2. Control Variables of Video Analysis

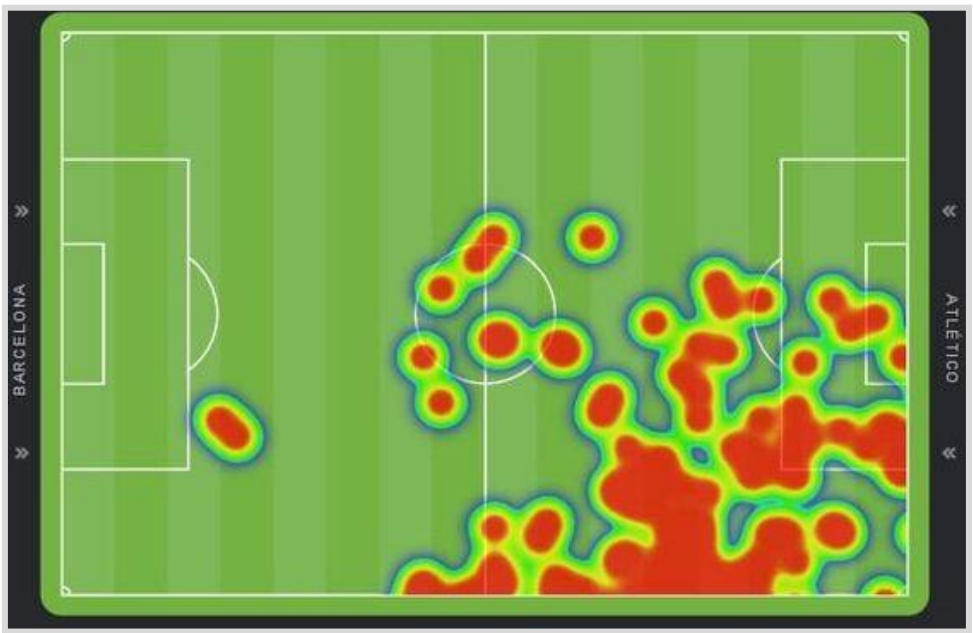
2.1 Physical and technical performance variables

2.1.1 Endurance control variables

The video analysis systems don't have the capacity to obtain data on the athletes' internal load. Even so, these video *tracking* systems are able to provide external load indicators that can be aligned with physical performance variables.

In this sense, players' tracking during competition allows knowing their position in space and time, through which data such as distance covered, speed, etcetera, can be obtained.

Figure 1: Graph of a player's pitch occupation in a game



Source: [Untitled image about a player's pitch occupation in a game]. (2016). Taken from https://www.pinterest.com/pin/128211920617998015/

One of the variables that is most associated to endurance is the **distance covered** by the athletes. This can be offered:

- Contextualized in the game such as, for example, when your team has the ball possession and when it does not.
- Categorized by its intensity or speed.
- Divided according to the time of the game, each part, every 15 minutes, individually or collectively.

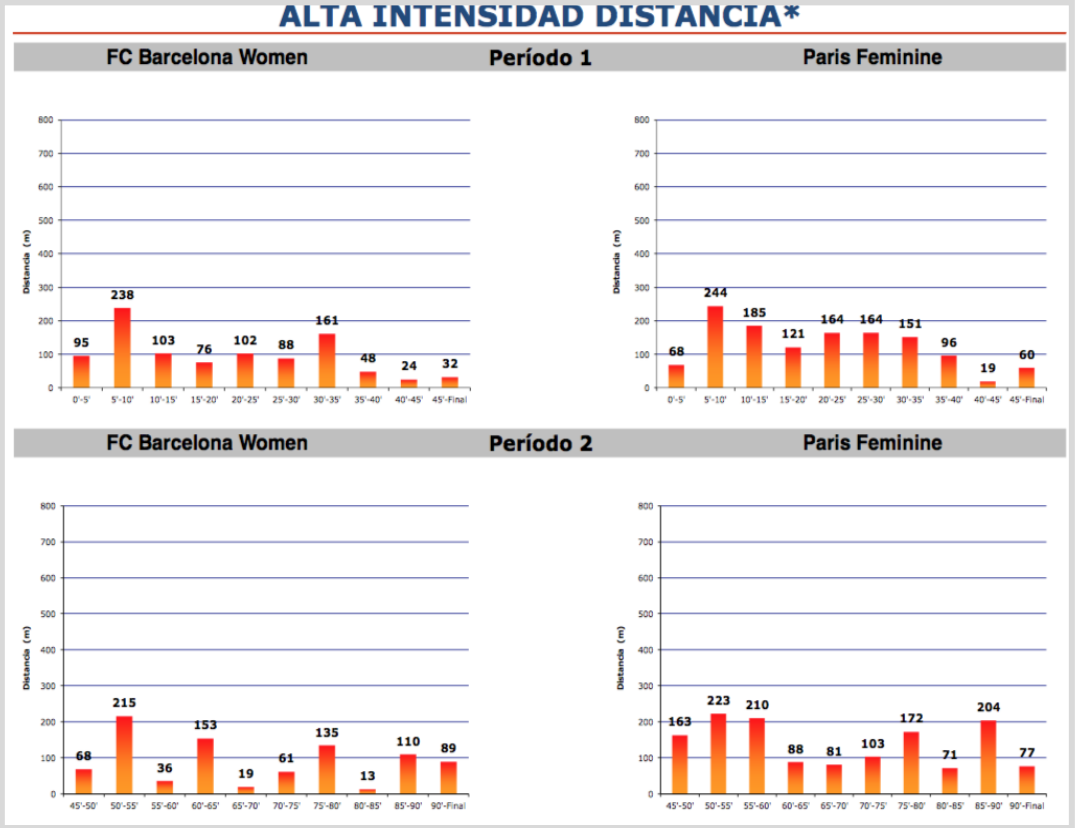
Figure 2: Comparative table between two football (soccer) teams

FC BARCELONA WOMEN		PARIS FEMININE
	DISTANCIA TOTAL	
116770	Distancia Total (m)	110770
7.5	Velocidad Media (km/h)	7.1
37805	Distancia Total en posesión (m)	47587
53886	Distancia Total en posesión del contrario (m)	39483
	SPRINT (+24 km/h)	
615	Sprint Distancia (m)	866
34	Número de Sprints	41
44:40.0	Tiempo medio entre dos Sprints (mn)	30:44.1
169	Sprint Distancia en posesión (m)	603
446	Sprint Distancia en posesión del contrario (m)	260
	ALTA VELOCIDAD (21-24 km/h)	
1252	Alta Velocidad Distancia (m)	1797
96	Número de Alta Velocidad	124
09:46.2	Tiempo medio entre dos Alta Velocidad (mn)	08:55.6
373	Alta Velocidad Distancia en posesión (m)	973
862	Alta Velocidad en posesión del contrario Distancia (m)	807
	CARRERA RÁPIDA (17-21 km/h)	
7100	Carrera Rápida Distancia (m)	7048
588	Número de Carrera Rápida	560
01:35.5	Tiempo medio entre dos Carrera Rápida (mn)	01:46.0
2245	Carrera Rápida Distancia en posesión (m)	3385
4570	Carrera Rápida en posesión del contrario Distancia (m)	3375
	CARRERA (14-17 km/h)	
12183	Carrera Distancia (m)	9955
1316	Número de Carrera	1063
00:40.9	Tiempo medio entre dos Carrera (mn)	00:51.1
3696	Carrera Distancia en posesión (m)	4886
7715	Carrera en posesión del contrario Distancia (m)	4272
	CARRERA LENTA (11-14 km/h)	
20391	Carrera Lenta Distancia (m)	17531
2558	Número de Carrera Lenta	2168
00:20.3	Tiempo medio entre dos Carrera Lenta (mn)	00:24.1
6920	Carrera Lenta Distancia en posesión (m)	8361
11500	Carrera Lenta en posesión del contrario Distancia (m)	7377
	MARCHA Y JOGGING (11-14 km/h)	
75230	Marcha y Jogging Distancia (m)	73572
3068	Número de Marcha y Jogging	2612
00:03.5	Tiempo medio entre dos Marcha y Jogging (mn)	00:03.6
24402	Marcha y Jogging Distancia en posesión (m)	29379
28794	Marcha y Jogging en posesión del contrario Distancia (m)	23392

