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Mestrado em Gestão de Informação
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Use of IoT technologies to improve shooting performance in basketball

André Salomão dos Santos de Almeida Antunes

Dissertation report presented as partial requirement for obtaining the Master's degree in Statistics and Information Management

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USE OF IOT TECHNOLOGIES TO IMPROVE SHOOTING PERFORMANCE IN BASKETBALL

by

André Salomão dos Santos de Almeida Antunes

Dissertation report presented as partial requirement for obtaining the Master's degree in Information Management, with a specialization in Knowledge Management and Business Intelligence

Advisor: Vítor Manuel Pereira Duarte dos Santos, PhD.

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DEDICATION

Nesta seção de agradecimentos e dedicações, escrevo em português, na minha lingua materna. Sendo esta etapa uma das mais importantes que tive até hoje, só posso dedicar este feito à minha familia. Se não fosse pelo constante suporte e apoio, não tenho a certeza se teria completado este passo. Por esse motivo o mérito de ter finalizado este estudo não é só meu, e quero fazer um agradecimento especial à minha madrinha, à minha mãe, ao meu pai e à minha avó. Um obrigado a todos!

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ABSTRACT

Technology is revolutionizing the world of sports in every way, from the experience of fans to the making and customising of training plans and even refereeing. Inertial sensors are now being used in many sports as they allow effective tracking of metrics that were previously not “within reach” without affecting the performance of players, due to the improvement of their size and “durability”. But it is not just the technological component that is evolving; new strategies and tactical displays are being increasingly seen in several sports, such as basketball. Indeed, in the NBA, in recent years a new trend has emerged as teams are shooting more 3pt shots, and the centre position is progressing as taller players are asked to be more skilled than ever.

However, although the game of basketball is changing, a gain in efficiency is not being observed in jump shooting since the percentages of 3pt shots made in the NBA are not increasing as it would be expected from the increase in 3pt shot attempts.

The purpose of this study was thus to analyse and make recommendations concerning the use of current technology for tracking shooting performance, as well as the use of new sensors. In order to do so, the main factors behind shooting success were taken into account, to guarantee that the recommendations were as well-founded as possible. The chosen methodology was design science research, where the proposed artifacts were submitted to validation through interviews, and according to received feedback, the proposed artifacts were updated.

KEYWORDS

Internet of Things; Sports; Basketball; Jump shot; Devices.

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LIST OF ABBREVIATIONS AND ACRONYMS

DSR	Design Research Technology
ESPN	Entertainment and Sports Programming Network
FG	Field Goal
FIBA	Fédération Internationale de Basket-ball (International Basketball Federation)
GMZ	Guaranteed Make Zone
GPRS	General Packet Radio Service
GPS	Global Positioning System
GSM	Global System for Mobile communication
IoT	Internet of Things
IP	Internet Protocol
ITPD	Interaction, Things, Process and Data
LAN	Local Area Network
LTE	Long-Term Evolution
MIT	Massachusetts Institute of Technology
NBA	National Basketball Association
NCAA	National Collegiate Athletic Association
NFC	Near-Field Communication
NFL	National Football League
RFID	Radio-Frequency Identification
VR	Virtual Reality
YMCA	Young Men's Christian Association

1. INTRODUCTION

1.1. BACKGROUND

With the evolution of technology, sports in general have significantly changed. Technological innovation has made an impact on the rules of different sports, on the athletic performance of players and, among other aspects, on the methodology of training of both players and referees. The latter is demonstrated by the use of Virtual Reality technology for referee training in professional leagues like the NBA and the NFL. In addition, when it comes to the rules of the game, with the introduction of video-referee technology, the margin for refereeing errors is reduced. And as far as players' performance training is concerned, sensors are gaining significant weight because they allow the extraction of data in real time, having an autonomy and size favorable to their use, something that had not happened in the past. This relationship between objects with sensors that communicate with each other is what has become known as IoT.

The concept of IoT is not new, dating back to 1982 when a group of students at Carnegie Melon University was able to retrieve information from an internet-connected coke machine concerning the number and temperature of available drinks. This was followed by the vision of ubiquitous computing put forth by Mark Weiser in 1991. A few years later, in 1999, Bill Joy spoke of an internet of sensors with device to device communication. In that same year, Kevin Ashton coined the term “Internet of Things” to describe a system of interconnected object (P. P. Ray, 2014) (Somayya Madakam, R. Ramaswamy, 2016). Since then, the concept has continued to mature and, in the last decade, IoT has been seen as a global network of things enabling anytime, anyplace connectivity for anything (Somayya Madakam, R. Ramaswamy, 2016).

These things can be both living organisms such as plants, animals and people, and lifeless objects such as buildings, appliances and a variety of gadgets and devices; all of which can be connected and share information through sensor technology (P. P. Ray, 2014).

According to Gartner Inc., 20.4 billion devices will be connected to the Internet by 2020. Cisco’s Internet of Things Group (IOTG) has estimated this figure to be over 50 million. Regardless of the actual figure, with the growing number of connected devices and the continuous technological advancements, IoT remains a hot research topic with endless possibilities (P. P. Ray, 2014).

Dave Evans describes it as “the first real evolution of the Internet – a leap that will lead to revolutionary applications” which could significantly change people’s lives in many ways (Evans, 2011). For example, the Internet has become sensory with physical objects capturing data that until now only human beings could. Furthermore, the Internet is going into unreached places such as inside the human body, on plants and animals, and into space through minuscule sensors and microprocessor chips (Evans, 2011) (Lopez, 2013).

Thus, IoT represents a technological revolution that is ushering in a new era of computing and communication (P. P. Ray, 2014) impacting all areas of society including sports and, in particular, basketball on which this report focuses.

1.2. Motivation

As already established above, IoT is an emerging topic of great significance in society at large with many conferences, papers, reports and news articles dedicated to it, and its use is predictably becoming increasingly pervasive. By connecting everyday objects through the internet and enabling data retrieval and analysis, it is allowing us to change our decisions and practice, which is in effect transforming the way we live, work and play sports.

While projections regarding the potential impact of IoT on the Internet and global economy vary depending on the source, all of them predict significant growth and influence. The most generous forecasts expect as many as 100 billion IoT connected devices and a global economic impact of up to $11 trillion by 2025.

This trend is not surprisingly mirrored in sports. Indeed, both research and applications of IoT are expanding very quickly in competitive sport in an attempt to maximise performance and wellbeing.

Sensors are now small enough that they can be worn without causing an issue to the players and technologically-advanced enough that they permit both fitness and activity data collection in real life practice. This, in turn, informs the training decisions of players and coaches resulting in improved fitness and performance (Espinosa, Lee, & James, 2015) (Dellaserra, 2013).

As will be discussed further on, devices such as inertial sensors are now being used to classify sports and reduce the time taken to analyse performance in competitive activities using video recordings – a more traditional means of technology. In basketball, inertial sensors have also been widely used. However, their use appears to be much more focused on measuring the shot output than the shooting mechanics i.e. the sum of factors that actually lead to a successful shot output.

There is hence room for improvement in this particular area. In fact, despite the increase in the capability and usage of technology in basketball, jump shot success rates have not improved over the years.

An analysis of NBA game statistics over time shows that while there is an increasing trend in 3pt shots taken, this is not the case regarding the percentage of 3pt field goals where growth is far more modest. This is an indicator that an increase in quantity is not being accompanied by an increase in quality or efficiency.

1.3. OBJECTIVES

In this dissertation, I will perform a review of the current literature on IoT starting with its use in sports at large and then moving on more specifically to its applications in basketball, with particular emphasis on the jump shot.

Firstly, I will explore the phases of the jump shot and the many variables that can influence its outcome. Furthermore, I will identify and describe the factors that contribute to a successful jump shot.

Secondly, I will investigate and discuss existing technology that measures basketball shooting performance. This will paint a picture of what performance factors are already being measured, as well as the extent and the level of success of such measurements. It will also indicate where current technology may be lacking.

Finally, based on the above, I will identify the gaps and make recommendations for new research and novel applications of existing/new technology targeting the key factors for an effective jump shot.

2. LITERATURE REVIEW

2.1. IoT

2.1.1. Concepts

Many definitions for IoT have been put forward over time by various groups with different interests and areas of expertise, yet there is still no agreed universal definition. However, as Pritpal Singh points out, all such definitions seem to have one idea in common – while the first version of the Internet focused on data created by people, the next version focuses on data generated by things. (Singh, 2016) Objects are equipped with technology that enables them to communicate with each other and their users, making them an integral part of the internet (Zanella, Bui, Castellani, Vangelista, & Zorzi, 2014). According to the US National Intelligence Council, everyday objects become "readable, recognisable, locatable, addressable and controllable via the Internet, whether via RFID, wireless LAN, wide-area network, or other means" (Evans, 2011).

In other words, real-world things are connected through embedded sensors and actuators via wired and wireless networks, frequently using the same IP that connects the Internet. These sensors can use both local area connections such as RFID, NFC, Wi-Fi, Bluetooth and Zigbee, and wide area connectivity including GSM, GPRS, 3G and LTE. Objects are thus enabled to sense the environment around them and capture specific data which is then sent to computers for analysis through the network. In this way, objects are able to not only interpret the conditions of the environment but also respond to them in a timely fashion (Somayya Madakam, R. Ramaswamy, 2016) (Lopez, 2013) (Swan, 2012).

Finally, one more definition is of note in that there is within it an attempt to identify the beginning of IoT. According to the Cisco Internet Business Solutions Group (IBSG), IoT can be defined as the moment in time when the number of connected things (here understood as physical objects) surpassed the number of connected people. This point in time, which represents the birth of IoT, occurred sometime between 2008 and 2009 (Evans, 2011).

2.1.2. Context for IoT

The rising number of low-cost sensors available on the market which offer different types of functionality and the wide range of devices that can now be connected, greatly increases the variety of potential applications for IoT in society. Some of the IoT applications that are already underway include home and industrial automation, medical aids and health self-tracking, sports performance monitoring, automotive and transportation management, improved distribution of the world's resources and so on (Zanella et al., 2014) (Swan, 2012) (Evans, 2011) (Partha Pratim Ray, 2015).

The benefits of IoT technology in different fields are many. In business, companies are now able to track and code objects increasing efficiency and process speed, bringing in better organisational systems, reducing error, preventing theft and increasing customer satisfaction (Singh, 2016) (Lopez, 2013). In the home, IoT technology can lead to lower energy consumption, a healthier and more comfortable environment and greater security. In healthcare, it can increase the quality of life of specific groups of people and monitor the health of many others leading to prompt action when required. In sports, athletic performance and enjoyment can also be optimised through adequate monitoring. On a global scale, it is being used to gather information and help us better understand our planet and its resources, enabling us to make better use of them and care for the environment (Evans, 2011). These are only a few of the potential benefits of IoT for society at large.

Nevertheless, there are a number of challenges that must be overcome for IoT to succeed in the long run. The sheer variety and heterogeneity of IoT applications has made it extremely difficult to identify solutions that meet the requirements of all possible scenarios. Furthermore, the wide range of devices, link layer technologies and services involved in the IoT system, have made the task of creating a uniform architecture that would work in different situations very challenging. (Zanella et al., 2014) Other technical issues that must be addressed include existing problems with data transmission (particularly location data), irregular wireless coverage, and difficulties with instant analysis and conversion of large data streams into meaningful, real-time and personalised recommendations. More work is also needed to further reduce the cost of sensors and increase battery life (Swan, 2012). In this context, it should be noted that a commercially viable nanogenerator, which uses body movements to generate energy, has been developed (Evans, 2011) and constitutes a significant step towards much needed self-sustainability.

Due to the complexity and novelty of IoT, an established best practice is also lacking. In addition, a clear and proven business model is necessary so as to attract investment for the deployment of innovative technologies that will allow further development (Somayya Madakam, R. Ramaswamy, 2016) (Zanella et al., 2014).

Lastly, with the rising amounts of information available through IoT technology, more work needs to be done to ensure the privacy and security of personal and confidential data (Cisco Systems, 2013).

The resolution of these and other identified problems is not insurmountable but will require the joint work of government, businesses, academia and other organisations. Moreover, in order to be welcomed by the public, future IoT applications should focus on adding tangible value to the lives of people (Evans, 2011).

2.1.3. IoT in sports

Despite being in its early stages, IoT for sports is a rapidly growing area of research. The practice of sports is deeply ingrained in our society and the competitive nature of professional sport places a premium on any information that might improve the performance of the athlete. The aim of IoT for sports is to ultimately enable athletes to function at an optimum level by collecting and analysing relevant types of data regarding their health and athletic performance (Partha Pratim Ray, 2015).

Ray, P.P. suggests that the IoT for sports architectural framework should be based upon the structure of the ITPD ring which stands for Interaction, Things, Processes and Data, see figure 1**.** The first step in this structure highlights the athlete's need to become familiar with and learn to successfully interact with the data collection or measuring devices (here referred to as "things"). These devices connect the objects to the network making the collected information available to the user. The next step focuses on the business and/or technological processes that mainly deal with the tasks of accumulation, communication and analysis. Their goal is to expedite and automate the flow of data (the last concept in the ring structure) from the moment it is captured by the aforementioned devices to the moment when it is displayed for analysis in a cloud-based or real-time platform (Partha Pratim Ray, 2015).

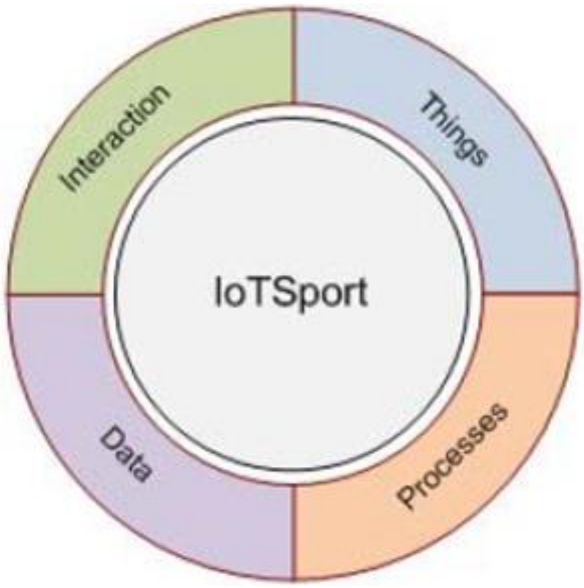

Figure 1. ITPD ring around IoTSport (from Ray, 2015)

Traditionally, and before IoT came into play, video recording was the only way of analysing the performance of athletes at an individual and collective level. Indeed, to this day, teams still film their training sessions and matches to gain a better understanding of what went wrong and why it went wrong; and find ways to ensure that mistakes are not repeated. For instance, in the NBA league, players and coaches in post-match interviews often refer to video analysis when speaking of adjustments that might need to be made in order for the team to succeed.

Moreover, with the advances in technology, match footage can now be fed into software that provides new visualization tools as in the case of TenniVis - a new visualization system for tennis matches that only requires the input of non-spatial game data like score, point outcomes and length, service information and video that can be recorded by a single consumer-level camera. The main goal of this system is to allow non-professional players and coaches to learn about their swings and service techniques through economic and feasible technology which provides clear visualization tools, like the Pie Meter and Fish Grid. This enables the detection of patterns and the sharing of newly gained knowledge between player and coach (Polk, Yang, Hu, & Zhao, 2014).

While video analysis remains a widely used tool in sport, recordings typically generate large amounts of data making the search for key events an extremely time-consuming process. To tackle this, the use of inertial sensors in combination with video has been attempted with a degree of success. In 2012, a general technique was proposed to show how inertial sensors could be used to index video. This was another tennis visualization system, but in this case the required data consisted of inertial data on strokes (collected by accelerometers or gyroscopes mounted in the racquet), a timestamp for these measurements and video data. The main advantage was that, by using this system, coaches were able to skip large amounts of irrelevant video data speeding up the process of analysis. In addition, if only the relevant video segments were stored, significant savings would be made (Rowlands, McCarthy, & James, 2012).

Inertial sensors are considered to be the present and the future of the classification of sports activities. In actual fact, it has been shown that it is possible to use accelerometer and gyroscope data to accurately classify sporting activities (Wundersitz et al., 2015). Nonetheless, one should be cautious when using sensor technology and ensure that both internal and external validations of devices and algorithms, as applicable, are satisfactorily carried out before considering the results accurate. The first microtechnology sensor to be validated both internally and externally was the minimaxX - a wearable microtechnology unit able to offer a valid method of quantifying the number and intensity of collisions performed in rugby leagues (Gabbett, 2013).

Wearable technology enables athletes to efficiently collect data in the familiar surroundings of their usual training location, thus avoiding the physical limitations of the laboratory environment and facilitating an authentic assessment of performance. Furthermore, recent reductions in sensor size have been undertaken to ensure that freedom of movement is preserved and minimal disruption is caused (Espinosa et al., 2015). The use of sensors presents major advantages such as the measurement of physical activity and monitoring of physical fitness which can be used to predict performance and prevent injury. In addition, when combined with biophysical markers, sensor data can be used to evaluate muscle damage and establish the required time period for full muscle recovery. Unlike other time-motion analysis systems, integrated technology offers real-time collection of information on various parameters including impact load, directional movement and activity identification (Dellaserra, 2013).

For instance, in 2015, a rugby study was conducted to determine whether the number of contact efforts had an impact on running intensity, for which data was collected using global positioning system units. The results showed that there was indeed an impact, with running intensity decreasing progressively as the number of contact efforts increased. Taking this into account, it is suggested that coaches should target defensive players in attack to affect their performance on offense (Johnston, Gabbett, Walker, Walker, & Jenkins, 2015).

Overall, an increase in battery power and memory storage combined with further reductions in product size could not only widen the use of this technology but also improve its functionality by providing quicker access to new information, which in turn could lead to significant improvements in the preparation, training and recovery programmes (Dellaserra, 2013).

2.2. BASKETBALL

Sports can be generally divided into two main categories: individual sports and team sports. As the name suggests, the level of success achieved in individual sports depends solely on the performance of the individual athlete. In contrast, the success attained in team sports relies on the performance of the whole group, even if some players arguably contribute to it more than others.

In 1891, James Naismith, an instructor at the YMCA International Training School in Springfield, was tasked with the creation of a new indoor team sport to keep his students in shape during the harsh weather conditions of the Massachusetts' winters. With the use of a basket of fruit, one soccer ball, and thirteen basic rules, basketball was born. As time passed, changes were made regarding the way the game was played, and the backboard was eventually added. The year of 1936 remains a historical year for basketball since it was entered in the Olympic Games as an official event for the first time.

2.2.1. Concept, rules and scoring

Concept

Basketball is a team sport in which two teams compete against each other. Each team is usually composed of twelve rostered players, with five on the court at any one time and up to seven on the bench. The objective of the game is to beat the opposing team by making goals and scoring more points than them. Goals are made by inserting the ball into the opponent's basket and preventing the opponent from doing the same as much as possible. The winner of the match is the team with the highest score at the end of regular time. In case of a draw, additional periods of five minutes (known as overtime) are added to game time, until there is a winner.

