Chapter

Application of Basketball Game Models through Sports Technology

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Abstract

The purpose of this chapter is to present the application of basketball game models through sports technology. The chapter contains introduction, terminology, sports technology practices, basketball models through technology, compilation of basketball models in sports technology, and references. In this chapter, there will be other sub-chapters that will be considered in case of depth exploration of the chapter, writing, processing, and modification of data from other authors. We will present realistically the most renowned thinkers and theorists of the field of models and sports technology from which to draw the most practical model of evolution of basketball.

Keywords: models, basketball game, sports technology

1. Introduction

Nowadays, the technology is inevitably important and is present everywhere. From the simplest daily task to the optimized complexity of training process, technological innovation products which seems to be the current reality we must deal with. Recent years have been quite challenging within this subject in sports context and innovations occurred rapidly. Sensors and mobile applications that control biometric data, video systems that analyses athlete's performance and stadiums that are a showcase of technology are some evidences of the emerging innovations that surround sport community [1].

As modern technology constitutes an indispensable element of modern sports, thus also of basketball, its application is practically without limits, regardless of whether it is used in the teaching process with an emphasis on basketball contents, or in the training process with the youngest basketball players or with top level professionals. In addition, in the process of including new technologies, it is important to educate all the participants included in the process so that they can all independently use these technologies, at least to a certain degree [2]. With the continuous development of informatization, networking and digitization of sports teaching, combing basketball teaching with computer technology and multimedia technology, numerous multimedia teaching course wares of pictures, character, sound and graphic in one have been developed to assist basketball teaching, which effectively improved the basketball teaching [3]. The world of sport is constantly changing due in large part to the integration of technology. Modern science now

allows athletes to go higher, move faster, and importantly, stay safer [4, 5]. Technology in sports is a scientific means by which athletes attempt to improve their training and competitive surroundings in order to enhance their overall athletic performance. The real time and rapid feedback systems for collecting and analysis sports data provide innovative and effective support for coaches and athletes [4, 6]. Basketball shooting is one of the most important techniques in basketball. It is the only way to score and it is the key technology in basketball technology, and it is also the core link of basketball tactics. Whatever attack tactics is ultimately to be attributed to the shooting score, while the purpose of defense is to limit the opponent's shooting, so as to create more scoring opportunities for him. So in a sense, the basketball game is a sport that limits the opponent's score by shooting himself [7, 8]. In this chapter will be implemented the application of basketball game models through sports technology.

2. Compilation of basketball models in sports technology

2.1 Heart rate sensors

Heart rate is an important indicator of bodywork and effort. Therefore, in spite of some limitations, its measurement is a very practical and useful way of monitoring and controlling the workload and effort of athletes in training and competitions. Therefore, in all sports sectors where an important factor of success is sustainability, therefore, heart rate meters are an indispensable and indispensable tool. T. i. The pulse meter (heart rate gauge) is becoming an almost obligatory part of the equipment even in recreational workouts [9]. In modern times there are a large number of measuring instruments on the market, which mainly enable the monitoring of heart rate values, and depending on various scientific, training or educational requirements, they measure several other parameters such as maximum heart rate, energy consumption, covered distance, time spent in a specific workload zone, difference in altitude, etc. [2].

The performance of basketball depends on many factors. Among them, fitness plays a very important role, and within them also maintainability and functional abilities. In 40 minutes of play, the basketball player carries about 4500 m of paths (**Figures 1** and **2**).

The performance of basketball depends on many factors. Among them, fitness plays a very important role, and within them also maintainability and functional abilities. In 40 minutes of play, the basketball player carries about 4500 m of paths with an average speed of just under 2 m/s [10]. The movements they perform are very diverse, varying in intensity and length. According to some authors [11, 12], basketball is 20 to 30% aerobic and 70 to 80% is anaerobic sports activity (**Figure 3**).

Often times students and coaches of basketball systems that in addition to real-time heart rate monitoring for all the players involved in the training process or a game, also enable entering relevant parameters, i.e. workload zones which are determined pursuant to some other protocols (e.g. spiroergometric in laboratory conditions), and based on which more precise intensity levels are individually determined [13]. In common crowds and even contacts between players, we can damage other players with it. This is also the reason that its use is prohibited in the game with rules, and it is often unheard of in trainings between trainers and players. Some players who are not accustomed to using the meter simply disturb it, and thus affect their concentration and accuracy. The next difficulty is that a player often very hardly monitors his heart rate on a small gauge during training, as he is

Figure 1.
The heart rate monitor is a compulsory device in all sports sectors where it is an important factor of performance sustainability. Web source: http://www.polar.fi/polar/channels/eng/.

Figure 2.
Heart rate monitor manufactured by POLAR (V800) with the corresponding chest strap (H7). Web source: www.polar.com.

usually burdened with other things to focus on. It is even more closely monitored by the player's heartbeat trainer. The communication between him and the player is, of course, limited, so he closely monitors the heartbeat of the player and his load [9]. This, of course, also means that he cannot respond in a timely manner with the appropriate instructions and instructions to the player. The data from the meter can only be obtained by the trainer after the end of the load, but most often only after the training. A long time ago, a Finnish manufacturer of Polar gauges developed a device, a heart rate measurement system, Team System, which is designed specifically for team sports, and also games from the human. However, this also does not allow immediate feedback or feedback. Online communication between an athlete and a trainer. The data stored on the transponder must be transferred to the computer afterwards using a special interface [9].