Source: Own elaboration based on the Prozone software, 2016.

TRANSLATION
Total distance (m)
Average speed (km/h)
Total distance with possession (m)
Total distance with opponent's possession (m)
SPRINT (+24 km/h)
Sprint distance (m)
Number of sprints
Average time between Sprints (mn)
Sprint distance with possession (m)
Sprint Distance with opponent's possession (m)
HIGH SPEED (21-24 km/h)
High speed distance (m)
High speed number
Average time between two high speed (mn)
High speed with opponent's possession distance (m)
FAST SPRINT (17-21 km/h)
Fast sprint distance (m)
Fast sprint number
Average time between two fast sprints (mn)
Fast sprint with opponent's possession Distance (m)
SPRINT (14-17 km/h)
Sprint distance (m)
Average time between two sprints (mn)
Sprint distance with possession (m)
Sprint with opponent's possession distance (m)
SLOW SPRINT (11-14 km/h)
Slow sprint distance (m)
Slow sprint number
Average time between two slow sprints (mn)
Slow sprint distance with possession (m)
Slow sprint with opponent's possession distance (m)
WALKING AND JOGGING (11-14 km/h)
Walking and jogging distance (m)
Walking and jogging number
Average time between two walking and jogging (mn)
Walking and jogging distance with possession (m)
Walking and jogging with opponent's possession distance (m)

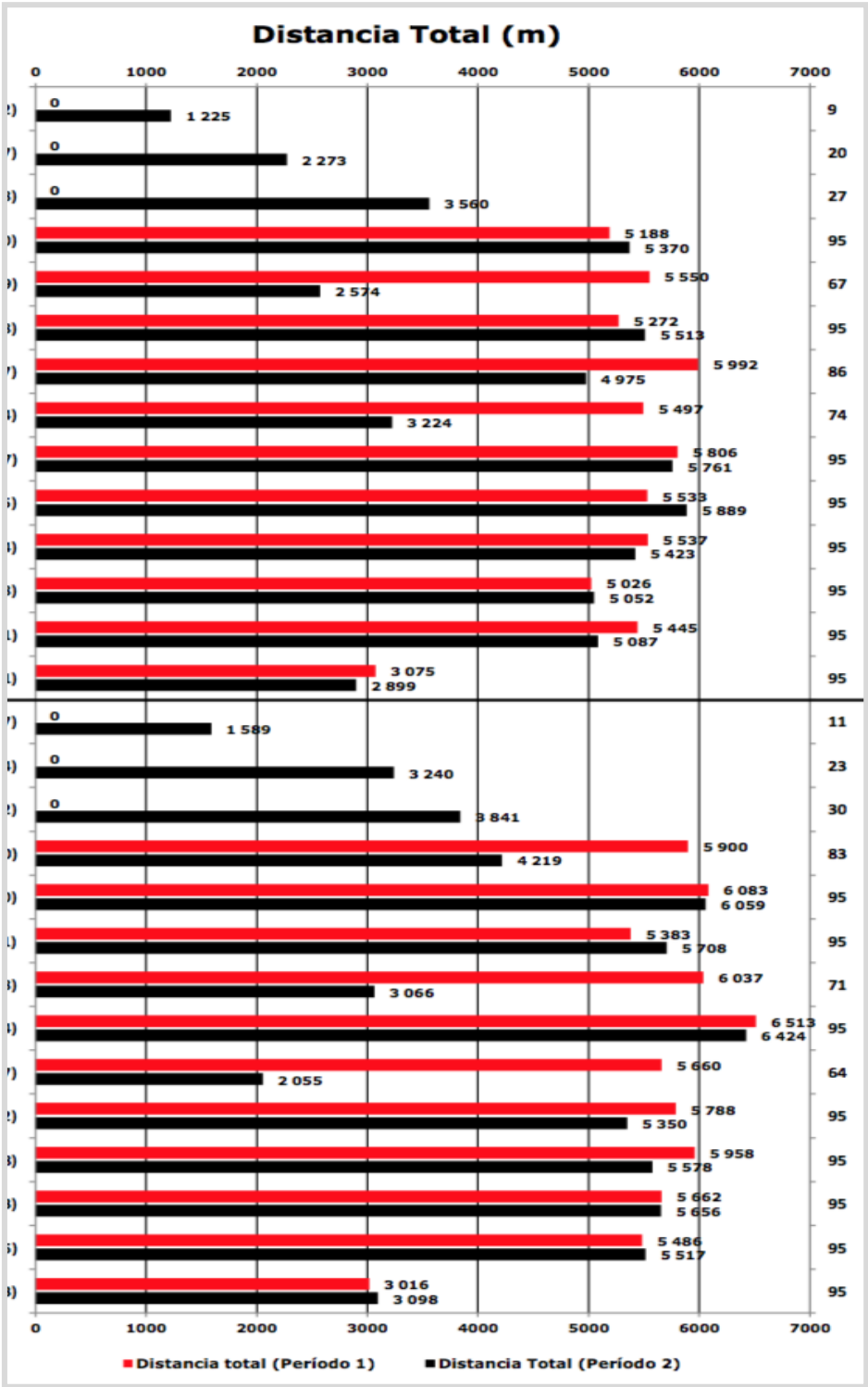
Figure 3: Intensity and distance



Source: Own elaboration based on the Prozone software, 2016.

TRANSLATION
HIGH INTENSITY DISTANCE*
PERIOD
Distance (M)
Distance (M)
Period 2
Distance (M)
Distance (M)

Figure 4: Total distance metrics



Source: Own elaboration based on the Prozone software, 2016.

