Module 4. Comprehensive internal and external load quantification for Load Management

In this module, you will learn about the key performance indicators most relevant for the most popular sports, including specific differences between player positions in team sports that qualify you to quantify different KPIs. But, before getting into the KPIs, we must have a contextual framework for the history of the game, as well as an understanding of the sport to grasp which KPIs would be relevant to collect, analyse, and extract insights for the benefit of the player and the team.

Baseball key performance indicators

History of baseball

America's favourite pastime, baseball, is said to have originated in American soil. For a while, baseball historians argued that it originated from a game called rounders in England. Baseball may well be derived from English rounders, cricket, or other bat-and-ball games across the globe, but it was in the United States that it became the fascination of a country. It is Americans who love the words 'take me out to the ball game.'

Figure 1. Baseball

Source: [online image of baseball], (n. d.), https://bit.ly/3T3Y5ts

The American League was formed in 1901, but it was in 1920 that the new rules of baseball were introduced, which significantly improved a batter's chance at making contact with the ball. This gave rise to the interesting statistic that, for nearly a decade from 1921 to 1930, batting less than .280 became nearly unheard of. Many credit this new rule for the unexpected increase in baseball's attendance and popularity, which in turn gave rise to economic prosperity within the United States.

This was a period in which many great players became known, including Babe Ruth, the 'Great Bambino', for his massive accumulation of home runs. Baseball's first All-Star Game was played at Comiskey Park in Chicago, Illinois in 1933, with the first night game played in 1935 at Crosley Field in Cincinnati, Ohio. Another milestone was the unveiling of the Baseball Hall of Fame, which took place in 1939. The first players inducted to the Hall of Fame were Ty Cobb, Babe Ruth, Honus Wagner, Christy Mathewson, and Walter Johnson (Freedman, 2010; Becker, 2007; Corcoran, 2010; Skipper, 2000; Ruggiero, 2011).

It was not until 1971 that the Society for American Baseball Research was developed. This group focused on developing new and novel methods aimed at advancing the game of baseball. They took pride in research and the utilisation of statistics. In 1980, Bill James coined the new term 'sabermetrics' referring to 'the search for objective knowledge about baseball.' Proponents of sabermetrics sought to arrive at meaningful measures of player performance. They developed measures of hitting, fielding, and pitching performance, and applied these measures to past and current professional players. The fundamental concept behind sabermetrics is the desire to measure and assess a baseball player's performance. Before analysing data we must collect, first we will collect data we must seek to understand the sport context.

Figure 2. Society for American Baseball Research

Source: Society for American Baseball Research, (n. d.), https://bit.ly/3CNU2Lh.

Format of the sport

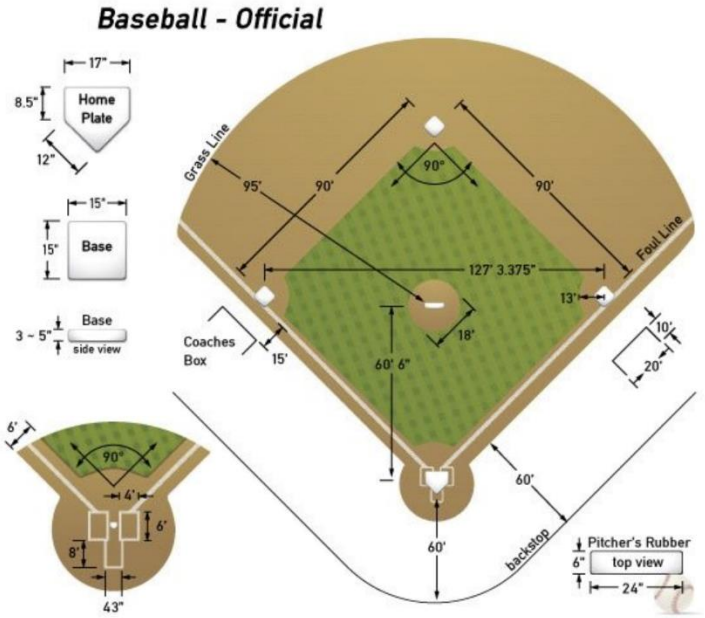
The game of baseball is played by two opposing teams, consisting of nine players each. Unlike sports in which time is quantified in intervals of quarters, baseball utilises the structure of innings. There are a total of nine innings that are terminated whenever a team gets three outs. Each team continues to send players to bat until three outs are accumulated. Outs are a result of being struck out while at bat, tagged out before touching base, or having the ball caught in the air. The team on offense scores by making runs. Runs occur when the batter makes a hit and runs through first, second, third, and home base. The pitcher throws the ball to the player at bat with the intention of striking him out (or sometimes making him walk). The fielding team, also known as the defense, is focused on causing the other team three outs as soon as possible, in order to complete the inning and switch roles to the offensive position. The term 'fielder' is used to refer to either infielders or outfielders who are on defense. The infield consists of first, second, and third bases, the pitcher's mound, and home plate. Outfielders are further than infielders from home base in the left, centre, and right fields. At the end of nine innings, the team with the higher score wins. Intricate details of the game include the fact that the hitter can receive anywhere from one to seven pitches: up to three strikes, and four balls. A strike is when a batter swings at a ball that is on a trajectory within his range, yet misses it completely; while a ball is when the pitcher throws the hitter a ball outside the hitter's range. Balls and strikes are called by the umpire behind home plate. A batter gets three strikes before being called out on strikes. A strike swinging occurs when the batter swings at a pitch and misses it. A strike looking is when the batter does not swing, but the umpire determines that the pitched ball was in the strike zone. Foul balls count as strikes until

the player has two strikes. Pitches outside the strike zone are called balls, and the batter is awarded first base, if he receives four balls.

Equipment used in baseball consists of helmets, wooden baseball bats (at the professional level), gloves specifically tailored to player positions, and cleats. Catchers require additional specific equipment due to their at-risk positions, including a helmet with facemask, knee guards (because of the constant squat-like stance), mitt, and a chest protector. The ball is hard in texture. It consists of an outer layer of stitched cowhide, a middle layer made of a combination of wool, polyester, cotton yarn, and an inner layer with a round cork centre. The official ball used in Major League Baseball weighs in the range of 141.75--148.83 grams, and typically has a circumference of 22.86--23.49 centimetres.

Although the outfield dimensions of baseball fields vary from one stadium to the next, the infield diamond is a standard ninety square feet. The pitching mound lies in the centre of the diamond, eighteen feet in diameter and ten inches higher than home plate. The first, second, and third bases are fifteen square inches, compared to the home plate which is seventeen square inches. The distance between all bases is a standard ninety feet. See the figure below.

Figure 3. Baseball diamond



Source: [online image of baseball diamond], (n. d.), https://bit.ly/3eAg3F9

Intricacies of the game to consider when choosing KPIs

The literature on physical measures relative to player position is scarce; there have been a few studies examining anthropometrics and body composition profiles for various player positions. One particular study examined the physical characteristics for various player positions within college baseball to determine whether or not player position profiles exist (Carda and Looney, 1994). According to their findings, pitchers tended to be taller and had less musculature than other positions. They found outfielders to have a more mesomorph-type body. Among infielders, differences within positions such as first, second, and third basemen were also apparent. They found that first basemen and shortstops tended to be taller than second basemen. Finally, this study found catchers weighed more than second basemen. Carvajal *et al.* (2009) provide additional discussion of body type and baseball prowess. Other physical variables that have been studied in baseball are flexibility and speed. Additionally, many coaches and scouts utilise assessments of flexibility and speed to predict the performance of baseball players. Hoffman *et al.* (2009) found that performance measures, and not anthropometric assessments, account for twenty-five to thirty-one percent of the variance in baseball performance. Findings from this study revealed that, for professional baseball players, grip strength, anaerobic power, agility, and speed are better predictors of performance than body

composition. Another study focused on age as a covariate (Mangine *et al*. 2013). This was confirmed by another study that found that the most important predictors of performance for baseball players were anaerobic power and speed, respectively. The study examined associations among anthropometric and performance measurements on fielding performance. It revealed that the maximal vertical jump and pro agility drill were better predictors of performance than body composition or anthropometrics.

Overall, professional baseball players have been found to possess the physical attributes of anaerobic power, speed, and agility. For instance, research has shown that grip strength is significantly greater for MLB players compared with rookies and semi-professional baseball players. MLB players also exhibit significantly higher anaerobic power, evident in their vertical jump peak power and vertical jump mean values. In addition, agility and speed, as quantified by the pro agility assessment and the 10-yard sprint, were also strong predictors of performance for professional baseball players compared to non-professional baseball players (Coleman and Lasky, 1992). The current MLB draft combine, an event that assesses physical and sports specific skills in baseball prospects garners data on several KPIs. See the table below as an example of the baseball prospects during the draft combine.

