned with the back to the basket in the direction of the basket with or without an opponent to score points or set up situations to score them by using the methods described in point 1a), and 2c) rebounding after a shot for a score. c) Rebounding occurs after a field goal attempt, free throw attempt, or failed tap, and involves an offensive player regaining possession of the ball following a missed shot at the hoop (either their own or their teammate's).

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Table 4. Example of offensive and defensive action coded using the Basketball Learning and Performance Assessment Instrument (BALPAI) (Adapted from Szwarc & Kekner (Szwarc & Lekner, 2022)(Szwarc & Lekner, 2022)).

Action	Component	Indicators
Offensive actions	3) Actions scoring points	a) Jump shot (from a spot, after changing positions, after dribbling); b) Running shot (after a pass, after dribbling); c) Back-up shot, which is preceded by fakes and pivots; d) Tap which involves pushing or striking the ball with one or more hands into the opponent's basket.
	4) Individual actions	a) Winning the ball: - obtaining possession of the ball (stealing it from the dribbler, taking it away, or acquiring ball possession); - assuming a lawful guarding position in the path of an offensive player; b) Inducing an offensive foul (charge), causing an opponent to commit a foul (5 or 8 seconds, traveling, double dribbling, carrying the ball, or crossing the line); c) Stoppage of play: placing the ball out-of-bounds; When a player (or more) from each of the opposing teams holds the ball in their hands such that none of them can take possession of it (holding the ball) d) Hindering the ball movement: pushing the dribbler towards sidelines – a defensive player takes a legal guarding position, next moves to guard his opponent pushing him;
	5) Actions gaining the play field with the ball	a) Playing the ball with passes, with or without dribbling, to move the ball from the backcourt to the frontcourt by passing to offensive players without dribbling or by passing while dribbling
	6) Actions preparing a situation to score points and creating a situation to score them	a) A competitor can gain the opportunity to shoot or pass the ball to a partner who can shoot (create a situation) or advance the game (prepare a situation) by doing one of the following: 1) offensive actions without the ball and without screens. They consist of maneuvers such as spiking, running around, walking away, and moving into position to receive the ball. 2) A competitor screens a partner or partners to escape a defensive player, then moves into position and receives the ball from a partner. As a result, the competitor gains the opportunity to shoot or pass the ball to a partner, enabling him to:
Defensive actions	7) Counteracting against gaining the play field with the ball:	a) Doubling (simultaneous or consequent) – actions of two defensive players taken to take away the ball from an opponent, force him to commit a violation or delay his offensive actions. b) Creating a temporary advantage in defense – assistance in partner's actions (running up to a player with the ball who has passed a defensive player until the partner's return to his position and then return to one's own on-ball defense – the so-called "help and re- cover"). c) Switching defense – actions of two or more defensive players who replace each other in guarding offensive players. d) Cooperation between three players against a teammate who is playing without the ball and using a screen when two defensive players work together against the opponent's screen ("help and recover," switching defense) to stop the player without the ball from moving into position, and the third defensive player disorients the opponent with the ball by passing to a teammate who is moving into position that would allow him to shoot (creating a situation) or advance the game.

Match Vision software Studio 3.0

In a previous investigation Fernández et al. (2009b), a recording instrument was used, which collected and analyzed data on the actions that occurred in the offensive ⅓ of the team, delimiting and defining the actions that occurred in the field area.

The registration tool utilized was Match Vision Software Studio 3.0 (Castellano et al., 2008), a user-friendly application designed to assist researchers in observing, coding, recording, and analyzing spontaneous behaviors in natural or habitual contexts. This interactive multimedia tool enables users to view and record digital game footage in formats such as .avi or .mpg directly on a computer screen. (Fernandez et al., 2009). The same author analyzed scoring percentages, success zones, significant ball movements leading to rebounds, significant ball movements resulting in errors, and counterattacks. The identification and evaluation of these offensive patterns in basketball have been made possible through the use of such software and systematic observation tools.

Other important parameters are the processes and mechanisms for monitoring and analyzing independent assessments of external demands or internal responses associated with basketball training and/or competition (Fox et al., 2017).

Time-motion analysis (TMA)

he rapid retrieval of data enhances its relevance for routine player monitoring, while proprietary software for data analysis eliminates the potential for human error and interpretation ambiguity often associated with methods like TMA (Fox et al., 2017). TMA is extensively utilized to monitor external training demands during basketball sessions. (Klusemann et al., 2012; McInnes et al., 1995; Narazaki et al., 2009; Torres-Ronda et al., 2016), competition (Ben Abdelkrim, Castagna, El Fazaa, et al., 2010; Hulka et al., 2014; Klusemann et al., 2013; Scanlan et al., 2011). Data collection through TMA may vary based on the system employed but generally follows consistent procedures..