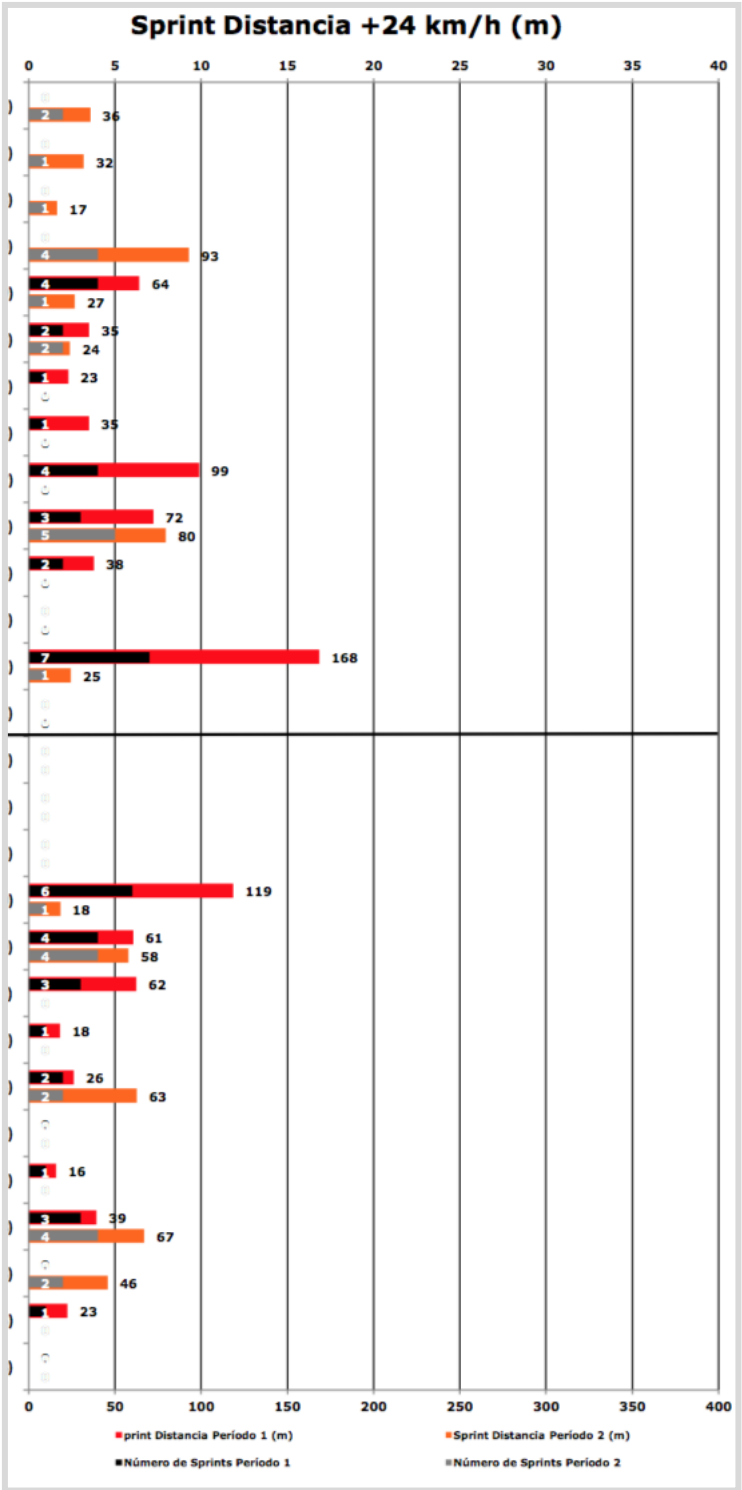
TRANSLATION

Total distance (m)

Total distance (period 1)

Total distance (period 2)

Figure 5: Sprint or high intensity sprint metrics



Source: Own elaboration based on the Prozone software, 2016.

TRANSLATION

Sprint distance + 24 km/(m)

Sprint distance period 1 (m)

Sprint distance period 2 (m)

Number of sprints period 1

Number of sprints period 2

All these parameters can be offered collectively for both teams or through individual reports for each athlete.

It is also important to point out that reports can be obtained through the control panel, which some *software* has, that integrates multiple measurements and from such control panel access to perform a detailed tracking of some of the metrics that particularly interests us at every moment.
The **control panel** logics should allow us, above all, that the information is useful to make decisions and, for that reason, one of the key factors is its clarity when designing it and presenting the variables we are most interested in controlling for every moment of use.

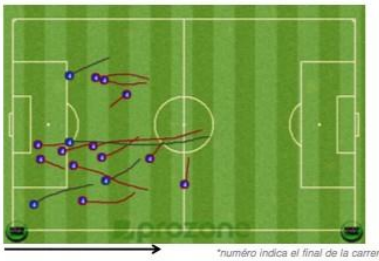
Figure 6: Control panel

FC Barcelona Women - Paris Feminine — **Tiempo de juego (mn) :** 95

23/03/2016

RESUMEN TÉCNICO	Número	Ganado
Posesiones Individuales	60	
Balones Recuperados	4	
Balones Perdidos	14	
Duelos al Suelo	11	36%
Duelos Aéreo	3	67%

Alta Intensidad (+21 km/h)*



*numéro indica el final de la carrera

RESUMEN FÍSICO	Distancia (m)	% de la Dist. Tot.	Número
Distancia Total (m)	12937		
Velocidad Media	8.2 km/h		
Distancia Total en posesión (m)	4263.4	33.0%	
Distancia Total en posesión del contrario (m)	6168.1	47.7%	
Distancia Total en posesión individual (m)	195.3	1.5%	
Alta Intensidad (+21 km/h) (m)	257	1.99 %	16
Tiempo media entre dos Alta Intensidad	05:54 min		
Alta Intensidad en posesión (m)	15.4	11.9%	
Alta Intensidad en posesión del contrario (m)	241.6	1.9%	
Alta Intensidad en posesión individual (m)	0.0	0.0%	
Sprint (+ 24 km/h) (m)	89	0.69 %	1
Sprint en posesión (m)	0.0	0.0%	
Sprint en posesión del contrario (m)	88.9	0.7%	
Sprint en posesión individual (m)	0.0	0.0%	
Alta Velocidad (21-24 km/h) (m)	168	1.3%	12
Alta Velocidad en posesión (m)	15.4	0.1%	
Alta Velocidad en posesión del contrario (m)	152.8	1.2%	
Alta Velocidad en posesión individual (m)	0.0	0.0%	
Carrera Rápida (17-21 km/h) (m)	857	6.6%	69
Carrera Rápida en posesión (m)	219.9	1.7%	
Carrera Rápida en posesión del contrario (m)	604.4	4.7%	
Carrera Rápida en posesión individual (m)	11.3	0.1%	
Carrera (14-17 km/h) (m)	1817	14.0%	191
Carrera en posesión (m)	619.3	4.8%	
Carrera en posesión del contrario (m)	1127.5	8.7%	
Carrera posesión individual (m)	60.8	0.5%	
Carrera Lenta (11-14 km/h) (m)	2815	21.8%	347
Carrera Lenta en posesión (m)	1049.2	8.1%	
Carrera Lentaen posesión del contrario (m)	1613.5	12.5%	
Carrera Lenta en posesión individual (m)	37.4	0.3%	
Marcha y Jogging (0-11 km/h) (m)	7192	55.6%	398
Marcha y Jogging en posesión (m)	2359.6	18.2%	
Marcha y Jogging en posesión del contrario (m)	2581.1	20.0%	
Marcha y Jogging en posesión individual (m)	85.8	0.7%	

Alta Intensidad Distancia (m)

OCUPACIÓN DEL CAMPO	Distancia (m)	% de la Distancia	Número
Distancia en su Campo	9300	72%	
Distancia en campo rival	3637	28%	
Alta Intensidad en su Campo	171	67%	13
Alta Intensidad en campo rival	86	33%	3
Sprint en su Campo	46	51%	3
Sprint en campo rival	43	49%	1

ACELERACIONES	Distancia (m)	Número
Aceleraciones Alta Intensidad	149	34
Aceleraciones A.I. en su Campo	96	20
Aceleraciones A.I. en campo rival	53	14

Ocupación del Campo

Aceleraciones Alta Intensidad

*numéro indica el final de la carrera

Source: Own elaboration based on the Prozone software, 2016.