There are two main basketball associations - FIBA and NBA. A summary of the rules by which FIBA is governed is given below, which is followed by a table 1 that outlines the main differences between the rules that apply to both associations.

Characteristics of the game

Basketball is played with a spherical ball and two baskets with backboards at either end of the court. The standard for a ball is approximately 75 centimetres in circumference and 600 to 650 grams in weight. The hoop is positioned 3.05 metres above the floor and has a diameter of 45 centimetres. The court itself has a number of lines and markings that are crucial to the game. The side-lines and baselines make up the perimeter of the playing area, and the midcourt line divides it in symmetrical halves. The free throw or foul line, as the name indicates, is used for free throws when fouls are committed. The three-point line surrounds the basket and helps determine how many points a shot is worth. The key, also known as the free throw lane (NBA) or restricted area (FIBA) is the area closest to the basket usually painted in a different colour to the rest of the court.

The duration of a basketball game is forty minutes (known as regulation in the NBA) split into four periods or quarters of ten minutes each. There is a fifteen-minute halftime between the second and third periods and a two-minute break between the first and second, and the third and fourth periods. Each team is allowed two timeouts during the first two periods, and three during the last two periods. Timeouts are one-minute breaks that can only be requested by the coach.

Basketball places no limit on the number of player substitutions that can be made during a game. However, teams can only switch players when the clock is stopped or the ball is declared "dead" by officials, such as when a foul is committed, a player is injured, the ball is out-of-bounds, following a timeout or when the opposite team scores a basket in the last two minutes of regulation or overtime.

Rules

General rules

Below is a summary of the main rules that guide the game. Breaking them results in immediate loss of ball possession and may have additional consequences such as in the instance of goaltending where the attempted shot that was interfered with is automatically considered made regardless of whether or not the ball made it through the hoop.

- The ball carrier cannot take more than two steps without dribbling, otherwise a travelling violation is called.
- Upon receiving the ball, a player can either pass, shoot or dribble but once dribbling is stopped, it cannot be reinitiated as this would constitute double dribble.
- A defensive player cannot interfere with the ball when it is in downward flight towards the basket or has touched the backboard in the process. Doing so would be considered goaltending.
- When a team has ball possession, a player from the offensive team cannot be more than three seconds in the key area, or a three-second violation is called.
- Upon gaining possession, a team has eight seconds to make the ball pass the half court, or an eight second violation is called.
- The offensive team has twenty-four seconds to take a shot; if the ball touches the rim and the team regains possession they have another twenty-four seconds. However, if no shot is taken within the allotted time, the team gets a shot clock violation.
- When the offensive team passes the half court line, it constitutes a backcourt violation to pass or dribble the ball back to the backcourt.

Fouls

Fouls are called when players break the rules and result in free throws for the other team. There are different types of fouls in basketball: personal fouls which can be offensive or defensive, and technical fouls.

Personal fouls involve illegal physical contact with an opponent either through holding, pushing or charging into the opponent. If a player was fouled in the act of shooting, he/she will be permitted to shoot as many free-throws as the points that the shot would have been worth, had it gone in successfully. If the foul is committed by a player of the team in possession of the ball, e.g. by charging into a defensive player, it is called an offensive foul and results in loss of ball possession for the team of the offending player. In contrast, defensive fouls are those committed by players of the team that does not have possession of the ball and include intentionally moving in front of and making undue physical contact with the ball carrier to hinder his/her progress.

Technical fouls are umbrella terms that cover a wide range of infractions such as hanging on the basket rim for any reason other than preventing injury to another player, excessive timeouts and undue delays of game. Nonetheless, many if not most, are related to the conduct of players including unsportsmanlike acts such as disrespectfully addressing or making physical contact with a referee, overreacting concerning a made call, and using profanity or taunting. An unsportsmanlike foul is called when a referee interprets the contact as unnecessary, and it is equivalent to a flagrant foul type 1 in the NBA, resulting in two free throws and ball possession for the opposing team. A disqualifying foul is called when the contact is deemed unnecessary and excessive, and results in the granting of two free throws and ball possession to the opposing team as well as the ejection of the offender. A player will be ejected if he/she commits any of the following: five personal fouls, two technical fouls, two unsportsmanlike fouls, one technical foul and one unsportsmanlike foul, or one disqualifying foul.

Scoring

A shot made inside the three-point line is worth two points, and one made behind it is worth three points. If the player is fouled in the act of shooting and makes the shot, he/she will receive the points and take one free throw as a bonus. Furthermore, a made shot will still count if it left the player's hand and time expired while the ball was still in the air.

Rule	FIBA	NBA
Playing time	4x10 minutes 5 minutes over-time	4x12 minutes 5 minutes over-time
Shot clock	24 seconds After offensive rebound: 14 seconds	24 seconds
3-point line	6.75m (6.60 on baseline)	7.24m (6.70 on baseline)
Time-outs	2 in first half 3 in second half 1 per OT	6 regular 2 per OT period
Individual foul	Foul out on 5 (personal and technical)	Foul out on 6 or 2 technical
Technical foul	1 free throw and possession of the ball at center	1 free throw per technical foul; play resumes at the point of interruption
Goaldtending	No blocking a ball in downward flight towards the rim. When the ball touches the rim, any player can play the ball	No blocking a ball in downward flight towards the rim

Table 1. Rules comparison (from FIBA 2014)

2.2.2. Major competitions

The main basketball leagues are the NBA (North American league), the Euroleague (European league) and the Liga Endesa (Spanish professional league). Contrary to sports such as football, in basketball the champion is not the team that accumulated the highest number of points at the end of regular season, but the one that wins the playoffs. To go to the playoffs, a team has to ensure a certain position in regular season. In the NBA there are 30 teams, 15 per conference. In each conference, 8 teams go to the playoffs where the first seed will face the eighth, the second will face the seventh and so on. Each round is the best of seven games and whoever wins 4, goes on to the next round. In figure 2 is an example of last year’s NBA playoffs’ bracket.

Figure 2. 2016 NBA playoffs' bracket

The biggest event at national team level is the Olympic Games, where teams are distributed into two groups of six teams each, according to their ranking. The top four in each group advance to the quarter-finals, where they will face a team from the other group. The rationale remains the same, with the first in group A playing the fourth in group B, the second in group A playing the third in group B and so on. Unlike the NBA, the rounds are decided with only one game; the team that loses is eliminated. If a team loses in the semi-finals, it will be given the opportunity to compete for the bronze medal.

The team that has come first in the Spanish league and the Euroleague more often than any other is Real Madrid with 33 and 10 wins, respectively. Regarding the Olympic games, not surprisingly, the team that won the gold medal most often was the United States national team with 15 victories.

2.2.3. Trends and challenges

Basketball is changing. Today, it is a much faster game than it was 20 years ago, with more possessions and more 3pt shot attempts. To demonstrate this evolution, all regular seasons from 2000-01 to the current one were analysed in terms of 3pt shot attempts, 3pt shots made, 3pt field goal percentage and the percentage of points obtained from 3pt shots.

With regard to 3pt shot attempts, whereas in 2000-01, on average, a team took 13.7 3pt shots per game; in the current season this average increased to 29 shots per game. The latter figure represents two more shots than in the previous season (2016-17) and more than double the figure for 2000-01. This increase is also shown by the fact that in the current season the team with the lowest number of 3pt shot attempts per game (22.5 attempts) still surpasses the team with the highest number of 3pt shot attempts per game (19.9 attempts) in 2000-01. As expected, the number of 3pt shots made also increased from 4.84 to 10.49 in the time frame considered.

In terms of percentages, from 2000-01 to 2017-18 the number of 3pt shot attempts and that of 3pt shots made rose by 111% and 116%, respectively.

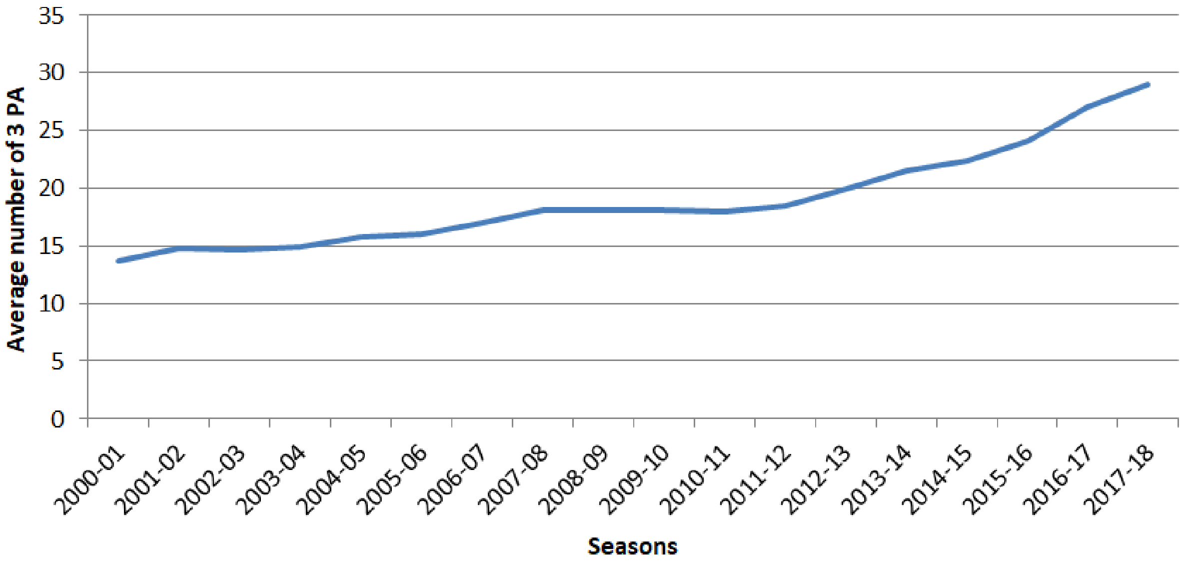

Figure 3. Average number of 3 point shot attempts per game in each season

These findings are directly correlated with the percentage of points obtained by each team from 3pt shots. On average, this season, nearly 30% of the points scored by a team in a single game are from 3pt shots. This is the highest percentage of the past 17 years and is almost twice that of 2000-01 (15.28%).

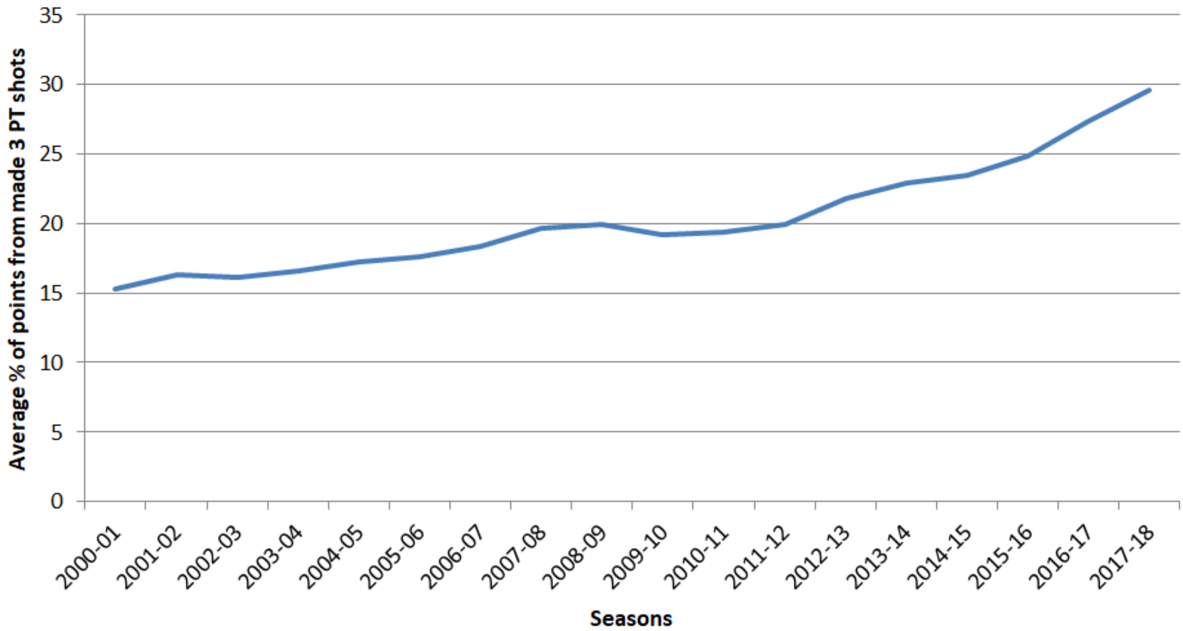

Figure 4. Average percentage of points resulting from 3 point shots per season

However, when it comes to the percentage of 3pt field goals, there is not such a marked upward trend. In fact, from 2000-01 to the current season, it only increased by 2 percent points. The 2008-09 season remains the one with the highest percentage (36.54%) in the last 17 years.

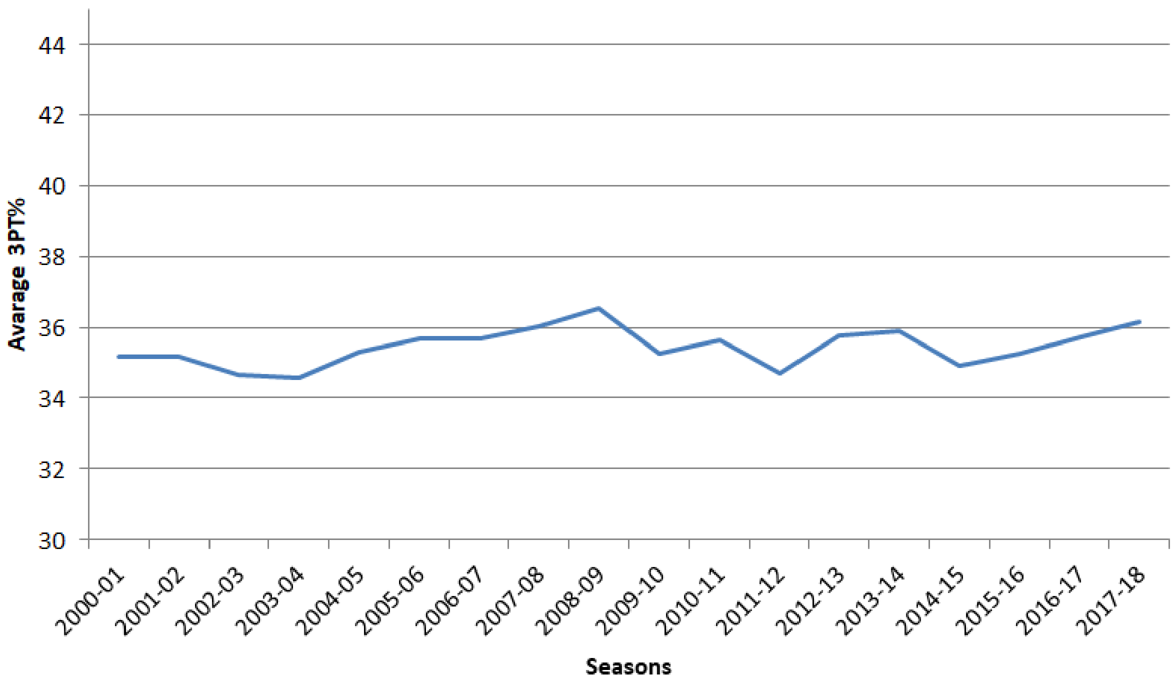

Figure 5. Average percentage of success of 3 point shots per season

These statistics help us understand how the game is evolving. For instance, they clearly show that while teams are taking more shots from behind the 3pt line, they are not being more efficient in scoring from that distance. In other words, the trend is the increasing use of 3pt shots and the challenge is to shoot more efficiently from that distance. Data supporting figures 3, 4 and 5 can be found in Annexes.

2.2.4. 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 organisation and variables that influence shooting performance. Below is a summary of the authors' discussion regarding each of these categories.

Ball trajectory

Upon examination of ball trajectory, three components stand out as decisive for a successful shot: release angle, velocity and height.

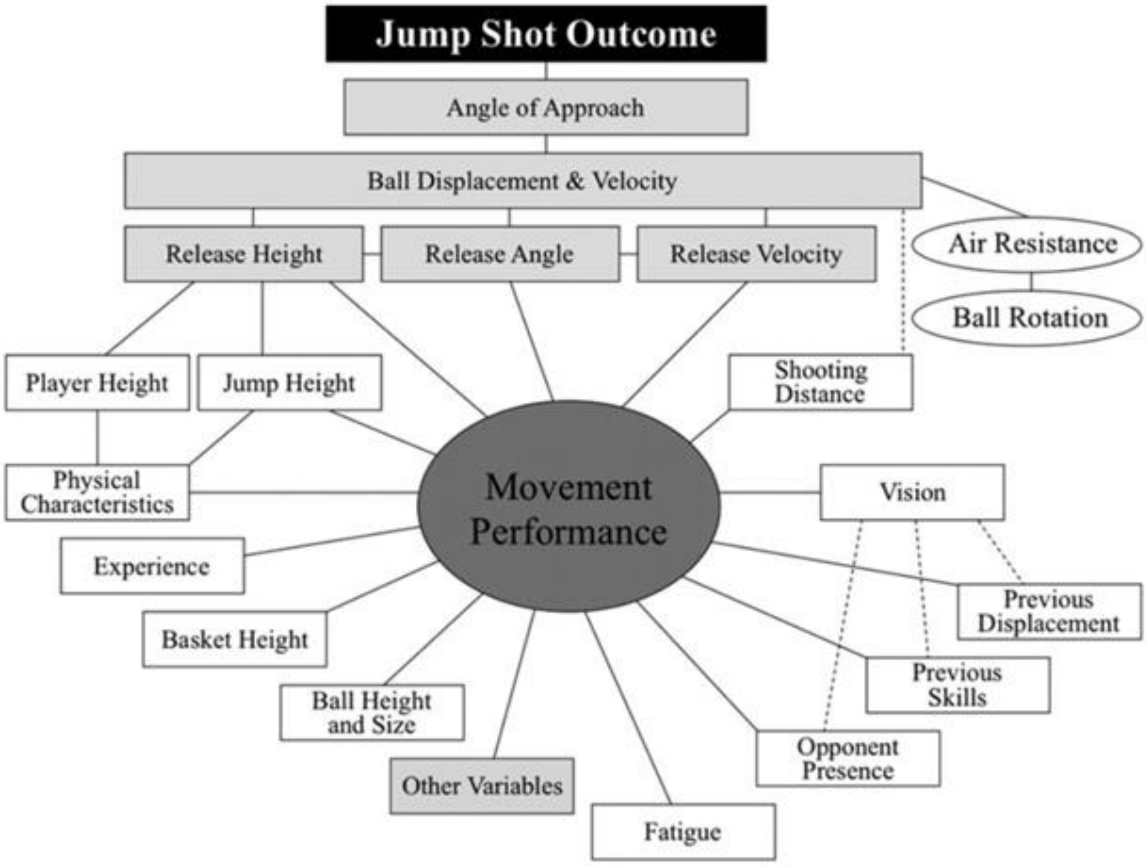

Figure 6. Variables that influence the basketball jump shot (from Okazaki, Rodacki, & Satern, 2015)

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 (Victor H A Okazaki et al., 2015).