2.1.1 Wearable tracking devices

In 2001 the Australian Cooperative Research Centre for Micro Technology, under Project 2.5 "Interface Technologies for Athlete Monitoring," began work to

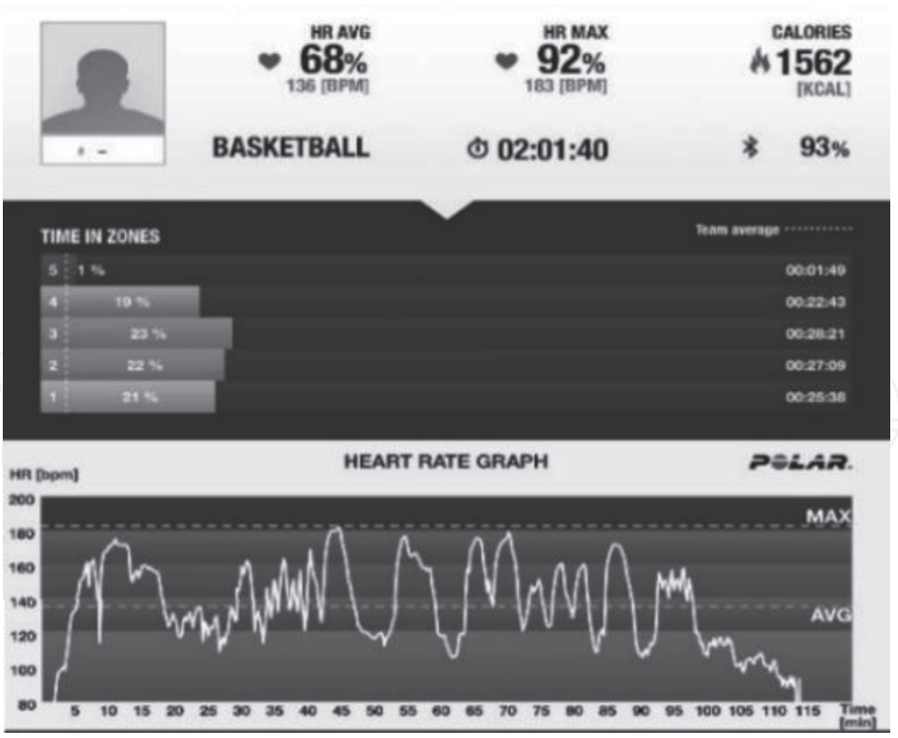

Figure 3.
Digital interface representation of the application program Polar Team. Web source: www.polar.com.

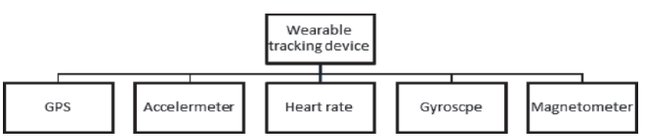

Figure 4.
The five sensors contained within a typical wearable tracking device.

develop unique and unobtrusive real-time athlete monitoring equipment [14]. Recent years have witnessed further development and the introduction of wearable tracking device. Technology to team sports with a view of providing objective and possibly real-time workload monitoring during training and game-play. Wearable tracking devices often contain multiple sensors (**Figure 4**) in a small, lightweight unit worn by players on their upper (dorsal) body (e.g., the MinimaxX S4 wearable tracking device is 0.088 m× 0.050 m× 0.019 m in dimension weighs 67 g). These devices may include global positioning system (GPS), accelerometer, heart rate (HR), gyroscope, and magnetometer sensors. Thus, time, position, distance, velocity, acceleration, heart rate, angular velocity and orientation can be synchronously recorded.

The GPS component of the wearable tracking device records information in regards to time, distance, position, direction, and velocity. Specifically, the GPS receiver within the device works off a network of satellites to triangulate its position [15]. However, signals from the satellites to the GPS can be influenced by the atmosphere, deviations off various local obstructions (e.g., stadiums), and the number of satellites available to the receiver (four set as a minimum to triangulate the position and altitude of the unit). Therefore, GPS data cannot be collected indoors [16] and are less accurate in enclosed stadiums where team sports are commonly played. Although, newer models have the capability of working off fixed nodes within enclosed stadiums to enable the indoor capture of GPS data (e.g., Optimeye T5, Catapult Innovations, Australia), these Wearable tracking device GPS Accelerometer Heart rate Gyroscope Magnetometer 31 units have only recently been released (end of 2014) and have not been validated. In addition, GPS data

cannot be used to quantify the workloads imposed on athletes during low velocity, high intensity movements, such as tackling and bumping in contact sports.

The HR component provides a non-invasive method of measuring HR in team sports [17] and is one of the most commonly used methods to indicate the intensity of exercise [18]. Although accurate in the field [19], HR may be influenced by a number of factors including environmental conditions (temperature, humidity, ambient air), hydration status, altitude [18], state of training, exercise duration, and medication [20].

The application of gyroscopes to human movement analysis is still developing (84). In team sports, the gyroscope provides information about angular velocity or rotation of a player's body (75). As human movement consists of mainly limb rotations around joints (84), gyroscopes are extensively used in gait analysis (75). However, in team sports the wearable tracking device is positioned on the upper body and this may limit its full potential. Gyroscopes are more commonly used in navigation and automotive fields (e.g., by integrating the rate of angular velocity, change in orientation, and direction from the initial reference orientation, direction can be obtained) [19], as well as in consumer products (e.g., anti-jitter compensation in cameras) [20]. A magnetometer measures the direction and strength of a magnetic field [21]. This data is then used to detect the direction of travel [22]. However, local disturbances in the magnetic field caused by electric currents, close permanent magnetic interference, 32 and large iron bodies can significantly affect its measurements [23]. These can also affect the magnetic field angle of inclination (the angle of the earth's magnetic field with respect to the surface of the earth) that is different at various locations around the world [23]. As a result, this sensor is predominantly not used in team sports. Although, research has shown that a combination of technologies such as accelerometers, gyroscopes and magnetometers can improve the accuracy and performance of either technology alone [24]. For instance, accelerometers can compensate the drift of the gyroscope about the axes of the horizontal plane, while magnetometers can do the same for the vertical plane [23]. The most relevant sensor to this thesis is the accelerometer. The accelerometer contained within wearable tracking devices is typically triaxial, samples at 100 Hz and has a range anywhere between ±6.0 to 12.0 g (Figure 2-8). For example, the MinimaxX S4 wearable tracking device contains a triaxial accelerometer (KXD94, Konix, USA) with a sampling frequency of 100 Hz and a range of ±10.0 g (**Figures 5** and **6**).