Table 1. MLB Draft Combine

MLB Draft Combine 6/16/22

Athlete	Position	School	30 Yard Sprint
Curtis, Jeric	Center Field	Tomball Memorial HS	3.50
Jones, Spencer	Right-handed Pitcher	Vanderbilt U	3.60
Scott, Victor	Outfield	West Virginia U	3.60
Gupton, Michael	Outfield	Rolesville HS	3.60
Wimmer, Braylen	Second Base	U South Carolina	3.60
Phelps, Robert	Shortstop	Allderdice HS	3.70
Roberts, Brett	Second Base	Florida State	3.70
Austin, RJ	Shortstop	Pace Academy	3.70
Martin, Maximus	Shortstop	Moorestown HS	3.70
Grady, Jace	Outfield	Dallas Baptist U	3.70

Source: Prospect Development Pipeline, (n. d.), https://atmlb.com/3epqaN1.

Understanding various player positions is essential for determining which measures are most suitable for predicting performance for a particular position. Let us take a look at the role of the pitcher. The pitcher must be able to throw the ball continuously. Thus, he must have great range of motion in his throwing arm, as well as muscular endurance, muscular power, and anaerobic power. Pitchers are also responsible for covering the area in the middle of the field near the pitcher's mound. With this in mind, it is imperative that assessments of flexibility (range of motion), upper body muscular endurance, muscular power, endurance, upper body muscular power, and anaerobic power be implemented. It is suggested that the throwing arm's external rotation and shoulder flexion be assessed using a goniometer. Pitchers should exhibit greater range of motion than the non-athletic population, which typically displays ninety degrees range of motion for external rotation. Professional baseball

pitchers have been reported to have external rotation values ranging from 124 degrees to 148 degrees, and flexion of a minimum of 180 degrees, thus emphasizing the importance of upper body flexibility for this position. Although muscular endurance and power are usually assessed using the bench press, for overhead (throwing) athletes such as pitchers, the bench press may actually hinder performance as well as predispose them to injury.

There is scarce research on optimal measures of muscular endurance and muscular power for overhead athletes. Further research is needed to fill the gap in this area. Implementation of measures of muscular endurance and power should be performed cautiously and under the supervision of a strength and conditioning coach. Moreover, assessments of internal and external rotation using manual muscle testing are strongly recommended. For anaerobic power, typical assessments may be utilised wherein the pitcher incorporates his core and entire body into the pitch in an explosive manner (Wilk *et al.*, 2002; Kolber *et al.*, 2010; Haupt, 2001; Durall, 2001; Wilk *et al.*, 2009; Brown *et al.*, 1988; Constant and Murley, 1987; Constant *et al.*, 2008; Wilk *et al.*, 1993; Kelly *et al.*, 1996; Seroyer *et al.*, 2010; Crotin and Ramsey, 2012; Johnson, 2013).

The position of a catcher requires squatting for prolonged periods of time. The catcher's role is to catch pitches and to prevent base runners from getting on base. The catcher must be able to react quickly to stolen base attempts, throw the ball to infielders, and repeatedly use his legs in an explosive manner, moving from a squat to a standing position. Additionally, he must be alert for any foul balls or pop-ups.

Accordingly, measures appropriate for assessing catchers include assessment of lower body muscular strength, power, and endurance. Assessment of vision, coordination, and anaerobic power are also recommended (Peng *et al.*, 2009; Fortenbaugh *et al.*, 2010; Alston and Weiskopf, 1972; Shaffer *et al.*, 2008; Hoffman, 2012; Wilk *et al.*, 2004; Laby *et al.*, 1996; Clark *et al.*, 2012; Fischman and Schneider, 1985; Classé *et al.*, 1997).

The shortstop is responsible for covering balls between second and third bases. His role includes backing up the second baseman when a player from the opposing team tries to steal a base. It would be beneficial to assess anaerobic power and reaction time

(Rader, 2008; Johnson *et al.*, 2001; Watkinson, 1998). For the most part, the outfielder's responsibilities are to catch balls hit into the outfield, be able to throw the ball long distances, and prepare for the following play. Although each fielding position is different, many of the assessments covered earlier are used to assess the fielder's overall muscular strength, power, and endurance, as well as anaerobic power. Measures for infielders should include assessments of reaction time and coordination in addition to the physical measures already mentioned (Shaffer and McBeath, 2002; Coleman and Lasky, 1992; Hoffman, 2006; Hoffman *et al.*, 2009; Dean *et al.*, 2011; Tamborra, 2007; Cox *et al.*, 2003; Raab, 2003; Masters, 1992; Martin, 2015).

Fútbol **(soccer) key performance indicators**

History of *fútbol*

The most popular sport in the world is '*fútbol*' and is also known by the name of soccer within the United States. Although there are many different versions of the early beginnings of *fútbol*, written text has been found referring to a similar game in China more than three thousand years ago. The game went by the name of 'Tsu Chu' and involved kicking a leather ball into an empty hole. Other *fútbol* historians note that, while this game was being played in the Eastern hemisphere, Native American tribes in the Western hemisphere were playing a kicking game called '*pasuckuakohowog*', which translates to 'they gather to play ball with the foot'. Researchers have also found traces of the game in Japan, Egypt, and Greece prior to it becoming popular in Europe and the Americas. In fact, kicking games may have been used to prepare warriors for battle. Around 600-1600 AD versions of a kicking game were recorded in the Americas. Mesoamerican civilizations formed teams and set up baskets around a designated area with the objective of kicking a rubber ball into them.

Figure 4. The history of soccer

Source: [online image of the history of soccer], (n. d.), https://bit.ly/3RYCdOX.

Ultimately, modern soccer originated in England, although among royalty it was frowned upon as a sport. English royalty were even known to imprison players of the game because of the ruckus it caused and its violent nature, which eventually led to its banning. In spite of these events, rules for play were codified at the University of Cambridge in 1848, and were known as the Cambridge Rules. The sport grew and began to be played in schools and universities all over the country. Official soccer rules, known as the Laws of the Game, were drawn up by Cobb Morley, now recognised as the 'father of soccer'. These rules were eventually accepted by the Football Association in 1863 and have withstood the test of time. The first governing body of soccer was the Football Association, as the game was originally called association football. The first official Football Association Cup was played in 1872. Leagues began to emerge in the late 1800s and early 1900s. The governing body of association football in Europe was the Union of European Football Association (UEFA) which was initiated in 1971. A few decades later, the popularity of soccer spread to the United States and,

in 1996, the organisation of Major League Soccer (MLS) was developed.

Format of the sport

The sport of *fútbol* is played with eleven players on each team. It is a game in which hands are not allowed to touch the ball, with the exception of the goalie. The objective is to score as many goals as possible against the opposing team, and have the higher score by the end of the game. There is a ninety-minute clock, split in two halves, with halftime in the middle. After a fifteen-minute halftime, teams switch sides.
The common goal is to score as many goals as possible and prevent the other team from scoring. A team is considered to have scored a goal when the soccer ball crosses the goal line. In soccer, there is a sudden-death overtime that involves additional time for each team to score a goal. The winning goal in overtime is called the 'golden goal'. If neither team has scored in the two additional fifteen-minute overtime periods, penalty kicks take place to decide the game. Penalty shots also occur when a player commits a foul within the area of his own penalty box. Consequences of foul play include receiving a yellow or red card. A yellow card from the referee represents a warning. Two yellow cards are the equivalent of a red penalty card. A red card is given to a player when he has done something significantly wrong. The player is then required to leave the field immediately, and is suspended for the following game.

Figure 5. The FC Barcelona - AC Milan connection continues

Source: FC Barcelona, 2022, https://bit.ly/3CTNhss.

Equipment utilised in modern-day soccer includes a pressurised spherical soccer ball, the inner layer of which is a latex bladder, and the outer layer stitched along the edges. The soccer ball's official dimensions are twenty-two centimetres in diameter and between sixty-eight and seventy centimetres in circumference. A FIFA-approved soccer ball is the highest quality ball, as gruelling tests of water absorption, air retention, air flight, and shape retention have been performed to make sure it is match-ready. The ball weighs between 410 and 450 grams. Dimensions of the official soccer field are typically 115 yards in length, by 74 yards in width. The field consists of several landmarks including the goal line, halfway line, centre circle, centre spot, penalty box (eighteen-yard box), penalty spot, penalty arc, goal box (six-yard box), corner arc, and the technical area. Finally, soccer uniforms are fairly simple and consist of a jersey with the name and number of the player on the back, shorts, shin guards, and soccer-specific cleats. The goalie requires additional padding and gloves with which to catch the ball (Luxbacher, 2005; Neilson, 2003; Gifford, 2008).

