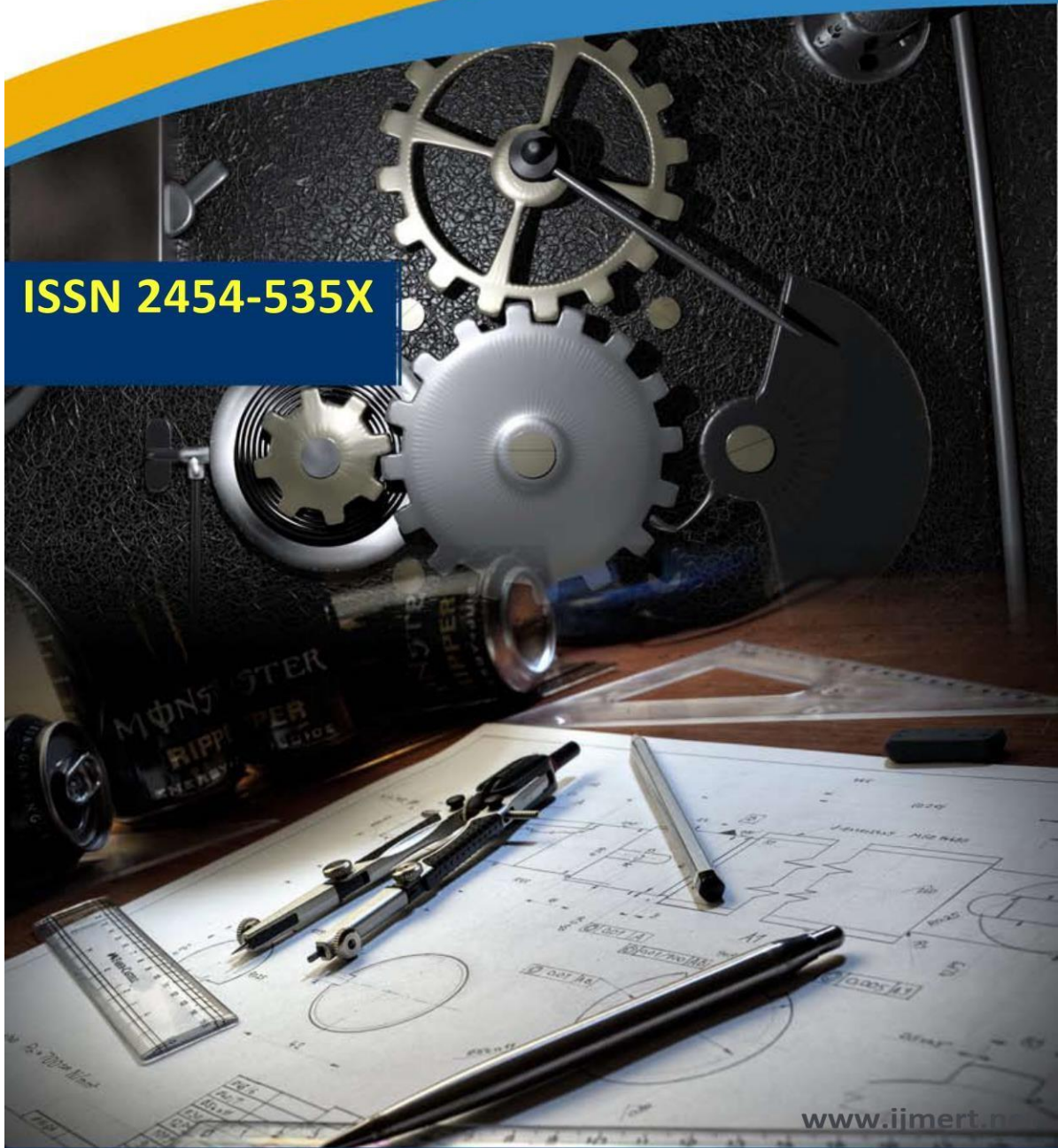




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**REVOLUTIONIZING MEN’S PROFESSIONAL FOOTBALL: A COMPREHENSIVE
ANALYSIS OF ARTIFICIAL INTELLIGENCE’S IMPACT ON TEAM PERFORMANCE,
INJURY PREVENTION AND GAME DYNAMICS**

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Abstract – The Integration of Artificial Intelligence (AI) technologies and football has gained significant traction in major clubs, leagues, and players world-wide. They have started exploring its potential to transform various aspects of the sport. This literature paper offers a comprehensive examination of the impact of AI on professional sports, presenting a global overview of how AI models and technology is being implemented in various dimensions of a football match, in and off pitch. It is being used in all key areas in football, such as player analysis, injury prediction, Goal Line technology, detecting offsides and minimizing errors and shows how it has revolutionized this game. Artificial Intelligence in sports is very new, but rapidly developing. The main purpose of this paper is to prove whether AI has an impact on the game of football? It includes data analysis done on football teams that use AI vs teams that do not over a period of years in the English Premier League. A p-value is used to determine the result at the end of the paper. In addition to its immediate effects this paper also explores the future of AI in football. This paper contributes to a deeper understanding of the technological transformation of the game and how it has made a huge difference in the sports industry today.

Index Terms – Artificial Intelligence, Semi-Automated Offside Technology, Player performance, Football, AI in sports.

I. INTRODUCTION

The Artificial Intelligence (AI) revolution has changed the way the world works today. As it is one of the most in-demand industries, it is safe to say that the artificial intelligence revolution is dominating in every sector. Everything in the world requires the use of AI from finance to healthcare to education. In recent years, we see the introduction of AI in sports as well, taking games to the next level. The use of AI in American football started in

the “late 1990s where teams used computer simulations to identify patterns” (Inclusion, 2023). Artificial Intelligence is being used by various sports such as basketball, hockey, football etc. and has increased the potential of these games. This paper focuses on how AI has impacted the most popular sport in the world, football. Out of 8.1 billion people, around “3.5 billion

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people” are die-hard football fans and there are “over 250 million players in 200 countries”, (The Sporting Blog, 2023). Thus, the football

industry is vast. The game of football is totally unpredictable; the game can change even at the last second. It is always these close matches

where the whole game turns around, which keeps the fans on their toes and makes the game thrilling. Football does also have its share of strange turn of events which can make the job of referees very difficult. For instance, the ‘hand of god’ goal was a goal scored by Diego Maradona’s hand, since the referee could not see it clearly in the 1986 World Cup, it was counted as a goal. This was the strangest goal ever, which came to be known as the “goal of