Video footage captures player movements using cameras mounted on stadium infrastructure or portable tripods positioned around the court. Most modern TMA systems described in the literature are semi-automatic, enabling automatic player detection on the court. Once recorded, the video files are processed using specialized software to digitize the images and extract relevant data. (L. Branquinho, Ferraz, Travassos, et al., 2021; L. Branquinho, Ferraz, Teixeira, et al., 2022). The data collected varies depending on the software and the analyst's requirements, but commonly sought metrics include speed, distance covered, movement durations, and movement counts.

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While the validity and reliability of TMA have been well-documented, the process of data analysis and interpretation is often time-consuming and resource-intensive, making it less practical for routine player monitoring. (Chambers et al., 2015).

However, a key limitation of TMA is the requirement for expertise in video analysis, as the analyst must manually identify each movement, leaving the process susceptible to human error. (Barris & Button, 2008). For instance, when classifying movements, TMA is one of the most widely used models for assessing the external demands of basketball training and competition. (Abdelkrim et al., 2007; Ben Abdelkrim, Castagna, El Fazaa, et al., 2010; Ben Abdelkrim, Castagna, Jabri, et al., 2010; Klusemann et al., 2012).

Eye-tracking technology

Eye tracking technology is grounded in theoretical and methodological principles from various disciplines, including psychology, neuroscience, computer science, and human-computer interaction (Hüttermann et al., 2018; Lai et al., 2013). Eye tracking is based on the understanding that our eyes move in distinct patterns, such as fixations (periods of stable gaze) and saccades (rapid eye movements between fixations). These patterns provide insights into how the visual system processes information and directs attention (Duchowski, 2003). The core concept in eye tracking is visual attention, which refers to the allocation of cognitive resources to specific visual stimuli. By tracking eye movements, researchers can infer what captures a person's attention and how attention is distributed across visual scenes (Hüttermann et al., 2018; Lai et al., 2013). Eye tracking helps distinguish between bottom-up processes (stimulus-driven attention) and top-down processes (goal-directed attention) (Hüttermann et al., 2018). Bottom-up processes occur when attention is drawn to salient visual features, while top-down processes involve cognitive control and prior knowledge guiding attention (Lai et al., 2013). Eye tracking can reveal how cognitive load affects visual behavior. High cognitive load may result in shorter fixations and increased saccadic movements, as the brain processes information rapidly to manage the demands of the task. Eye movements are linked to decision-making processes (Holmqvist et al., 2011). Gaze behavior can show how individuals gather information before making choices, whether in sports, reading, driving, or other activities (Hüttermann et al., 2018; Lai et al., 2013).

Methodologically, eye tracking technology utilizes specialized hardware devices, including infrared cameras and illuminators, to capture and record eye movements. These devices typically employ pupil and corneal reflection or image-based techniques to track the eyes (Hüttermann et al., 2018). Before data collection, eye tracking systems require calibration, where participants focus on specific points on the screen to establish a mapping between gaze coordinates and screen coordinate (Hüttermann et al., 2018; Lai et al., 2013). Validation checks are used to assess the accuracy of eye tracking data during the experiment (Hüttermann et al., 2018; Lai et al., 2013). Analyzing eye tracking data involves processing raw gaze data to identify fixations, saccades, and other eye movement events. Researchers use various algorithms and filters to clean and interpret the data (Lai et al., 2013). Eye tracking data is often visualized using heatmaps, gaze plots, scan paths, and areas of interest (Jin et al., 2023). Heatmaps show areas where participants gaze most often, while gaze plots and scan paths illustrate the sequence of eye movements (Duchowski, 2003). Researchers use statistical methods to draw conclusions from eye tracking data. These analyses can involve comparing gaze behavior between different conditions, groups, or tasks to identify significant patterns and relationships. In basketball, the design of eye tracking experiments is crucial to answering specific research questions (Damas & Ferreira, 2013; Knudson, 2013). Factors such as stimuli presentation, task instructions, and the order of conditions are carefully controlled to minimize confounding variables (Damas & Ferreira, 2013). Overall, eye tracking technology offers valuable insights into human visual perception, attention, and decision-making processes (Knudson, 2013). The combination of theoretical principles and rigorous methodological approaches enables researchers to gain a deeper understanding of how people interact with their visual environment and aids in various fields, including psychology, marketing, human-computer interaction, and sports science (Hüttermann et al., 2018).