Intricacies of the game to consider when choosing KPI

Although soccer technically consists of eleven positions, there are four distinct categories in which they can be placed. The first category is the goalie, second are the defenders (full backs), third includes midfielders (half-backs), and the fourth category is that of forwards (strikers). The eleven positions can be shifted a bit, meaning that based on the formation, there may be more or fewer defenders, midfielders, or forwards on the field. There are two very popular formations common in today's game. There is the 4-4-2 formation, which consists of four defenders, four midfielders, two forwards, and the goalie. Then there is a 4-3-3 formation that has four positions as defenders, three as midfielders, three forwards, and of course the goalie. The number of fullbacks, midfielders, and forwards may deviate based on the strategy of play, according to whether the coach wants to incorporate a more offensive or defensive style of play.

It is important to understand formations, as most often they are indicators of a team's style of play, whether offensive, balanced, or defensive. A team that has an offensive style of play is always trying to find a way to score and is on the attack. Typical formations of teams that play using a more offensive style teams include the 4-4-2, 4-3-3, 4-2-4, 3-4-3, and 3-5-2. On the other hand, a team whose goalie may not be strong or a team facing an opposing team whose offense is extremely strong may be better off using a defensive style of play. Such a team may implement a 4-5-1, 5-3-2 or the versatile 4-4-2 formation.

Literature on physical and psychological measures for professional soccer players reveals very interesting findings. Rampinini *et al*. (2007) examined a repeated-sprint ability (RSA) protocol, which consisted of maximal sprints lasting from one to seven seconds with interspersed short recovery period. They found RSA to be a more accurate assessment of anaerobic power than a single sprint assessment of match performance for soccer players. The assessment was quantified by a video-computerised match analysis image recognition system called ProZone. The RSA measure was found to be a more precise measure of match performance due to its ability to simulate real-time soccer matches. Another study examining anthropometrics and age characteristics of professional soccer players found no significant differences in match performance by age. However,

the results did show that current players in the position of goalie, central defender, and centre forward seem to be older and have gotten taller than soccer players forty years ago.

The Rampinini *et al*. (2007) study suggests that today's goalies, central defenders, and centre forwards are older and taller than players in those positions forty years ago. Additionally, this study found that midfielders and wing players displayed lower BMI and reciprocal ponderal index (a measure of leanness) compared with players in positions centrally located on the soccer field. In 2010, a protocol simulating soccer games was developed and termed the ball-sport endurance and sprint test, nicknamed the BEAST90 protocol by Williams *et al*. (2010). This assessment measures movement patterns and physical demands, replicating those that occur in a real-life soccer match. Amateur soccer players were tested to assess the validity and reliability of this protocol. Validity and reliability were established by comparing the values obtained from two separate assessments (with a gap of seven days in between) of fifteen amateur soccer players on distance, movement, peak heart rate, and oxygen uptake. The values in the two trials were comparable and did not significantly differ, confirming the reliability and validity of the BEAST90 protocol. This protocol is recommended for assessment of cardiorespiratory endurance and anaerobic power typically evidenced in a ninety-minute soccer match (Williams *et al*., 2010). See the table below for reliability values.

Table 2. Test-retest reliability values for the BEAST90 protocol

Table 3. Test-retest (trial 1 vs. trial 2) reliability values for $BEAST_{90}$ protocol ($n = 15$).*

Measure	Interval	Change in mean (95% CI)	Typical error (95% CI)	Percent typical error (95% CI)
Circuit time (s)	First half	−5.6 (−9.24, −1.98)‡	4.6 (3.39, 7.31)	2.4 (1.80, 3.8)
	Second half	−8.3(−13.44, −3.25)‡	6.5 (4.76, 0.25)	3.2 (2.4, 5.1)
	Full time	−7.0 (−10.95, −3.00)‡	5.1 (3.72, 8.00)	2.6 (1.9, 4.1)
12-m sprint time (s)	First half	−0.01 (−0.04, 0.02)	0.04 (0.03, 0.06)	1.8 (1.25, 2.90)
	Second half	−0.02 (−0.08, 0.04)	0.07 (0.05, 0.12)	3.2 (2.30, 5.37)
	Full time	−0.01 (−0.06, 0.03)	0.05 (0.04, 0.09)	2.4 (1.70, 3.97)
20-m sprint time (s)	First half	−0.01 (−0.03, 0.01)	0.03 (0.02, 0.05)	0.9 (0.69, 1.49)
	Second half	−0.01 (−0.10, 0.08)	0.11 (0.08, 0.18)	3.3 (2.4, 5.1)
	Full time	−0.01 (−0.06, 0.04)	0.06 (0.05, 0.10)	1.9 (1.39, 3.02)
VJ (cm)	First half	−1.6 (−3.07, −0.13)†	1.8 (1.31, 2.91)	4.5 (3.24, 7.33)
	Second half	−1.8 (−3.41,−0.12)†	2.1 (1.54, 3.31)	6.6 (4.80, 10.62)
	Full time	−1.7 (−3.20, −0.20)†	1.8 (1.33, 2.96)	5.3 (3.78, 8.59)
HR ($b \cdot min^{-1}$)	First half	−3.6 (−8.19, 0.91)	4.8 (3.35, 8.40)	2.8 (1.97, 5.02)
	Second half	−2.4 (−6.25, 1.45)	3.8 (2.62, 6.94)	2.2 (1.51, 4.05)
	Full time	−3.1 (−6.77, 0.57)	3.6 (2.50, 6.62)	2.1 (1.43, 3.84)
RPE	First half	1.5 (1.13, 2.42)	12.0 (8.67, 19.62)	12.0 (8.67, 19.62)
	Second half	−0.03 (−1.05, 1.00)	1.3 (0.96, 2.06)	9.9 (7.15, 16.03)
	Full time	−0.2 (−1.21, 0.88)	1.3 (0.97, 2.10)	10.4 (7.49, 16.84)
Shooting accuracy	First half	2.1 (−2.09, 6.38)	5.2 (3.76, 8.36)	23.1 (16.23, 39.70)
	Second half	5.6 (1.23, 9.91)†	5.3 (3.86, 8.57)	25.5 (17.87, 44.11)
	Full time	8.2 (0.90, 15.53)†	9.0 (6.50, 14.44)	19.6 (13.83, 33.35)

*CI = confidence interval; HR = heart rate; VJ = vertical jump; RPE = rate of perceived exertion.
†$p < 0.05$.
‡$p < 0.01$.

Source: Williams *et al.*, 2010, p. https://bit.ly/3yFjVeZ.

Regarding psychological assessments for *fútbol* athletes, the literature is scarce. In 2001, Filaire *et al.* (2001) examined seventeen male professional soccer players' mood states. The findings revealed that professional soccer players who played well displayed the positive attributes of the iceberg profile and performed optimally during their soccer matches, and that successful performance coincided with the typical iceberg profile in these professional soccer players. Additionally, they found a significant decrease in vigour, paired with increased levels of tension and depression, in professional soccer players who performed poorly. It is important to know that soccer players have a tendency, because of the nature of sport, to suffer disproportionately from pulled muscles in the thigh area (twenty-three percent more), knee injuries (seventeen percent more), and ankle injuries (also seventeen percent more) compared to athletes in other sports. Another study examined the relationship between lower body muscles and anaerobic power in soccer players (Robineau *et al.*, 2012). Researchers specifically assessed the quadriceps and hamstring muscle groups as they relate to sprint speed, squat jump, and countermovement jump height reach. They found that over the length of a soccer match, squat jump height and sprint speed were significantly reduced, while no changes were found in countermovement jump. This

implies that the squat jump may be a more relevant measure of the anaerobic power pertinent to in soccer matches.

Chamari *et al*. (2008) examined lower body explosiveness utilised in the squat jump and countermovement jump with a modification that included five consecutive strides prior to, and post, the actual jump. They called the five consecutive strides jump test the '5JT' and implemented it with fifteen elite soccer players. They found that the 5JT had a significant positive correlation with both the standard squat jump measure and countermovement jump. Chamari *et al*. (2008) suggested that the 5JT could also be used as an assessment of anaerobic power. Additionally, these researchers noted that distance covered during a soccer game significantly differed between player positions, with midfielders and forwards covering approximately twelve kilometres compared to defenders who typically cover about ten kilometres. Although research on key performance indicators measures of *fútbol* players is more abundant than for other sports, there is still a long way to go (Chamari *et al*., 2008).