2.2 Diagnostic equipment manufactured by Microgate, IT

The OptoJump testing system is a measuring instrument composed of two identical 1 m-long panels based on optical technology. Each panel contains 96 LEDs

Figure 5.
An accelerometer (left), MinimaxX S4 wearable tracking device (middle), and example sports vest (right). Web source: http://elite-perf.com/.

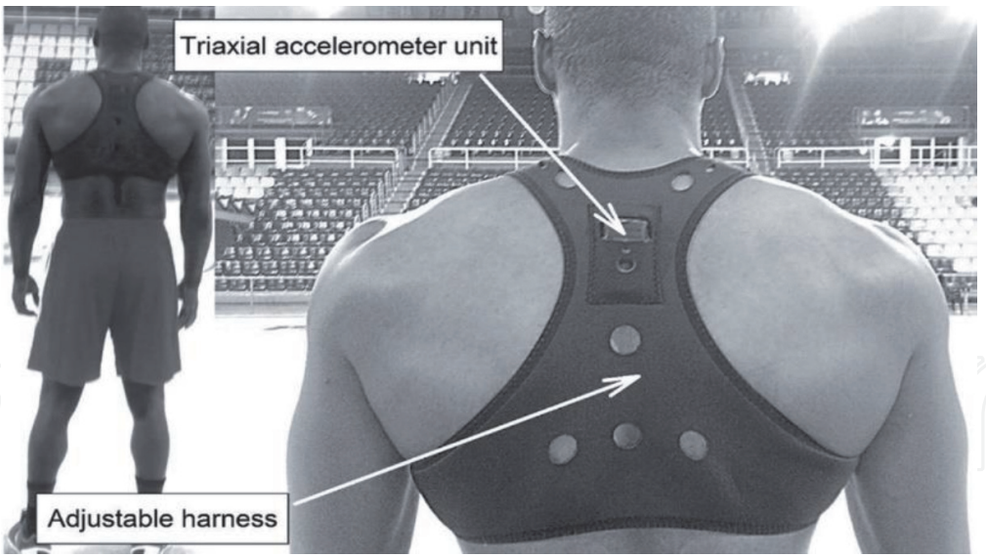

Figure 6.
Triaxial accelerometer unit fitted to the upper back between the shoulder blades of each player using an adjustable harness.

Figure 7.
Polar developed Team System to measure heart rate in team sports. Web source: http://www.polar.fi/polar/channels/eng/.

which are all interconnected by the impulses that they transmit. The described system is connected by a USB cable to a portable laptop and it is managed via the OptoJump Next application program [2]. The device itself can primarily be used in diagnostics of various parameters in performing different jumps, such as reflection height, duration of contact with the surface, duration of the jump, etc. It can also be applied for determining specific kinematic parameters in walk analysis (OptoGait) and run analysis. The above mentioned ultimately enables objective diagnostics, as well as implementation of corrective kinesiological operators for the purpose of correcting certain established imbalances, which finally aims at enhancing the locomotor system of children. Considering that explosive leg strength has a significant impact in the specification equation of basketball from the aspect of motor abilities, this instrument can also be used for assessing all the parameters based on which the analysis of the desired results can be performed in assessing explosive leg strength (**Figure** 7) [2].

Likewise, in certain basketball research, this device had been used for assessing certain parameters of performing a jump shot in different variable and situational conditions as a means of observing parameters such as duration of contact with the surface, reflection height, duration of the jump, etc. [2, 12, 25]. The practical value of this instrument is in its mobility and applicability in realistic conditions, as well

as in the fact that it can also measure parameters that are manifested during specific movements that players perform in basketball. Considering that explosive leg strength has a significant impact in the specification equation of basketball from the aspect of motor abilities, this instrument can also be used for assessing all the parameters based on which the analysis of the desired results [2]. Moreover, the OptoJump is composed of two video cameras which record a player's motor motion during the performance of a specific test, enabling a standardized analysis of the results obtained from the video recording during subsequent processing. In addition to the above mentioned, in combination with the Gyko device, it allows an assessment of the duration of the concentric and eccentric phase during a basic or specific motor movement. Due to the short duration of the said movements, it is absolutely impossible to obtain the desired results in this sense via subjective assessment. By using video technology, it is also possible, in addition to the obtained data, to analyze the slow movement and detect certain errors, as well as potential improvements. The data can also be presented to the student/athlete in order for him/her to determine the accuracy of the analysis for himself/herself. Such an approach is very important because of trust and further motivation, as well as for the formation of the relationship between the teacher/coach and the student/player and vice-versa [2, 9].

2.3 Witty SEM system

This measuring instrument also represents the Microgate technology and it is comprised of several (1–16) sensor indicators (size 7×5 cm^2). Each of the indicators is composed of a series of LEDs that have the possibility of forming specific marks in the shape of various direction indicators, numbers and letters which are then displayed in different colors. The device is managed by a program console that, in addition to some pre-programmed tests, has the option of designing custom tests that are specific for each particular sport (e.g. basketball [2, 9, 26]) (**Figure 8**).

Based on the obtained results, it is possible to assess the examinee's score in basic and situational tests for assessing agility, reaction time or coordination, as well as in evaluation processes of acquiring certain motor skills in combination with the mentioned motor abilities (e.g. ball dribbling) (**Figure 9**) [9].