TRANSLATION
FC Barcelona Women – Paris Feminine
Game time (mn): 95
03/23/2016
TECHNICAL SUMMARY
NUMBER
WON
Individual possessions
Recovered balls
Lost balls
Ground challenges
Air challenges
PHYSICAL SUMMARY
Distance (m)
% of dist. Tot.
Number
High intensity (+21 km/h) *
Total distance (m)
Average speed
Total distance with possession (m)
Total distance with opponent's possession (m)
Total distance with individual possession (m)
High intensity (+21 km/h) (m)
Average time between two high intensities
High intensity with possession (m)
High intensity with opponent's possession (m)
High intensity with individual possession (m)
*number indicates the end of the sprint
Sprint (+24 km/h) (m)
Sprint with possession (m)
Sprint with opponent's possession (m)
Sprint with individual possession (m)
High speed (21-24 km/h) (m)
High speed with possession (m)
High speed with opponent's possession (m)
High speed with individual possession (m)
Fast sprint (17-21 km/h) (m)
Fast sprint with possession (m)
Fast sprint with opponent's possession (m)
Fast sprint with individual possession (m)
Slow sprint (11-14 km/h) (m)
Slow sprint with possession (m)
Slow sprint with opponent's possession (m)
Slow sprint with individual possession (m)
Walking and jogging (0-11 km/h) (m)
Walking and jogging with possession (m)
Walking and jogging with opponent’s possession (m)
Walking and jogging with individual possession (m)
High intensity distance (m)
SPACE OCCUPATION
Distance (m)
% of the distance
Number
Distance from own half
Distance from opponent’s half
High intensity in own half
High intensity in opponent’s half
Sprint in own half
Sprint in opponent’s half
ACCELERATIONS
Distance (m)
Number

High intensity accelerations
H.I. accelerations in own half
H.I. accelerations in opponent's half
Space occupation
High intensity accelerations

2.1.2 Speed control variables and RSA

As already mentioned in the previous topic, video analysis systems are able to offer external load indicators. In that sense, most of the optical systems offer the geolocation of the athletes 25 times per second, which should be enough to obtain all of the external load indicators through mathematical formulas. Let's take into account that TV channels record at 25 or 30 images per second, and with that they achieve an image that is continuous and with no deformation or delay for the viewers.

Continuing with the indicators, for example, to know the speed or acceleration, it would be enough to apply the following formulas.

$$V = \frac{d}{t}$$

Being speed **V** equal to the quotient between distance **d** and time **t**.

$$a = \frac{V}{t}$$

Being acceleration **a** equal to the quotient between speed **V** and time **t**.

Even so, when *tests* were performed to assess the reliability of these systems, numerous errors were detected as speed and, above all, acceleration is increased (Stevens, De Ruiter, Van Niel, Van de Rhee, Beek and Savelsbergh, 2014). It should be said that optical systems improve a lot year after year and are becoming more reliable.

The most efficient system we have nowadays to measure acceleration are triaxial accelerometers, which the athletes can wear in their bodies, through *wearable* devices or technology.

Optical systems can provide us information collectively or individually. As an example, you can see in figure 7 a comparative table of what this system, in particular, calls **high intensity**.
High intensity is a concept associated to speed and that, in most of the products found in the market, refers to efforts the athlete makes above 21 km/h.

Another value commonly used is ***sprints*** and it refers to efforts made by the athlete above 24 km/h.

The stage of development of the discipline is still incipient and, in many cases, it is found that the data it works with are inconsistent, because they are full of inconsistencies, mainly terminological ones. Anyway, sports industry is becoming familiar with these concepts, the nomenclature, the reliability of the data, etcetera This allows development to be deepened and professionalized year after year.

Figure 7: Comparison between high speed and acceleration

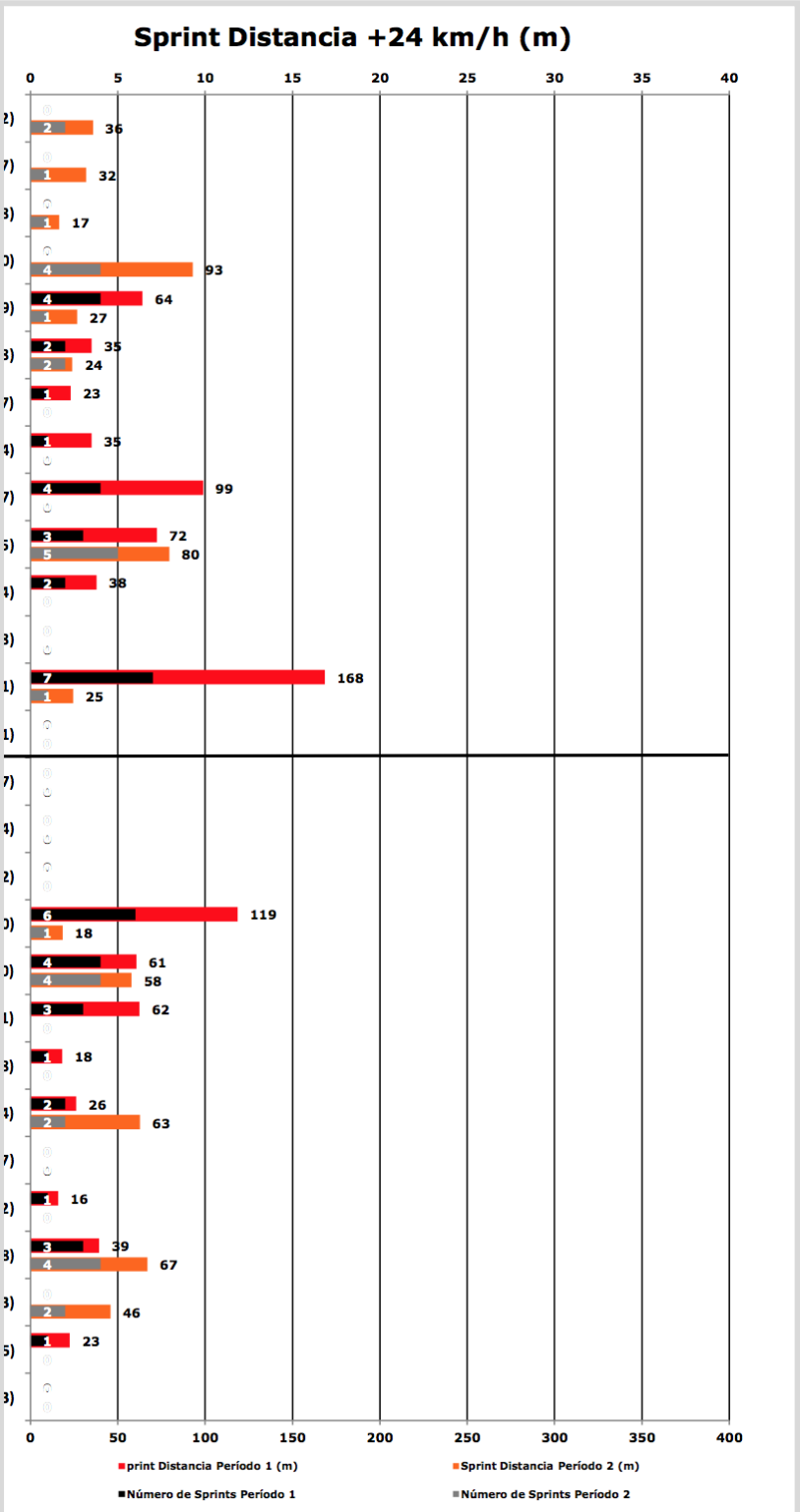
ALTA INTENSIDAD (+21 km/h)		
1867	Alta Intensidad Distancia (m)	2664
130	Número de Alta Intensidad	165
07:49.2	Tiempo medio entre dos Alta Intensidad (mn)	07:14.6
543	Alta Intensidad Distancia en posesión (m)	1576
1308	Alta Intensidad Distancia en posesión del contrario (m)	1067
ACELERACIÓN ALTA INTENSIDAD		
1237	Aceleración Alta Intensidad Distancia (m)	1120
306	Número de Aceleración Alta Intensidad	252
03:41.2	Tiempo medio entre dos Aceleraciones Alta Intensidad (mn)	05:19.7