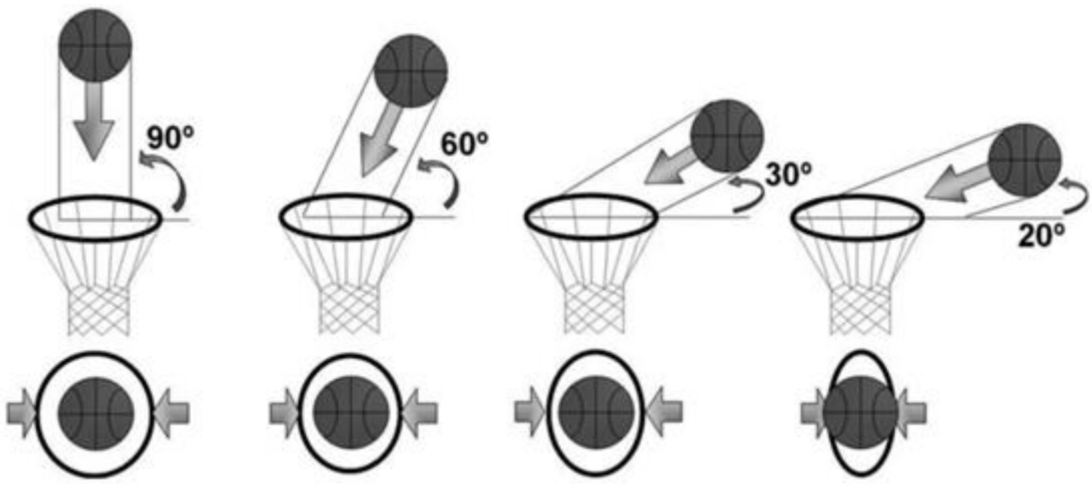

Figure 7. Virtual target of the basket rim as a function of the angle of entry of the basketball (from Okazaki et al., 2015)

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 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 travelled 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 (Victor H A Okazaki et al., 2015).

The authors thus demonstrate that "these three factors (ball vertical displacement, ball horizontal displacement and velocity) are affected by release velocity, angle and height".

Release velocity

The release velocity of the ball is inversely related to movement accuracy and consistency, which is explained by the fact that the variability of body segments decreases as the velocity of release goes down.

Hence, it stands to reason that players should give preference to release angles that permit low movement velocity. Nonetheless, players that are shorter in stature or that do not possess enough upper body strength will have to generate greater segmental velocities to ensure that the shot reaches its destination. This is because players of a smaller stature release the ball at a lower height than taller players, meaning that the vertical displacement is increased. Equally, players with less upper body strength, when shooting from the same distance, will have to compensate for the lack of strength by releasing the ball at a higher velocity so that the ball reaches the basket (Victor H A Okazaki et al., 2015).

Flexion of the wrist on release is a method frequently used by professional basketball players to lower release velocity, as it imparts a spin to the ball and increases the rotation along its trajectory. However, as common as this technique may be, players still need to make sure that their upper body is coordinated and the shooting hand, elbow and trunk are fully aligned, as the smallest deviation of the elbow could cause lateral rotation of the ball which is not ideal (Victor H A Okazaki et al., 2015).

Release angle

There is no consensus regarding this factor. It is known that the release angle has a direct influence on the angle of entry of the ball into the basket, very much defining the area where the ball can pass through the hoop. In light of this, several studies have been carried out to determine the ideal angle of release. Table 2 shows the angles suggested by several such studies as presented in Okazaki's literature review. (Victor H A Okazaki et al., 2015).

Author(s)	Angles	Evidence
Mortimer (1951)	54°–58°	Theory
Hartley and Fulton (1971)	45°	Theory
Brancazio (1981)	45°–55°	Theory
Satern (1988)	52°–55°	Free Throw (Women)
Elliott and White (1989)	~53°	Jump Shot (Women)
Elliott (1992)	44°–47°	Jump Shot (Men)
Elliott (1992)	48°–50°	Jump Shot (Women)
Miller and Bartlett (1993)	47°–52°	Jump Shot (Men)
Knudson (1993)	~52°	Theory
Southard and Miracle (1993)	~58°	Free Throw (Women)
Miller and Bartlett (1996)	48°–55°	Jump Shot (Men)
Hamilton and Reinschmidt (1997)	55°–63°	Free Throw (Theory)
Rojas et al. (2000)	44°–47°	Jump Shot (Men, with and without opponent)
Nunome et al. (2002)	50°–60°	Free Throw (Wheelchair)
Malone et al. (2002)	55°–59°	Free Throw (Wheelchair)
Okazaki and Rodacki (2012)	~65°	Jump Shot (Men)
Okazaki, Lamas, Okazaki, and Rodacki (2013)	~63°	Jump Shot (Children)

Table 2. Different release angles reported in the literature (from Okazaki et al., 2015)

The release angle of the ball may vary depending on release speed, on differences in the speed of the joint segments during the distinctive jump shot phases, and on the distance between the player and the basket. For this reason, and because this angle can also be largely determined by the height of the athlete, it is not possible to define an optimal angle that would work for every player in every scenario. There is thus an argument for a more case-by-case approach where the aforementioned factors can be taken into account in the identification of the release angle that would provide a higher shooting percentage (Victor H A Okazaki et al., 2015).

Release height

The release height is determined by the player's height, jump height, wingspan and segmental movements upon the act of shooting. One good practice when performing jump shots is to release the ball at the peak of the jump, which allows players to maximize their release height and shoot with greater stability as the vertical velocity is almost null at this point (Victor H A Okazaki et al., 2015).

Another shooting practice that is regularly observed in professional basketball is the elbow extension at release, which enables players to shoot from a greater height and impart a higher velocity to the ball upon the act of shooting. However, it is not only the upper body that plays a major role in the release height of the ball. The proper use of the lower limbs is fundamental for a good jump shot as it lets the player shoot from a greater height and generate momentum that will relieve the shoulder, elbow and wrist, making the shooting motion more fluid. Ineffective use of the lower limbs in preparation for the jump shot often results in a shorter shot (Victor H A Okazaki et al., 2015).

In summary, the organisation of body segments upon the act of shooting is key for the success of the jump shot and, therefore, must be refined during training as it becomes a major part of the shooting pattern of each player (Victor H A Okazaki et al., 2015).

Ball entry attributes

In last year's MIT Sloan Sports Analytics Conference, Rachel Marty and Simon Lucey presented a research paper where, using Noahlytics (a sensor tracking system), they investigated three attributes of shot entry from over 1 million 3-point shots. These attributes, which were measured from the perspective of the shooter (i.e. the point of the hoop closest to the shooter was considered the front of the hoop) are: left-right defined as the "distance between the straight shot line and the point where the ball actually crosses the hoop plane"; depth which meant the "distance between the front of the hoop tangent line and the point where the ball crosses the hoop plane"; and angle which was the "angle between the hoop plane and the tangent to the ball flight parabola at the hoop plane". Based on these three attributes, the following six shooter factors were identified: left-right value and consistency, depth value and consistency, and angle value and consistency. In order to identify correlations between these factors and successful shots, a data driven method was used to generate knowledge.

By analysing data recorded by Noahlytics, in what regards the values category, both left-right and depth attributes had symmetrical distributions (as can be seen in figure 8 and 9), however the angle attribute followed a slightly asymmetrical distribution. Concerning the consistency category, in all attributes shooters with greater consistency tend to have better shooting percentages, as can be observed in figure 10 (Marty & Lucey, 2017).

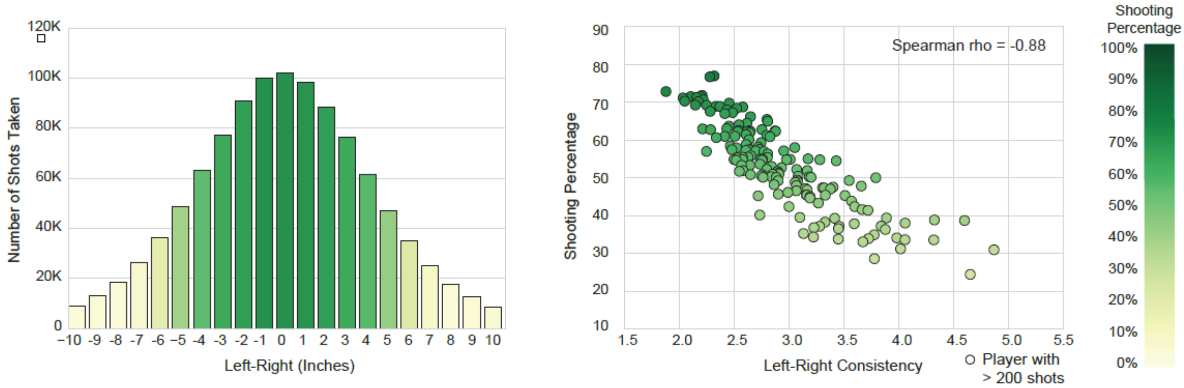

Figure 8. Left: Distribution of the Left-Right values for all 3-point shots measured. Right: correlation between Left-Right consistency and 3-point shooting percentage for individual shooters (from Marty & Lucey, 2017).

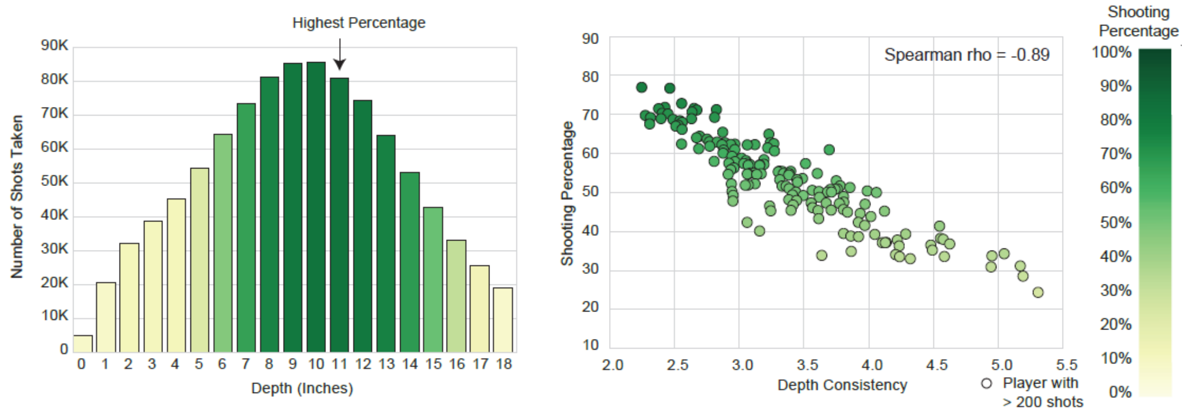

Figure 9. Left: Distribution of Depth values for all 3-point shots measured. Right: correlation between Depth consistency and shooting percentage for individual shooters (from Marty & Lucey, 2017).

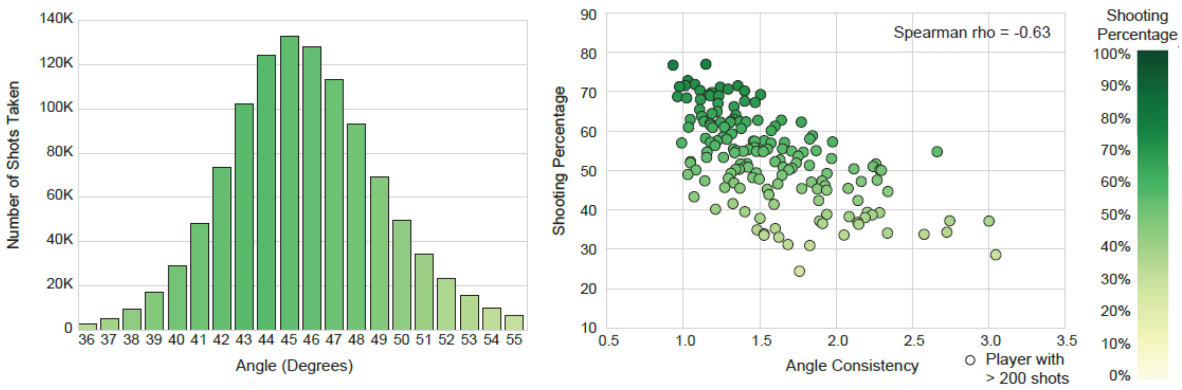

Figure 10. Left: Distribution of Angle values for all 3-point shots measured. Right: Correlation between Angle consistency and shooting percentage for individual shooters (from Marty & Lucey, 2017).

In the next phase, Rachel and Simon introduced the term "Guaranteed Make Zone" (GMZ), which includes all depths with greater than 90% shooting percentage. As the angle of entry is directly related to the depth of the ball while passing through the hoop, an analysis was made to see what depth (by inch) belongs to the GMZ and what angles of entry are mostly observed in these shots. As presented in the figure 11, the depth varies from 7 to 14 inches and the corresponding angle of entry is around 45 degrees.

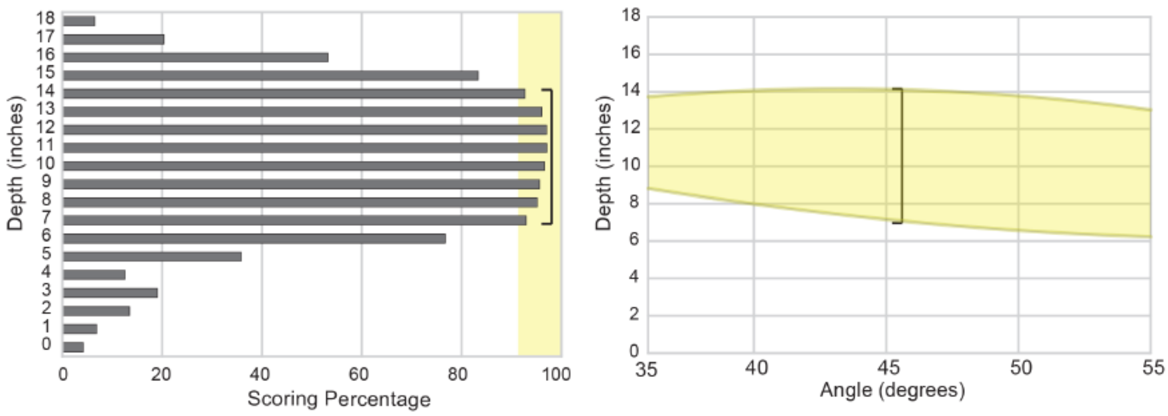

Figure 11. Left: Make percentage at each Depth value for straight shots with an Angle value of 45°. Right: Guaranteed Make Zone (GMZ) for straight shots across all Angle values (from Marty & Lucey, 2017).

By overlaying the GMZ with the shooter factors previously mentioned, the study concluded that left-right consistency, angle median, angle consistency and depth median are factors that can predict and improve shooting performance. These are actionable factors in the sense that they can be implemented through instant verbal feedback techniques during training and the results can be measured. Since depth consistency is influenced by too many factors, it was considered an outcome and was not included in the actionable factors for improving shooting percentage (Marty & Lucey, 2017).

In order to analyse the improvement potential of different players, a cluster was designed. Based on the four actionable shooter factors, fifteen groups were created according to the players' level of proficiency in the different categories. The heatmap in figure 12 suggests that the players with better performance were the ones proficient in all classes. The opposite can also be said, as players who were not proficient in every category had the worst percentages.

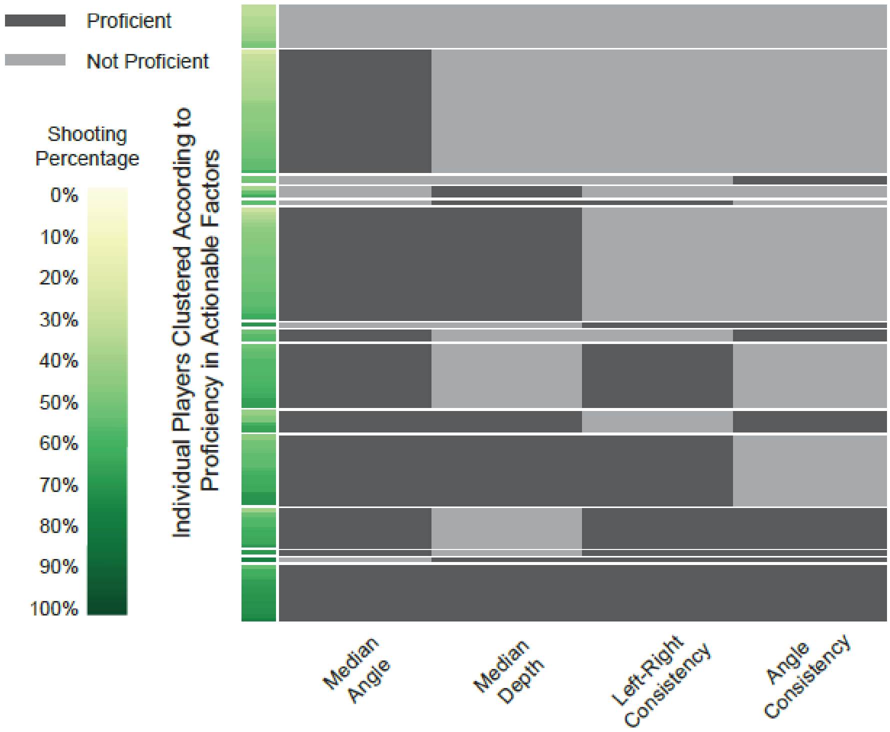

Figure 12. Heat map showing players clustered by their proficiency at the four factors (from Marty & Lucey, 2017).

In this study, the median shooting percentage of the cluster where all factors were considered proficient was 68%, however in the opposite cluster (i.e. factors assessed as not proficient) it was 39%.

For the purpose of showing how these factors can help to predict a player’s performance, a case study was made about a player, which is referred to as player Y. This player was a 64% 3-point shooter and was proficient in every category except for depth median, which was only 8.5 inches. It was estimated that if he managed to raise his median value to 10.5 inches, a slightly deeper shot, he could raise his shooting percentage in 6 percentage points, becoming a 70% 3-point shooter. This is because a slight increase in depth median will automatically translate into a greater overlap between the player’s shot distribution and the GMZ meaning greater efficiency, as shown in figure 13.