2.4 The chronometer Witty-timer

The compact size, ergonomic shape, and innovative design make the Witty timer practical and easy to use. Graphical icons and on-screen instructions on its

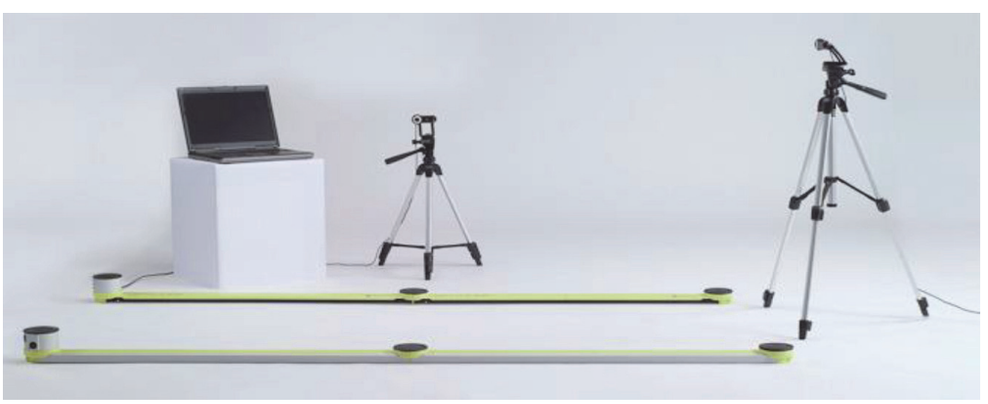

Figure 8.
OptoJump system. Web source: www.optojump.com.

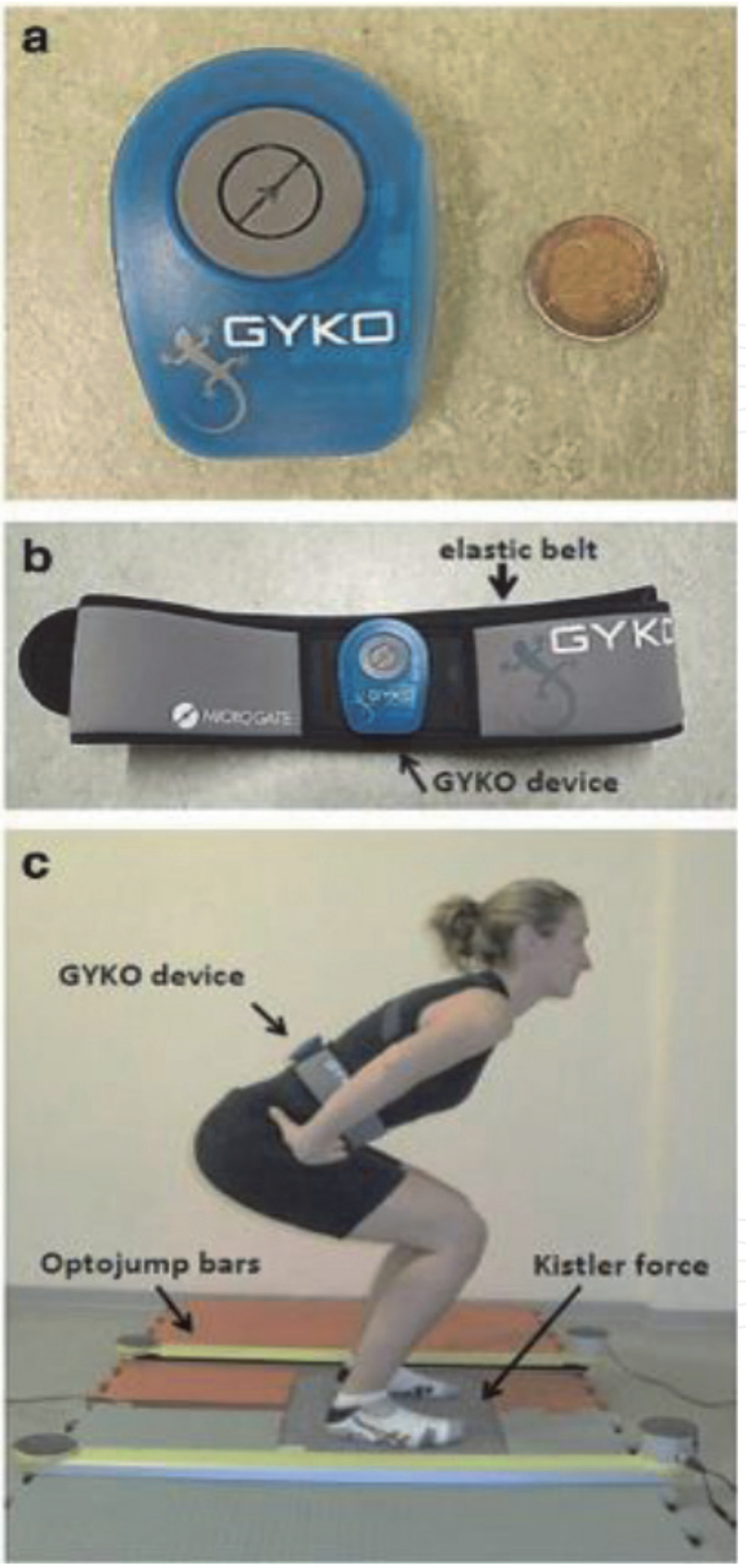

Figure 9.
Gyko sensor. Web source: http://gyko.microgate.it/en. (a) GyKo inertial measurement tool for the analysis of the movement of any body segment, (b) GyKo mounted on a belt, and (c) using the Gyko device

color display ensure user-friendliness and ease of use. With8 different radio frequencies to choose from, it is possible to work simultaneously with several Witty timing systems (timer and photocells) in the same training area. Various preconfigured test types are available (single tests, group tests, in-line tests, go and

return, counter, etc.), plus the user can also create customized test protocols directly on the timer (**Figures 10** and **11**) [27].

2.5 Telemetric measurement of current utripa

The use of telemetric technology brings considerable advantages over the conventional method of measuring heart rate. In particular, they come into force in the games of the man. T. i. telemetry eliminates the majority of weaknesses or the deficiencies that make the measurement blink in the classic way in the mentioned sports are less useful [9]. The basic idea of the telemetric method of measuring heart rate is remote measurement.