This is a literary paper which includes a deep study on the various uses of AI in football, such as Virtual Assistant Referee (VAR), Semi-Automated Offside Technology (SAOT), Goal Line Technology. These AI technologies help the referees in making the right decisions making the game a clean, smooth & fair one. Further, this paper talks about AI-assisted wearables, Impact of AI on Player Performance, Analysis of Opposition, Role of AI in recruiting team members and Injury Analysis. These are the most important ones as they increase the efficiency and potential of the players, making the game even more interesting. Recruiting team members is a crucial part of teams as football is a team sport and requires the coordination of all the players. AI helps teams get the best of the best players across the world. In addition, 2 data analyses were conducted on 3 premier league teams, (2

II. USES OF AI IN FOOTBALL

1. VAR

The officiating team in a football match usually consists of a referee, 2 assistant referees, a fourth official and nowadays, a Video Assistant Referee (VAR). The main role of a VAR is to help the referee on-field with additional information in 4 match-changing scenarios in “

While there are several soft factors that have had an influence on the successful use of VAR, the technology component is usually integrated video feed.” (FIFA, 2021)

According to the FIFA Board (FIFA, n.d.), “The VAR is involved in all decision making in the match. Two different VAR set-ups are currently permitted: full VAR systems, which

the century” (Szymanski, 2022). This is where Artificial Intelligence plays a huge role. It helps referees make decisions based on statistics and information using technology with accurate results in no time. Artificial Intelligence in sports has recently developed, and football has benefited from it in many ways, extending the scope of AI to injury prevention, improved efficiency, and revolutionizing athlete performance.

use AI, & 1 does not use AI). In the first one, it was done on the performance of two teams that use AI vs the team that does not use AI to prove whether AI impacts the team performance. In the second one, analysis was done based on the number of days lost due to injury by the teams that use AI vs the one that does not, again to prove whether AI helps in injury prevention or not. Using these stats, we can learn the real impact of AI in this vast game of football. Ultimately, the aim of this paper is to enhance the understanding of the impact of Artificial Intelligence by discussing in depth about the various uses and its dynamic implementation in this field. It is important to understand its working, as these advancements in AI are not only changing the way football works but also the way teams, players and fans perceive the sport.

case the decision made by the main referee was not clear and thereby minimize errors by analysing videos in real time. The VAR team has access to assist the main referee only in the cases of: goals, penalties, red card offences and mistaken identity.

into an existing broadcasting system. The quality of this installation is essential in order to provide the VAR with a reliable, high-quality

use at least four and up to an unlimited number of cameras; and VAR Light, which uses four to eight cameras and requires the system to be fully operated by the VAR itself.”

The VAR is used to decide whether a goal should be counted or not due to potential reasons such as, fouls, red card, offside or even handball. They use video technology to go back and replay the match scene from various angles. The VAR team will alert the referee on the field if there is any clear error. The VAR only advises, the final decision is made by the referee. Therefore, he may choose to review it by looking at the footage or agree with the VAR’s decision.

The VAR technology was first created and launched by the Royal Netherlands Football Association in 2013. But only “in 2017, the

Italian, German and other leagues started to adopt this technology.” (AnalySport, 2023). The use of video assistant referees (VARs) in football was first officially used in 2018 FIFA world cup, and that FIFA was considered the “cleanest world cup of all time” (Keshav et al., 2020,). As we can see from the table below, the accuracy rates have increased by 5.8%, in a game like football, as already discussed, even a 1% increase in accuracy can turn the game around. Therefore, we can see that the accuracy after the use of AI is beneficial and is accurate by 98.80%, and removes the biasness or error in judgement, thus helping the referees make better decisions.

Decision Accuracy Before vs after use of AI

Accuracy before VAR	Accuracy after VAR
93%	98.80%

Source: International Football Association Board study & used in (Keshav et al., 2020.)

Upon the intervention by the VAR in the quarterfinal between Manchester City and Tottenham Hotspur, two game-changing decisions were made. “Fernando Llorente’s winner for Tottenham was allowed to stand following a review but Raheem Sterling’s goal, in the dying moments of the tie, which could have sent City through, was cancelled.” (SportStar, 2022). Therefore, VAR has helped mitigate common decision errors made by

referees, making the sport of football more efficient and fairer.

There was a lot of controversy before, but it has come a long way, it was used in the Qatar FIFA World Cup 2022. It is also being used in the English Premier League, La Liga’s, and The Brazilian Serie A. It is constantly improving and has developed an offside detecting accurate technology as well.

2. Semi-automated Offside technology (SAOT):

2.1 What is offside?

Offside is a fundamental law in football, a very complicated one to understand. A position in the game of football is an offside position, if the body part of a player of team 1 crosses the last person defending the goal (other than the goalkeeper) of the opponent team 2, it is an offside committed by team 1. Although if the ball is passed by another player of team 1 and then the player crosses the last defender of team

2, it is not considered to be an offside. If an offside is committed, then the defending team (team 2) gets a free kick.

The purpose of the offside rule is to prevent the strikers from waiting near the goal post and to score when the ball is passed to them directly, making it difficult for the players to score and more interesting for the observer.

Offsides are usually monitored by two assistant referees on both side lines. However, offside is the most difficult to be accurately judged by referees, as humans are more prone to making errors due to apparent limitation of our eye. “Errors made by Assistant Referees (AR) in

judging offside may often be the result of the relative optical projections of the players on the AR’s retina.” (Sanabria J. et al., 1998). This means that, regardless of the quality of the AR, judgement errors are inevitable owing to the apparent limitations of our system. The above

was proved in a recent study on errors in judgement of offside in football. Football being one of the most competitive sports, there is no room for even 1% error and offside offence can change the game drastically. This is because the defending team is awarded a free kick, For instance, during the 2002 World Cup, “Spain was eliminated by South Korea after a number of controversial offside calls” and led to the hosts winning 5-3 on penalties. (McQuilling, 2022). Like these there were many other matches that faced controversial offside decisions which led to the dissatisfaction among the fans and teams. Before the use of SAOT technology, the referees took a lot of time to decide as they had