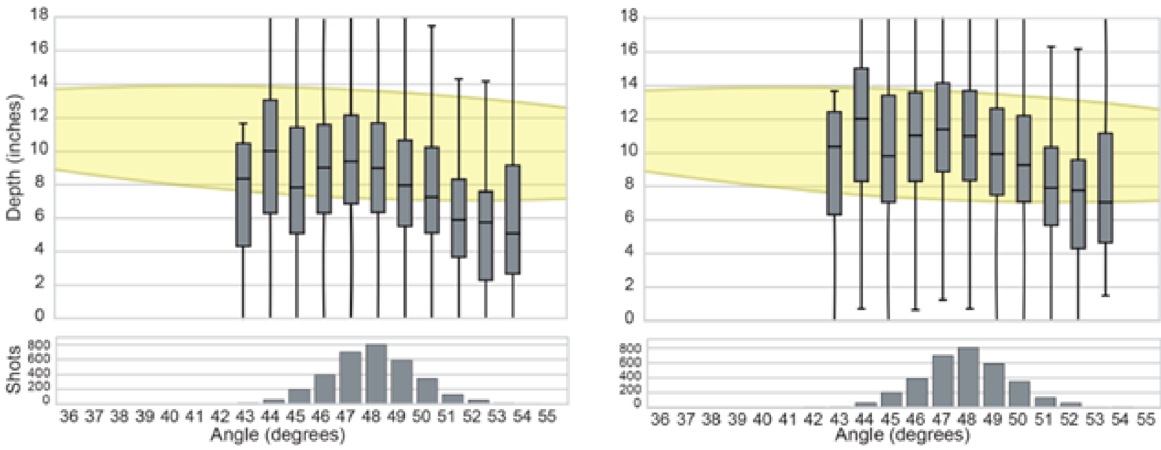

Figure 13. Left: Current shot distribution of Player Y where Depth median is not centred in the GMZ. Right: potential shot distribution of Player Y if his median Depth is improved by centring in the GMZ (from Marty & Lucey, 2017).

The study concluded that the analysed factors can be used to predict and improve shooting percentage and create a better understanding of what particular areas of a player's shot need to be improved. It was suggested to use audio feedback to help the player identify these specific aspects, so that they can focus on what can be improved (Marty & Lucey, 2017).

According to Noah basketball, Noahlytics has analysed over 100 million shots and the key factors behind success have been identified as strong muscle memory, shooting the ball straight with a 45-degree angle of entry and having the ball entering the hoop 11 inches deep into the basket and two inches past the centre.

Phases of the jump shot

When it comes to the act of jump shooting each individual has his unique arrangement/pattern/ gesture/approach, nonetheless there is a generic combination of observed segmental movements. With the objective of classifying these movements, researchers performed a biomechanical analysis on the jump shot to illustrate the sequence or order of action of the different segments. By analysing the shooting performance of ten individuals, five different phases were identified during the jump shot based on the diversity of movement (Victor H A Okazaki et al., 2015).

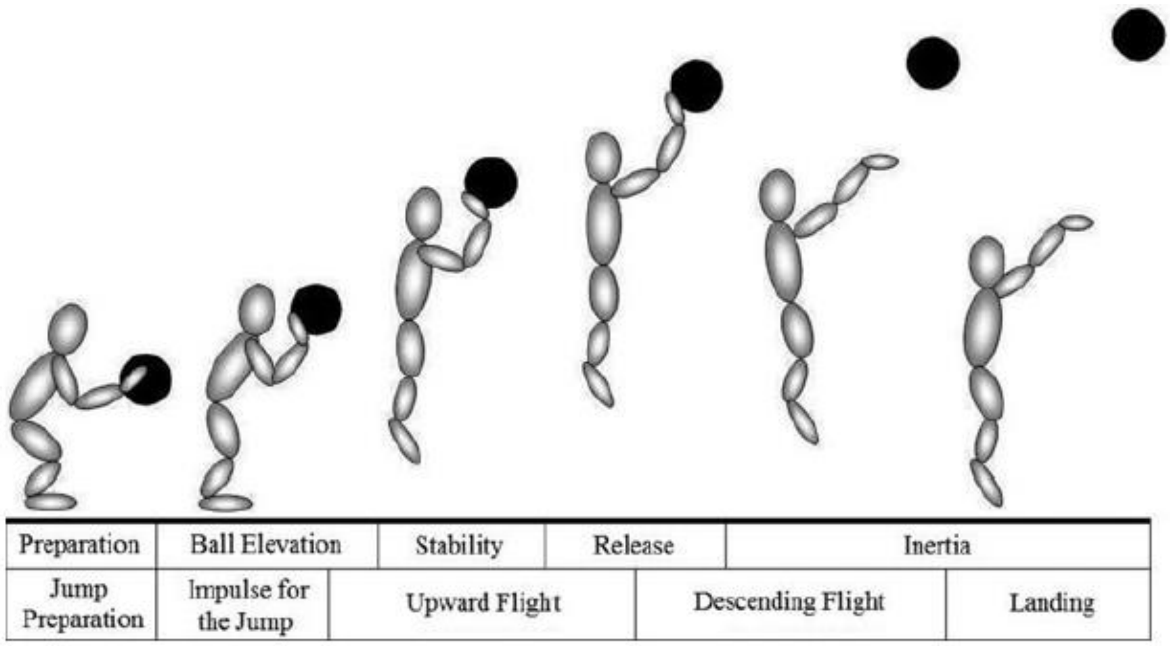

Figure 14. Phases of the jump shot (from Okazaki et al., 2015)

Preparation phase

This phase is the starting point in which the player should have his/her elbow and wrist semi-flexed and hands positioning the ball at waist level with fingers spread out to facilitate the slide through at release. The feet must be spread shoulder width apart and the body weight evenly distributed between both feet. Some players opt to have the foot, on the same side as the shooting hand, slightly ahead of the other to increase stability and reduce upper body rotation during the act of shooting. If a player follows these steps prior to receiving the ball, he/she is prepared to shoot as soon as he/she catches the ball without having to make any adjustment. The main advantage in this is that the defensive player, more often than not, does not have time to contest the shot giving the shooter less opposition. This phase ends when the player starts to elevate the ball (Victor H A Okazaki et al., 2015).

Ball elevation phase

In this phase, the player starts to flex his/her shoulder and elbow as he/she positions the ball for release. The wrist does not show signs of variation, rather it is the elbow joint that starts to decelerate as the shoulder flexion increases. As the ball is lifted up, it should be close to the player's body so as to reduce the body's horizontal displacement. In addition, the athlete must have his/her shoulder, elbow and wrist aligned during the process and make sure that the elbow is below the ball at all times. This phase ends as the elbow becomes steady and ceases its flexion (Victor H A Okazaki et al., 2015).

Stability phase

The stability phase takes place when the elbow stops flexing and begins its extension. This movement is in sync with the deceleration of the shoulder joint's extension, enabling the upper body to be balanced while the ball is being positioned for its release. While in the beginning of this phase, the wrist joint is still accelerating as it extends, as the movement progresses it starts to slowdown in line with the other upper body joints (elbow and shoulder). It is not just the upper body that is in motion in this phase, the lower limbs extend at the same time. Players that need to generate more force during their shot, might shorten or even skip this phase to benefit from the energy created by the elbow's extension (Victor H A Okazaki et al., 2015).

Release phase

The release phase begins with the extension of the elbow followed by wrist flexion and ends when the ball is no longer in contact with the shooting hand. Supported by the stability that was gained in the previous phase, at this stage joints will accelerate their movement once again. Elbow extension is identified as the most important moment of the shot, with the full extension of this joint being commonly observed among expert players. Concerning wrist flexion, some authors argue that it should take place shortly after the elbow is extended, while others propose that it should occur before the elbow's full extension. When the shooting hand launches the ball, it must be done through finger and wrist flexion in order to apply the desired trajectory as well as backward rotation of the ball during flight. As Okazaki explained, "greater wrist flexion, coupled with the application of rotation to the ball at release, has been observed as a characteristic of the performance of expert players" (Victor H A Okazaki et al., 2015).

It is very important that the ball is released at the peak of the jump because at that moment the player is in his/her highest and most stable point. When the ball is released before this brief period, the athlete is passing the vertical velocity of his/her body into the shot (thus skipping the stability phase as seen before) and while it enables him/her to shoot deeper, it also affects his/her balance and consequently shot accuracy. If the ball is released after the peak of the jump, the amount of strength that the upper body has to generate is higher, resulting in greater velocity from the joints at release and therefore less movement accuracy and consistency (Victor H A Okazaki et al., 2015).

Inertial phase

Finally, the inertial phase commences when the ball is released and is no longer in contact with the shooting hand; and ends when the player lands on the floor. It represents the gesture taken during release and is defined by shoulder flexion and complete flexion of the wrist, elbow extension and the hand parallel to the floor with fingers pointing towards the basket (Victor H A Okazaki et al., 2015).

Additional variables

In Okazaki's literature review on the basketball jump shot, a number of variables that have impact on shooting mechanics were identified and, therefore, should be considered when acknowledging an attempt.

Physical characteristics

Physical characteristics that influence the performance of the basketball jump shot include the player's height, limb length, and ability to generate force and velocity. While player height and wingspan influence ball release height in that taller players tend to shoot from higher heights, if taller players do not use their lower limbs as expected, by jumping, they will not benefit from their natural advantage and smaller players might actually release the ball higher as proven in (Miller & Bartlett, 1996). Players that are not able to generate the required velocity at release have to produce more force to compensate for it. However, as previously mentioned, it should be borne in mind that by increasing the force or velocity at release, an athlete is also increasing movement variability, consequently affecting the shot's success (Victor H A Okazaki et al., 2015).

Fatigue

According to Allen fatigue results in the decline of muscle performance caused by its intense activity. Its main consequences are reduced force production, decreased velocity of shortening and slowed relaxation. The combination of these elements is associated with great reductions in performance, especially when it comes to rapidly repeated movements (Allen & Westerblad, 2001). Muscle fatigue causes a decrease in the muscle activation pattern, affecting the sense of joint position which influences balance (Abd-Elfattah, Abdelazeim, & Elshennawy, 2015).

A number of studies were carried out in order to assess whether or not fatigue had an impact in jump shooting mechanics and accuracy. The methodology used in most of these studies consisted in having the player perform jump shot series as the level of fatigue increased. To ensure this, between each series, the player engaged in physical activity like jumping and running. In what regards shooting motion, some important observations were made. Firstly, the elbow joint angle decreased resulting in a decrease of the wrist and elbow's height at release. In the last series of one of the studies, there was a decrease of as much as 21 degrees in elbow joint angle that resulted in a decrease of a shoulder average height of 11 cm and a decrease of wrist average height of 16 cm, when compared to the first series (Frane & Matej, 2009) Other observations include the fact that shoulder joint angle increased; jump height differences between series were statistically significant since the athlete jumped increasingly lower as the series progressed, and hip joint angle decreased (Frane & Matej, 2009) (Slawinski, 2015). Even though it was proven that fatigue had an impact on the kinematics of jump shooting, and in one of the studies the number of made field goals was at its lowest in the last series (maximum fatigue), it was not possible to establish a relationship between fatigue and shot accuracy (Victor H A Okazaki et al., 2015).

Shooting distance

Shooting distance has an impact on the act of shooting. When it changes, the shooter makes adjustments to his/her gesture, and changes in release height, angle and velocity are observed. As the distance increases, the player has to achieve greater velocity at release which causes greater variability of movements and affects performance (Victor H A Okazaki et al., 2015).

In 2012, a study was conducted to evaluate the impact of shooting distance. In this study, 10 expert players performed jump shots from three different locations: close distance (2.8 m), intermediate distance (4.6 m) and far distance (6.4 m) from the basket. Researchers collected information on kinematics using a digital camcorder to capture the act of shooting followed by standard 2D analysis. The results showed that shot accuracy decreased from 59% to 37%, from close to long range. Ball release height decreased from 2.46 m to 2.38 m, when comparing close to intermediate range, and reached a minimum of 2.33 m when players shot from long range. As expected, release angle decreased from 78.92 degrees (close range) to 65.60 degrees (intermediate range). In contrast, ball release velocity increased from 4.39 m/s (close range) to 5.75 m/s (intermediate range), reaching a maximum value of 6.89 m/s from long distance (Victor Hugo Alves Okazaki & Rodacki, 2012).

The changes in release height, angle and velocity of the ball caused by movement adaptations were suggested as the main factors that influence jump shot accuracy when distance varies (Victor H A Okazaki et al., 2015) (Victor Hugo Alves Okazaki & Rodacki, 2012).

Presence of an opponent

In basketball, there is a high probability that the player in possession of the ball will have to perform a jump shot while being guarded by a defensive player. When facing such opposition, and to increase his/her chances of success, the player has to make adjustments in the act of shooting which mostly include: higher release angle of the ball, greater elbow extension, higher release height, quicker release and lower vertical displacement from the centre of gravity (Rojas, Cepero, Oña, & Gutierrez, 2000) (Victor H A Okazaki et al., 2015). In this scenario, players are focused on releasing the ball before facing opposition from their opponent in order to reduce the chances of the shot being blocked. To do so, athletes tend to have a more upright position at the beginning of the upward movement of the ball, enabling them to initiate the shot from a greater height. Players also have a more stable base for generating greater initial velocity of the ball (Rojas et al., 2000). In this case, the knees are not flexed as usual, translating into a shorter but quicker jump. Even though players opt for a quick and high release, it is also observed that when they release quick enough, the release height can be lower since there is an absence of contest given that the opponent does not have time to challenge the shot (Victor H A Okazaki et al., 2015).

In conclusion, since it has been proven that opposition influences the mechanics of the shot and consequently performance (Victor H A Okazaki et al., 2015), it stands to reason that training would benefit from practice with an opponent to prepare players to successfully deal with the demands that they are most likely to face in a game situation (Rojas et al., 2000).

2.2.5. Technologies in Basketball

2.2.5.1. Current situation

Today, the NBA is considered one of the most technologically-advanced sports leagues in the world. Like in NFL and other major North American leagues, technology plays a key role both during training sessions and during the course of the actual games.

The use of wearable technology, such as ClearSky and Optimeye by Catapult, Zebra wearable tags or Zephyr Bioharness systems, is already an everyday practice for NBA teams, as pointed out by Jen Booton (Booton, 2017).

In her post, Jen identifies the main technology storylines of 2017. Regarding wearable technology, due to the increase in its use, the NBA has imposed limits on the scope of data provided by such equipment. Data can only be used to monitor players' health and performance, and it is prohibited to use it for commercial purposes or contract bargain and to make it public.

Another added technological innovation was the emergence of VR. VR was intended to improve the experience of fans and refereeing. The NBA broadcasts to more than 200 countries and VR allows fans to watch games from the first row or the most spectacular angles, enabling every fan to feel like he/she is in the arena. In 2017, once a week, a regular season game would be made available in VR to NBA League Pass users.

But the use of VR goes beyond the fan's experience; it is also aimed at refereeing. In this context, the NBA has decided to use VR and data-driven analytics to recruit and train referees, since it is capable of monitoring the accuracy of calls made by referees and, consequently, tracking the amount of errors made (Booton, 2017). In the NFL, referees have a VR training platform.

However, the role of technology with regard to refereeing does not end there. In the 2014-15 NBA season, the NBA Replay Centre was launched. The Replay Centre provides the officials with the best angles to inform their calls, the objective being to improve the accuracy and response time of the calls. According to the NBA's official website, the Replay Centre is equipped with 94 HD monitors and bandwidth capacity to download the entire digitized Library of Congress (more than 158 million documents) in over 30 minutes.

In the Replay Centre, there are 17 replay operator stations and 3 replay manager stations making up a total of 20 work stations, not including the referees. To make this possible, all 29 NBA arenas are connected to the Replay Centre, which allows every fan in the arena to see the same replays that the officials are watching and contributes to a better understanding of why the call was made. Last season, the NBA decided to expand the role of this facility by enabling active referees in the Replay Centre to make the calls after review in every case except for player altercations or flagrant fouls, as stated in the NBA's official website. With greater responsibility in making judgement calls and an optimized process to display the replays, the average review time dropped from 42 to 31.9 seconds.

Currently, all in-game statistics displayed on the NBA official website are provided by SportVU, a player tracking system. Each arena used by the NBA has six cameras that capture the exact position of every player and ball at a rate of 25 frames per second. The data provided by this system is analysed and stored within specific software, enabling data to be shared in real time. With the use of this tracking system, not only is it possible to provide precise data that is not accessible in other ways, but it is also shared with teams and some media outlets like ESPN or Bleacher Report. Some examples of complex data recorded by SportVU are the amount of touches per 100 possessions by each player, the shooting percentage of the opposite team while a certain player is on the court, or even the percentage of rebounds won by a player when facing opposition. These statistics provide more detail than ever and enable a greater understanding of the game instead of the usual number of points, rebounds and assists by each player. The main advantage of data being provided in real time is that it feeds information to the coaching staff that can lead to possible changes in the line-up, as a result of what is happening in the game, which supports decision-making during the game.

2.2.5.2. IoT in Basketball

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 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.

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 (Weartesters, 2017) (Evo1, 2017).

Figure 15. Evo one smart basketball

Wilson X

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 10ft 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 different shot angles or locations within the same range which could be very useful especially for players who shoot better from different positions (O'Kane 2015).

Figure 16. Wilson X smart basketball

Figure 17. Wilson X application modes

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 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.

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.

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 (Fritz 2014).

Figure 18. 94fifty gear

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 (Tomislav Rupčić, Ljubomir Antekolović, Damir Knjaz, Bojan Matković & Cigrovski, 2016).

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 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 10ft 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.

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. ShotTracker gear

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 customise workouts to the needs of each player (ShotTracker 2017).

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. Hoop tracker gear

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 minimise 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 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 analyse 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 (Isom 2014).

Figure 21. Hoop tracker features

The software also comes with some fun games that will keep the player engaged while improving his/her skills, such as the 3pt challenge, the all FG mode or the 100pt challenge (Hooptracker 2017).

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.

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 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 (Luteberget, Spencer, & Gilgien, 2018).

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 judgement, 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 2014-15 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 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 (Newcomb 2016).

Figure 22. Catapult's ClearSky T6

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 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 filter data by different variables like court placement, player name or even made or missed shot, for example.