Speed, agility, and anaerobic power are typically assessed for all soccer positions. The UEFA training ground and FIFA websites are great resources often utilised in the MLS soccer combine, as well as by other teams seeking to measure and assess soccer performance. But it must be recognised that measures and assessments should be designed for specific player positions. Taking a closer look at the role of each position, information can be extracted and utilised to develop more relevant and predictive assessments of soccer performance. The position of defender typically requires greater anaerobic power capacity rather than aerobic capacity. Defenders also tend to be lower in technical skill, but have greater tackling ability in comparison to midfielders and strikers. As mentioned previously, players in centre positions, particularly centre defenders, are taller than right and left defenders. Athletes playing the sweeper position are usually smaller and quicker. Anaerobic power, agility, and lower body muscular strength should be assessed for defenders. Additionally, the psychological makeup of a defender has been recognised to include high levels of motivation, persistence, and resiliency. Relevant psychological assessments include SMS-6, MMPI, and the 16PF (Wong, 2008). A midfielder, regardless of whether designated to play in a more offensive or defensive style, should possess extremely high cardiorespiratory endurance and anaerobic power. A midfielder

may have some advantage if he is tall, such as in winning headers. Conversely, a short midfielder may be quicker and more agile in eluding defenders. The midfielder position also requires the ability to see the game, spot teammates, make accurate passes, and set up plays. Of all soccer positions, midfielders are considered to control the pace of the game. They must be versatile enough to transition from defense to offense, pass the ball to the striker, and take the shot themselves. Assessments of cardiorespiratory endurance, as well as anaerobic power are strongly recommended. Additionally, the BEAST90 protocol is recommended for assessment and training, as it encompasses both aerobic and anaerobic capacity characteristics. Lower body muscular endurance and power assessments are also recommended for players in this position. The midfielder position requires that the athlete have high levels of vigour, the ability to think under pressure, create plays, as well as possess quick reflexes and decision-making ability. Thus, it is recommended that midfielders be assessed on the iceberg profile, the CSAI-2R, the Wonderlic, and the IAT to assess confidence and anxiety levels, cognitive ability, and reaction time reflexes.

When it comes to the position of forwards, the position mainly responsible and receiving credit for making goals, there are tall forwards and short forwards. The position of a forward requires quick decision-making skills and the ability to score goals. Thus, forwards should have high levels of anaerobic power, extremely high-shooting accuracy, great vision, anticipatory skills, and killer instincts. They must have the ability to handle pressure and be able to finish the play by scoring the goal. Measures of anaerobic power such as jump tests, RSA, and agility are strongly recommended for this position.

As for assessing the skill and technique needed for the scoring ability that is crucial to the position of a striker, incorporating a game-like simulation similar to that used by the NBA (for spot-up shooting and shooting off the dribble) should be implemented; but for soccer in this case. For instance, for a forward it might be useful to incorporate drills and assessments that include dribbling and passing defenders, shooting from each side of the field, and scoring. Drills such as these will help to better assess skills and predict future in-game performance for the forward position. Also, assessments of vision and reaction time using the IAT are recommended. Regarding psychological assessments, the SOQ and the TSCI are

great surveys of confidence that are known to be reflective of handling high-pressured situations. The MMPI, TAT, and 16PF may be used to assess player personality, but there is yet to be a diagnostic that quantifies the 'killer instinct.' A goalie requires great anticipatory skill, eye-hand coordination, flexibility, and anaerobic power. Recommended associations include the IAT, back scratch test, trunk rotation test, and the static squat jump. Additionally, a goalie should possess certain psychological traits specific to this position. The goalkeeper's position is very solitary. Thus, the player should display some degree of independence which may be assessed using the 16PF or the MMPI. At the end of the soccer match, goalies have been said to feel one of two ways: like a winner, or like a failure. Goalies must have extreme concentration, thus an ability to get into the zone and remain in a state of flow should be assessed using either the Flow Questionnaire or the Flow State Scale. Finally, when it comes to being scored on, the goalie should have what is called a 'short-term memory', so as not to affect future performance.

Combining the assessment of physical and psychological constructs with analytics is a new and better way of strategizing and predicting performance that can be developed in *fútbol*. Until recently, soccer analytics have been silent or dormant. A book about soccer, *The Numbers Game* (Anderson and Sally, 2013), reveals that, shockingly, 99 % of the time players do not have the ball, and 98.5 % of the time they run without it. The typical soccer player has possession of the ball for an average of 53.4 seconds throughout the entire course of a soccer match (Anderson and Sally, 2013).

Sports analytics revolution has been at the forefront of sports science and technology, utilised by players, coaches, and team management to optimise performance and, consequently, the chances of winning.

American football key performance indicators
History of the sport

American football is not only a beautifully complex game, full of strategy and intricacy: it is the quintessential sport of the United States. In fact, playbooks specific for offensive and defensive plays have been carefully designed to train players in the different strategies that can be used against opponents.

The game of football is rumoured to have evolved from games which involve kicking, possibly soccer and rugby.

Legend has it that an individual who was playing *fútbol* (soccer) suddenly became tired midgame of kicking the ball around, so he picked it up with his bare hands and began to run with it, and a new game was formed. As the game grew popular, football leagues began to develop across the country, and in 1922 the American Professional Football Association changed its name to the National Football League (NFL).

Figure 6. History of American football

Source: [online image of the history of American Football], (n. d.), https://bit.ly/3S8XE00.

The early part of the century saw the growth of football, the most significant event of which was the development of the American Football League (AFL) in the 1930s. The first NFL playoff game was held in Chicago in 1932. The NFL's inaugural player was Jim Thorpe, who later became the president of the NFL. The 1950s were known for the development of the Eastern and Western divisions and the addition of championship games.

In 1959, the American Football League (AFL) was founded, but it was not until the late 1960s that the first AFL-NFL Super Bowl took place and was won by the Green Bay Packers. In the 1970s, the Miami Dolphins won Super Bowl VII with the significant record of a perfect winning season. During this period, the AFL joined

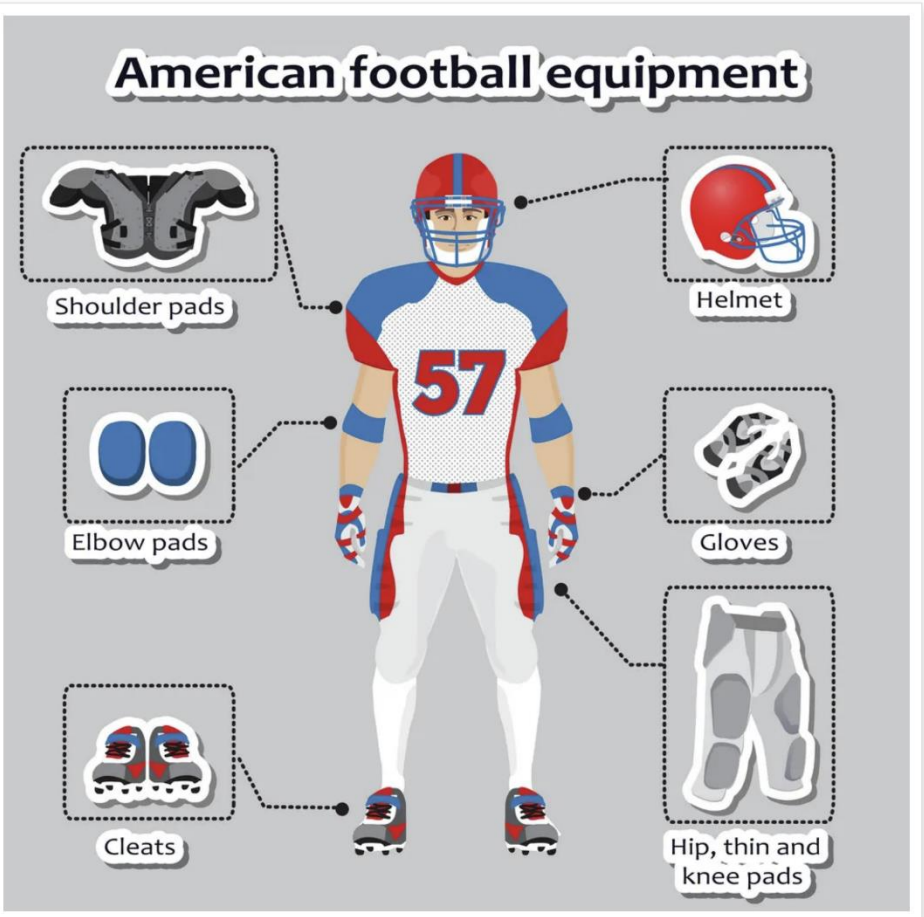
the NFL and, as a result, two subdivision conferences emerged: the National Football Conference (NFC) and the American Football Conference (AFC). Both the NFC and the AFC are comprised of sixteen teams each and have their own playoffs. The victors of each conference then meet at the Super Bowl, where the winner is crowned the NFL champion (Frommer and Gifford, 2015).

Fundamental rule changes were implemented in 1974. The rules were modified, and the game made more exciting with the introduction of sudden death in overtime, goal posts were relocated to the end lines, and the place for the starting kick-off was changed from the forty-five to the thirty-yard line. More recently, safety rules have been in the spotlight due to growing evidence of the deleterious effects of concussions. Research findings have led to innovation in equipment, such as additional padding and sensors in helmets and shoulder pads.

Format of the sport

The football uniform consists of a helmet, which nowadays is specifically designed to attenuate the effects of being tackled and reduce the potential harm from concussions. Shoulder pads and kneecaps are mandatory, along with a mouth guard, cleats, same-coloured socks, and a number identifying the player on the jersey. The sport of football technically requires only a ball of conical shape, typically brown in colour and of leather material with seams and a weight of four hundred grams (Peterson, 1996). Although the game can be played anywhere, in a park or an empty street, the official playing field is one hundred yards long and fifty-three and one-third yards wide, and has end zones and goal posts at both ends, where touchdowns and field goals are scored. Throughout the field are yard markers which look like dashes on the field and are placed there to help the players, fans, and officials keep track of the ball as well as the yardage covered by players.