** Sin Portero*

Source: Own elaboration based on the Prozone software, 2016.

TRANSLATION
HIGH INTENSITY (+21 km/h)
High intensity distance (m)
High intensity number
Average time between two high intensity (mn)
High intensity distance with possession (m)
High intensity distance with opponent's possession (m)
HIGH INTENSITY ACCELERATION
High intensity acceleration distance (m)
High intensity acceleration number
Average time between two high intensity accelerations (mn)
*Without goalkeeper

Figure 8: *Sprints* by player



Source: Own elaboration based on the Prozone software, 2016.

TRANSLATION

Sprint distance + 24 km/(m)

Sprint distance period 1 (m)

Sprint distance period 2 (m)

Number of sprints period 1

Number of sprints period 2

2.1.3 Biomechanical and motor execution analysis

Many studies have researched the kinematics of the sports skills, above all, the description of the technique or other variables that affect performance. In turn, many of these skills or abilities are complex movements, three-dimensional, involving many joints (Smith, Gilleard, Hammond, and Brooks, 2006).

The shot is the most studied skill in football. Although there are several kinds of shots, the most reported type in literature is the shot at maximum speed with the instep to a stopped ball. In contrast, other skills such as throw-in or goalkeeper saves have received less attention (Lees and Nolan, 1998).

The angle most used by players is around 43° (Egan, Verheul and Savelsberg, 2007), which coincides with previous research that reported an approximation angle near 45°, which generates the maximum speed of the ball (Isokawa and Lees, 1988). The length of the last step is of great importance for a maximum shot. Stoner and Ben-Sira, 1981, reported a longer last step when professional players performed a long-distance shot (1.69m) compared to a medium-distance shot (1.50m) In this way, an association was made between a longer step with a higher degree of pelvic retraction, which allows a higher range of pelvic protraction (anterior rotation of the shot side) (Lees and Nolan, 2002).

Figure 9: First phase of the shot

Source: Screenshot ofBiomechanics (Devan, 2015, https://www.dailymotion.com/video/x35n7de)

Figure 10: Biomechanical shot analysis

Source: Screenshot of Biomechanics (Devan, 2015, https://www.dailymotion.com/video/x35n7de)

Kinematics is the branch of classical mechanics that describes the motion of points, bodies, and systems of bodies, regardless of the causes of that motion (Whittaker, 1904). In the laboratory, kinematics study is performed with instruments, such as optoelectronic devices, which have the advantage of providing great precision in tracking markers. However, they have the disadvantage of being expensive, with a complex configuration and procedures that require an expert technician, apart from not being portable.

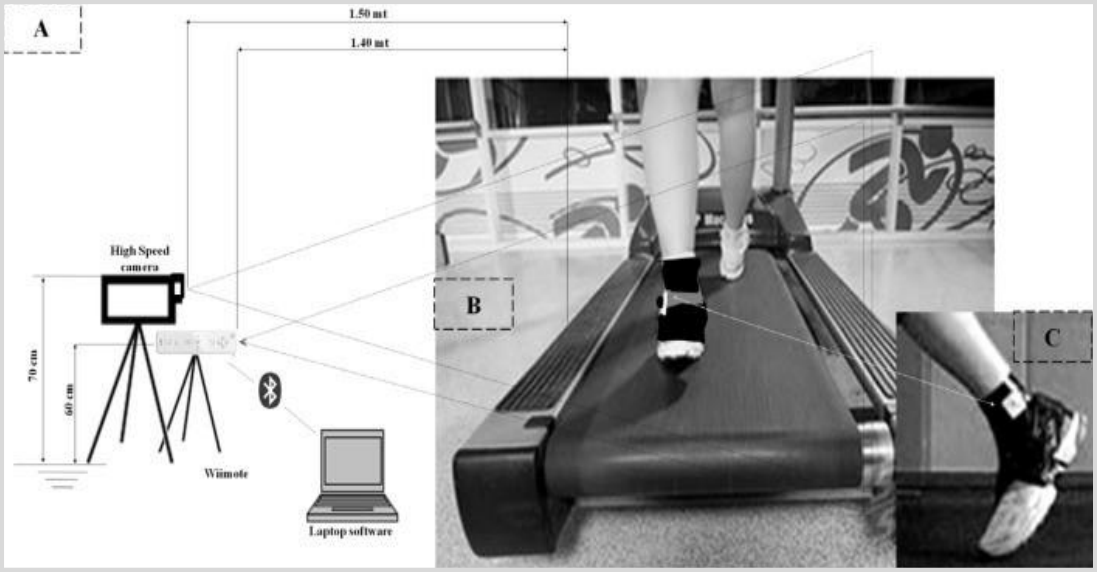
Movement capture, on the other hand, is an intensely used tool (Ekman and Friesen, 1969) which, thanks to technological innovations, can generate high definition video images. However, these technologies also have some disadvantages, such as post-analysis of the data, which takes a long time and requires great attention to follow the marks (Bharatkumar, Daigle, Pandy, Qin, y Aggawrwal, 1994).

In recent years, Nintendo has introduced in the market a tool (the Wii-Remote) capable of following an active marker that emits light in an infrared spectrum (Clark, Paterson, Ritchie, Blundell and Bryant, 2011).