Discussion

One of the most significant changes influencing sports development worldwide is, undoubtedly, the application of science to address sports-related challenges. This involves the use of increasingly sophisticated technology, supported by scientific data, which enables the establishment of a framework for reading and analyzing sporting realities. In this context, game observation, recording, and interpretation have emerged as critical components(2001b) One of the most significant changes influencing sports development worldwide is, undoubtedly, the application of science to address sports-related challenges. This involves the use of increasingly sophisticated technology, supported by scientific data, which enables the establishment of a framework for reading and analyzing sporting realities. In this context, game observation, recording, and interpretation have emerged as critical components (Garganta, 2001). Consequently, the game has been elevated to an object of study, with researchers seeking to analyze and evaluate the reasonsbehind a team's victories and defeats .(Hölzemann & Van Laerhoven, 2018)(Hölzemann & Van Laerhoven, 2018).

From an international perspective, basketball stands out as the sport with the most extensive body of research, particularly in studies focused on observing and analyzing player behavior (Leser et al., 2014)(Leser et al., 2014). However, there remains a gap in evidence regarding the tools and technologies used for observation and analysis, especially alternative methods for assessing complex technical-tactical skills that directly impact player performance during training and competition (Drinkwater et al., 2008; Ziv & Lidor, 2009)(Drinkwater et al., 2008; Ziv & Lidor, 2009).). The reliability and validity of the information gathered through these observation and analysis tools are crucial, as they enhance the decision-making capabilities of both coaching staff and athletes.

A current trend in sports is the use of diverse observation and analysis instruments to gather data on the technical-tactical performance of athletes or teams. This information supports decision-making during games, competitions, and the planning and periodization of training (Barros et al., 2002)(Barros et al., 2002). Research centered on game analysis has significantly contributed to understanding the characteristics, patterns, and nuances of team and player behaviors, leading to both conceptual and methodological advancements (Marcelino et al., 2011).). Early analyses were conducted without theoretical support, relying on rudimentary techniques such as pen-and-paper methods to record success or failure rates in specific game fundamentals. Over time, game observation and analysis became rec-

ognized as vital components of the preparation process in team sports, enabling the identification of structural game principles, effectiveness criteria for individual and collective performance, and the adaptation of training models based on established theoretical frameworks (Sampaio, 1998). Moreover, it became clear that evaluating a player's performance solely based on points scored, successes, or errors is insufficient (Tavares, 2006),). Instead, a comprehensive assessment of sports performance, incorporating various indicators (physical, technical, tactical, and psychological), has been established as a valid, objective, and reliable method (Hatem et al., 2020; Sampaio, 1998).). This has led to a growing demand for advanced observation and analysis methods, with sports science researchers increasingly contributing to this field to ensure more robust data analysis (Barros et al., 2002; Marcelino et al., 2011).

In today's competitive and training environments, where athletes, particularly elite or high-performance individuals, face immense demands, it is essential that training programming and planning are highly individualized and data-driven. This approach ensures that training processes align with the physiological demands of the game and the specific roles athletes perform on the field. From a practical standpoint, the development of game and training observation tools is a critical first step for coaches and technical staff to manage and monitor the impact of training sessions on athletes. This, in turn, is a key factor in achieving success in the training process (Kiely, 2012). From a physiological perspective, collecting individualized responses to training and competition stimuli helps understand how athletes manage loads over short-term (acute fatigue) and long-term (chronic fatigue) periods. Monitoring these responses using the acute/chronic workload ratio provides valuable insights into an athlete's readiness (Gabbett, 2016).

From a physiological perspective, collecting individualized responses to training and competition stimuli helps understand how athletes manage loads over short-term (acute fatigue) and long-term (chronic fatigue) periods. Monitoring these responses using the acute/chronic workload ratio provides valuable insights into an athlete's readiness (Garganta, 2001) .). With the advancement of tools and methods over the years, coaches and researchers now have access to a wealth of information derived from game observation and analysis. This information is crucial for enhancing knowledge about the game and improving the performance of athletes and teams. Data collected from observing athletes in natural contexts (training and competition) is now considered one of the most influential variables in learning and the effectiveness of sports actions (Garganta, 2001). Consequently, understanding proficiency in various tasks is fundamental for assessing how well athletes' performance aligns with recommended game and training models.