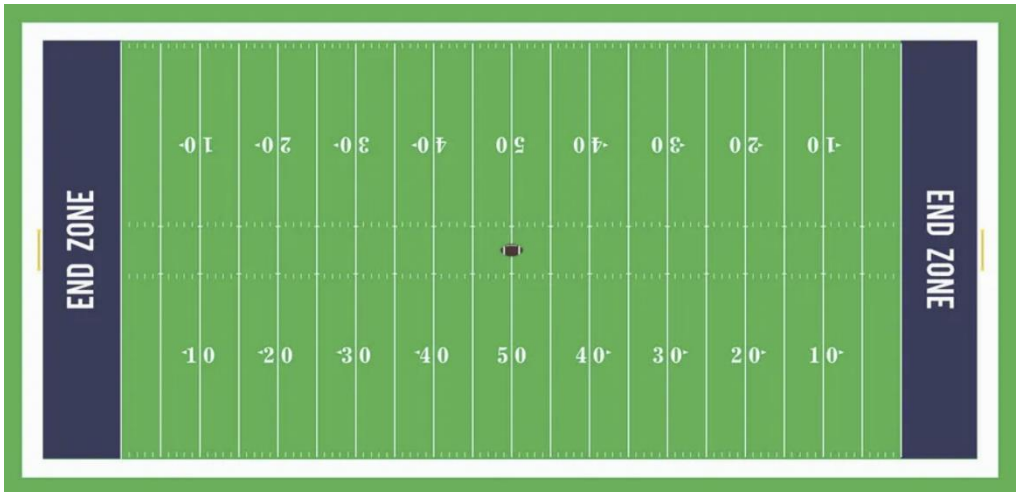
Figure 7. American football equipment and uniform



Source: [online image of American football equipment and uniform], (n. d.), https://bit.ly/3MKPLgd.

The yard markers that are located in the centre of the field are known as hash marks and are designed to set the boundaries for where a play can begin. Each play begins with the ball placed at the exact spot on the field where the previous play ended, unless the play finished outside the hash marks (away from the middle of the field). If a play finishes outside the hash marks, the next play begins with the ball placed on the hashmark closest to where the play ended.

Figure 8. American football field



Source: [online image of the American football team], (n. d.), https://bit.ly/3RW5E45.

The sport of American football is a game that is quantified and played within four quarters. Each quarter consists of fifteen minutes, with a twelve-minute half-time break occurring between the second and third quarters. The teams alternate sides and play on different sides of the fields each quarter. The team that possesses the ball at the end of the first and third quarters continues to have possession at the start of the following quarter. However, this rule does not apply before or after halftime because the second half is begun with a kick-off.

In the NFL, each team must play sixteen games during the regular season, a requisite being that each team play every other team within its division twice. There are four teams per division, thus within one's own division a total of six games are played. In addition, both AFC and NFC teams must play all teams from one other division within their conference, adding another four games. Further, each team plays all the teams in one division from the opposite conference, racking up another four games. Lastly, two final games are played against two teams within their own conference that they have not played previously.

A football team is composed of eleven players. The team in possession of the football is called the offense; their objective is to score a touchdown. On the other hand, the eleven-man team which does not have possession of the ball is called the defense. The defense's objective is to prevent the offensive team from scoring, as well as to get possession of the ball as quickly as possible (by intercepting). However, if the offensive

team scores, roles are automatically switched, as is possession of the ball. This manner of play continues until time runs out.

A football game begins with the 'kick-off' when the ball is kicked from the defensive team's thirty-five-yard line by the 'placekicker', whose job is to kick the ball as far as he can into the opponent's territory. The opposing team will try to counter by catching the ball and running it down the field as far as they can before being tackled.
For deep kicks that travel into the end zone, the opposing team may elect to not return the kick and instead opt for a 'touchback', which automatically gives the team possession at their own ten-yard line. Kick-offs that travel at least ten yards are known as a 'live-ball' and can be recovered for a possession by both the kicking and receiving team. Teams usually prefer to kick the ball deep into their opponent's territory to make the opposing offense drive the length of the field, but at times teams alter their strategy and attempt an onside kick (short kick-off) in hopes of recovering the kick before the opponent has an opportunity to do so.

Within the game, another form of initiation is the well-known 'snap', a cue that is traditionally used to start each play. The centre 'snaps' the ball under his legs to the quarterback, who is typically recognised as the player position 'calling plays' in code. The quarterback then decides within seconds what to do with the ball, whether to throw it to a teammate or run it down the field.

Figure 9. NFL Miami Dolphins football teammate about to snap

Source: [online image of NFL Miami Dolphins], (n. d.), https://bit.ly/3T4x1u7

Each team consists of an eleven-man team. Each team is formed of three different sections which, oddly enough, are also called teams: the offensive team, the defensive team, and the special teams. The offensive team, also known as offense is the part of the team which has possession of the ball and whose objective is to score a touchdown. Conversely, the defensive team, also known as the defense, is the section of the team whose main objective is to stop the other team's offense. The special team's unit consists of players used in kicking situations such as kick-offs, punts, field goals, and point-after-touchdown attempts (Gargano, 2010).

Within each team are several positions that encompass very different physical and psychological attributes. Arguably, the most important position is the quarterback, which requires the ability to make decisions quickly under pressure. The quarterback leads the offensive team and informs his teammates playing offense of the plays they will be executing.

There are only two ways for the offense to advance the ball, by running or passing the ball. There are several ways to score points. The most common ways include the touchdown which scores six points, the extra point which yields a single point, the two-point conversion for two points, safety also for two points, and a field goal which is three points. Some fewer common methods of scoring points include the defensive two-point conversion in which the defense returns a failed point-after-touchdown attempt by the offense, a one point safety which can also be earned on point-after-touchdown attempts, and the fair-catch kick which scores three points and happens when a team elects to attempt an uncontested field goal in lieu of running a normal play from scrimmage.

A fundamental concept in football is that of 'downs'. Basically, the offense has four attempts in which to gain a total of ten yards. If the team is successful in its first attempt, it earns a first down and another set of four downs, as well as the opportunity to gain another ten yards. Play typically ends if the player is tackled to the ground, one or both knees touch the ground, or if he runs, or is forced, out of bounds.

A turnover, such as a fumble or interception, can be a game changer. A fumble occurs when a player drops the ball or loses possession when he was considered to have possession of the ball. Alternately, an interception occurs when a defensive player from the opposing team catches a ball that was not intended for him, causing a shift in the momentum of the game.

Intricacies of the game to consider when choosing KPIs

An understanding of how to play the game answers the following question: 'what are the things you have to do to play the game?' As sports and data scientists we are led to ask what are the things needed to do well to win, or be the best at this sport. Logically, this leads us to discuss assessment and measurement of variables affecting football performance.

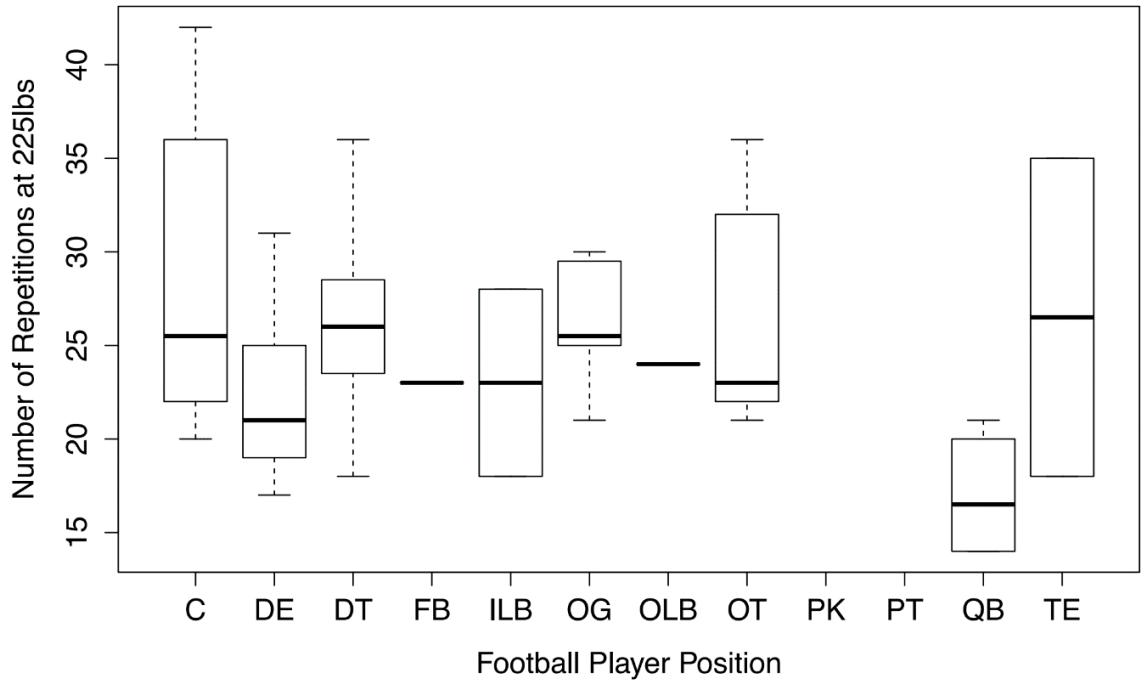
The NFL has established its own battery of physical measures for rookies and players new to the NFL, called the NFL Scouting Combine. It consists of the following physical tests: forty-yard dash, bench press, vertical jump, broad jump, three-cone agility drill, and the 20-yard shuttle (5-10-5 agility test). These assessments are conducted once every year as part of the NFL Combine. Factors such as speed, anaerobic power, agility, muscular strength and power are assessed. The NFL periodically restructures the NFL Combine performance tests and variables measured in order to improve the prediction of player performance.