They are only equipped with a transmitter, which, with the help of an elastic band, is attached to the chest, just like in classical measurements. A sufficiently strong receiver gives the trainer immediate feedback on the heartbeat of the athlete and allows you to monitor real-time exercise intensity. A very useful system for measuring heart rate in team sports was developed by the Swedish company Activio. It was created in cooperation with the Swedish basketball team. He also successfully used it during preparations for the 2003 EP appearance in Sweden [9].

2.6 Shooting critical components

In 2015, a literature review was made by Okazaki to identify the factors behind a successful jump shot. In order to do this, the authors divided the potential factors into three categories: ball trajectory, segmental movement organization and variables that influence shooting performance. Below is a summary of the authors' discussion regarding each of these categories.

Figure 10.
Witty SEM system. Web source: http://www.microgate.it/Training/Witty/WittySEM.

Figure 11.
The chronometer witty timer.

2.6.1 Ball trajectory

Upon examination of ball trajectory, three components stand out as decisive for a successful shot: release angle, velocity and height (**Figures 12** and **13**).

The angle of entry of the ball into the basket is one of the most important factors for shooting success. This is due to the fact that by increasing the angle, one instantly increases the width of the basket, giving the ball a larger area to go in. There are three variables that, together, determine this angle: vertical displacement, horizontal displacement and velocity (**Figure 14**) [28].

The vertical displacement of the ball is negatively correlated with the release height and positively correlated with the release angle. In other words, the lower the release height and/or the wider the 15-release angle, the greater the vertical displacement of the ball. In simple terms, the vertical displacement of the ball may be defined as the vertical distance traveled by the ball from the moment it is released to the moment is reaches the basket. The horizontal displacement of the ball is a similar concept, but from a horizontal perspective; i.e. it represents the distance between the shooter and the basket. An increase in horizontal displacement must be accompanied by a corresponding increase in the velocity of the ball if the ball is to reach the basket [28]. The authors thus demonstrate that "these three factors (ball vertical displacement, ball horizontal displacement and velocity) are affected by release velocity, angle and height".

2.7 IoT in Basketball

2.7.1 Evo one

Evo one is a smart basketball that is meant to give feedback to the user upon the act of shooting. When the user shoots the basketball, he will hear a beep if the ball's backspin rate is 2–3 rotations/second (the ideal rate). The purpose of this feature is to let the user know that his attempt was successful and create shot consistency

Figure 12.
A powerful antenna directly connected to the computer allows measurement at a distance of up to 200 m, and the transmission and storage of data on the computer.

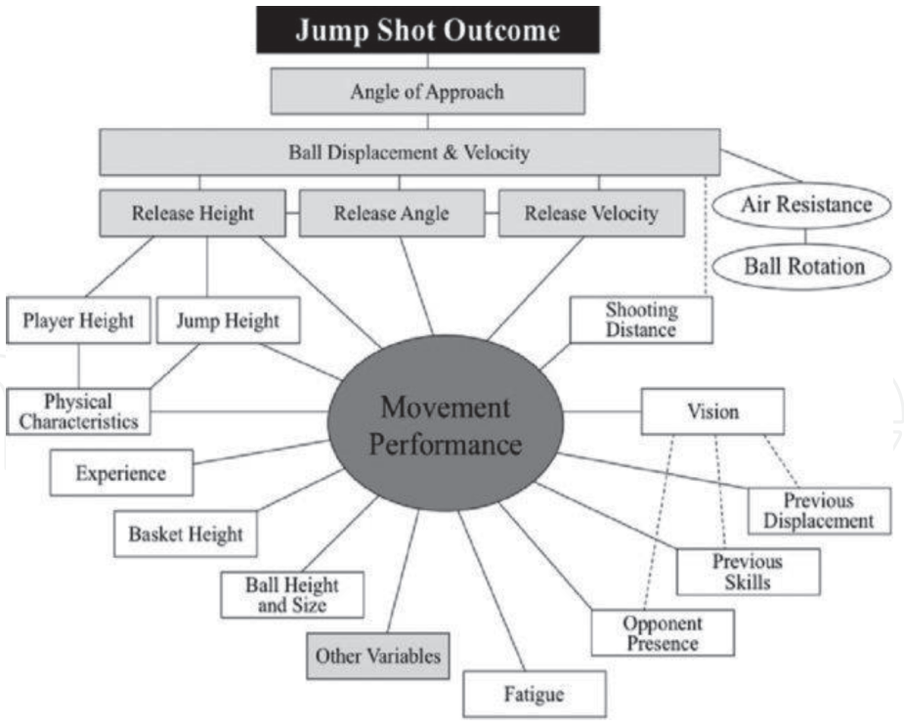

Figure 13.
Variables that influence the basketball jump shot (Okazaki et al. [28]).

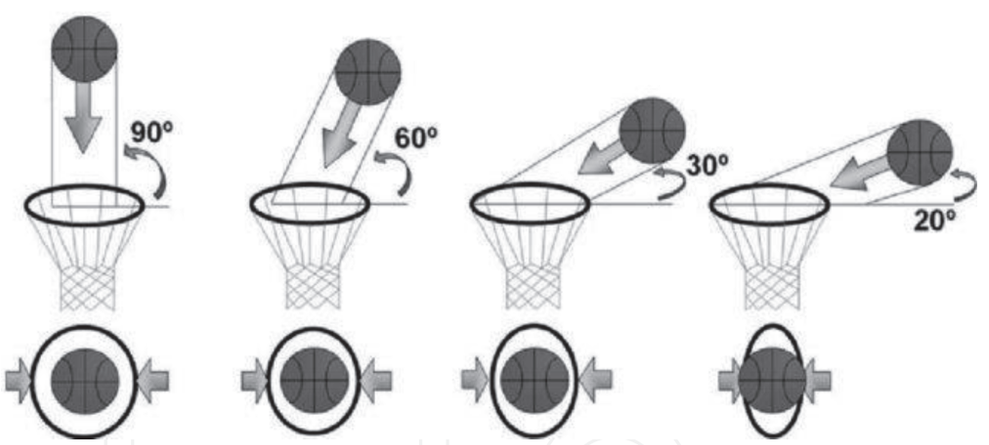

Figure 14.
Virtual target of the basket rim as a function of the angle of entry of the basketball (Okazaki et al. [28]).