Based on the quantity of advantages of this technology, this tool can be used to study kinematics in sports. Wii-Remote can be connected to an active marker attached to a part of the body and allow the study of kinematics. Padulo, et al. (2015) validated MarkWiiR comparing it with high-frequency video analysis, while they studied this spatial movement of the marker in the malleolus, during walking and running at different speeds. What these authors

showed is that Wii-Remote and the active marker MarkWii-Remote offer an excellent validity regarding video analysis.

Figure 11: Analysis using Wii-Remote



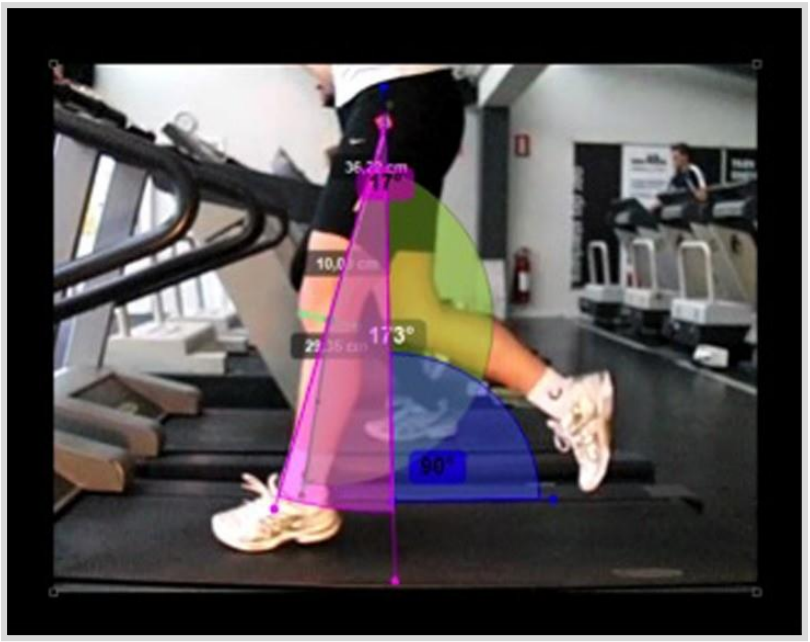
Source: Padulo et al, 2015, p. 54.

Experimental disposition:

- A: camera, Wii-RemoteTM, and laptop position respect the treadmill.
- B: An individual on the treadmill.
- C: MarkerWiiRTM Infrared lead and the passive marker attached to the individual's ankle.

In clinical practice, however, simpler methods are used. The kinematics of the joints during sprint is quantified, as we said previously, mainly by two-dimensional video recordings (2D) and *motion* analysis *software*. However, the applicability of this approach depends on the ability of clinicians to reliably quantify kinematics. Damsted, Oestergaard Nielsen and Henrik Larsen (2015) investigated the reliability inter- and intra-evaluator in order to quantify knee and hip angles and tread during the sprint. They used a 2D video installation with the Kinovea 0.8.15. *motion* analysis *software*. These authors found that the reliability of the analysis of different evaluators is enough to use the 2D *motion* analysis techniques. However, the interpretation must include a critical evaluation of the *motion* analysis system, before considering the conclusions obtained.

Figure 12: Screenshot of image in the quantified angles.



Source: Damsted, Oestergaard Nielsen and Henrik Larsen, 2015, p. 150.

- In the green angle, knee flexion can be observed: relative angle between the tibia and the femur.
- In the blue angle, hip flexion can be observed: relative angle between thermal and the line perpendicular to the treadmill.
- The pink angle shows flexion through the greater trochanter of the femur.

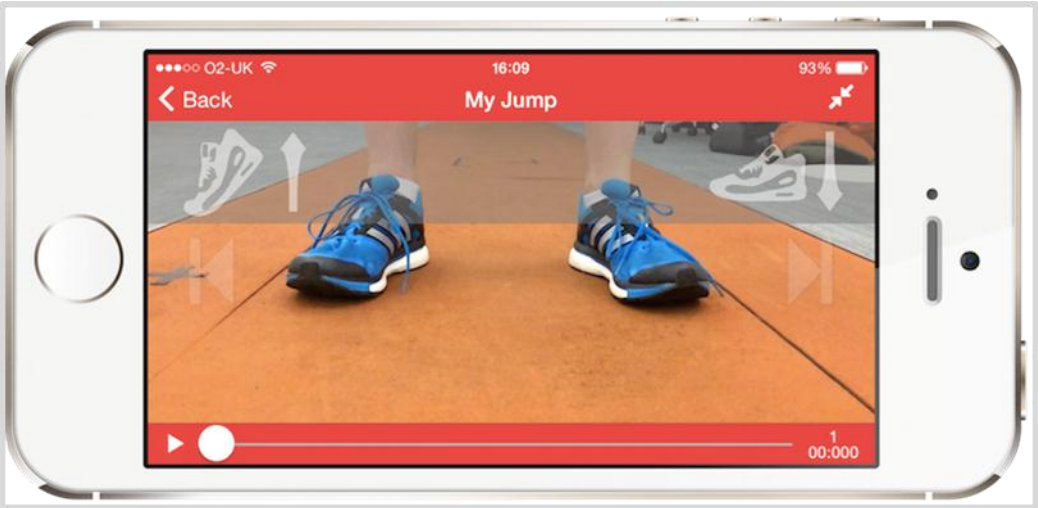
Another way of assessing the biomechanical quality of sports gestures is by means of devices that indirectly quantify the physical fitness of athletes. In this way, for example, asymmetries can be determined and their possible correlation with structural or functional asymmetries assessed by other methods.

Vertical jumps are commonly used to evaluate physical fitness in many populations.

The *gold* standard method to quantify jump capacity has been the force platforms that can do it using the jump's flight time and the individual's ground take-off speed. The use of jump platforms, just as accelerometers, infrared platforms and high-speed cameras has been validated to measure the flight time of the vertical jumps, but all have potential limitations. Firstly, they are expensive for coaches and its use is mainly confined to university an elite club's laboratories. Secondly, many of them are very heavy and you need specific *software* to analyse the data (Balsalobre-Fernández, Glaister and Lockey, 2015).

The latest kinematic analysis technology available in the market is the application created by Apple company, known as My Jump. This technology, less expensive and more portable, was recently validated (Balsalobre-Fernández, Tejero-González, del Campo- Vecino and Bavaresco, 2014) and combines the use of a high-speed camera and *software* to evaluate the vertical jump height. It costs USD 9.99. The evaluation process takes about five minutes, plus 30 seconds for each jump height calculation. It is important to mention that the relationship found between the height of the jump by force platform and My Jump in a jump with countermovement was almost perfect (ICC = 0.997, 95% CI: 0.996- 0.998, p < 0.001) (Balsalobre-Fernández et al, 2015).

Figure 13: My Jump iPhone app



Source: Balsalobre-Fernández et al, 2015, p. 3.