2.2 How does this technology work?

Semi-offside technology uses data (coordinates of each player on the field as well as the ball) to track and calculate offsides. It consists of an AI tool that simultaneously processes data coming from a connected ball and optical sensors, so that the data of the players is in real time. Tracking cameras which are installed in the roof of the stadium are used to get these data points. These specialized cameras use a subfield of AI called Computer vision algorithms. Using these algorithms, they are equipped to track players and get “29 precise points on the player’s body, 50 times per second”. (Guadenz Boesch, 2023). Usually, the

“Artificial Intelligence (AI) transforms the data collected by the cameras into an animation that illustrates the offside offence on screen.” (AnalyiSport, 2023). This involves showcasing the 3D model of the furthest player on the

2.3 How does AI function?

Computer Vision is a subfield of AI that makes computers detect objects and people from images and videos. Using AI only, cameras in the stadium get the data about the players in real time. Artificial Intelligence gets its data in the form of values- the % of the colours, red, blue, or green is present in each pixel. How are the players detected from this type of data? They use CNN (convolution neural network) which works by detecting objects layer by layer. Since they are just machines and do not have a human

which increases the chances to score a goal, thereby increasing the chance to win the game. Making an error in this area is not acceptable and not at all fair to the team that is being accused of an offside offence.

to analyse manually, this eventually disrupted the flow of the match. “During the 2018 FIFA world cup in Russia, the team of referees took more than 70 seconds to make a decision” (Wikipedia, n.d.). Therefore, to minimize these errors, to provide accurate decisions faster and increase the true sportsmanship of the game, FIFA designed Semi-offside technology to mitigate these issues. It was introduced for the first time in the FIFA World Cup 2022.

player’s toe or shoulder is used to determine whether it is an offside or not. Al rihla adidas, the official match ball, provides insights for offside as it has a sensor for the measurement of inertia, placed in the centre. “It tracks and sends 500 data points per second.” (Guadenz Boesch, 2023). The moment the ball is kicked, we can get the exact location of the players on the pitch. This is possible by inputting the data collected in an AI model. Using this information, the AI automatically triggers a visual alert to the Virtual Assistant Referee (VAR) team, which make the final decision, if it is an offside or not.

screen for both the referee and anxious fans to see, thereby eliminating any confusion relating to the offside decision. This is one way in which AI makes the game less controversial, leaving no room for speculation in the game.

brain like us, we need to train them by making them understand which object is what. We can do this by feeding questions and answers, through which it will be able to identify the object. For instance, if you close your eyes and pick any random object, by touching it and feeling it, you can make out its features, similarly computers instead of touching and feeling, they ask questions and answers to understand its features. This in CNN would be known as the first layer, known as Convolution.

After identifying the first layer, you will further ask questions and as it gets answered, the layers of the object will increase. Once enough data is gathered to guess, a classification process will be used to compare the computer's hypothesis with known objects provided by us. In the use of SAOT, these models are always given a "training dataset" which includes huge databases containing information for each player of each team already identified by humans. Through the mentioned processes they identify the players on field and when time comes, detect if an offside has been committed or not. They use pose estimation which is a fundamental task in computer vision and artificial intelligence that involves tracking and detecting joints of human body parts in an image or video. Pose estimation utilizes pose and orientation to predict and track the location of a person or object. Accordingly, pose estimation allows programs to estimate poses of a body in an image or video. So how does this pose estimation work? According to (Guadenz Boesch, 2023), this is a 2-step process, wherein, they first make "human bounding boxes" and then take the "coordinates of joints" of a person inside each box. It also claims to use "a Deep cut model which works bottom-up" (from down to up) by detecting the number of people in an image and then predicting the joint locations for each image. This method estimates "each body joint first and then groups them to form a unique pose." (Guadenz Boesch, 2023). This is also used in SAOT as after the player is detected using computer vision, a framework is made out around the player, after which pose, estimation is used to detect the coordinates of the joints (such as elbows, knees etc). They then compare

According to the FIFA's website, "The workflow of semi-automated offside technology and the connected ball technology have been successfully trialed at numerous test events and live at FIFA tournaments, including the FIFA Arab Cup 2021™ and the FIFA Club

3. Goal Line Technology:

In FIFA World Cup 2010, there were a few instances where the main referee may have misjudged the ball, and had made an error in judgement. A few examples are, "Frank Lampard's disallowed goal against Germany, and they lost to Germany (4-1)" (Wilson,

it with the coordinates of the defender of the opposite team, if the first person (in this case) joint coordinate exceeds the position of the other player, it is an offside else it is not. Therefore, this is the most accurate method for detecting offsides. AI is also used to create 3D models to accurately represent the players in their on-field positions at the time the ball was kicked. SAOT also uses 3D modelling which is a part of limb-tracking technology, the location of each body part is used to build a human body representation (such as a body skeleton pose) from visual input data, to identify which part is furthest to make it easy to detect an offside. The animation is available to watch for VAR officials and spectators, both those in the stadium and those watching via live broadcast. Therefore, CNN computer vision algorithms and pose estimation models, help them get the position of the players in real time and detect each body part, enabling the VAR team to decide if it is an offside or not. "SAOT came with the promise that it would be both more precise and quicker, cutting decision times from an average of 70 seconds to 25" (MacInnes, 2022), whereas VAR concentrates more accuracy than speed, which can disrupt the flow of the match. Therefore, VAR and SAOT work together to increase the efficiency of the game. SAOT is also expected to eliminate most human error, which has been a large source of controversy since VAR began.

Additionally, making digital animations depicting offside incidents available for everyone to see, addresses the issue of transparency and helps fans to understand the rationale behind the decision making.

World Cup 2021™. During these matches, the new technology was able to support the video match officials by helping them to make more accurate and more reproducible offside decisions in a shorter period." (FIFA, 2022)

2020). Sometimes, the referee again makes an error and awards a goal that might have been misjudged and the defending side insists that there is an error in the decision. For instance, "the goal that gave England a 3-2 lead in the 1996 World cup vs Germany" (Morely, 2018).