through muscle memory. It measures the ball's backspin using only one sensor located inside the ball. While there are already a number of reviews on this device, the performance product review website Weartesters provides possibly the most succinct and accurate summary of its pros and cons. According to them, apart from the fact that the ball has been made according to regulation size and weight making it no different to a common basketball, the main pro identified by the consumers is its leather cover which gives the user a good grip and touch. Having said this, a leather cover makes it more of an indoor ball than an all-surface ball [29]. Regarding the cons, there are some considerable ones such as the dead spot on the ball where the sensor is inserted, which affects dribbling capacity and turns it into a simple catch and shoot ball, preventing it from being used in a game. However, for the purpose of shooting this is not a major concern. Another important issue is the inconsistency of the sound feedback. Indeed, the ball does not provide feedback unless the player's fingers are aligned with its ribs even if the shot is perfect in terms

of backspin, which poses serious questions regarding the feasibility of its use in a real game situation where quick catch and shoot is fundamental and players do not have time to adjust their grip. In addition, it is unable to differentiate between a pass and a shot attempt, i.e. should the fingers be aligned, it will beep whenever it reaches the ideal backspin, even if it was a pass. Furthermore, it has been noted that the lack of consistent and accurate feedback can promote some bad habits in shooting motion (**Figure 15**) [4, 30].

The main purpose of the Wilson X smart basketball is to track field goal accuracy. It is made to regulation size and weight with a solid grip and durability, suitable for both indoor and outdoor use. The sensor is embedded within the ball and does not require charging (lasting for 100,000 shots). In addition, the product comes with a mobile app which enables the user to track his/her performance on his/her mobile phone via Bluetooth connection. However, there are some limitations. For instance, in order to ensure tracking accuracy, the ball must go through a hoop at least 10 ft. tall, with a tight net and rigid backboard, and it must hit the floor. A number of consumer reviews highlight two important issues. The first one is related to inaccurate tracking of field goal percentage and attempts. In actual fact, the ball has been reported to record some made shots as missed and vice versa, and to not acknowledge some made attempts at all. While Wilson estimates that the ball has an accuracy of 97%, the American technology news and media network-The Verge argues that it is only around 80%. This is not great news since the main purpose of the ball is to monitor field goal percentage. The second main concern is related to the synchronization between the ball and the user's mobile phone. Users have described the process as more difficult than advertised and plagued with interruptions throughout. Another criticism has to do with the fact that the app only provides a basic shot chart showing the player's accuracy rate from specific shooting ranges, but not from 27 different shot angles or locations within the same range which could be very useful especially for players who shoot better from different positions (**Figures 16** and **17**) [31].

On a more positive note, the app provides four interesting modes that will keep the user engaged while practicing. The first mode is called free range and is essentially a shoot-around game tracker that shows shooting percentage as well as distance from the hoop. The free throw mode tracks made/missed shots in real time from the free throw line. In the buzzer beater game mode, the clock keeps ticking and the player is required to repeatedly shoot under pressure as every shot made adds seconds to the clock extending the game experience. Finally, the game time

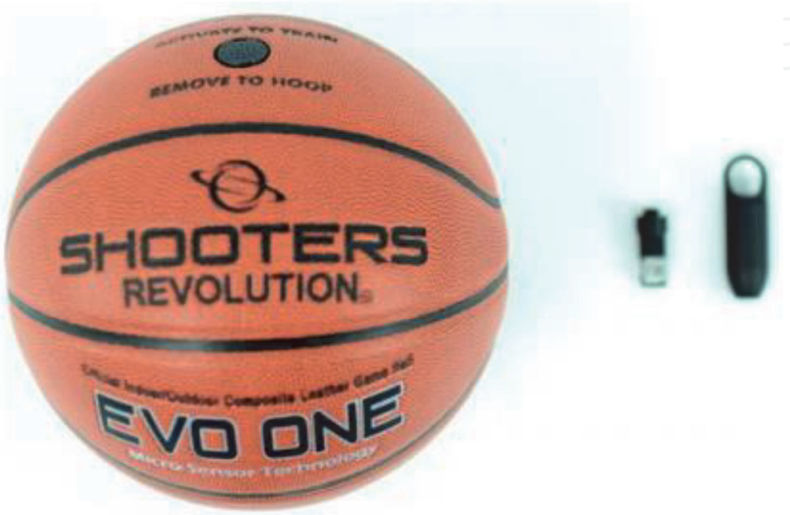

Figure 15.
Wilson X. Web source: https://evo1sports.com/product/evo-one-sensorized-basketball/.

Figure 16.
Wilson X smart basketball. Web source: https://evo1sports.com/product/evo-one-sensorized-basketball/.

Figure 17.
Wilson X application modes. Web source: https://www.prodirectbasketball.com/responsive/pro-ditect/wilson-x-connected.aspx.

mode recreates a real game environment including actual crowd sounds and commentary. It tracks both field goal percentage and points, and lets the player know whether his/her effort was sufficient to secure the victory [29].

Although these game modes attempt to make the user more familiar with playing under pressure, without another actual player guarding and blocking the user in real life, their help in improving game performance remains limited.