Biomechanics in sports offers methods through which very fast actions that take place sport can be recorded and analysed in detail (Lees en Reilly and Williams, 2003). Biomechanical development techniques have helped to understand underlying mechanisms of performance, although their use is limited. However, there are many characteristics of the game that are susceptible to biomechanical treatments and, consequently, opportunities for the biomechanics are good regarding their contribution to football science (Lees and Nolan, 1998).

2.1.4 Analysis of sport-specific technical executions

Currently, optical systems are not yet able to offer analysis data of specific technical executions. There are no automated or robotized systems that allow acquisition of these data by the machines. It is necessary the

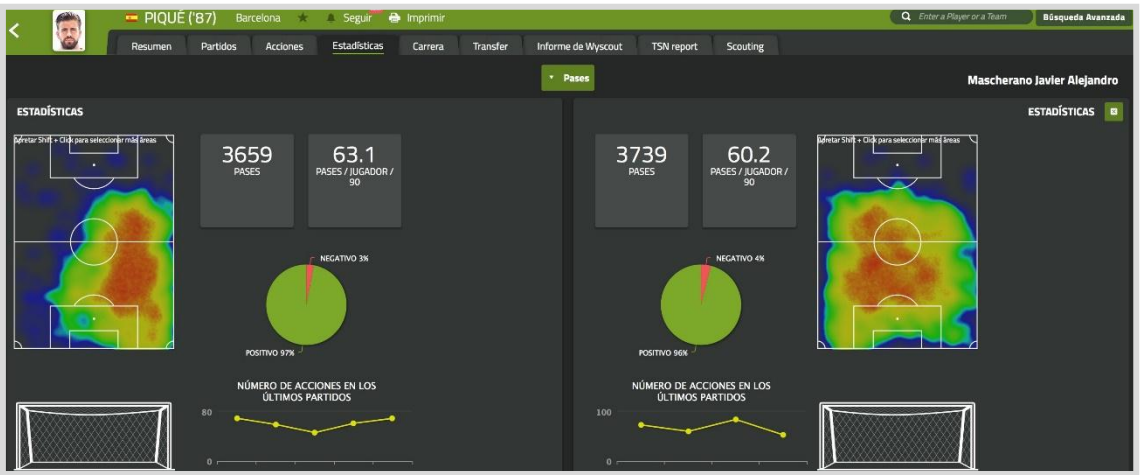
intervention of a human who, subjectively, collects these data, which are later integrated into the services that video analysis companies provide. In this way, the final solution does come complete, but you must know that the technical data are acquired by humans.

In this data acquisition there are many differences, both in criteria and quality. There are companies that choose to train their technicians very exhaustively and work with a quality close to 95% and in real time. Once this work is checked, in about two hours the information is served with a quality level close to 98%.

When speaking about quality, it refers to when a company defines what an attempt on goal is, all of the events qualified as attempt on goal follow the criterion defined by this company (Liu, Hopkins, Gómez and Molinuevo, 2013). Something different is if the customer agrees with this definition.

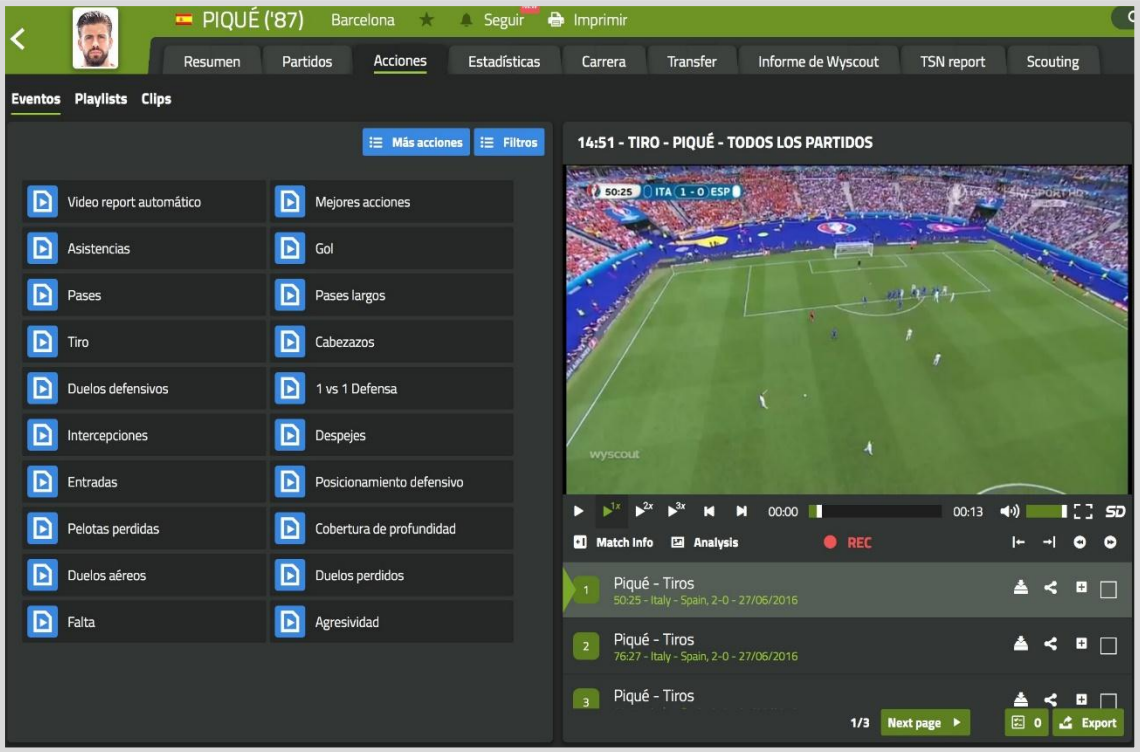
One example that clarifies this topic is about correct passes. Often, companies provide this data when a player passes the ball to a teammate and this pass is not intercepted by an opponent. For most of the sport coaches this data is not enough, since a player can pass the ball to a teammate, but perhaps it is the worst option he had, he sends it with inadequate force, performs it oriented to his teammate's least skillful leg or with little precision, or the teammate has to make a greater effort to control the ball, etcetera. All these situations are catalogued as a good, correct, right, pass, etcetera.