These incidents ruin the real essence and sportsmanship of the game, therefore the Fédération Internationale de Football Association (FIFA) and the International Football Association Board (IFAB) decided to introduce Goal Line technology in the FIFA world cup 2012, with the aim of minimizing human errors. So, what is Goal Line technology? It is the technology that is used to determine whether it is a goal or not. A goal is when the ball goes into the goal post without being defended by the goalkeeper. However, in

3.1 How Does This Technology Work?

There are 2 main Goal Line Technologies that are approved by FIFA and IFBA: GoalRef and Hawk-eye (Sony owned system). “Goal Control, a camera-based system which uses 14 high-speed cameras located around the pitch and directed at both goals, was used at the 2013 Confederations Cup, partly as a trial for use at the next year's World Cup.” (Wikipedia, n.d.).

In Hawk-eye, 14 high speed cameras, 7 aimed at different angles to each goal-post are used in this system. Computer vision algorithms are used to analyse and detect objects and track their movements from images and video frames captured by the cameras. “It involves tracking the ball in each time frame and predicting its trajectory. By analysing the images from different camera angles, Hawk-Eye's system uses triangulation techniques to pinpoint the exact position of the ball in three-dimensional space.” (Wikipedia, n.d.). This data recreates a virtual picture of the ball and its actual position using its tracking data and real-time ball. Ultimately, it has achieved its main purpose, and has removed the vagueness of whether the ball has crossed the line or not, and decisions

4. AI-assisted Wearables Technologies:

All the wearables used in football are: Tracker vests, the athletes wear a vest with integrated heart rate sensors and the sensor device (that is inserted into the vest) has the typical 3-axis Accelerometer, 3-axis Gyroscope (angular rate sensor), 3-axis Magnetometer and small GPS tracker with Antennas (inserted in the vest) for the satellites and the local tracking system. These are known for tracking the physical metrics. But for the number of passes made,

a game, like football, anything can happen. Therefore, there are situations where it is difficult for the referee to decide whether it was a goal or not. Goal Line technology is the most essential, as the only way to decide which team wins is by the number of goals scored by each team. If there is an error or bias in making the decision, it affects the whole match and can be unfair to the opposite teams. This is where Goal Line Technology is useful and can give accurate decisions in less time.

position. This picture can be used by the referees to decide whether it is a goal or not. Hawk-eye is more about real-time data processing, computer vision (which is a SUBFIELD of AI), and mathematical calculations to determine the ball's position.

“Hawk- Eye Technology offers a recreated virtual animation of the incident. The virtual animations can be shown immediately after a goal-line incident.” (Biradar, n.d.). This broadcasts the goal and gives the spectators a clear understanding of the decision and removes all biasness. “Goal line technology has its criticisms, such as impacting the flow of the game, taking away the human error/decision making process, and the costs of the technology for lower league clubs.” (AnalyiSport, 2023). But the technology is constantly developing, especially with the increased datasets and GPS trackers, Goal Line technology has improved a long way since its original inception in 2012.

made are based on real time, supporting the officials on field.

kick speed, stride length etc., any specific movement related to leg or feet, there are sensors present on the athlete's leg, known as soccer specific sensors. These sensors are usually worn on the calf (near the knee) and near the feet (either inside or attached to the boot).

Therefore, there are two types of wearables – technical wearables that track number of passes made, length of the kicks, power of the kicks

etc. and physical sensors – which track speed, acceleration etc.

4.1 How Do These Wearables Work?

Using the satellite “it picks up your position and it picks up your speed, in the same way that any other GPS device does, and then it splits up the data into elements that you'd want to analyse.” - According to Kevin McDaid, co-founder of GPS tracker company Catapult (Jobs In Football, 2023). This system has an additional feature where it can show at which periods of the match the players are the most active and peak of their performance. It can track 1250 data points per second. The heart rate monitors record the heart rates and the accelerometer gives the acceleration of each player. This data is essential as it gives the coach an idea about each player's fitness level. The coach can therefore decide on the fitness program as per each player's requirement.

For example, if a coach is worried that a certain player is not fully fit and has less stamina than required, tracking that player's sprints and heart rates can help put light on the situation. If the player must cover 10 km, but his heart rate is very high by the 5th km, then it is a problem and the coach will provide a specific solution for that player. Meanwhile if the player's data shows that the player is over training, there is a risk of injury, the coach will tone down the training for him. The data from each training

session is recorded in spreadsheets and fed into an AI model which can detect any change in pattern in any specific area. Using this data during matches, it allows the coaches to decide if the player needs to be substituted or not, which can play a major role for the team performance and reduces risk of injury.

However, how does the physical or technical metrics data provide such conclusions? The position of these players is tracked through computer vision as well as Global Positioning System. “Each player wears a sensor module that calculates various characteristics from the sensor data and sends these to the central processing unit, which in turn uses support vector regression to estimate each player's speed.” (Fraunhofer, n.d.)

This data is fed into an Artificial Intelligence model, which has various algorithms. These models are trained using huge datasets of 1000's of previous matches. Furthermore, after these models have been trained, they can identify any specific patterns observed in the real-time datasets and draw conclusions. Therefore, they help to develop customized strength, revival, and training programs for each player.

5. Impact of AI on Player Performance:

Performance analysis is the use of video and data to analyse the game of players and teams and find ways to improve them. For decades, managers, coaches, players have analysed old videos and recorded their game to find their mistakes. Although, now they are using cutting-edge data science and video analysis to make better-informed choices. New technology has enabled us to collect much more information. Therefore, a huge amount of data is being stored in huge databases. This data helps in game strategy, optimizing team line ups, studying opponents' moves and recruiting better players. Also, it provides us with the number of passes made and goals shot. AI can be beneficial in assisting coaches with valuable

analysis in the fast-paced game of football due to its ability to quickly process any information. Understanding a player's performance depends on various factors such as player movement, position, and real time ball tracking.

Clubs are looking at the data and adapting their tactics to get better results. According to (AnalyiSport, 2022), “if you look, the distance from where the players shoot is much more than 10 years ago.” A professional analyst said that, this is due to the use of data analytics, that they now know from which angle or point or position they have maximum chance of scoring a goal.

5.1 How is the data gathered?

Wearable technology as mentioned allows coaches to track every movement, as well as all our health dynamics such as acceleration, speed, and heart rate. Stadiums such as the Qatar Stadium have cameras all around and under their roofs, as well as cameras on drones, allowing everything to be recorded during matches and training sessions. This technology process detects individual players from images using computer vision, and AI models identify if they are running, walking, or jumping, and which foot they are passing the ball with.