2.8 94fifty

The 94fifty smart basketball enables the user to check his/her shot arc, rotation and release speed. It is a ruggedized ball of regulation size and weight, with a good grip suitable for both indoor and outdoor use. It does have a dead spot that can be found while dribbling but, as for Evo 1, this is not a major concern for shooting practice alone. While, at first, the ball was unable to track made or missed shots,

with the increment of the smart net, this function has now been made possible. Furthermore, unlike the previous basketballs, this one can be charged wirelessly and has approximately 8 hours of battery life with continuous use. Following performance analysis of some of the best basketball shooters, the developers concluded the optimal range for shot arc to be between 42 and 48 degrees, ideal backspin between 130 and 150 rotations per minute and best release speed under 0.7 seconds, and they calibrated the ball accordingly. When shot, the ball provides instant feedback regarding what is being measured. Thus, if it is arc, there will be positive feedback if the player's shot arc falls within the optimal range, and an alert message if not. In addition, the app offers a wide variety of drills designed to improve performance in specific categories, such as dribbling and shooting. In the latter category, on which this report focuses, there are various drills available with different levels of difficulty - from playground all the way to professional, and there can be combinations of shot accuracy with shot arc, release speed or shot rotation.

However, there are limitations to what the ball can measure at any given moment. For instance, the ball can only measure and display one indicator at a time and is not equipped with certain useful tools such as GPS for determining shooting location. Hence, before performing a shooting drill, the player needs to select what indicator to measure, identify his/her shooting location and whether it is a free throw or not (e.g. jump shot). Nonetheless, overall the range of workouts offered by the app does facilitate skill improvement and player engagement (**Figure 18**) [32, 33].

In studies that were carried out to assess the reliability of the 94fifty, it was concluded that it is not only possible to use it for practical purposes but also for scientific reasons given the accuracy of the obtained results. It was also considered an important instrument for the overall improvement of the basketball training process since this device allows the user to receive valuable feedback [34].

2.8.1 ShotTracker

ShotTracker is a shooting tracking system that registers missed and made shot attempts. For it to work, the user has to have a wrist sensor that captures shot

Figure 18.
94fifty gear. Web source: https://test-94fifty.myshopify.com/products/two-ball-pack.

attempts and a net sensor that registers whether or not the ball went in. Since there is no need for basketball sensors or smart balls, the player can choose his/her basketball of preference, which is an advantage as smart basketballs have been criticized for having different grips and not always having the touch of a regular ball. However, the fact that the net sensor has to be attached to the net which typically is 10 ft. above the ground may become a major inconvenience, especially in public places, since a ladder would be needed to reach the net and attach the sensor. Furthermore, if there are multiple players shooting at the hoop with the net sensor, all the shots will be taken into account, and this presents a problem for measuring individual performance [29].

Nevertheless, ShotTracker remains user friendly in other ways, coming with a wrist band, a sleeve and even a shirt giving the user different options to correctly wear the sensor. In addition, both sensors can be charged at the same time and are weather proof. With this equipment, the user is able to track his/her field goal percentage and shooting location (**Figure 19**) [29].

In addition, the app enables the user to look at his/her results in real time and assess progress over time by checking personal daily, weekly and monthly stats. Another great advantage of the app is that coaches can monitor the players' results and, based on the feedback from the drills, identify areas of weakness and customize workouts to the needs of each player [35].

2.8.2 Hoop tracker

The Hoop Tracker is a basketball shot tracking smartwatch which provides real time feedback on the player's shot attempts. It detects shooting location at all times and whether the shot was made or missed (**Figure 20**).

In order to do this, only two pieces of equipment are required: a wireless shot detector and a smartwatch. The shot detector is held in place by a powerful magnet designed to not impact the outcome of the shot which is a key feature. It also comes with a mounting pole which enables the user to place it on the rim safely from the ground, giving it an advantage over the Shot Tracker. The wristwatch, although lightweight and intended to be worn on the non-shooting hand to minimize the chance of damage and obstruction to the shot, is still an accessory that is not used in a game situation and, therefore, not ideal from this perspective. However, it can be

Figure 19.
ShotTracker gear. Web source: https://shottracker.com/.

Figure 20.
Hoop tracker gear. Web source: https://shottracker.com/.

quite useful as real time results are only a quick glance away during workout. When the ball goes through the hoop, it activates the sensor, which subsequently sends a signal to the watch that the shot was made. When a shot is missed, the vibration created by hitting the backboard or the rim is detected by the accelerometer sensors which send a signal to the watch that the shot was missed. Moreover, the developers incorporated a delay in the signal to account for the shots that bounce around the rim before going in. The only shot it cannot automatically detect is the air ball, for which there is a button on the watch that can be pressed to record it as a miss. With access to shooting percentages from different locations, players can evaluate their success rate from different positions on the court e.g. free throws, three-pointers, etc. and take advantage of the training modes available for those positions. Once their data is uploaded, they can access the Hoop Tracker dashboard on their own computer and analyze their stats, track their long-term progress and identify their strengths and areas for improvement. There is also a coach mode which allows coaches to monitor their players' progress and customize training accordingly (**Figure 21**) [36].

The software also comes with some fun games that will keep the player engaged while improving his/her skills, such as the 3 pt. challenge, the all FG mode or the 100 pt. challenge [37]. All in all, they have tried to appeal to both professional players and coaches with regard to training modes and stats, and to amateur lovers of the game by offering fun games and even a calorie counter.

2.8.3 Catapult

Catapult's ClearSky T6 is a tracking system unlike any other. It combines inertial data sensors with RF ultra-wideband tracking systems to determine the athlete's

Figure 21.
Hoop tracker features. Web source: http://www.hooptracker.com/.

exact location, whether indoors or outdoors, without needing satellite reception tools like GPS which may be unreliable inside some modern sports facilities. It uses triangulation between anchors that can be set up relatively quickly throughout an arena or stadium to continually ping the devices for real time location information. A recent study confirmed that its calculation of position, distance and average speed from the local positioning system shows a low level of error, with an average difference in distance lower than 2%, which validates the use of this technology for indoor analysis of team sports. Nonetheless, it was concluded that the placement of anchor nodes and field of play in relation to the walls of the building has great influence on the location positioning system output [38]. Catapult technology does not only capture the location, but it also measures PlayerLoad—a one number validated metric that shows work rate, and even health indicators like heart rate. Developed with the Australian Institute of Sport, PlayerLoad summarizes all the data points provided by micro movements into one understandable number and is measured instantaneously approximately 100 times per second. This metric takes into account the acceleration made in all possible directions, front, sideways and upwards. Distance-based measures can lead to errors of judgment, for instance, in basketball all players attack and defend so while the distance covered may be the same, the number of jumps, rotations and contacts is misrepresented. An acceleration-based metric, such as PlayerLoad, indicates the mechanical load on muscles and joints.