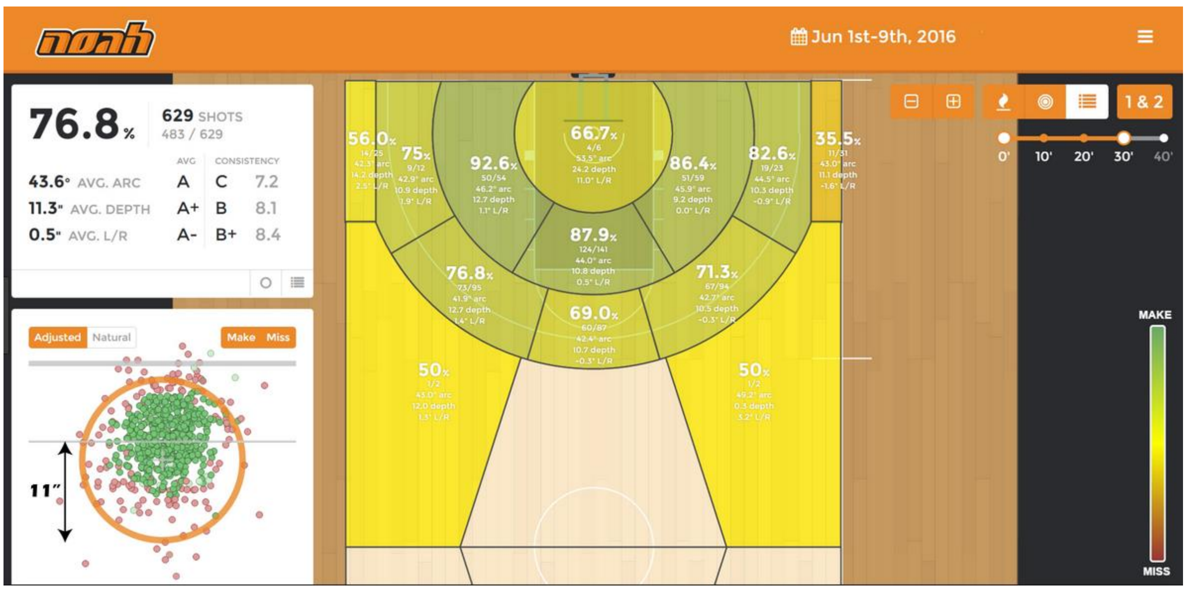

Figure 23. Noahlytics entry attributes

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 (Noah, 2017).

By way of summary, a compilation of the metrics that are captured by each device is shown in table 3.

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

Table 3. Metrics measured by current devices

3. METHODOLOGY

3.1. DSR

A review of current literature reveals some differences in the definitions proposed for Design science research. Nevertheless, in every study the same premise is found; the objective of this methodology is to build an artifact that enables a gain in performance, the completion of a specific task or the generation of better understanding that facilitates the satisfaction of existing needs. The artifact goes through rigorous evaluation to assess its feasibility and usefulness concerning the problem which it was built to resolve. Design science research is therefore a suitable methodology for the purpose of this report since in order to validate what is proposed an implementation is not required, that is, there are other mechanisms that can be used to evaluate the suggestions made (Hevner, March, Park, & Ram, 2004).

DSR has four types of artifacts: constructs, models, methods and instantiations. A construct is an artifact that arranges the vocabulary of a domain by giving it shape. It is used to describe the problems within a domain and specify the corresponding solutions by defining terms that should characterize tasks. A model is a set of elements that expresses the relations between constructs. Models concern usefulness and not feasibility, as they need to capture reality's structure to present a useful representation. A method is a group of steps designed to perform a specific task. It uses a number of constructs and the associated model. The purpose is to transform a model in a resource to solve a problem. Finally, instantiation is the implementation of the artifacts in their environment. It gives the previously determined constructs, models and methods, an opportunity to be implemented in a real environment, giving the user an overview of its feasibility and efficiency (Lacerda, Dresch, Proença, & Antunes Junior, 2013).

Furthermore, Design science research is divided into five steps or phases. The first one is problem awareness, where the problem or challenge to be addressed is identified. This is followed by suggestion, where the objectives for the solution are defined. The third step is the development of the actual artifact. Next is the evaluation, where the artifact is analyzed and tested in the conditions proposed for validation. Lastly, it is in the reflection phase that the artifact is updated and the results are discussed. If in this phase, the conclusion is reached that the proposed solution was insufficient to resolve the problem, a new cycle begins (Hevner et al., 2004).

Figure 24. Design Science Research cycle (from Mendonça 2015)

3.2. STRATEGY OF THE RESEARCH

The strategy of design science research relies on the aforementioned five phases. Below is the application of these phases to the topic at hand.

In the problem awareness phase, the obstacle to be overcome is identified as the lack of efficiency gain in the jump shot technique with the advancement of technology. The literature review carried out for the purpose of this report, indicates that the metrics measured by current devices and the content of provided feedback, do not give the required support to improve shooting performance.

In the second phase, the suggestion is made that in order to see improvement in shooting technique and consequently accuracy, players need to have a better understanding of what they might be doing wrong and how they can make successful adjustments. This information is supposed to be captured and displayed by inertial sensors.

The third phase is where the actual development of the artifact matrices for amateur and professional levels takes place.

The fourth phase is the evaluation of the artifacts and given the lack of knowledge of the general population about this technology and the details of jump shooting technique, interviews took place to validate the quality of the proposed artifacts.

The fifth phase is the reflection stage, where proposed artifacts are updated according to input generated from the evaluation and results are shared.

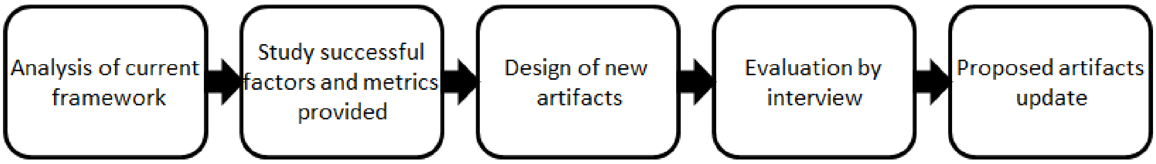

Figure 25. Design Science Research methodology adopted to current investigation

4. PROPOSALS, RESULTS AND DISCUSSION

4.1. ASSUMPTIONS OF THE PROPOSED ARTIFACTS

In a literature review on the jump shot (Victor H A Okazaki et al., 2015), it was concluded that ball trajectory is explained by the player's gesture upon the act of shooting. In addition, it was shown that there are external factors that have a direct impact in shooting motion such as the level of fatigue of a player or the opposition he/she is facing while performing his/her shot. The sensors and metrics presented in Table 4 provide evidence that there is a focus on the measurement of ball trajectory and shot's success, but the behavior that precedes and results in any given outcome is being neglected. There is not a single metric evaluating the player's gesture.

	Current	Smart ball	Net sensor	Wrist sensor	Hoop sensor	Smart watch	Backboard sensor	ClearSky T6
Shot outcome and location	Made or miss	Tracks if the shot was successful (requires net)			Tracks if the shot was successful	Tracks if the shot was successful	Tracks if the shot was successful	
	Entry angle						Measures entry angle when ball reaches the hoop	
	Shot depth						Measures ball depth when reaching the hoop	
	Left-right position						Measures lateral position of the ball within the hoop	
	Other variables	Shot arc, ball rotation	Made or miss	Shot attempt		Shot attempt and location	Shot attempt and location	
Shooting mechanic	Distance between feet							
	Weight distribution by both feet							
	Jump height							
	Jump height at release							
	Elbow angle (extension at release)							
	Wrist angle (flexion at release)							
	Shoulder angle							
	Vertical trunk inclination							
	Wrist/elbow/shoulder allignment							
	Shot follow through							
Additional factors	Fatigue							Measure heart rate and PlayerLoad
	Opposition							

Table 4. Present Artifact Matrix

Knowing shot location and accuracy helps to obtain a better understanding of where players are performing at a higher level, nevertheless, it does not show what was done wrongly and how it can be improved. Given that there has already been a large focus on ball trajectory, the following suggestions will rely heavily on the physical movements of the player upon the act of shooting (shooting mechanics) and the factors that can lead to differences in this behavior. In this endeavor, the findings from the literature review on the jump shot have been taken into account.

Wristband sensor

From the studied devices, only the ShotTracker used a wristband to count the number of shot attempts made by a player. But while this already helpful, it could be explored further. If extra sensors were incorporated into the wristband, which is feasible due to the increasingly smaller sizes of these devices, important data like release height and wrist angle at release could be obtained. As previously stated, release height in combination with release angle, are key factors that help to explain the angle of entry of the ball into the basket.

Another valuable usage of the wristband might be to evaluate how the player performs when facing an opponent. By determining the closeness between the player's shooting hand and the hand of the defensive player as well as the height of the blocking attempt, it will be possible to gain a greater understanding of how shooting mechanics are influenced by opposition and its consequences on ball trajectory.

Metrics: release height, wrist angle, closeness of contest, height of contest, shoulder/elbow/wrist plane

Vert sensor

The Vert sensor has the ability to track the jumping activity of an athlete as it retrieves the maximum height achieved during the jump. It would be very useful to have communication between the vert sensor and the wristband at release; this way it would be possible to know the exact jump height reached by the player at release and how close it is to the desired value which is the maximum, as the player should release the ball at the peak of the jump. The reliability of this sensor has already been tested, and it was considered fit to measure jump height in in-game situations for both basketball and volleyball. It also has the ability to provide real time feedback (Mahmoud, Othman, Abdelrasoul, Stergiou, & Katz, 2015) (MacDonald, Bahr, Baltich, Whittaker, & Meeuwisse, 2017).

Metrics: maximum jump height, jump height at release

Sleeve sensor

Nowadays, it is possible to measure joint angle with high precision using low-cost wearable inertial sensors (El-Gohary, 2013). Elbow extension plays a major role in release height and release angle. Since the sleeve is a common accessory in basketball with no scientific use, it would be helpful to integrate an inertial sensor into the sleeve that could correctly measure the elbow's angle at release, by communicating with the wristband sensor.

Metric: elbow angle, shoulder/elbow/wrist plane

Jersey sensor

Currently, jerseys are also only being used as an accessory without any scientific advantage. As suggested for the sleeve, if a sensor was integrated in the shoulder joint, it would allow the tracking of the shoulder angle at release. Trunk inclination should be close to vertical at release, as this is a performance characteristic seen in expert players. Another good practice drawn from the observation of expert players in action is having the shoulder, elbow and wrist aligned in the same plane of motion (Victor H A Okazaki et al., 2015). It is important to note that metrics like trunk inclination and shoulder joint angles have already been studied with the use of sensors (Bergamini et al., 2013; Gert S. Faber, 2005; Yoon, 2017) and therefore it would be theoretically feasible to measure them through sensor integration into the jersey as suggested above.

Metrics: shoulder angle, trunk inclination, shoulder/elbow/wrist plane

In this report, two artifact matrices will be presented, one for amateur level and one for professional level. The main difference between them is that for professional level it is assumed that players train in indoor facilities that are fully capable of having technology like catapult or Noahlytics installed. On the other hand, amateur level recommendations do not require facilities to perform measurements.

Smart ball

From the list of analyzed devices, the smart ball that offers the most comprehensive variety of metrics measurements is the 94fify. The ability of the ball to measure release speed, shot arc and ball rotation at once make this product very useful to amateur players that do not have access to the tools and technology made available to professional athletes. Furthermore, its ability to autonomously identify if the shot was successfully made, coupled with the metrics previously mentioned, provide a great level of detail when merged with metrics seen for previous wearable sensors.

Metrics: shot arc, ball rotation, made or miss

Noahlytics

Noahlytics has revolutionized shooting tracking in basketball. The detail of the metrics it measures is so great that new factors that influence shooting performance have been identified (Marty & Lucey, 2017). By merging the metrics of this system with shooting metrics captured by wearable inertial sensors, it is possible to establish the relation between ball trajectory and shooting motion. For the first time, analysts will be able to have detailed input on the end to end process of the jump shot. By running appropriate statistical tests, patterns can be discovered based on statistical evidence of how shooting parameters explain trajectory elements.

Metrics: shot location, entry angle, shot depth, left-right position

Catapult

One factor that was shown to influence shooting mechanics is fatigue. It was demonstrated that fatigue has an impact on the ability of muscles to respond to physical exertion, resulting in a decrease of the elbow joint angle that causes lower angle and wrist height at release and lower jumping ability. This being said, researchers failed to identify a correlation between fatigue and shooting accuracy. Since the metrics used were heart rate and other such factors, it would be interesting to see if a more complex metric like PlayerLoad that is an acceleration-based metric unlike the regular distance-based ones, could have different results in this regard.

Metrics: PlayerLoad, heart rate

Figure 26 and table 5 show at what point each shooting mechanic metric will be measured by the corresponding sensor.

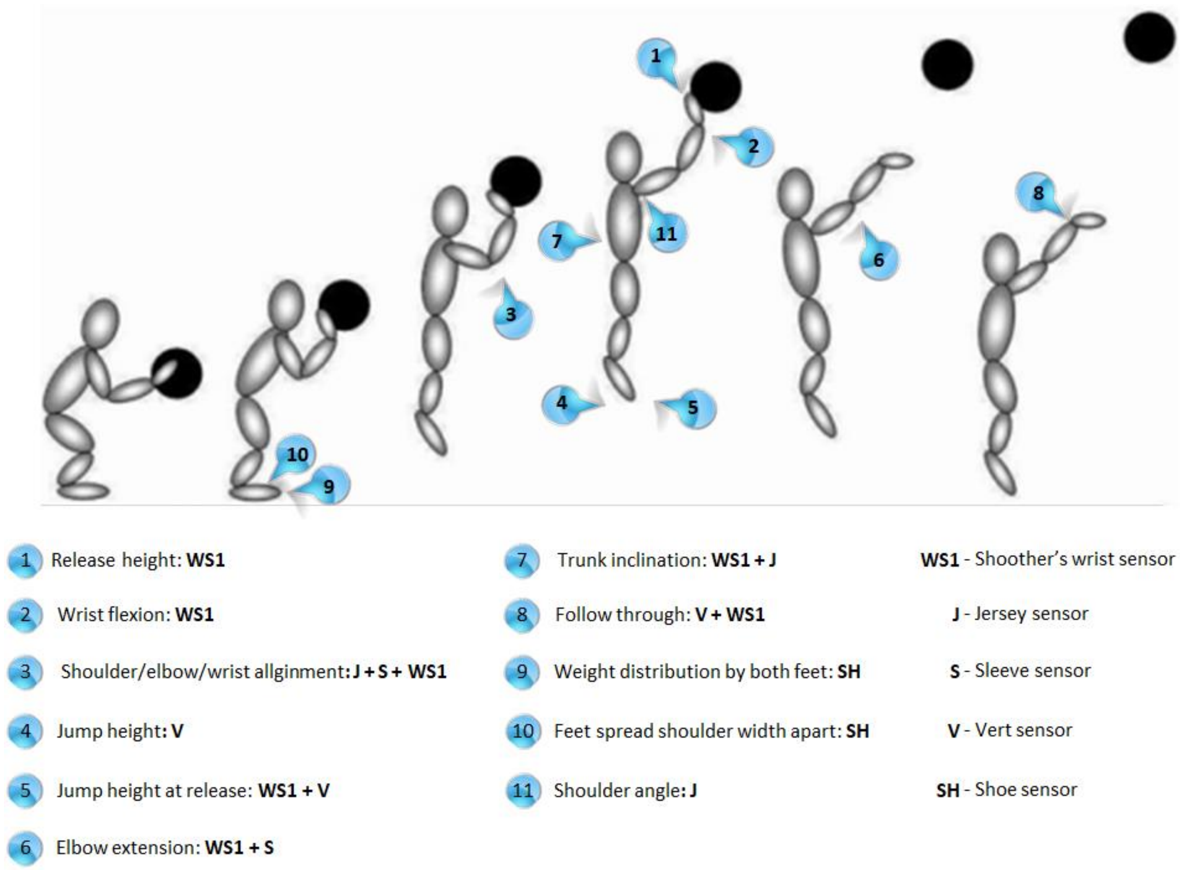

Figure 26. Suggested use of sensors for the measurement of metrics

	Phases					Sensors					
Metrics	**Preparation**	**Ball elevation**	**Stability**	**Release**	**Inertial**	**Jersey**	**Vert**	**Sleeve**	**Wrist (player)**	**Wrist (opponent)**	**Shoe**
Release height				✓					✓		
Wrist flexion				✓					✓		
Opponent proximity				✓					✓	✓	
Height of opponent's contest				✓					✓	✓	
Shoulder/elbow/wrist alignment			✓	✓		✓		✓	✓		
Jump height			✓	✓			✓				
Jump height at release				✓			✓		✓		
Elbow extension				✓				✓	✓		
Trunk inclination				✓		✓			✓		
Followthrough					✓		✓		✓		
Weight distribution by both feet		✓									✓
Shoulder angle				✓		✓					

Table 5. Suggested measurement of metrics by phase and sensor

Feedback

By comparing the devices under analysis in what concerns audio feedback, it is possible to conclude that audio feedback is given based on the outcome of the shot. It is either provided in the form of 'beeps', as in Evo One, to stimulate muscle memory or by giving the exact metrics concerning how the ball went through the rim, as in Noahlytics. Even though this type of feedback allows players to create muscle memory, it is not the most advised. This is because the majority of users that are training to improve their jump shot are not expert players, so the possibility that they do not possess a good understanding of how each movement impacts the outcome of the shot must not be ignored. Taking into account that today's technology enables the monitoring of players' shooting mechanics, valuable feedback can be provided in this regard.

In 1993, a study was conducted to demonstrate how to provide appropriate feedback concerning the jump shot technique. Six key technique points were identified as critical in the shooting motion and adequate feedback was determined for each based on understandable terms. As an example of what was proposed, for the two critical points "optimize height of release" and "ball rotation", the suggested terms to use in the feedback were "extend at the top of the jump" and "flip the fingers" under the ball at release, respectively (Knudson, 1993). Comprehensible feedback as illustrated above can improve the understanding of the player and generate knowledge on the best practices of the jump shot. Table 6, shows the suggested audio feedback for different metrics.

Metrics	Feedback
Release height	"Extend at the top of your shot"; "Don't forget to use your legs"
Wrist flexion	"Flip the fingers under the ball"; "Flex your wirst at release"
Jump height at release	"Release the ball at the peak of your jump"
Elbow extension	"Extend at the top of your shot"; "Extend the elbow at release"
Trunk inclination	"Keep your upper body straight"

Table 6. Audio feedback suggestions

4.2. Proposed Artifacts

In the following tables the two proposed artifact matrices, one for the amateur level and one for the professional level, are presented in summary form.