Through implementation of computer vision, they track the points of each player from those videos in real time and detect the body limbs and different poses of the players.

As mentioned before, AI models do not have a logical brain like ours, and therefore must be trained to perform a certain way. AI models need to identify each player on the team to store the data of that player and draw predictions or conclusions for them. The AI model is trained using thousands of match recordings from all different football levels, that show various team players, their poses, their jerseys, their players with camera angles, to detect the players and their movements.

They train the deep neural network to track individual players and get data on how the player's position is relevant to others. This helps to improve the performance of the whole team by improving team coordination. They

6. Analysis of opposition teams

Opposition analysis is used to analyse the other teams using videos of previous matches to get data. When a team is preparing for a match, they do not only think about their team, they also try to find the best ways to beat their opponents. "In the past, this information would have been gathered by scouts and coaching staff who attended the matches of forthcoming opponents and made notes on what they saw." (AnalyiSport, 2022).

Nowadays, we use Artificial Intelligence to get the data points of each player and their position. The same AI models and techniques are used as mentioned for player analysis. This helps them

can also track the ball's position in real time which can be used to determine goals as well.

The data is important and includes various factors which can be combined to give metrics that "such as Expected Goals (xG), which measures how likely a chance is to result in a goal" (AnalyiSport, n.d.) or from which angle it would have been a better chance to shoot and other interpretations of how well the team or individual is playing.

By collecting and analysing large amounts of data, AI algorithms can identify patterns and trends that may not be immediately apparent to human analysts. Through these interpretations, the analysts of the team can improve the team's performance and correct the mistakes of each player as well as post-game analysis. This data and metrics can be used by analysts to identify each player's weaknesses and strengths, thereby helping in strategizing.

Analysing data has become so important that, for the first time, in the 2022 Qatar world cup," FIFA made an app for players to scan a code and get insights on their performance" (FIFA, 2022). It gave them all the data that could be gathered by real time tracking points through computer vision from videos recorded by cameras and drones and data for distance, speed, and number of goals through wearable technology.

analyse the other opponents in detail, providing more information than a human eye can see and it is less time consuming as they can use specific information they need. Whereas before this technology, they used to analyse and make notes looking at the videos and judge based on their knowledge and experience. Usually, each team has an opposition analyst that instructs the team and gives solutions based on the interpretations made.

Oppositional Analysis is important as they can study the style the opponent team plays (each team has its own way of playing and strategies) and use their best suited strengths

against them. Using these teams can understand their strengths and weaknesses.

“In the modern game, there is also an emphasis on transitions. An analyst will look at what a team does in the moments immediately after winning back possession and how it responds when it loses the ball.” (AnalyiSport, 2022)

Analysts can also look at individual players and strategize accordingly. For example, if their

centre-forward scores the most goals, then the coach can assign one of the defenders to stay with him the whole time.

According to (AnalyiSport, 2022), a professional data analyst claims that they use “internal models to decide what games to watch on the opposition”. The source also claims that “the data helps them find the most relevant games that depict the style of the team against similar teams.

7. Role of AI in recruiting team members:

Recruiting team members is a very crucial task. As football is a team game, all 11 players need to be exceptionally good and need to have good coordination for the team to win. Even if one player is not performing well, the whole team will suffer the consequences. Therefore, recruiting needs to be done carefully.

The role of a football scout is to travel from one place to another, to watch players that they have heard about play in matches. This traditional method of scouting can be time-consuming, exhausting, and inaccurate as it is based on

hope and expectations rather than information. However now, with development in technology, teams and clubs are harnessing the power of data analysis within their scouting department. Therefore, with the vast amount of data and resources scouting has changed.

No longer do football teams leave recruitment decisions solely up to the judgement of scouts and word of mouth “Potential recruits now need to impress the clubs or major teams with their stats, and not only an impressive performance in a match.” (AnalyiSport, 2023).

7.1 What is data driven scouting?

It involves the analysis of player performance data taken from thousands of matches in order to make recruitment decisions. Through platforms like Wyscout, teams now have access to huge databases which give access to data and live footage for thousands of players across hundreds of competitions.

Clubs can now access talented players from around the world, who they would not normally

well in a certain position within the team’s tactics and match the player accordingly. For example, if the club needs a goalkeeper, who is good at saving the balls, they would look at stats such as the speed with which the goalkeeper moves and the number of goals saved by him.

Each team having their own metric which is not known by other teams, allows them to spot players that other clubs might have overlooked. “For this reason, the exact formula that clubs use in their own metrics are always kept secret. They do not want to lose the competitive advantage it gives them.” (John, 2022)

be able to send scouts to watch them. This data allows the analysts to get a complete picture of the player. They can look back into the past to get a sense of how consistent they are.

Data driven scouting enables clubs to have some structure while recruiting. The clubs first decide which position players and player traits they require. Then they take the skills that a player needs to perform

Now to gain more advantage, teams are now looking to Artificial Intelligence models for player scouting. “AiSCOUT is a fully automated talent analysis and development platform which, with the use of artificial intelligence, can analyse athletes around the world using only a mobile phone. Teams including Burnley FC and Chelsea FC have been using this technology” (Ajose, 2023).

The mobile app presents players with specific drills to complete, based on what the teams are looking for. From there it analyses their

performances and with every trial or drill, the AI will analyse through computer vision which tracks their movement and gives data regarding the number of passes, shots, tackles, their speed etc. and looking at this data, the engaging team gives their feedback. Based on this AI algorithm, the clubs decide whether the players are suitable for their team. This algorithm enables coaches to bring together a team with the best players suited for their strategies and enhances the potential of the team. Recruitment of the players using AI would be an unbiased decision, as it is based on the statistics and skills of each player, thereby giving everyone a fair opportunity. This eliminates irrational choices being made by the coaches. Thus, the use of AI to select players based on their skills, improves the whole team's performance, and gives them an edge over their rivals.

Another system which enables the use of Artificial Intelligence is called eyeball. "Eyeball works by providing a high-resolution camera raised high enough above the pitch to provide 180-degree views and create an angle for artificial intelligence software to work" (Eyeball, n.d.). First, the teams upload their match schedule into the eyeball calendar and the camera automatically activates accordingly. The camera records the players on the pitch and the clubs can even zoom in manually and see any player that fascinates them. Using computer vision, they derive AI powered data such as the highlights,

movements of the players (through which they can calculate the velocity, no. of passes made etc) and other statistics. They also track the ball, and use AI models to get data points to access data regarding the speed and velocity the ball was kicked etc.