There are clear differences in the physical and psychological makeup between sports and further sub categories among player positions. Measures differ in importance from position to position, and therefore the optimal KPI for one sport may not be relevant for another, likewise for athletes in different positions within the same sport.

An example using American football would include that of the player position of quarterback which requires quick reaction time, decision-making skills, anaerobic power, and flexibility, among other factors. Furthermore, other psychological assessments can provide insight into the quarterback's mindset and abilities, which have been well known to affect performance in this particular sport. The quarterback requires a high 'football IQ' so a test of cognitive ability or intelligence is highly recommended. Currently, the Wonderlic is used in

professional football. Additionally, it is recommended that reaction time as well as confidence be assessed for players in this position, especially because the ability to play under pressure is key. The Wonderlic, IAT, and CSAI-2R should be utilised when assessing a quarterback. Conversely, the players attacking the quarterback should be assessed differently. Emphasis should be placed on KPIs that quantify first-step explosiveness (anaerobic power), muscular strength, and muscular power (Martin, 2016). All of these physical measures should be considered in addition to video playback, tape study, and game-time performance. Psychological assessments recommended for this player position include the Cattell's Sixteen Personality Factor Questionnaire and the Competitive Aggressiveness and Anger Scale (CAAS) (King, 2006). The defensive tackle position should be assessed quite differently. There is also a difference between a nose tackle and a pass-rushing three-tech defender. The typical stats of a nose tackle include a mean height of six feet and mean weight of 300 pounds. Nose tackles are known to run the forty-yard dash in under five and a half seconds and bench press more than thirty repetitions with a resistance load of 225 pounds. See the figure below for an example of the difference by player position on the number of repetitions performed with 225 pounds.

Figure 10. Number of repetitions performed of 225lbs by player position



Source:King, 2006

Although similar to the nose tackle, a typical defensive tackle averages a mean height of six feet three inches, and a mean weight of 280 pounds. Players in this position are known to be quicker, running the forty-yard dash in under five seconds, yet they have a good deal of muscular endurance (although slightly less than the nose tackle) and are able to do an average of twenty-five repetitions with a resistance load of 225 pounds on the bench press. The descriptive statistics mentioned above describe how players in similar positions may differ physically, thus emphasizing the need for individualised performance assessments.

Assessment of players for the running back position should include measures of vision and speed because the position requires excellent eye-hand coordination and the ability to find openings in a fast-paced, high-pressured game situation. That is not to say speed is not important. Speed is important, but only if a player has the ability to retain possession of the ball and change direction quickly. A running back benefits by having an explosive first step. Other assessments relevant to this position include physical measures of agility and lower body muscular power, such as the 20-yard shuttle and the maximal vertical jump. Other physical measures that should be assessed include the ability to change direction quickly, otherwise known as agility and lower body muscular power (explosive first-step).

Additionally, psychological assessments recommended include the IAT and the Wonderlic. The position of wide receiver is founded on speed and the ability to change direction quickly. The wide receiver's objective is to catch the ball and gain as many yards as possible toward the end zone in order to score a touchdown. Thus, this position requires excellent eye-hand coordination in order to catch the ball under the constant pressure that is applied by defenders from the opposite team. Assessment measures recommended for this position include speed, anaerobic power, agility and balance. Psychological assessments recommended for the position of a wide receiver include the SOQ, the IAT, and the CSAI-2R. Defensive ends are typically characterised by being big, fast, and strong. Throughout the years, athletes in this position seem to be getting bigger, faster, and stronger. Aside from physical attributes, these athletes must also have the ability to make split-second decisions, particularly, whether to target the quarterback or the running back. Erroneously, in the past, scouting teams relied heavily on categorising athletic ability simply by assessing a player's performance in the forty-yard dash. However, muscular strength is crucial for defensive ends as it is a fundamental requirement for tackling ball carriers, stopping forward momentum on runs, and taking on double teams by the offense; tackling, stopping runs, and halting double teams aimed at the quarterback. The typical height and weight of defensive ends participating in the combine range between six feet and six feet seven inches, with a mean height of six feet three inches and weight between 235 and 352 pounds. Physical measures recommended for this position include upper and lower body muscular strength and power using the bench and leg press (or squat).

It is important to examine appropriate variables for each position played. For instance, if a defensive lineman has a slow first step, intuitively it may seem to be due to lack of speed or anaerobic power. In fact, the slow first step may stem from his inability to concentrate or focus. Thus, it is important to examine both physical and psychological variables. Another major attribute for the defensive tackle includes reaction and anticipatory skills. The ability of the defensive tackle to read and react effectively against the offense is crucial to success in this position. It is strongly recommended that measures of agility, such as the three-cone drill and the 505-agility test, as well as the explosive first step test, be used. The ability to cut and change directions is extremely relevant to this

position. Muscular strength and endurance, depending on the tackle position being played, and as assessed by the bench press should be more greatly emphasized for this position than others. In addition, a test of leg strength and power is recommended. Squats or leg press can be used to assess muscular leg strength, power, and endurance. Underestimated by many, the legs are responsible for the transfer of power and strength up through the core and upper body, when used appropriately. Another important set of attributes for all football players includes reaction time and anticipatory skills. The ability of defensive players to read and react effectively against players on the offense is crucial to their success. The same is true for offensive players facing opposing defenders.

The ability to cut and change directions is extremely relevant to the majority of positions on a football team. Measures of agility include the three-cone agility drill, the pro agility drill, and the 20-yard shuttle. As for anaerobic power, a common feature is having an explosive first step and therefore an assessment such as the maximal vertical jump and countermovement jump tests are recommended. Upper body strength and endurance using the bench press is strongly recommended for offensive and defensive linemen, especially for those players who play in the middle of the line. That would include offensive guards, offensive centres, and defensive tackles. In addition, a test of leg strength and power is recommended. Squats or leg presses can be used to assess muscular leg strength, power, and endurance. Additionally, both the vertical jump and broad jump can be used to ascertain the explosive power a player has available in his lower body. Underestimated by many, the legs (when used appropriately) are responsible for power and strength being transferred up through the core to the upper body.

Basketball key performance indicators
History of the sport

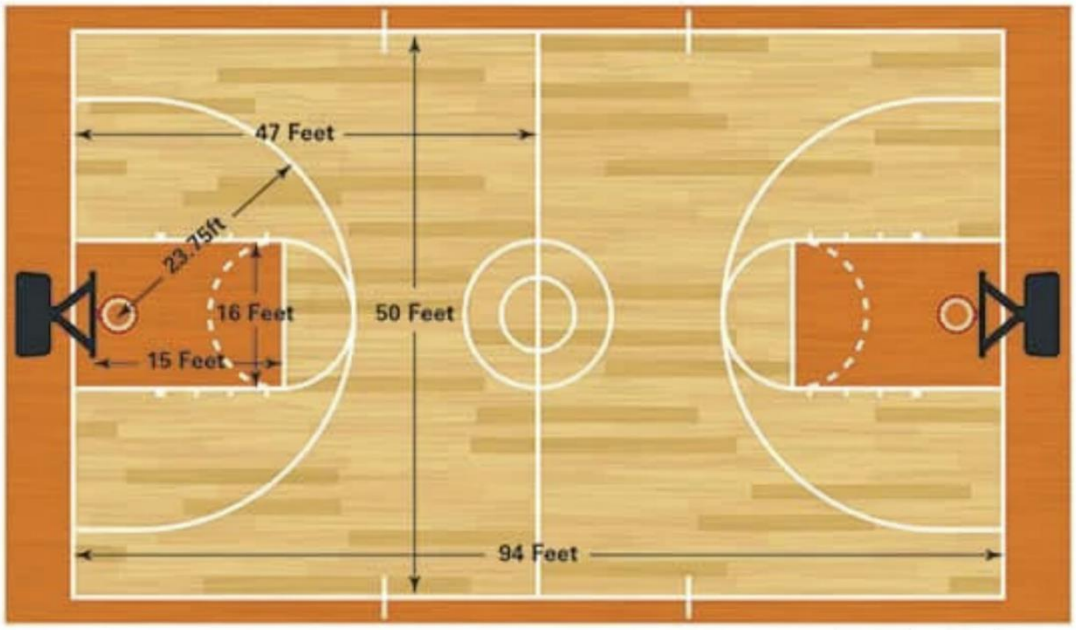
Rumour has it that the beginnings of the sport of basketball date back as far as 500 years to ancient Mexico. Others declare that the contemporary version of the game was developed by James Naismith. Let us fast forward to the 1890s when the game we now recognise as basketball was officially established, and the first real game was played in Springfield, Massachusetts. Although many people may think that women's basketball came into