	Amateur	Smart ball	Wristband sensor	Vert sensor	Sleeve sensor	Jersey sensor	Shoe sensor
Shot outcome and location	Made or miss	Tracks if the shot was successful (requires net)					
	Entry angle						
	Shot depth						
	Left-right position						
	Other variables	Shot arc, ball rotation	Shot attempt and location				
Shooting mechanic	Distance between feet						Measure right before jump
	Weight distribution by both feet						Measure force generated at jump motion
	Jump height			Measure max height of the jump			
	Jump height at release		Provide release exact moment	Measure height of the jump at release			
	Elbow angle (extension at release)		Provide release exact moment		Measure the angle of the elbow during release		
	Wrist angle (flexion at release)		Measure the angle of the wrist during release				
	Shoulder angle		Provide release exact moment			Measure shoulder angle at release	
	Vertical trunk inclination		Provide release exact moment			Measure trunk inclination at release	
	Wrist/elbow/shoulder allignment		Provide release exact moment			Track wrist/elbo/shoulder plan at release	
	Shot follow through		Measure wrist angle at landing (follow through)	Indicate when the jump has ended			
Additional factors	Fatigue						
	Opposition		Measure height and closeness of contest				

Table 7. Future artifact matrix for amateur level

	Professional	Wristband sensor	Vert sensor	Sleeve sensor	Jersey sensor	Shoe sensor	Backboard sensor (Noahlytics)	Catapult (ClearSky T6)
Shot outcome and location	Made or miss						Tracks if the shot was successful	
	Entry angle						Measures entry angle when ball reaches the hoop	
	Shot depth						Measures ball depth when reaching the hoop	
	Left-right position						Measures lateral position of the ball within the hoop	
	Other variables						Shot attempt and location	
Shooting mechanic	Distance between feet					Measure right before jump		
	Weight distribution by both feet					Measure force generated at jump motion		
	Jump height		Measure max height of the jump					
	Jump height at release	Provide release exact moment	Measure height of the jump at release					
	Elbow angle (extension at release)	Provide release exact moment		Measure the angle of the elbow during release				
	Wrist angle (flexion at release)	Measure the angle of the wrist during release						
	Shoulder angle	Provide release exact moment			Measure shoulder angle at release			
	Vertical trunk inclination	Provide release exact moment			Measure trunk inclination at release			
	Wrist/elbow/shoulder allignment	Provide release exact moment			Track wrist/elbo/shoulder plan at release			
	Shot follow through	Measure wrist angle at landing (follow through)	Indicate when the jump has ended					
Additional factors	Fatigue							Measure heart rate and PlayerLoad
	Opposition	Measure height and closeness of contest						

Table 8. Future artifact matrix for professional level

4.3. VALIDATION

The validation of the proposed artifacts in this report was conducted via interview. Since the technology topic is specific, instead of using a questionnaire it was decided that the interview method would be more suitable as the interviewer would be able to give context and collaborate with the interviewee during the process.

4.3.1. Target Audience

The target audience for the interviews was current or former basketball players, coaches or journalists. The probability of these groups having a better understanding of what technology could benefit the players' shooting mechanics is greater than the common sports fan. In principle, by interviewing players and coaches with different levels of experience, conclusions might be drawn on how the level of expertise is related to the openness to the adoption of technology for training performance.

4.3.2. Sample

As mentioned before, the sample was composed of former players and coaches, basketball personas that are related to the sport. However, due to the absence of response when contacting professional teams and network stations, the only participants in the interview process were of an amateur level. Although this does not mean that the interviewees were not qualified to participate in the study or able to provide adequate feedback, it would nonetheless have been extremely useful and relevant to compare and contrast the points of view of amateur and professional athletes and coaches. This is therefore seen as a limitation in this report.

The volunteers that participated in the interviews were two former players with different levels of experience, one former coach with significant experience as a player and one current coach with a high level of experience.

Participant	Gender	Age	College player	Club player	Coach
1	M	24	2		
2	M	25	2	5	
3	M	42		12	6
4	M	50		15	20

Table 9. Overview of personal information and basketball experience

Variables used in table 9:

- Participant: ID of the participant
- Gender: M for male, F for female
- Age: age of the interviewee in years
- College player: number of years played in college
- Club player: number of years played in a club

- Coach: number of years in a coaching capacity

4.3.3. Summary of interview guide

The purpose of the interviews was to validate the recommendations about how current and new technology can improve jump shooting performance. The first page was designed to welcome the interviewee, give some context on the objective of the study and collect personal information such as the age and gender of the participant as well as the level of expertise/experience in the area. The following question introduced the devices under analysis in the literature review and asked the interviewee to identify which devices he had knowledge of. The next question required the participant to examine tables 3 and 4 which show every metric calculated by each sensor currently in use and, upon examination of the data, state whether he believed the metrics were relevant to the improvement of shooting mechanics and justify the answer.

In the following question, the interviewee was presented with another table (table 10), where the metrics considered relevant in this literature review were displayed. He was then asked to assess each metric according to how relevant it is to the success of the jump shot. To do so, the following Likert scale was provided: 1 – Strongly Disagree, 2 – Disagree, 3 – Agree, 4 – Strongly Agree. This particular version of the scale was chosen because it was even and did not offer a neutral answer. Since there is sometimes a tendency of respondents to pick this answer to avoid further justification, this option was removed so that the interviewer could receive as much feedback as possible from the participants.

I consider that ... is relevant / has influence in the sucess of the jump shot	Strongly disagree	Disagree	Agree	Strongly agree
Release height				
Wrist flexion at release				
Opponent proximity				
Height of opponent's contest				
Shoulder/elbow/wrist alignment				
Jump height				
Jump height at realease				
Elbow extension				
Trunk inclination				
Weight distribution by both feet				
Feet spead shoulder width apart				
Shoulder angle				

Table 10. Interviewees' views on the impact of suggested metrics on the success of the jump shot

After tables 7 and 8 were presented and analyzed, the respondent was asked if merging the metrics from the literature review with the ones that are currently being measured by existing products (displayed in the tables), would bring value to the athlete and respective coaching staff concerning the athlete's jump shooting performance.

In the question that followed, the respondent was asked if audio feedback should be given from an outcome perspective such as the angle of entry of the ball into the basket or the exact location where it went in, or if it should be about the act of shooting focusing on behavior corrections. Immediately after this, a table was presented with examples of audio feedback for different metrics, and the interviewee was then asked to identify which were relevant and could lead to corrections in the act of shooting the basketball.

Finally, the last question was an open one, inviting the participant to suggest new metrics that could be added to the proposed artifacts as well as new uses that could be assigned to current devices or new sensors altogether, drawing from his knowledge and experience, and from the data set before him.

Section	Description
Personal data	This section is filled with interviewee's personal data like gender, age and years of experience of the subject
Current artefacts	The respondents will identify the artefacts he knows and will evaluate the ones in study
Factors of success behind a jump shot	The respondents will grade the proposed metrics according to importance for the success of a jump shot
Evaluating the proposed framework	After presenting the proposed frameworks, the interviewees will provide feedback on its utility
Audio feedback	Respondents elaborate on the expected type of feedback and identify relevant metrics for this purpose
Suggestions to usage of artefacts	The participants suggest new uses for current artefacts or new artefacts to monitor different metrics

Figure 27. Summary of the interview's sections

4.3.4. Results

In the first section, the interviewees were asked to identify the devices that they had knowledge of and assess the value of the metrics that they captured for the improvement of shooting performance. To do so, tables (3 and 4) were presented. Overall, it became clear that the respondents were largely unfamiliar with the devices and sensors included in this report. This is one of the reasons why it was deemed important to conduct an interview instead of handing a questionnaire, as the interviewer had the opportunity to explain in detail the purpose and functioning of every artifact including how the metrics were calculated. Great care was taken to supply only clear, objective and necessary information to the participants so as to not even hint at the personal views and opinions of the interviewer. This was done in order to reduce as much as possible the introduction of bias in the responses.

With a more informed perspective of what was being studied, the responses of all participants on the whole pointed in the same direction. They stated that although the metrics under analysis provided a good understanding of the locations where the player was more efficient, they did not help the athlete to improve his shooting technique. It was expressed that even though the player could access his/her historical track record, to see how he/she was evolving, the gadgets did not point out the aspects of his/her gesture that might need some adjustments. Player 1 added that nowadays technology is able to extract even more information than the metrics currently captured and stated that if sensors were combined, there would be a better understanding of the process as more information would be available. Player 2 highlighted that data provided by these instruments is still raw and unable to translate into information that can lead to the improvement of the player's shooting performance. Coach 1 considered Catapult's PlayerLoad fatigue metric as an interesting one that may explain differences in the shooting motion, nonetheless, he could not see how metrics like made or missed shots, gave any advantage when trying to improve shooting technique.

In the section of the interview that followed, participants were asked to grade the metrics identified in the literature review. The table used was table 10; the results were compiled and shown below in table 11.

Interviewees	Minimum	Maximum	Average	Standard deviation
Release height	3	4	3,50	0,58
Wrist flexion	3	4	3,75	0,50
Opponent proximity	3	3	3,00	0,00
Height of opponent's contest	3	4	3,25	0,50
Shoulder/elbow/wrist allginment	3	4	3,75	0,50
Jump height	2	4	2,75	0,96
Jump height at release	3	4	3,50	0,58
Elbow extension	3	4	3,25	0,50
Trunk inclination	2	4	3,25	0,96
Weight distribution by both feet	3	4	3,25	0,50
Feet spread shoulder width apart	2	3	2,50	0,58
Shoulder angle	3	3	3,00	0,00

Table 11. Interviewees' assessment of the metrics

Examination of the results indicates that, overall, "Jump height" and "Feet spread shoulder width apart" are not considered as relevant as the other metrics; and created some disagreement. In order to understand whether opinions differed between levels of expertise, and knowing that players are not as experienced as coaches, the results were split by group as shown below:

Players	Minimum	Maximum	Average	Standard deviation
Release height	4	4	4,00	0,00
Wrist flexion	3	4	3,50	0,71
Opponent proximity	3	3	3,00	0,00
Height of opponent's contest	3	4	3,50	0,71
Shoulder/elbow/wrist allginment	4	4	4,00	0,00
Jump height	3	4	3,50	0,71
Jump height at release	4	4	4,00	0,00
Elbow extension	3	4	3,50	0,71
Trunk inclination	4	4	4,00	0,00
Weight distribution by both feet	3	4	3,50	0,71
Feet spread shoulder width apart	3	3	3,00	0,00
Shoulder angle	3	3	3,00	0,00

Table 12. Players' assessment of the metrics

Coaches	Minimum	Maximum	Average	Standard deviation
Release height	3	3	3,00	0,00
Wrist flexion	4	4	4,00	0,00
Opponent proximity	3	3	3,00	0,00
Height of opponent's contest	3	3	3,00	0,00
Shoulder/elbow/wrist allginment	3	4	3,50	0,71
Jump height	2	2	2,00	0,00
Jump height at release	3	3	3,00	0,00
Elbow extension	3	3	3,00	0,00
Trunk inclination	2	3	2,50	0,71
Weight distribution by both feet	3	3	3,00	0,00
Feet spread shoulder width apart	2	2	2,00	0,00
Shoulder angle	3	3	3,00	0,00

Table 13. Coaches' assessment of the metrics

It is possible to conclude that coaches believe these two metrics are not relevant, and that the disagreement is related to the level of expertise.

The section after, contained tables (7 and 8) which referred to the two proposed artifact matrices, one for the amateur level and one for the professional level. When asked if they believed that with the suggested new use of current and new technology, there could be an improvement in shooting performance caused by adjustments in the shooting technique, the responses were positive. The respondents unanimously agreed that by adding these metrics, users would gain a better understanding of what could be improved in their shooting gesture. They also believed that by having this much information, it would be possible to find out if the outcome attributes of the shot, like the angle of entry of the ball, could be explained by analysing the attributes related to the act of shooting.

Player 1 showed some reluctance about the use of that many sensors, insisting that they must not have the slightest effect on the player while performing the shot. Player 2 stated that, from his perspective, the implementation of such artifact does not seem necessary at the amateur level, because he believed that the players' main objective at that level was to compete in a healthy environment and develop team spirit, which did not require the use of this type of technology. Furthermore, he added that the data collected by this network of connected sensors would require analyses of a technical or expert player to generate knowledge among the users.

In the audio feedback section, interviewees were asked to elaborate on what type of feedback they considered to be more relevant to improve shooting performance i.e. knowing about the shot outcome or receiving tips about their gesture while shooting. In this question, both the players and the coaches agreed that the second type of feedback would benefit players more because an improvement in shooting technique would ultimately translate into an improvement in the outcome of the shot. Still, one of the coaches stated that for expert players with already established shooting mechanics, this type of feedback would not be useful and receiving feedback about the outcome would be more appropriate.

After this, the participants were shown a table with the gestures that could be corrected and the terms used to do so. Respondents unanimously agreed that this would make sense for wrist flexion, jump height at release and elbow extension. Release height was identified as a dependent variable of elbow extension and wrist flexion, and the interviewees agreed that receiving specific feedback about the adjustments to be made would benefit the player. Feedback about trunk inclination was not found useful to correct the player's shooting technique.

In the final question of the interview, the respondent was asked to suggest some new metrics or new uses for current or new sensors. On the whole, the respondents seemed to be somewhat overwhelmed and failed to suggest the use of new technologies. However, when it came to new metrics, three factors were identified – release velocity, ball rotation and players' emotional status.

4.4. DISCUSSION

After analysing the answers given by the interviewees, it is clear that technology can play an important role in the improvement of basketball jump shooting performance. By and large, the respondents agreed with the suggested metrics, and even the factors that were not consensual, on average, were considered relevant. While looking at the proposed artifacts, one respondent pointed out that the amateur artifact might not make sense as the motivations of amateur athletes and their age would likely not justify such an investment. This view may be explained, at least to a certain extent, by the fact that this sample consisted only of Portuguese participants, and sport in Portugal is associated to a great degree, if not almost entirely, with football. As far as basketball is concerned, first league matches are not even given television broadcast. In light of this, many may not see the need to go to the trouble and expense of incorporating some of the studied technology into the Portuguese teams, even those in the first league.

However, the same does not occur in the United States of America. Basketball at University level is recognized worldwide and it is estimated that this year, its tournament (March Madness) has been broadcast to more than 97 million North American spectators and 180 countries, according to the NCAA official website. Given the amount of funds involved in amateur basketball, as well as the fact that the best players in the world are eligible for the draft to join the NBA, it makes senses that the preparation for it would be carried out in great detail and amateur players would have at their disposal the best technological tools to optimize their performance.

The same respondent drew attention to the fact that data collected by the proposed instruments was not easily interpretable and might need some support from an expert player or even a technical staff member. This is why it is suggested to implement audio feedback; with this tool, the player would know exactly what he/she must adjust to improve his/her performance, requiring less analytical skill.

Following the analysis of tables (11, 12 and 13), it is possible to conclude that coaches did not consider “Jump height” and “Feet spread shoulder width apart” relevant metrics to explain the success of the jump shot. For this reason, both metrics are going to be excluded from the proposed artifacts. For audio feedback, the proposed table was also updated as respondents did not find the “Release height” and “Trunk inclination” feedback useful for the improvement of shooting performance.

With respect to the final question, when asked for suggestions regarding metrics that could bring value to shooting performance and new usage of current or new sensors, respondents focused on three metrics – release velocity, ball rotation and emotional status. When it comes to technology, participants were not able to identify by what instruments these metrics should be measured.

Release velocity was one of the factors studied in the literature review; however, it was not included in the artifacts because there was not a consensus on how this metric should be interpreted. From one perspective, lower release velocities are linked to greater movement accuracy, and as a result there is less variability in the movement of body segments leading to greater consistency (Victor H A Okazaki et al., 2015). On the other hand, some claim that greater release velocities allow the player to shoot without facing opposition; the argument being that even if the player is being closely opposed, if he/she has a quick release, the opponent will not have time to contest and the adjustments that would be needed when facing an opponent may not be required. Since the interpretation of this metric was not clear, it was decided to not include it in the proposed artifacts. Nonetheless, as pointed out by the respondents, the combination of this metric with others can translate into new information and some patterns can be identified between the release velocity and the players shooting mechanics, mainly while facing opposition (one factor taken into account in the proposed artifacts). For this reason, the metric will be taken into account in the updated artifacts.

Ball rotation was initially only being considered for the amateur level because Noahlytics provides a great amount of outcome variables. Nonetheless, the respondents believed this factor could be used to complement outcome variables and should be included. For this reason, the smart ball sensor was added to the proposed professional level artifact, to measure release speed and ball rotation.

The other metric that was suggested by the respondents to be added to the artifacts is the emotional status of the player. Basketball is a game of sprints which means that teams can score a lot of points without response and, after adjustments made by the opposing coach; they can concede as many points in a row. In addition, in a basketball game, players are always attacking against the clock as each team’s ball possession only lasts 24 seconds. For these reasons, players are asked to perform under pressure a great number of times in a single game, and players who are mentally strong and sharp tend to perform better in late game situations. The confidence level of a player can fluctuate between possessions; whether by getting dunked on by another player or by being taunted after a blocked shot, these actions can cause the player to “hide” from the game and not feel confident to take the shot. By being able to have access to the emotional status of the player, coaches would be in a better position to decide which players remain confident enough to take the shots in late game situations.

It would also be important to analyse the adjustments made by players in their shooting mechanics, when feeling emotionally unstable or excessively stressed from being under great pressure. For this reason, it was decided to add this metric to the proposed artifacts.

In this context, Muse’s headband is a device that registers brains’ signals through a variety of sensors. By using all of its 7 sensors, this headband measures brain activity and has the ability to keep one informed about his/her progress, translating brain signals into sounds (Muse 2017). Even though in sports there is not much technology used for this purpose, this device is evidence that one of the next steps of wearable technology can be monitoring the players’ emotional status and its effects on performance. As in basketball, the headband is a usual accessory that would not have implications in the shooting motion; therefore it would be feasible to adopt this artefact. The purpose for using this device in this study would be to measure brain activity and search for patterns between this and shooting performance.

The updated artifacts matrices are shown below, as well as the audio feedback table, with feedback resultant from the validation method.

	Amateur	Smart ball	Wristband sensor	Vert sensor	Sleeve sensor	Jersey sensor	Shoe sensor
Shot outcome and location	Made or miss	Tracks if the shot was successful (requires net)					
	Entry angle						
	Shot depth						
	Left-right position						
	Other variables	Shot arc, ball rotation, release speed	Shot attempt and location				
Shooting mechanic	Weight distribution by both feet						Measure force generated at jump motion
	Jump height at release		Provide release exact moment	Measure height of the jump at release			
	Elbow angle (extension at release)		Provide release exact moment		Measure the angle of the elbow during release		
	Wrist angle (flexion at release)		Measure the angle of the wrist during release				
	Shoulder angle		Provide release exact moment			Measure shoulder angle at release	
	Vertical trunk inclination		Provide release exact moment			Measure trunk inclination at release	
	Wrist/elbow/shoulder allignment		Provide release exact moment			Track wrist/elbo/shoulder plan at release	
	Shot follow through		Measure wrist angle at landing (follow through)	Indicate when the jump has ended			
Additional factors	Fatigue						
	Opposition		Measure height and closeness of contest				
	Emotions						

Table 14. Updated artifacts' matrix for amateur level

	Professional	Smart ball	Wristband sensor	Vert sensor	Sleeve sensor	Jersey sensor	Shoe sensor	Backboard sensor (Noahlytics)	Catapult (ClearSky T6)	Headband sensor
Shot outcome and location	Made or miss							Tracks if the shot was successful		
	Entry angle							Measures entry angle when ball reaches the hoop		
	Shot depth							Measures ball depth when reaching the hoop		
	Left-right position							Measures lateral position of the ball within the hoop		
	Other variables	Ball rotation, release speed						Shot attempt and location		
Shooting mechanic	Weight distribution by both feet						Measure force generated at jump motion			
	Jump height at release		Provide release exact moment	Measure height of the jump at release						
	Elbow angle (extension at release)		Provide release exact moment		Measure the angle of the elbow during release					
	Wrist angle (flexion at release)		Measure the angle of the wrist during release							
	Shoulder angle		Provide release exact moment			Measure shoulder angle at release				
	Vertical trunk inclination		Provide release exact moment			Measure trunk inclination at release				
	Wrist/elbow/shoulder alignment		Provide release exact moment			Track wrist / elbow / shoulder plan at release				
	Shot follow through		Measure wrist angle at landing (follow through)	Indicate when the jump has ended						
Additional factors	Fatigue								Measure heart rate and PlayerLoad	
	Opposition		Measure height and closeness of contest							
	Emotions									Brain activity

Table 15. Updated artifacts' matrix for professional level

Metrics	Feedback
Wrist flexion	"Flip the fingers under the ball"; "Flex your wirst at release"
Jump height at release	"Release the ball at the peak of your jump"
Elbow extension	"Extend at the top of your shot"; "Extend the elbow at release"

Table 16. Updated table of audio feedback

5. CONCLUSIONS

5.1. SYNTHESIS OF THE DEVELOPED WORK

The objective of this study was to recommend new uses for current sensors and new sensors that would result in improved shooting performance in basketball. Given that this is a theoretical study, the chosen method was design science research, a methodology that relies on four major premises: the search for flaws, the making of suggestions to correct the identified flaws, the validation of the suggestions made, and lastly the update of the initial proposals taking into account the feedback received during validation.