Teams also use Kognia with computer vision to gain insights from match recordings. Through these insights they have an increasing data-base for players all around the world. By developing algorithms from this database, clubs can recruit players for a particular position.

"Another change is a greater emphasis on predicting future performance. At first, clubs used data to see how well a player has previously performed, now data companies and analysts are developing metrics and using AI modelling to try to predict how a player will develop and how well they will play in the future." (AnalyiSport, 2023). This is important as many are raw players who might not be able to survive in professional level team football.

"Chelsea's rather public takeover is demonstrating the importance that modern owners place on an effective data-led recruitment system. But this is just one example. Many clubs are refining their scouting departments behind closed doors as they look to the future." (AnalyiSport, 2023) Overall, data driven recruitment is more efficient, accurate, less time consuming and gets ahead of the competition

8. Injury Analysis

A sport like football has fans all over the world. Every year the performance of football players is getting better. With increase in performance due to high-speed, intensity and acceleration, there is also an increased risk of injury. Football being one of the most competitive sports, injuries are inevitable. However, injuries caused to an individual, may cost him his match and long absence from the competition, which in turn affects the performance of the team. Therefore, I think success of any football team at any level, is majorly based on minimizing injuries and maximizing the performance of the team. Thus, to avoid injuries wearable

technologies were used by teams in training and FIFA allowed the use of wearables in matches from the 2015-16 season onwards.

Player's training methods, strategies, and their playing environment, all play a major role in sports related injuries. Football players' ability to compete is significantly impacted by sports injuries. The recurrence as well as the seriousness of the player's injury also determines the performance of their team, as more serious is the injury, a greater number of games are missed by the players. It has been said that "The most common sports injuries in

football are to the knees, including athlete’s tibia joint soreness, tendonitis, sacral syndrome, quadriceps tendinitis, and athlete’s knee surrounding bursitis. There are also traumatic injuries, overuse injuries, heat injuries, and concussions” (Jinyu Qioa, 2022). Therefore, with the recent growth in Artificial Intelligence and technology, they are trying to minimize injuries by using data to predict injuries.

As such, the relationship between training and injury is a major area in football (as it is in all sports). “The athlete’s technical ability, awareness of personal safety, and level of activity are all determined by external influences during practice. During this time, the athlete is also receiving medical attention. As a result of poor warm-up preparation, poor technique, and lack of awareness, football players are more likely to suffer knee injuries than other athletes” according to an analysis of

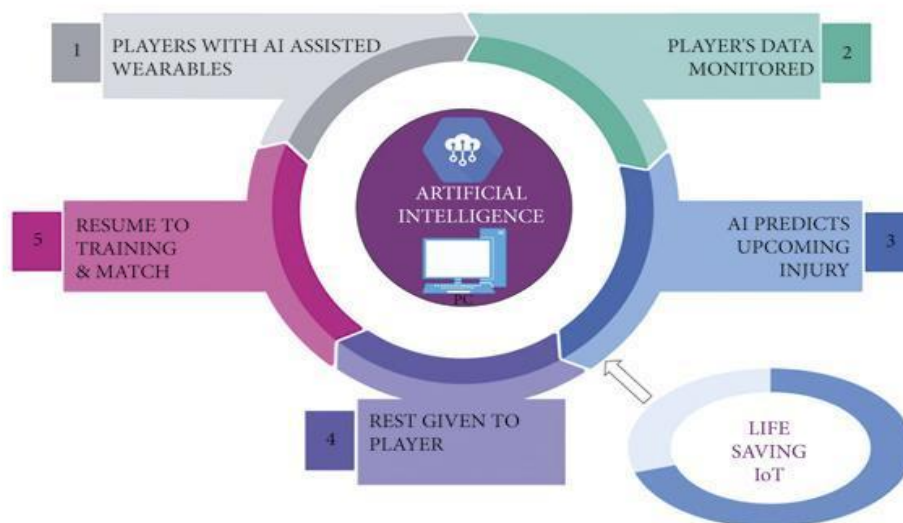
healthcare data in reference (Jinyu Qioa, 2022). These factors can also be used to predict injuries in players, but it is still difficult to predict exactly as there are still a lot of unknown factors. Although, using machine learning techniques, an approximate risk of injuries can be prevented which will still help football players and their overall performance.

In a study of 200 Shandong Province football players, circumstances leading to knee injuries and their training performance were recorded, it was evident that knee injuries affected the overall performance of the players. “A total of 100 athletes were injured throughout the game, with 27 cases of acute knee trauma, 19 cases of pre-existing knee ailments, and 11 cases of knee strains.” (Jinyu Qioa, 2022). But recently, there have been advancements in technology, machine learning predictions and evolutionary methods which have reduced the number of injuries.

8.1 Processes involved for injury prediction is:

Injuries are common during football matches and are caused due to high-speed action along with running. Before the introduction of AI in sports, the traditional way to predict that the players would get an injury shortly was, with

the knowledge of the coaches and health check-ups during training and matches. But nowadays, players of the top teams are monitored using wearable technologies.



Source: (Jinyu Qioa, 2022)

The AI-assisted wearables help the coaches and players to monitor the heart rate, speed and

distance covered during the matches and training sessions as seen in the image markings

(1) and (2) above. Real time tracking of players can also show the coaches how hard each player is practicing, so they can ensure that the workload on the players is a reasonable amount and help maintain that as well.

From the image marking (3), the data collected is then fed into an AI model to detect the player patterns as well as any upcoming injury that can be caused due to a certain situation recorded during the match or practice sessions. For example, changes in heart rate and other factors may serve as early warning signs of stress or overtraining. Therefore, it can predict injuries and help coaches and players prevent them, using data sets with metrics.

By processing videos and using computer vision and pose estimation, it can get data and detect changes in joints, muscle activation patterns and overall movement mechanics. They analyse the movements of the players by using “biomechanics and identifying any deviations that may lead to injuries” (John, 2022). By monitoring these metrics, AI can help athletes and medical professionals intervene before minor issues escalate into major injuries.

AI excels at analysing datasets and identifying patterns or co-relations, as mentioned in this

III. METHODOLOGY

1. Data Analysis on AI-assisted Wearables:

In this section, we describe our methods of data analysis to determine whether the use of AI has increased team performance.