existence fairly recently, this is far from the truth; the first official women's game also took place in the 1890s and was played in Northampton, Massachusetts (Wegener, 2014; Staffo, 1998; Naismith, 1941, and Hult, 1991). The current way we play the game of basketball as we know it today was developed by James Naismith of Springfield, Massachusetts, in 1891. Basketball was originally played using peach baskets. In 1906, the peach baskets were replaced by backboards with metal hoops. It is interesting to note that the original ball used to play the game was a soccer ball. It was not until a few decades later that the brown-orange ball was used. The game of basketball was demonstrated during the Olympic Games in 1904. Later in 1932, eight countries came together to form the International Basketball Federation or FIBA. Initially, the organisation was intended to oversee amateur players only. It held its first world championship for men's basketball in 1950 in Argentina. Although basketball debuted at the 1904 Olympics, it was not officially included as an Olympic sport until the 1936 games held in Berlin.

In 1989, FIBA began to include professional players in the league, making them eligible to play for the first time in the 1992 Olympic Games. During these games, the best and most recognised players from the NBA came together to form the 'Dream Team' (Brownell, 2008; Eschker *et al.*, 2004).

Since the original rules of basketball were established in 1892 by James Naismith, they have undergone several revisions and additions throughout the years. The official rules include not only the parameters of the game, but also regulations regarding equipment and apparel. The equipment required includes a backboard that is six feet wide and three-and-a-half feet high, and a rim that is located ten feet above the ground with a diameter of eighteen inches. The game is played on a court that is ninety-four feet long and fifty feet wide.

Figure 11. Official NBA basketball court dimensions



Source: [online image of official NBA basketball court dimensions], (n. d.), https://bit.ly/3s1bLtj.

The official ball in the NBA has a circumference of twenty-nine and one-half inches (74.93 cm) and a weight of twenty-two ounces (623.6 grams). Uniforms consist of long shorts and a jersey, typically with a number and the team's name on both the front and back sides (though there are exceptions), along with a pair of high-top sneakers; Naismith, 1941).

Figure 12. Evolutions of the basketball

Source: [online image of evolutions of the basketball], (n. d.), https://bit.ly/3T2ZY9M.

Format of the sport

The objective of the game is to score more points than the opposing team. Points are earned by making shots into the opponent's basket or net. A shot that goes through the basket can be worth one, two, or three points, based upon where it is taken from and the situation. For instance, a shot that goes through the basket is worth one point when taken from the free throw as a result of a foul or penalty. Shots made throughout the game are worth two points from inside the three-point line and three points from outside the three-point line. Shots that go through the basket are called field goals.

An NBA basketball game lasts forty-eight minutes, consisting of four twelve-minute quarters, whereas an FIBA game consists of four ten-minute quarters. Both leagues allot a fifteen-minute half-time break between the second and the third quarters, at which time the teams switch sides on the court. If both teams are tied by the end of four quarters, a five-minute overtime period is added. The clock is stopped when timeouts or fouls occur, so an NBA game ends up lasting much longer than forty-eight minutes, and an FIBA game longer than forty minutes.

The start of a basketball game is cued by the tip-off, with the ball being tossed up between two players, one from each team. In the second half of the game, the team that failed to win the tip-off is given first possession of the ball. As in football, the team with possession of the ball is called the offense and

the other team the defense. But unlike football, there are only five players on each team, and they play both offense and defense. Basketball play is continuous, interrupted only by fouls, timeouts, and between-quarter breaks. However, different from American football, the same five players play both offense and defense. In basketball, the team that does not have the ball is on the defense (Berg, 1995).

If you choose to be a data scientist for basketball, you should learn about player positions and the physicality involved with each position. You should know the fundamentals of the game. A basketball team consists of five players, each with a designated role: point guard (PG), shooting guard (SG), centre (C), power forward (PF), and small forward (SF). These are the traditional five player positions, although today there are players that play multiple positions and are considered hybrid players playing hybrid positions. See the figure below for typical location of player traditional player positions.

Figure 13. Traditional five-man player positions in basketball

Source: [online image of traditional five-man player positions in basketball], (n. d.), https://bit.ly/3rSqW8n.

Intricacies of the game to consider when choosing KPIs

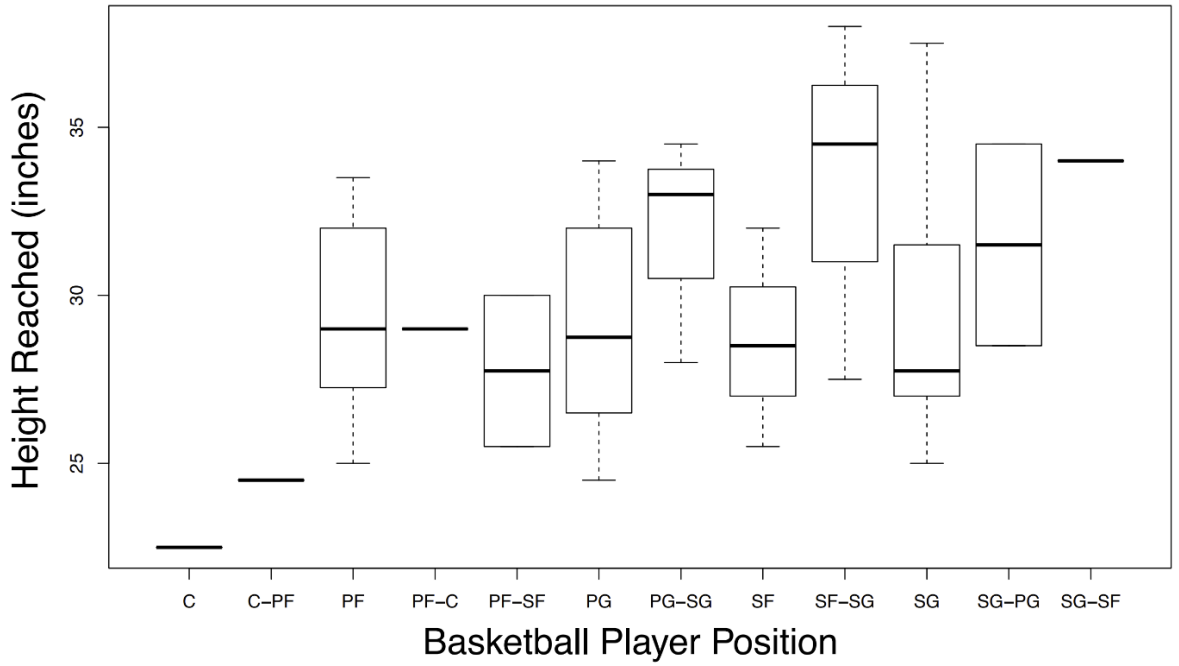
The point guard is responsible for leading, dribbling, and passing. Players in this position, although tall, are usually

the shortest players on the team. The role of point guard requires the ability to call plays as well as to execute them. While on offense, the player in this position needs to be a good passer as well as quick on his feet. When on defense, his role is to prevent shots from being made and to steal the ball from the other team. For the point guard, measures of speed and agility are fundamental. The three-cone agility drill, lane agility drill, or three-quarter sprint may be used to assess change of direction (COD) and speed. In addition, this position requires both aerobic and anaerobic power. Thus, a player should be tested for cardiorespiratory fitness through either a laboratory assessment such as the VO2 max or a field test such as the Cooper 1.5-mile run/walk submaximal test. Anaerobic power should be assessed using the Wingate cycle test, the maximal vertical reach, countermovement jump, static squat vertical jump, or maximal vertical jump. Psychological constructs that should be examined for this player position include team cohesion, confidence, decision-making ability, and leadership skills. Recommended psychological assessments include the GEQ, CSAI-2R, and the IAT (Sallet *et al*., 2005; Dirks, 2000).