In the first phase, the shooting factors behind a successful jump shot were identified, after which an investigation was conducted to determine what gadgets with sensor technology are currently being used and what metrics are being measured.

After comparing the indicators that are being measured by these devices with the factors behind a successful jump shot, it became evident that there is a big gap to be filled as the shooting technique metrics remain unmeasured, which is of no help whatsoever to the user when it comes to understanding how he/she can improve his/her performance.

By taking into account the metrics that need to be captured, the measuring capabilities of currently used devices and the potential uses for new ones, two artifacts were proposed, one for the amateur level and another for the professional level. In order to comprehend if the suggestions that were put forward made a real contribution to the resolution of the problem, a set of interviews was conducted.

Analysis of the results of the interviews indicates that the metrics provided by current devices enlarge the users' understanding of the locations on the court where they are more efficient and allow them to track their evolution through time; however, they provide no valuable feedback that would enable the users to improve their shooting technique.

Despite the small sample size, the results from the interviews add to the already mounting evidence that the use of IoT, having a set of sensors connected and registering specific metrics, in this context would benefit the user as he/she could have access to useful data explaining exactly how he/she is performing and what adjustments might be made to improve his/her performance. It was also mentioned that by combining outcome variables with shooting factors, relationships can be found and possibly predict the outcome of the shot based on shooting metrics.

In addition, it was concluded that audio feedback can contribute to the improvement of the shooting technique, as it enables players to correct their motion through easily understandable commands instead of hearing what they can observe themselves – the outcome of their shot. Audio feedback was considered to be particularly important to adjust wrist flexion, elbow extension and the height of the jump that led to ball release.

Finally, release speed, ball rotation and emotional status were the metrics suggested by the respondents to complement the proposed artifacts which were updated accordingly with suitable devices.

5.2. LIMITATIONS OF THE RESEARCH

As this is an academic research report, some limitations were encountered and aspects that could be improved were identified.

The major limitation concerning this study was related to the sample used for the interviews. Even though the coaches were experienced which contrasted with the players' level of experience, it would have been very useful to have participants from both amateur and professional levels as well as journalists. This would have brought in different perspectives and provided valuable feedback about diverse aspects. Furthermore, having representatives from all levels within the sport, amateur, professional and academic world could have greatly enriched the conclusions. The invitations for the interviews were sent to professional teams and sports television networks, but no answer was obtained.

Another limitation about the sample was that the respondents had no prior knowledge of the studied devices and, although the interviewer endeavoured to give them objective information in a clear and concise way about each device, participants still seemed overwhelmed and were not able to suggest new uses for current or new technology. It would have been interesting to analyse the feedback from a person with more experience in the field.

5.3. FUTURE WORK

As for the next steps, I would consider repeating the interview process with professional athletes or people used to working with technology in sports in order to compare their feedback.

The following step would be the implementation in a smaller scale of the proposed network of sensors. This would allow the collection of specific data that could help determine whether the shot outcome can be statistically predicted by mixing the proposed shooting metrics.

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ANNEXES

2000-01					2001-02				
TEAM	3PM	3PA	3P%	%PTS 3PT	TEAM	3PM	3PA	3P%	%PTS 3PT
San Antonio Spurs	5,4	13,3	40,7	16,9	Sacramento Kings	5,2	14,1	36,7	14,9
Los Angeles Lakers	5,4	15,5	34,4	16	Los Angeles Lakers	6,2	17,5	35,4	18,4
Philadelphia 76ers	3,2	9,8	32,6	10,1	San Antonio Spurs	5,3	14,8	36,2	16,6
Sacramento Kings	5,8	16,5	35,4	17,2	Dallas Mavericks	7,6	20,1	37,8	21,6
Dallas Mavericks	6,3	16,5	38,1	18,8	New Jersey Nets	4,9	14,6	33,8	15,3
Utah Jazz	4	10,4	38,1	12,3	Detroit Pistons	6,9	18,4	37,6	22
Milwaukee Bucks	6,9	18,1	37,9	20,4	Minnesota Timberwolves	4,8	12,8	37,8	14,6
Phoenix Suns	4	12,9	31,5	12,9	Boston Celtics	8,5	23,7	35,9	26,5
Miami Heat	5,8	16,9	34,5	19,7	Portland Trail Blazers	5,7	16,1	35,4	17,6
Portland Trail Blazers	4,5	12,9	34,9	14,1	Seattle SuperSonics	6	15,8	37,8	18,3
New York Knicks	4,8	13,6	35,1	16,1	Charlotte Hornets	4,2	12,1	34,8	13,5
Minnesota Timberwolves	3,9	11	35,7	12,1	Orlando Magic	7,6	20,2	37,3	22,6
Toronto Raptors	5,2	14,2	36,9	16,1	Utah Jazz	3,4	10,3	33,3	10,7
Charlotte Hornets	4,1	12	34,6	13,5	Philadelphia 76ers	2,6	8,7	29,9	8,6
Houston Rockets	6,1	17,2	35,7	19	Indiana Pacers	4,9	14,6	33,9	15,3
Seattle SuperSonics	5,7	14,3	39,9	17,5	Toronto Raptors	4,7	13,5	34,9	15,5
Orlando Magic	6	16,4	36,4	18,4	Milwaukee Bucks	7,2	19,3	37,5	22,2
Indiana Pacers	4,8	14,1	34,2	15,7	Los Angeles Clippers	5	14	35,6	15,6
Denver Nuggets	6,2	17,6	35,5	19,4	Washington Wizards	3,7	9,6	38,8	12
Boston Celtics	7,2	19,9	36,3	22,9	Miami Heat	3,8	11	34,7	13,1
Detroit Pistons	4,7	13,6	35	14,9	Phoenix Suns	4,4	13,4	32,7	13,8
Los Angeles Clippers	4,4	13	33,9	14,2	Atlanta Hawks	5,2	14,6	35,4	16,5
Cleveland Cavaliers	2,7	8	33,4	8,7	New York Knicks	5,8	16,4	35,3	18,9
New Jersey Nets	4,4	13,2	33,3	14,3	Cleveland Cavaliers	4,7	12,5	37,7	14,9
Atlanta Hawks	4,1	11,4	35,7	13,4	Houston Rockets	6	18	33,5	19,7
Vancouver Grizzlies	4	11,5	34,3	13	Denver Nuggets	5,2	15,7	32,9	16,8
Washington Wizards	3,4	10,3	32,4	10,8	Memphis Grizzlies	4,1	13,4	30,7	13,7
Golden State Warriors	3,4	11,8	29,3	11,2	Chicago Bulls	3,7	10,6	34,6	12,3
Chicago Bulls	4	11,6	34,6	13,7	Golden State Warriors	3,9	12,1	32,2	12

2002-03				
TEAM	3PM	3PA	3P%	%PTS 3PT
Dallas Mavericks	7,8	20,3	38,1	22,6
San Antonio Spurs	5,5	15,5	35,4	17,1
Sacramento Kings	6	15,7	38,1	17,7
Minnesota Timberwolves	3,6	9,8	36,8	11
Detroit Pistons	6,5	18,1	35,8	21,3
Los Angeles Lakers	5,9	16,7	35,6	17,7
Portland Trail Blazers	4,6	14	33	14,6
New Jersey Nets	4,2	12,7	33,2	13,3
Indiana Pacers	4,6	13,6	33,9	14,3
Philadelphia 76ers	3	9,6	31,1	9,3
New Orleans Hornets	4,9	13,1	37,6	15,7
Utah Jazz	2,7	7,8	34,9	8,7
Boston Celtics	8,8	26,3	33,4	28,4
Phoenix Suns	4,8	14	34,3	15,1
Houston Rockets	5,4	15,5	34,6	17,1
Milwaukee Bucks	7,1	18,6	38,3	21,5
Orlando Magic	6,9	19,4	35,7	21,1
Seattle SuperSonics	5,6	15,7	35,3	18,1
Golden State Warriors	5,2	15,1	34,4	15,2
New York Knicks	7,4	19,3	38,3	23,1
Washington Wizards	3,1	9,9	31,2	10,1
Atlanta Hawks	4,9	13,9	35,2	15,6
Chicago Bulls	4,3	12,2	35	13,4
Memphis Grizzlies	5,7	15,6	36,5	17,5
Los Angeles Clippers	4,8	14,4	33,1	15,2
Miami Heat	4,2	13,4	31,6	14,9
Toronto Raptors	5	14,5	34,3	16,5
Cleveland Cavaliers	3,6	10,9	32,7	11,7
Denver Nuggets	2,8	10	27,8	10

2003-04				
TEAM	3PM	3PA	3P%	%PTS 3PT
Indiana Pacers	5,5	15,6	35,1	18
Minnesota Timberwolves	4	10,9	36,3	12,6
San Antonio Spurs	5	13,9	35,8	16,3
Los Angeles Lakers	4,5	13,6	32,7	13,6
Sacramento Kings	7,3	18,3	40,1	21,4
Detroit Pistons	4,1	11,8	34,4	13,5
Dallas Mavericks	6,2	17,8	34,8	17,6
Memphis Grizzlies	5,5	16	34	16,9
New Jersey Nets	4,6	13,7	33,6	15,3
Houston Rockets	6,3	17,1	36,6	21
Denver Nuggets	4	12	33,6	12,5
Miami Heat	5,9	16,5	35,7	19,7
Utah Jazz	3,1	9,6	32,1	10,4
Milwaukee Bucks	4,9	14	35	15
New Orleans Hornets	6,5	20,3	31,9	21,2
Portland Trail Blazers	4,6	13,4	34,6	15,4
New York Knicks	5	13,6	36,4	16,1
Golden State Warriors	5,2	15,6	33,4	16,8
Seattle SuperSonics	8,8	23,6	37,3	27,2
Boston Celtics	6,7	19,5	34,6	21,2
Cleveland Cavaliers	3	9,6	31,4	9,7
Philadelphia 76ers	4,1	12,1	34,2	14,1
Toronto Raptors	5,6	15,8	35,6	19,7
Phoenix Suns	5,1	14,7	34,5	16,1
Atlanta Hawks	5,1	15,2	33,5	16,5
Los Angeles Clippers	4	12,5	32,1	12,7
Washington Wizards	5,3	15,5	34,2	17,3
Chicago Bulls	5,2	15,3	34,2	17,5
Orlando Magic	5,2	15,2	34,4	16,7

2004-05				
TEAM	3PM	3PA	3P%	%PTS 3PT
Phoenix Suns	9,7	24,7	39,3	26,4
Miami Heat	5,8	15,4	37,7	17,1
San Antonio Spurs	6,2	17	36,3	19,3
Dallas Mavericks	5,6	15,5	36,4	16,5
Detroit Pistons	4,4	12,8	34,5	14,2
Seattle SuperSonics	8,1	22,2	36,5	24,6
Houston Rockets	6,7	18,5	36,4	21,3
Sacramento Kings	6,4	17	37,4	18,4
Denver Nuggets	3,9	11,5	34	11,8
Chicago Bulls	6,2	17,5	35,7	19,8
Boston Celtics	5,3	15,3	34,9	15,8
Memphis Grizzlies	6,5	18,1	35,7	20,8
Washington Wizards	6,3	18,3	34,3	18,7
Indiana Pacers	6,6	19,2	34,4	21,3
Minnesota Timberwolves	4,8	14	34,5	14,9
Philadelphia 76ers	6,2	17,7	34,8	18,6
Cleveland Cavaliers	3,7	11	33,2	11,4
New Jersey Nets	5,3	14,7	36,2	17,4
Los Angeles Clippers	2,8	8,2	34,5	8,8
Orlando Magic	3,9	11,2	34,9	11,8
Golden State Warriors	7,6	21,6	35,2	23,1
Los Angeles Lakers	7,9	22,1	35,5	23,9
New York Knicks	5,4	15,1	35,6	16,6
Toronto Raptors	7,9	20,5	38,5	23,8
Milwaukee Bucks	4	11,3	35,1	12,2
Portland Trail Blazers	5,1	14,2	36,2	16,5
Utah Jazz	3	9,3	32,8	9,8
Charlotte Bobcats	3,9	10,7	36,3	12,4
New Orleans Hornets	5,1	16	31,5	17,2
Atlanta Hawks	3,7	11,9	31,2	12

2005-06				
TEAM	3PM	3PA	3P%	%PTS 3PT
Detroit Pistons	6,8	17,7	38,4	21
San Antonio Spurs	6,4	16,6	38,5	20,1
Dallas Mavericks	5,1	13,6	37,4	15,4
Phoenix Suns	10,2	25,6	39,9	28,3
Miami Heat	6,1	17,6	34,5	18,2
Cleveland Cavaliers	6,1	17,9	33,9	18,6
Memphis Grizzlies	7,2	19,2	37,4	23,4
New Jersey Nets	5,8	17,6	33	18,6
Los Angeles Clippers	3,5	10,3	34,4	10,9
Los Angeles Lakers	6,7	19,3	34,9	20,3
Denver Nuggets	4,3	13,1	32,5	12,8
Sacramento Kings	6	17,2	35,1	18,3
Washington Wizards	6,1	17	35,7	17,9
Chicago Bulls	6,8	18	37,9	20,9
Indiana Pacers	6,5	18,7	34,9	20,9
Utah Jazz	3,8	11,3	33,6	12,3
Milwaukee Bucks	6,2	16,3	38	19
New Orleans Hornets	3,7	10,8	33,9	11,8
Philadelphia 76ers	4,6	12,6	36,4	13,8
Orlando Magic	3,6	9,7	37,6	11,5
Seattle SuperSonics	7,4	19,9	37,1	21,6
Golden State Warriors	7,6	22,3	34,1	23,2
Houston Rockets	5,7	17,2	33,2	19
Boston Celtics	5,7	15,7	36,2	17,4
Minnesota Timberwolves	3,8	11,5	32,9	12,4
Toronto Raptors	7,4	19,8	37,5	22
Atlanta Hawks	5,2	14,1	36,7	16
Charlotte Bobcats	5,2	15,4	33,9	16,2
New York Knicks	3,9	10,8	36,2	12,2
Portland Trail Blazers	4,4	12,7	34,9	15

2006-07					2007-08				
TEAM	3PM	3PA	3P%	%PTS 3PT	TEAM	3PM	3PA	3P%	%PTS 3PT
Dallas Mavericks	6,5	17,1	38,1	19,6	Boston Celtics	7,3	19,1	38,1	21,7
Phoenix Suns	9,6	24	39,9	26,1	Detroit Pistons	5,9	16,2	36,6	18,3
San Antonio Spurs	7,3	19	38,1	22,1	Los Angeles Lakers	8,1	21,4	37,8	22,3
Detroit Pistons	5,5	15,9	34,4	17,1	New Orleans Hornets	7,7	19,8	38,9	22,9
Houston Rockets	8,6	23,1	37,2	26,6	San Antonio Spurs	7,2	19,6	36,9	22,8
Utah Jazz	4,3	12,9	33,5	12,8	Houston Rockets	7,1	20,8	34,2	22,1
Cleveland Cavaliers	6	17,1	35,2	18,7	Phoenix Suns	8,5	21,5	39,3	23,1
Chicago Bulls	5,9	15,1	38,8	17,8	Utah Jazz	5	13,4	37,2	14
Toronto Raptors	6,5	17,9	36,3	19,5	Orlando Magic	9,8	25,3	38,6	28
Denver Nuggets	5,9	17,6	33,6	16,8	Dallas Mavericks	6	17,1	35,2	18
Miami Heat	6,4	18,8	34,3	20,4	Denver Nuggets	6,9	19,6	35,5	18,8
Golden State Warriors	8,5	24	35,6	24	Golden State Warriors	9,3	26,6	34,8	25,1
Los Angeles Lakers	7,4	21	35,3	21,5	Cleveland Cavaliers	6,7	18,8	35,8	21
New Jersey Nets	7,4	20,4	36,3	22,8	Washington Wizards	7	19,7	35,6	21,3
Washington Wizards	6,8	19,7	34,8	19,7	Portland Trail Blazers	6,6	17,4	37,7	20,6
Los Angeles Clippers	3,8	11	34,8	12	Toronto Raptors	7	17,8	39,2	20,9
Orlando Magic	4,2	11,7	35,6	13,2	Philadelphia 76ers	3,7	11,6	31,7	11,4
New Orleans Hornets	5,5	15,3	36,2	17,4	Sacramento Kings	6,2	16,7	37,3	18,2
Indiana Pacers	5,9	16,9	34,6	18,4	Atlanta Hawks	4,7	13,1	35,6	14,3
Philadelphia 76ers	3,5	10	34,5	10,9	Indiana Pacers	9,2	24,6	37,4	26,6
Charlotte Bobcats	5,6	15,6	35,7	17,3	New Jersey Nets	6,1	17,4	34,8	19
New York Knicks	5,8	16,7	34,6	17,8	Chicago Bulls	5,8	15,9	36,3	17,8
Sacramento Kings	6,5	18,5	35	19,1	Charlotte Bobcats	6,5	17,6	36,7	19,9
Minnesota Timberwolves	4,7	13,3	35,3	14,6	Milwaukee Bucks	5,5	16	34,4	17
Portland Trail Blazers	5,2	15	34,6	16,6	Los Angeles Clippers	4,3	13,2	32,4	13,7
Seattle SuperSonics	6,4	17,7	36,2	19,4	New York Knicks	6	17,7	33,7	18,5
Atlanta Hawks	4,2	12,7	32,9	13,3	Memphis Grizzlies	7,6	21,7	34,9	22,5
Milwaukee Bucks	6,4	18	35,6	19,2	Minnesota Timberwolves	5,4	15,4	35	16,9
Boston Celtics	5,7	15,6	36,7	18	Seattle SuperSonics	3,8	11,5	33,3	11,7
Memphis Grizzlies	6,1	16,6	36,7	18	Miami Heat	6	16,7	35,8	19,7