Eye-tracking technology has gained traction in sports, including basketball, as a tool for understanding players' visual behavior, decision-making, and on-court performance. This technology provides coaches, researchers, and sports scientists with valuable data on how players use their visual attention during gameplay, contributing to performance analysis and player development. According to Sousa & Fereira (2013) (2013),) found that basketball coaches focus on interpersonal areas at the start of their visual survey, while less experienced coaches concentrate on offensive players with the ball. This highlights the need to understand how coaches at different performance levels perceive basketball games visually. For players, research suggests that gaze behavior changes when attempting to shoot, particularly in the presence of opponents and based on their height (Esteves et al., 2021)(Esteves et al., 2021). For instance, shorter interpersonal distances between the shooter and the defender result in more fixations on the defender's body and fewer on the rim, with no significant changes in fixation duration. Additionally, taller attackers tend to have better shooting effectiveness (Arede, Ferreira, et al., 2020)(Arede, Ferreira, et al., 2020). Indeed, basketball performance is influenced by a complex interplay of variables, including speed, agility, acceleration, visual cognitive processing, reaction time, movement fluidity, physical adaptation, motor and cognitive skills, concentration, spatial awareness, vertical jump ability, multi-directional change, and hand-eye coordination(Hassan et al., 2023)(Hassan et al., 2023).

A current trend in sports is the use of various instruments to gather data on the technical-tactical performance of athletes or teams, supporting decision-making during matches and in the planning stages of training. Performance has increasingly become a focus of scientific research in sports pedagogy and performance analysis, driving the development of systems for collecting and analyzing data in real-game situations (Damas & Ferreira, 2013; Knudson, 2013)(Damas & Ferreira, 2013; Knudson, 2013).). The most commonly used tools for monitoring and analyzing technical and tactical processes include video recording and data processing, often complemented by microsensor technology (Teixeira, Alves, et al., 2022; Teixeira et al., 2021) (Teixeira, Alves, et al., 2022; Teixeira et al., 2021). Combining observation and analysis methods is considered essential for obtaining more reliable results, though further research is needed to establish the effectiveness of these combinations. Quantifying training loads and qualifying technical-tactical processes through data collection during training and competition is crucial for analyzing training periodization and shaping technical and tactical strategies (Knudson, 2013)(Knudson, 2013). The available literature on the practical application of observation and analysis methods provides valuable insights into optimizing sports performance and decision-making (Szwarc & Lekner, 2022)(Szwarc & Lekner, 2022).). However, challenges remain, including measurement precision, difficulties in capturing specific variables, and limitations in analysis software, such as errors caused by overlapping player (Gabbett, 2016)(Gabbett, 2016).

Conclusions

Game analysis, supported by scientific and technological advances, has become an indispensable tool for sports development in basketball. Observation and interpretation of player and team behaviors not only improve understanding of game dynamics but also guide the training process in a more effective and individualized way. The multidimensional nature of competitive performance, influenced by physical, technical, tactical and psychological factors, requires robust and reliable analysis methods capable of providing accurate data for decision making.

Game analysis, supported by scientific and technological advances, has become an indispensable tool for sports development in basketball. Observation and interpretation of player and team behaviors not only improve understanding of game dynamics but also guide the training process in a more effective and individualized way. The multidimensional nature of performance, influenced by physical, technical, tactical and psychological factors, requires robust and reliable analysis methods capable of providing accurate data for decision making.

Thus, the evolution of analysis tools reflects the growing

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complexity and demands of modern sport. These instruments allow monitoring training loads, evaluating technical-tactical performance and understanding how athletes respond to stimuli in different contexts, whether during training or competition. The application of observation and analysis instruments in basketball has proven to be valid, reliable and replicable, offering a solid basis for continuous performance improvement.

However, there remain challenges that need to be clarified. One of the main challenges is comparing observation strategies that combine different instruments to optimize data collection and interpretation. Furthermore, the integration of physical, technical, and tactical factors continues to be a critical gap in research, representing a future direction for studies in this field. This integration is essential for a holistic understanding of sports performance, allowing coaches and researchers to develop more effective training methods.

The standardization and integration of different methodological approaches are crucial to overcoming current limitations and expand the applicability of results in sports practice. As new tools and methodologies emerge, a promising horizon opens up for maximizing the potential of athletes and teams, solidifying sport as a field of excellence and continuous innovation. Future studies should focus on integrating multiple dimensions of performance and comparing observation strategies to improve the quality and reliability of the data collected. In this way, game analysis will continue to play a vital role in the pursuit of sporting excellence.

Conflict of interest

The authors declare that there are no conflicts of interest.

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