The shooting guard is usually considered the team's best overall shooter, particularly from the outside of the court. The shooting guard is recognised as the best shooter on the team. His role requires attributes such as great eye-hand coordination, the ability (psychologically) to move on quickly from a missed shot, and outstanding shooting skills. He should be able to shoot from anywhere on the court and have good court sense to get open and make shots. When playing defense, the player in this position is responsible for guarding the other team's shooting guard, so he also needs the ability to anticipate the moves of other players and be quick enough to get to the ball before the opposing players take shots. The measures integral to the shooting guard position includes coordination, shooting skill, anaerobic power, speed, and agility. To better assess coordination and shooting skill, drills that simulate on-court dribbling and shooting are useful for predicting a shooting guard's game-time performance. The spot-up shooting and non-stationary shooting assessment are appropriate. Anaerobic power may be assessed through maximal vertical reach or other jump tests mentioned previously. See below the figure for performance by player position on the max vertical jump. The graph displays that the better performers on this assessment are the hybrid of small forward – shooting guard position followed

by the hybrid position of the point guard – shooting guard position. Keep in mind that the traditional pure point guard and pure shooting guard player positions do approximate the hybrid positions in terms of their maximal data point, but the bulk of the data points are well below the other player positions aforementioned.

Figure 14. Vertical jump by player position



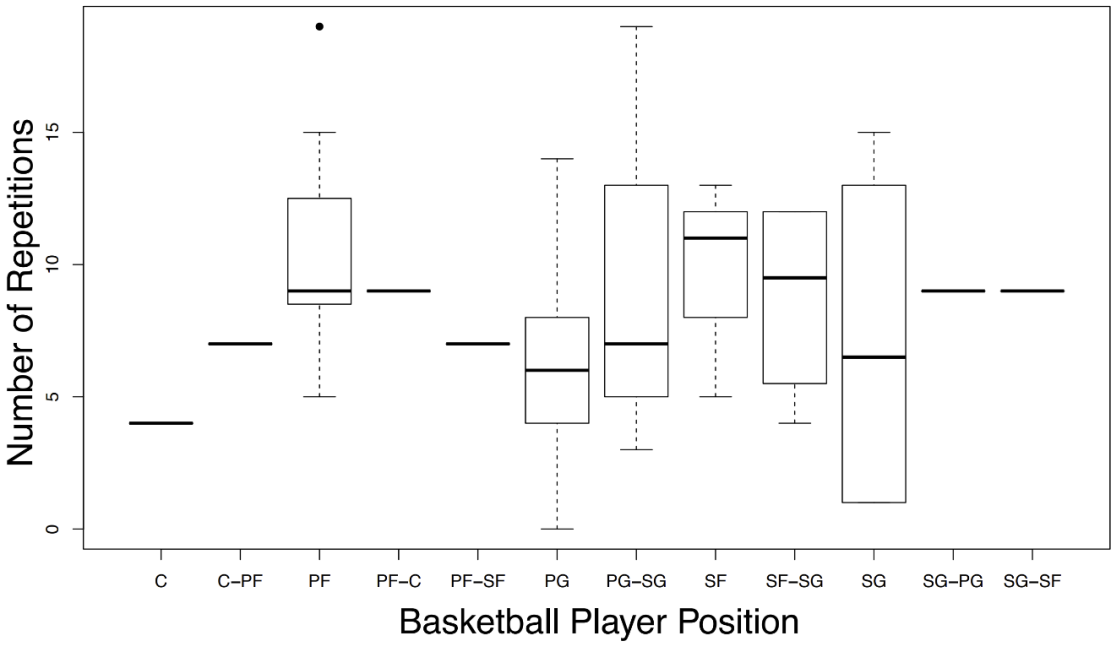
Source:Sallet *et al.*, 2005

Speed may be assessed by the shuttle run or the three-quarter sprint. To test agility, the lane agility drill is appropriate, along with the pro agility or three cone drill assessments. Primary psychological constructs that should be assessed include

confidence, anxiety, and resilience. Recommended psychological measures include the SOQ, CSAI-2R, BDI, and the 16PF (Berri, 2004; Crust and Clough, 2005).
Regarding the small forward, his height usually falls between the mean heights of other player positions---taller than guards, shorter than the power forward, and much shorter than the centre. Small forwards are typically taller than guards, shorter than power forwards, and much shorter than centres. The small forward requires great athletic ability, if not the most among the five positions in basketball. The small forward must be strong and fast enough to get near the perimeter to take shots, drive the ball to the hoop, and get offensive rebounds. Additionally, the small forward must be strong in defense and possess incredible balance, to prevent drives from the opposing team as well as obtain defensive rebounds. Finally, since the small forward position is multifaceted and requires great endurance, CRF should also be considered an influential factor.

Measures recommended for a small forward include the bench press to test for muscular strength, muscular power, and muscular endurance. See the figure below for an analysis of performance on the bench press by different player positions including hybrid position. In the figure below, it is well displayed that the position of small forward have the highest median of bench presses performed with significantly less variability than the hybrids of shooting guards and point guards.

Figure 15. Number of repetitions of bench press performed by player positions



Source:Sallet *et al.*, 2005

Small forwards should also be assessed in the vertical jump and maximal vertical reach for anaerobic power. The lane agility drill and the shuttle may be used to test for speed and agility. Psychological variables to be considered for this player position include competitiveness and aggressiveness. Psychological variables to be considered for this player position include competitiveness and aggressiveness, which can be assessed using the CAAS, the 16PF, and the TAT psychological assessments (Ackland *et al.*, 2007; Drinkwater, 2008; Carter *et al.*, 2005).

The power forward is usually very tall, only second in height to a centre. As a consequence, they are known to rebound fairly well. Some power forwards are so versatile that they might be considered hybrid players. For instance, the term 'stretch four' refers to a shooting power forward, who conceptually stretches out the floor because of his shooting ability. Power forwards usually rebound fairly well. Some power forwards are sufficiently versatile to be considered hybrid players---able to play both forward positions and one other position, such as shooting guard. The term 'stretch four' describes a power forward with superior shooting ability and an ability to 'stretch out the floor' because he can make three-point shots as well as drive to the basket.

Measures recommended for power forwards include using the bench press for assessment of the bench press for muscular strength, power, and endurance. Measures of anaerobic power such as the vertical jump height and maximal vertical reach are recommended. In addition, measures of agility such as the lane agility assessment, or three-cone agility assessment, should be incorporated to examine speed of change of direction for this player position. They should be tested for vertical jump and maximal vertical reach to assess anaerobic power. Also relevant are the lane agility drill and the shuttle for speed and agility testing. Psychological variables to be considered for the power forward are anxiety and confidence. Psychological measures such as the CSAI-2R, SAS, and the SCAT are recommended for the assessment of confidence and anxiety (Sampaio and Brewer, 2006; Bosco *et al*., 1983; Jones and Swain, 1992;; Klavora, 2000).

Like other players, the centre is expected to get open and make shots, but most of these shots will be close to the basket. The centre is typically the tallest player on the team and consequently his role consists of obtaining rebounds. On defense, he is expected to block shots and rebound. The centre's height is a big help in this regard.

For the centre, measures of muscular strength, muscular power, anaerobic power, flexibility and reach are recommended flexibility and reach, and anaerobic power. Assessments that are appropriate include the bench press test for muscular strength, with the maximum amount of weight being lifted for three to five repetitions. For muscular power, it is recommended to use a pneumatic machine for the bench press we recommend a chest press performed using a pneumatic machine because of the explosive nature of this assessment (through the concentric portion of the bench press). Assessments of anaerobic power include the max vertical jump and the vertical leap. Measures of flexibility and reach such as the trunk rotation test and the sit and reach assessment are recommended. Psychological assessments recommended for the centre include self-efficacy, 16PF, and SOQ (Cronin and Mulder, 2005; Martin, 2015).

Interestingly, the fascination with player profiles has even led the world of technology to incorporate sports performance parameters. It is interesting to see that video gamers have picked up on the concept of distinct characteristics across player positions. Height restrictions have been incorporated

in the video game NBA 2K. Visual Concepts, the game developer, has gone as far as to implement style-of-play parameters in the most recent versions of NBA 2K (Kayali, 2013). The NBA has developed a set of measures to assess player strengths and weaknesses, using not only shooting percentage statistics, but also physical fitness assessments. Basketball player positions are quite unique from each other and as such require attention to details that only distinguish player positions, but those that are the best in that position compared to less successful players in that position.

To identify players for each position and to compare players at a particular position, we need to utilise measures appropriate for that position as the traditional five player positions are sufficiently distinct in their needs. Measurement of physical and psychological constructs can better provide us with insights on what measures should be utilised or weighed more heavily by player position. Player profiles will allow for better prediction of basketball performance as well as talent identification for future recruit (Brown *et al*. 1988;; Simenz *et al*., 2005).

In summary, there are many physical and psychological factors that contribute to a football player's performance. The proper use of relevant measures and assessments for each player position is crucial in order for sports scientists to develop more accurate sports performance models and to make meaningful recommendations to trainers and coaches.

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