2008-09					2009-10				
TEAM	3PM	3PA	3P%	%PTS 3PT	TEAM	3PM	3PA	3P%	%PTS 3PT
Cleveland Cavaliers	8	20,4	39,3	23,9	Cleveland Cavaliers	7,3	19,3	38,1	21,6
Los Angeles Lakers	6,7	18,5	36,1	18,7	Orlando Magic	10,3	27,3	37,5	29,9
Boston Celtics	6,6	16,5	39,7	19,5	Los Angeles Lakers	6,5	19	34,1	19,1
Orlando Magic	10	26,2	38,1	29,6	Dallas Mavericks	6,8	18,3	37,2	20
Denver Nuggets	6,7	18	37,1	19,2	Phoenix Suns	8,9	21,6	41,2	24,2
Portland Trail Blazers	7,3	19	38,3	21,9	Atlanta Hawks	6,4	17,7	36	18,9
San Antonio Spurs	7,6	19,8	38,6	23,6	Denver Nuggets	6,6	18,5	35,9	18,7
Houston Rockets	7,6	20,2	37,5	23,1	Utah Jazz	5,4	14,7	36,4	15,4
Dallas Mavericks	7	19,9	35	20,5	Boston Celtics	6,1	17,5	34,8	18,4
New Orleans Hornets	6,8	18,6	36,4	21,2	Oklahoma City Thunder	5,1	15	34	15,1
Utah Jazz	4,8	13,7	34,9	13,8	Portland Trail Blazers	6	16,9	35,4	18,3
Atlanta Hawks	7,3	19,9	36,6	22,3	San Antonio Spurs	6,8	18,9	35,8	20
Phoenix Suns	6,7	17,6	38,3	18,5	Miami Heat	6	17,4	34,6	18,7
Miami Heat	7,1	19,9	35,7	21,7	Milwaukee Bucks	7,9	22,1	35,6	24,2
Chicago Bulls	6	15,8	38,1	17,7	Charlotte Bobcats	5,6	16,2	34,6	17,7
Philadelphia 76ers	4,2	13,1	31,8	12,8	Houston Rockets	7,9	22,4	35,1	23,1
Detroit Pistons	4,6	13,2	34,9	14,6	Chicago Bulls	4,3	13	33	13,2
Indiana Pacers	8	21	37,8	22,7	Memphis Grizzlies	4,2	12,4	33,7	12,3
Charlotte Bobcats	6	16,3	36,6	19,1	Toronto Raptors	6,3	17	37,1	18,2
Milwaukee Bucks	6,2	17,2	36,3	18,8	New Orleans Hornets	7	19,2	36,3	20,8
New Jersey Nets	8	21,2	37,6	24,3	Indiana Pacers	8	23,1	34,8	23,9
Toronto Raptors	5,8	15,7	37,2	17,7	Los Angeles Clippers	5,9	17,8	33,2	18,5
New York Knicks	10	27,9	36	28,6	New York Knicks	9,1	26,2	34,6	26,6
Golden State Warriors	6,7	18	37,3	18,5	Detroit Pistons	4,6	14,5	31,4	14,6
Memphis Grizzlies	4,9	13,5	36	15,5	Philadelphia 76ers	5,8	16,8	34,3	17,7
Minnesota Timberwolves	6,6	18,8	35,3	20,3	Golden State Warriors	7,7	20,6	37,5	21,3
Oklahoma City Thunder	4	11,6	34,6	12,4	Washington Wizards	5,3	14,9	35,3	16,4
Los Angeles Clippers	6,5	18,5	35,4	20,6	Sacramento Kings	5,9	16,9	34,9	17,6
Washington Wizards	4,8	14,6	33	15	Minnesota Timberwolves	4,9	14,4	34,1	15
Sacramento Kings	7,1	19,4	36,8	21,3	New Jersey Nets	4,6	14,5	31,8	14,9

2010-11					2011-12				
TEAM	3PM	3PA	3P%	%PTS 3PT	TEAM	3PM	3PA	3P%	%PTS 3PT
Chicago Bulls	6,2	17,3	36,1	19	Chicago Bulls	6,3	16,9	37,5	19,8
San Antonio Spurs	8,4	21,1	39,7	24,2	San Antonio Spurs	8,4	21,3	39,3	24,2
Miami Heat	6,7	18	37	19,6	Oklahoma City Thunder	7,2	20	35,8	20,8
Dallas Mavericks	7,9	21,6	36,5	23,5	Miami Heat	5,6	15,6	35,9	17,1
Los Angeles Lakers	6,4	18,1	35,2	18,9	Indiana Pacers	5,9	16,1	36,8	18,2
Boston Celtics	5	13,6	36,5	15,5	Los Angeles Lakers	5,5	16,8	32,6	16,9
Oklahoma City Thunder	5,9	17,1	34,7	17	Memphis Grizzlies	4,2	12,9	32,6	13,3
Orlando Magic	9,4	25,6	36,6	28,4	Atlanta Hawks	7,5	20,2	37	23,2
Denver Nuggets	8,1	20,8	38,8	22,5	Los Angeles Clippers	7,8	21,8	35,7	24
Portland Trail Blazers	6,3	18,3	34,5	19,7	Boston Celtics	5,5	15	36,7	18
Memphis Grizzlies	3,8	11,3	33,4	11,3	Denver Nuggets	6,6	19,9	33,2	19
New Orleans Hornets	5,4	15	36	17,1	Orlando Magic	10,2	27	37,5	32,3
Atlanta Hawks	6,1	17,4	35,2	19,3	Dallas Mavericks	7,5	22,2	33,9	23,6
Houston Rockets	8,3	22,5	36,7	23,4	New York Knicks	7,8	23,3	33,6	24
New York Knicks	9,3	25,4	36,8	26,3	Utah Jazz	4,1	12,8	32,3	12,5
Philadelphia 76ers	5,4	15,2	35,5	16,4	Philadelphia 76ers	5,3	14,6	36,2	16,9
Phoenix Suns	8,5	22,6	37,7	24,4	Houston Rockets	7,2	20,2	35,9	22,2
Utah Jazz	5,3	15,3	34,6	16	Phoenix Suns	6,7	19,6	34,3	20,5
Indiana Pacers	7,1	20,2	35,4	21,4	Milwaukee Bucks	6,6	19,2	34,5	20
Golden State Warriors	8,4	21,3	39,2	24,2	Portland Trail Blazers	7,2	20,9	34,6	22,4
Milwaukee Bucks	5,9	17,2	34,2	19,2	Minnesota Timberwolves	7,2	21,6	33,2	22
Charlotte Bobcats	4,8	14,7	32,7	15,4	Detroit Pistons	4,8	13,9	34,6	15,9
Los Angeles Clippers	6,3	18,5	33,8	19	Golden State Warriors	7,9	20,5	38,8	24,4
Detroit Pistons	5,8	15,3	37,6	17,8	Toronto Raptors	5,5	16,3	34	18,3
New Jersey Nets	5,6	16,3	34,3	17,8	New Jersey Nets	7,7	22,4	34,2	24,8
Sacramento Kings	5,2	15,6	33,5	15,8	Sacramento Kings	6,2	19,7	31,6	18,9
Washington Wizards	4,8	14,4	33,2	14,7	Cleveland Cavaliers	6,7	19,3	34,6	21,5
Toronto Raptors	4,2	13,3	31,6	12,7	New Orleans Hornets	3,9	11,8	33,3	13,1
Cleveland Cavaliers	6,2	18,2	34,2	19,5	Washington Wizards	5,2	16,3	32	16,7
Minnesota Timberwolves	7,2	19,1	37,6	21,3	Charlotte Bobcats	4	13,5	29,5	13,7

2012-13					2013-14				
TEAM	3PM	3PA	3P%	%PTS 3PT	TEAM	3PM	3PA	3P%	%PTS 3PT
Miami Heat	8,7	22,1	39,6	25,5	San Antonio Spurs	8,5	21,4	39,7	24,2
Oklahoma City Thunder	7,3	19,4	37,7	20,7	Oklahoma City Thunder	8,1	22,4	36,1	22,9
San Antonio Spurs	8,1	21,5	37,6	23,5	Los Angeles Clippers	8,5	24	35,2	23,5
Denver Nuggets	6,4	18,5	34,3	18	Indiana Pacers	6,7	18,8	35,7	20,8
Los Angeles Clippers	7,6	21,4	35,8	22,7	Houston Rockets	9,5	26,6	35,8	26,5
Memphis Grizzlies	4,7	13,5	34,5	15	Miami Heat	8,1	22,3	36,4	23,8
New York Knicks	10,9	28,9	37,6	32,6	Portland Trail Blazers	9,4	25,3	37,2	26,4
Indiana Pacers	6,9	19,7	34,7	23,7	Golden State Warriors	9,4	24,8	38	27,2
Brooklyn Nets	7,7	21,5	35,7	21,7	Memphis Grizzlies	4,9	14	35,3	15,4
Golden State Warriors	8	19,9	40,3	23,8	Dallas Mavericks	8,8	22,9	38,4	25,2
Chicago Bulls	5,4	15,4	35,3	17,5	Chicago Bulls	6,2	17,8	34,8	19,8
Houston Rockets	10,6	28,9	36,6	29,9	Phoenix Suns	9,3	25,1	37,2	26,6
Los Angeles Lakers	8,7	24,6	35,5	25,6	Toronto Raptors	8,7	23,4	37,2	25,8
Atlanta Hawks	8,6	23,2	37,1	26,4	Brooklyn Nets	8,6	23,4	36,9	26,3
Utah Jazz	6,2	16,9	36,6	18,9	Washington Wizards	7,9	20,8	38	23,5
Boston Celtics	6,1	17,2	35,8	19,1	Charlotte Bobcats	6,3	17,9	35,1	19,5
Dallas Mavericks	7,4	19,9	37,2	21,9	Minnesota Timberwolves	7,3	21,4	34,1	20,5
Milwaukee Bucks	7,3	20,4	36	22,2	Atlanta Hawks	9,4	25,8	36,3	27,8
Philadelphia 76ers	6,3	17,5	36	20,3	New York Knicks	9,3	24,9	37,2	28,2
Toronto Raptors	7	20,3	34,3	21,5	Denver Nuggets	8,6	23,9	35,8	24,6
Portland Trail Blazers	8,2	23,2	35,3	25,3	New Orleans Pelicans	5,9	15,9	37,3	17,8
Minnesota Timberwolves	5,5	18	30,5	17,2	Cleveland Cavaliers	7,1	20	35,6	21,8
Detroit Pistons	6,3	17,6	35,6	19,8	Detroit Pistons	6,2	19,3	32,1	18,4
Washington Wizards	6,6	18,2	36,5	21,4	Sacramento Kings	6	18	33,3	17,9
Sacramento Kings	7,4	20,5	36,3	22,3	Los Angeles Lakers	9,4	24,8	38,1	27,5
New Orleans Hornets	6,5	18	36,3	20,8	Boston Celtics	7	21,1	33,3	21,9
Phoenix Suns	5,9	17,7	33	18,4	Utah Jazz	6,6	19,2	34,4	20,9
Cleveland Cavaliers	6,7	19,3	34,6	20,7	Orlando Magic	6,9	19,5	35,3	21,3
Charlotte Bobcats	5,7	17,1	33,5	18,4	Philadelphia 76ers	7	22,5	31,2	21,2
Orlando Magic	6,2	18,7	32,9	19,7	Milwaukee Bucks	6,7	18,9	35,3	21

2014-15					2015-16				
TEAM	3PM	3PA	3P%	%PTS 3PT	TEAM	3PM	3PA	3P%	%PTS 3PT
Golden State Warriors	10,8	27	39,8	29,4	Golden State Warriors	13,1	31,6	41,6	34,3
Atlanta Hawks	10	26,2	38	29,2	San Antonio Spurs	7	18,5	37,5	20,1
Houston Rockets	11,4	32,7	34,8	32,8	Cleveland Cavaliers	10,7	29,6	36,2	30,9
Los Angeles Clippers	10,1	26,9	37,6	28,4	Toronto Raptors	8,6	23,3	37	25,2
Memphis Grizzlies	5,2	15,2	33,9	15,7	Oklahoma City Thunder	8,3	23,7	34,9	22,5
San Antonio Spurs	8,3	22,5	36,7	24	LA Clippers	9,7	26,7	36,4	27,9
Cleveland Cavaliers	10,1	27,5	36,7	29,3	Atlanta Hawks	9,9	28,4	35	29
Portland Trail Blazers	9,8	27,2	36,2	28,7	Boston Celtics	8,7	26,1	33,5	24,8
Chicago Bulls	7,9	22,3	35,3	23,4	Charlotte Hornets	10,6	29,4	36,2	30,9
Dallas Mavericks	8,9	25,4	35,2	25,5	Miami Heat	6,1	18	33,6	18,2
Toronto Raptors	8,9	25,1	35,2	25,5	Indiana Pacers	8,1	23	35,1	23,7
Washington Wizards	6,1	16,8	36	18,5	Detroit Pistons	9	26,2	34,5	26,6
New Orleans Pelicans	7,1	19,3	37	21,6	Portland Trail Blazers	10,5	28,5	37	30,1
Oklahoma City Thunder	7,7	22,7	33,9	22,2	Chicago Bulls	7,9	21,4	37,1	23,4
Milwaukee Bucks	6,6	18,3	36,3	20,4	Dallas Mavericks	9,8	28,6	34,4	28,8
Boston Celtics	8	24,6	32,7	23,8	Memphis Grizzlies	6,1	18,5	33,1	18,6
Phoenix Suns	8,5	25	34,1	24,9	Houston Rockets	10,7	30,9	34,7	30,1
Brooklyn Nets	6,6	19,9	33,1	20,2	Washington Wizards	8,6	24,2	35,8	24,9
Indiana Pacers	7,5	21,2	35,2	23	Utah Jazz	8,5	23,9	35,5	26
Utah Jazz	7,4	21,7	34,3	23,5	Orlando Magic	7,8	22,2	35	22,8
Miami Heat	6,8	20,2	33,5	21,5	Denver Nuggets	8	23,7	33,8	23,6
Charlotte Hornets	6,1	19,1	31,8	19,3	Milwaukee Bucks	5,4	15,6	34,5	16,3
Detroit Pistons	8,6	24,9	34,4	26,1	Sacramento Kings	8	22,4	35,9	22,7
Denver Nuggets	8	24,8	32,5	23,8	New York Knicks	7,4	21,5	34,6	22,7
Sacramento Kings	5,6	16,5	34,1	16,6	New Orleans Pelicans	8,6	23,8	36	25
Orlando Magic	6,8	19,5	34,7	21,2	Minnesota Timberwolves	5,5	16,4	33,8	16,3
Los Angeles Lakers	6,5	18,9	34,4	19,8	Phoenix Suns	9	25,8	34,8	26,8
Philadelphia 76ers	8,4	26,3	32	27,5	Brooklyn Nets	6,5	18,4	35,2	19,7
New York Knicks	6,8	19,7	34,7	22,3	Los Angeles Lakers	7,8	24,6	31,7	24
Minnesota Timberwolves	5	14,9	33,2	15,2	Philadelphia 76ers	9,3	27,5	33,9	28,7

2016-17					2017-18				
TEAM	3PM	3PA	3P%	%PTS 3PT	TEAM	3PM	3PA	3P%	%PTS 3PT
Golden State Warriors	12	31,2	38,3	31	Boston Celtics	11,5	30,4	37,7	33
San Antonio Spurs	9,2	23,5	39,1	26,2	Houston Rockets	15,3	42,3	36,2	40,9
Houston Rockets	14,4	40,3	35,7	37,5	Golden State Warriors	11,3	28,9	39,1	29,9
Boston Celtics	12	33,4	35,9	33,4	Detroit Pistons	10,8	28,9	37,3	31,2
Cleveland Cavaliers	13	33,9	38,4	35,4	Cleveland Cavaliers	12	32,1	37,2	32,4
LA Clippers	10,3	27,4	37,5	28,3	San Antonio Spurs	8,5	24,1	35,2	24,8
Toronto Raptors	8,8	24,3	36,3	24,8	Toronto Raptors	11,8	33	35,8	31,7
Utah Jazz	9,6	26	37,2	28,7	Portland Trail Blazers	10,3	28,1	36,6	29,3
Washington Wizards	9,2	24,8	37,2	25,3	Philadelphia 76ers	11	29,8	36,9	30
Oklahoma City Thunder	8,4	25,8	32,7	23,8	Indiana Pacers	9	24,5	36,9	25,7
Atlanta Hawks	8,9	26,1	34,1	25,9	Minnesota Timberwolves	8	22,5	35,7	22
Memphis Grizzlies	9,4	26,5	35,4	27,9	Denver Nuggets	11,5	30,9	37,1	31,3
Indiana Pacers	8,6	23	37,6	24,7	New Orleans Pelicans	10,2	28,2	36,2	27,4
Milwaukee Bucks	8,8	23,7	37	25,4	Washington Wizards	9,9	26,5	37,5	27,9
Chicago Bulls	7,6	22,3	34	22,2	Milwaukee Bucks	8,8	24,7	35,5	24,7
Miami Heat	9,9	27	36,5	28,7	Miami Heat	11	30,6	36	31,9
Portland Trail Blazers	10,4	27,7	37,5	28,9	New York Knicks	8,2	23,3	35,2	23,6
Denver Nuggets	10,6	28,8	36,8	28,5	Utah Jazz	10,8	29,6	36,6	31,2
Detroit Pistons	7,7	23,4	33	22,8	Charlotte Hornets	10	27,2	36,9	27,9
Charlotte Hornets	10	28,6	35,1	28,7	LA Clippers	9,5	26,8	35,4	26,1
New Orleans Pelicans	9,4	26,8	35	26,9	Oklahoma City Thunder	10,7	30,4	35,4	29,9
Dallas Mavericks	10,7	30,2	35,5	32,8	Los Angeles Lakers	10	29,1	34,5	27,8
Sacramento Kings	9	23,9	37,6	26,2	Orlando Magic	10,3	29,3	35,1	29,9
Minnesota Timberwolves	7,3	21	34,9	20,8	Memphis Grizzlies	9,2	26,2	35,2	27,9
New York Knicks	8,6	24,7	34,8	24,7	Phoenix Suns	9,3	27,9	33,4	26,9
Orlando Magic	8,5	26,1	32,8	25,4	Brooklyn Nets	12,7	35,7	35,6	35,7
Philadelphia 76ers	10,1	29,8	34	29,7	Sacramento Kings	9	24	37,5	27,3
Los Angeles Lakers	8,9	25,7	34,6	25,5	Dallas Mavericks	11,8	32,8	36	34,6
Phoenix Suns	7,5	22,6	33,2	20,9	Atlanta Hawks	11,2	31	36	32,5
Brooklyn Nets	10,7	31,6	33,8	30,3	Chicago Bulls	11	31,1	35,5	32,2