Hypothesis:

The hypothesis for this analysis is to prove that teams that use AI-assisted wearables have performed better than teams that do not use AI-assisted wearables. Null hypothesis here is that there is no significant difference between the

Method:

For this analysis, data was collected from the Premier League official website (Premier League, n.d.) (AnalyiSport, 2022), (Ishan Ontech, 2022), (McCaskill, 2018). For more information you can refer to the [spreadsheet](#) which includes data on the 3 football teams that were used for analysis,

paper, AI models are trained by giving it pre-existing data, therefore by inputting large datasets of players, past injury records and performance metrics, it can predict future injuries. “This predictive analysis takes into account various factors, such as training load, sleep patterns, recovery rates, and previous injury history.” (Inspirit AI, 2023).

Coaches can now calculate the probability that a player will get injured in the coming days more precisely. Therefore, after the identification of an injury by the AI model, proper rest is usually given as seen in image marking (4). The player will recover and heal fully in a medically instructed period and wearable trackers also track the progress of a player’s recovery when they are returning to full fitness. This considerably reduces the players chance of getting injured, saving the team from losing their matches and affecting their performance.

After the player has recovered, he will be allowed to play (from the image marking (5)), this time with moderate training and again the data will be taken and checked. In case of further injury detection, this process will be repeated. Therefore, this is how AI ensures the safety of the players.

performance of teams that use AI and teams that do not use AI. Alternative hypothesis here is that there is a significant difference between the teams.

Top 2 teams that are the most developed and advanced in terms of AI tools are taken, Manchester City and Liverpool. In contrast to a team, a new castle that does not use Artificial Intelligence is taken as the control. I have taken their position in the table in the seasons in

which they implemented AI, from 2017 till now.

There are a total of 6 seasons. By testing out the paired t-values for each team that uses AI with teams that do not use AI, we can get the p-value. The p-value will determine whether it

was a coincidence or that it was a significant value. If the p-value is less than 0.05 (Alpha) value, then I can reject my null hypothesis and support my alternative hypothesis. If it is more than 0.05, then I will fail to reject my null hypothesis indicating I do not have data to support my evidence.

2. Data Analysis of Injury prevention using AI:

Hypothesis:

The hypothesis for this analysis is to prove that AI reduces the number of days missed by a player in contributing for his team, indirectly increasing the performance of a team. The null

hypothesis here indicates that there is no significant difference between the days missed for two teams, one which uses AI tools to predict injuries and one that does not.

Method:

I have collected the data from various public official sites and resources, such as (Carey, 2022), (Austin, 2017), (McMahon, 2022) and (Bowen, 2018). For more information you can refer to the [spreadsheet](#), which includes data on 4 teams that were used for this analysis.

I collected data for 3 teams, the top 2 teams that are most advanced in using AI, Manchester City and Liverpool and West Ham that do not use Artificial Intelligence as my control. I have collected data for each season since 2016-17 as that is when these teams started using AI. I have not included 2020,2021 and 2022 as many players were affected by covid and missed games because of that as well.

IV. RESULTS

I have collected the positions of the clubs from 2013 onwards, but used values only from 2017 (the year the 2 clubs started using AI) to calculate the p-values.

Clubs	2013-2014	2014-2015	2015-2016	2016-2017	2017-2018	2018-2019	2019-2020	2020-2021	2021-2022	2022-2023
Liverpool	2	6	8	4	4	2	1	3	2	5
Man city	1	2	4	3	1	1	2	1	1	1
New Castle United	10	15	18	0	10	13	0	12	11	4

Position of these premiere leagues in each season from 2013-14 onwards

1. F-Test Two-Sample for Variances for Liverpool and Newcastle:

	<i>Liverpool</i>	<i>Newcastle United</i>
Mean	3.625	7.1428571
Variance	4.83928571	32.142857
Observations	8	7
df	7	6

F	0.15055556
P(F<=f) one-tail	0.01247156
F Critical one-tail	0.25866737

From my first analysis, while comparing Liverpool and Newcastle united my p-value is 0.01, which is less than 0.05. Therefore, rejects my null hypothesis, indicating that there is a significant difference between the team that uses AI compared to the one that does not.

2. F-Test Two-Sample for Variances for Manchester City and Newcastle United:

	<i>Manchester city</i>	<i>Newcastle United</i>
Mean	3.625	8.5
Variance	4.83928571	42.285714
Observations	8	8
df	7	7
F	0.11444257	
P(F<=f) one-tail	0.00525302	
F Critical one-tail	0.26405823	

For the comparison between Manchester City

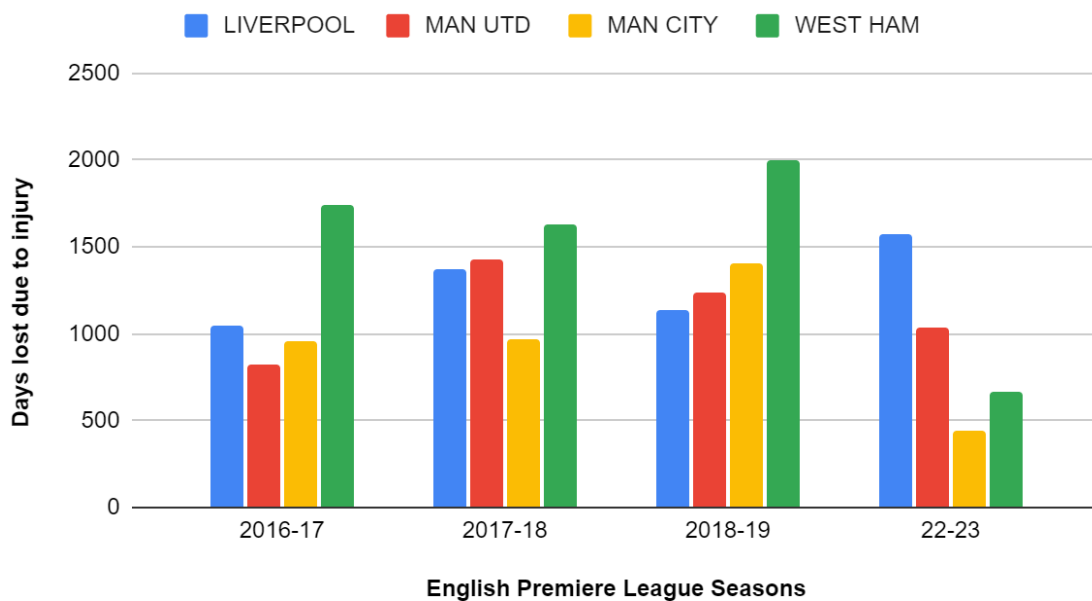
and Newcastle, the p-value is 0.005, which is less than 0.05, rejecting my null hypothesis. This also supports my alternative hypothesis.