In the 2014–2015 season, the Golden State Warriors used catapult technology during practice (NBA has not allowed the use of inertial sensors in the actual game) to help monitor the players' work load and optimize its management. The outcome speaks for itself as the Warriors finished regular season with the least amount of time lost to injury in the league. The challenge going forward relies on 32 understanding the correlation between workload and injury patterns. By identifying the thresholds, greater knowledge is achieved regarding the players' tolerance level, and coaching staff may prevent players from leaving their optimal loading zone. The same can be applied to performance; patterns may be identified regarding workload and performance, enabling staff to know at what load levels the athlete will perform best. In summary, catapult provides new data which can be transformed into information if adjusted data mining techniques are applied, and consequently generate knowledge from the findings (**Figure 22**) [39].

2.8.4 Noahlytics

Noahlytics is a shooting tracking system that tracks players' shots from anywhere in a basketball court. It measures the location from where the shot was taken whether the shot was made or missed, entry angle, depth and left-right position of the ball when reaching the hoop and provides real time feedback. It has the ability

Figure 22.
Catapult's ClearSky T6. Web source: https://www.catapultsports.com/products/clearsky-t6.

to capture the position of the ball 30 times per second, ensuring that the trajectory and position of the ball when reaching the hoop is precisely recorded. Users can find information about their shots in a cloud-based platform in real time and are able to

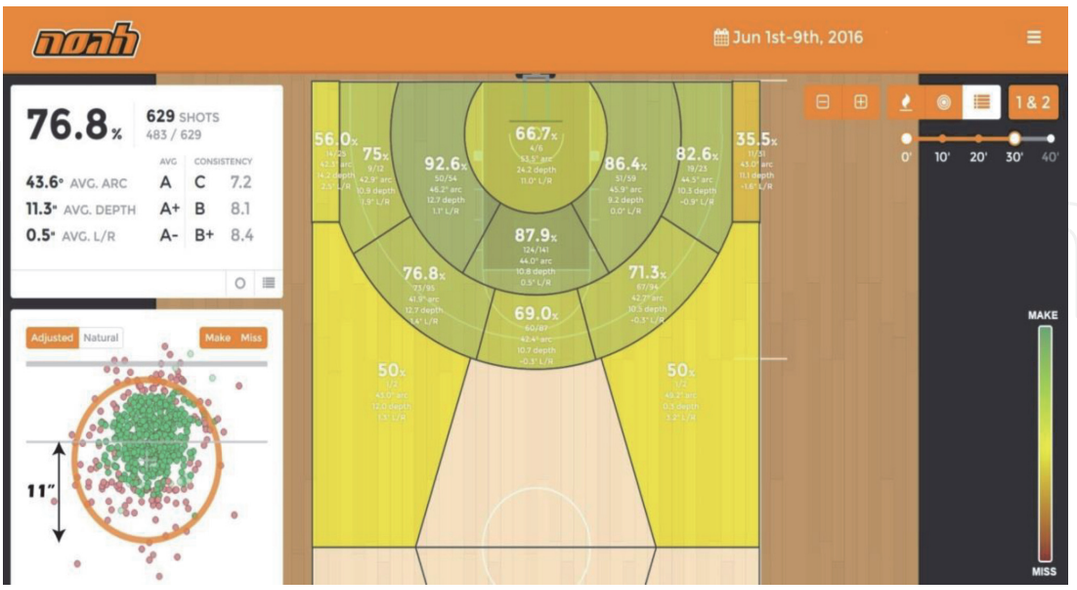

Figure 23.
Noahlytics entry attributes. Web source: https://www.noahbasketball.com/blog/noah-basketball-launches-new-noahlytics-data-service.

Current	Evo1	Wilson X	94fifty	ShotTracker—individual	Hoop tracker	Noahlytics	Catapult
Smart ball	Ball rotation	Made or miss (requires net), shot location	Release speed, shot arc, ball rotation				
Net sensor			Made or miss	Made or miss			
Wrist sensor				Shot attempt			
Hoop sensor					Made or miss		
Smart watch					Shot attempt, shot location, made or miss		
Backboard sensor						Entry angle, shot depth, left-right position, made or miss, shot location	
ClearSky T6							Heart rate, PlayerLoad

Web source: https://www.noahbasketball.com/blog/noah-basketball-launches-new-noahlytics-data-service.

Table 1.
Metrics measured by current devices.

filter data by different variables like court placement, player name or even made or missed shot, for example (**Figure 23**).

Noahlytics was the system used to record the ball entry attributes of over 1 million shots in Marty and Lucey's winning research paper. Based on the conclusions of the study, its potential is undeniable as registered data contributed to greater understanding of the factors behind the success of a basketball shot. For this reason, Noah Basketball won the 2017 Startup Competition in its category at the Sloan Sports Analytics Conference [40].

By way of summary, a compilation of the metrics that are captured by each device is shown in **Table 1**.

3. Conclusion

In this humble chapter we tried to analyze the application of game basketball patterns through sports technology. In which we have presented some of the latest equipment, technology tools and which serve to increase the performance of basketball game. In the end we can conclude that in this chapter will be considered the application of basketball game models through sports technology the last time is very important in raising the performance of basketball players. Based on many years of experience as a player, trainer, a good connoisseur of theory and scientific-experimental practice, basketball pedagogue, as well as the use of contemporary professional and scientific literature for this chapter, it is very well seen that the application of game models of basketball through sports technology is important for the basketball game.

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