Therefore, using these values, it can be proved that there is a significant difference between teams that use AI vs teams that do not.

For the second analysis on injury prevention, we can see from the graph below, that West Ham (green) has the highest number of days missed due to injury when compared to Liverpool (blue), Manchester United and Manchester City. Therefore, this proves that Artificial Intelligence plays a role in predicting injuries. This helps with team performance as if there are less injuries, more players are available and can give their best performance. This data rejects my null hypothesis, supporting the alternative hypothesis.

Thus, AI is directly related to the increase in performance of the players and does have an impact in the field of football in terms of player performance and injury prevention.

Days missed due to Injury in each season:



V. DISCUSSION

From the above analysis conducted, there is a correlation between AI and injuries as well as team performance but it is not a causation. In a sport like football, there are a lot of people and different factors involved. Factors such as intuition of the coaches, skills of the players, coordination between the players, funding of the team and luck affecting the overall performance of the team. For instance, in a certain year, it could be that one of the teams using AI won the cup by chance or luck and not necessarily because of the use of AI. Furthermore, each team’s manager’s experience, intuition, and way of doing things can cause the team to win. Consequently, how each coach handles a situation is very different, that difference can lead a team to victory or defeat. Similarly, different players have different skill sets, strengths, and weaknesses. Therefore, we can say that there is no definite reason for a particular team to win and thus, we cannot say that the use of AI has been instrumental in the victory of the team. Although, we can say that AI could have been one of the factors that helped achieve the success.

The fact that there is no way of determining which team is going to win, is what makes the game so exciting, unique and keeps the fans entertained. If AI was directly related to the success of a team, the game would not have been able to keep its fans on their toes and would take away the essence of a football game.

Moreover, there is another correlation between teams that have funding and less injuries and better performance. The teams that have more money, have better technological resources, and utilize advanced models of AI, thereby having an advantage, and minimizing more errors and maximising team performance.

As we have already mentioned, AI has impacted football in a revolutionizing manner and provided a lot of benefits, however, it does have some limitations.

- High Costs:

Artificial Intelligence involves use of technology for getting data Such as wearables, cameras, and other external gadgets. Its widespread application in football has increased the operation costs. Also, with

advancement in technology, it will be necessary to update and maintain the hardware and software of Artificial Intelligence systems, therefore the maintenance and repair costs are very high.

- Privacy And Security:

With the use of huge databases, comes higher chances of data breaches and identity thefts. As

- Over-reliance On Technology:

Reliance on technology is essential, but over-reliance can have negative consequences. By over-relying on Artificial Intelligence, coaches lose the ability to think and make decisions by them-selves. For instance, coaches and referee's might have to make a quick decision based on their observations and intuitions if the machine is not working, but due to over-reliance on technology, they fail to do so. Furthermore, in sports, human interactions are very important and athletes sometimes may require more personalized feedback and emotional support during the game. Unfortunately, Artificial Intelligence models lack the ability of emotional interaction and creativity. Afterall they are machines and unlike humans, they cannot feel.

The most trending question or argument in the world today is whether AI can replace human jobs, in this case, coaches?

Coaches do undergo a lot of stress as they are under constant pressure to make the right decision. In a game like football, there is no room for errors. Even a minor error can make a large impact on the game. Therefore, this is where Artificial Intelligence can help relieve

VI. CONCLUSION

From this literature review and analysis, we can understand the impact Artificial Intelligence has created in the field of football. Football is no longer a simple game, advancement in technology has given this game a totally new dimension, taking it to a new level. With the help of AI, teams now can discover their true potential and achieve their goals, which were thought to be impossible. As we have seen, AI helps the different areas of football such as: Injury analysis, player performance and helps in making decisions. It relieves the stress of

Artificial Intelligence requires data to be collected on athlete's performance and movements, athletes may be concerned about how their data is used or shared. Furthermore, if the data is not stored and secured correctly, there is a risk that unauthorized parties might access it, leading to breach of privacy and security.

the stress of referees and coaches to make the final decision. The involvement of technology such as semi-automated offside technology, VAR and Goal-Line Technology reduces the errors and increases the efficiency of the game. Artificial Intelligence also helps coaches, enhance the team performance by player analysis and helps predict and prevent injuries as we have seen above.

However, sports like football require human emotional interaction but machines lack the ability to do so. Athletes along with the AI machine feedback, they also require emotional support and understanding. Therefore, Artificial Intelligence can be implemented to help coaches and referees and not replace them completely.

Artificial Intelligence is beneficial in the game of football and being used for the betterment of the game. It increases the overall competitiveness while leaving no room for partiality and inaccuracy. It has changed the world and improved our ability to function and advance faster. Thus, AI has made a significant impact.

referees and minimizes the errors, making football a fair and efficient game. Coaches can now implement new methods and strategies to train the players and reduce the number of injuries, resulting in exceptional performance of the team. Through AI, players from all over the world can now get an opportunity to play in the top leagues. It also saves scouts the time, money, and energy. Overall, with the latest gadgets, the fan experience has also been enriched, keeping fans glued to the game & also

ensuring a fair game and raising their football spirits.

The data analysis on 6 teams in the English Premier League, ranging from seasons 2013-2022, is done based on the number of days missed due to injury and position in the league in the respective seasons. The conclusion drawn from the data analysis is that after the introduction of Artificial Intelligence, the number of days missed due to injuries have reduced and team performance has increased

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after the use of AI-assisted wearables. Therefore, this proves that Artificial Intelligence does have an impact on football and increases the potential of the game. I believe that this is just the beginning, with rapid growth in technology and Artificial Intelligence, the future of football is bound to grow. If there is human involvement along with the implementation of AI methods, it will keep the fire of football in fans alive.

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