Figure 14: football player's technique analyses through manual tagging



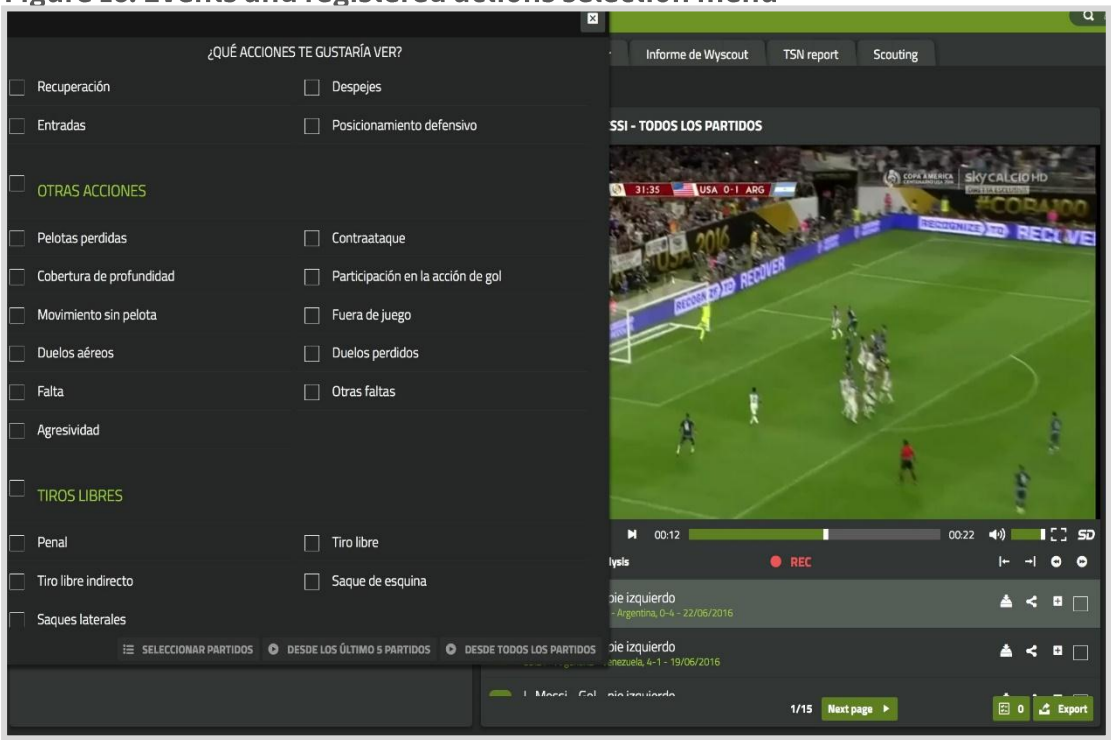
Source: Own elaboration based on the Wyscout software, 2016.

Figure 15: Video analysis and tagging



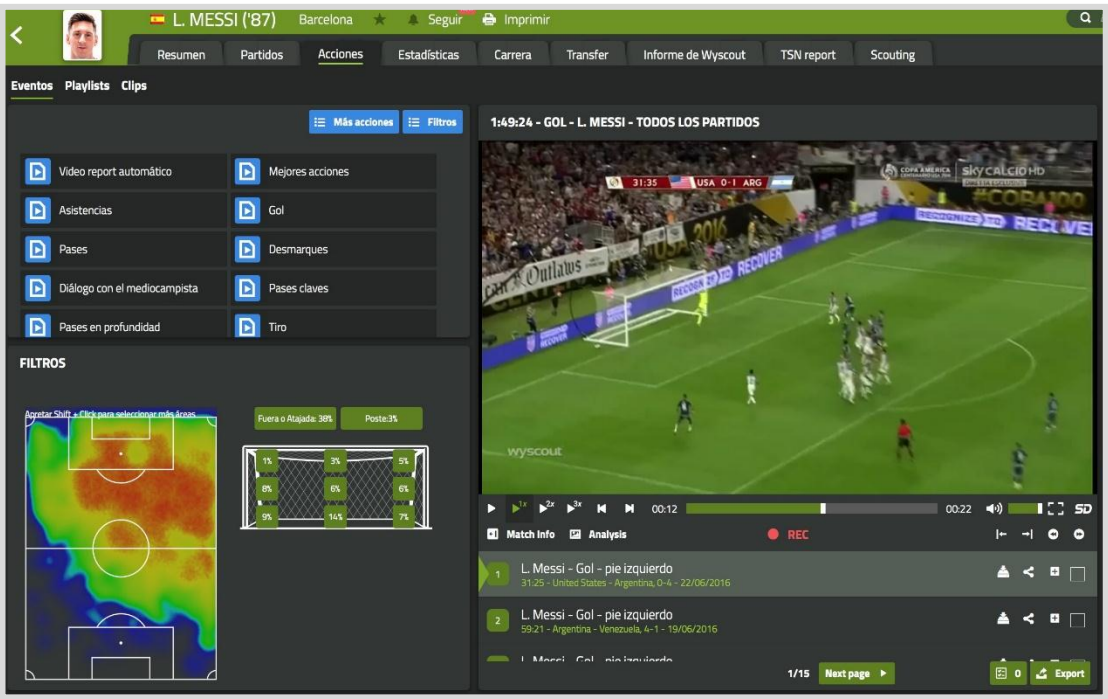
Source: Own elaboration based on the Wyscout software, 2016.

Figure 16: Events and registered actions selection menu



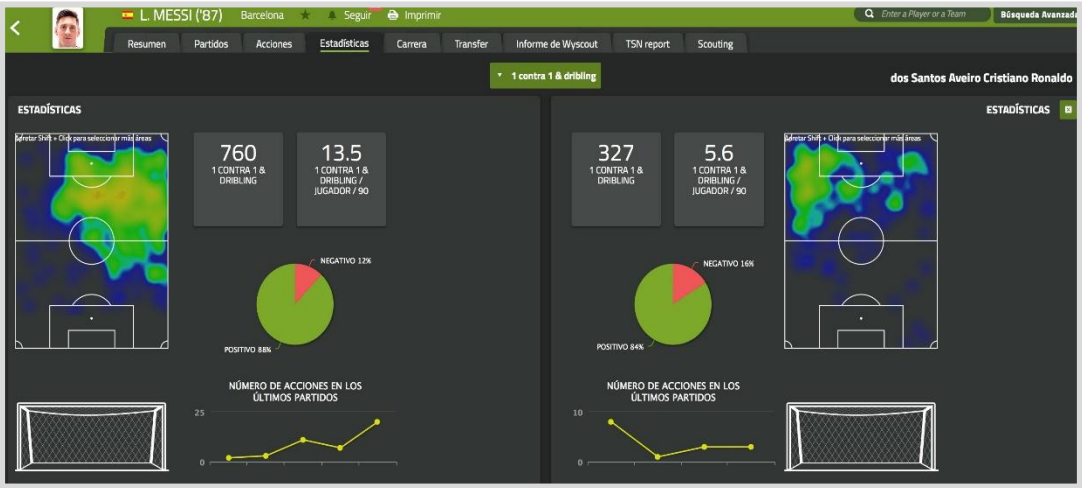
Source: Own elaboration based on the Wyscout software, 2016.

Figure 17: Control panel with video



Source: Own elaboration based on the Wyscout software, 2016.

Figure 18: Graphic analysis of a football player's performance



Source: Own elaboration based on the Wyscout software, 2016.

2.2 Physical and technical performance tactical and strategic performance

2.2.1 Behaviour of the player according to their role

Video analysis allows analysing players objectively, through the information provided by third parties, such as OPTA Sportsdata does it with a high level of reliability, but it is important to take into account that reliability might be further strengthened through more advanced and specific player tracking techniques (Liu et al, 2013), and video analysis also allows analysing players subjectively, which is what each club's own analysts do.

It is difficult to find objective analyses performed by third parties to be useful when analysing a player's role in a team, since that role he plays in each team is only known by the members of the team and the coaching staff. Even so, there are concepts that can be taken advantage of, but are generally the least. Going back to what was discussed in previous topics, there are companies that offer us data like the ones we can see in figure 14.
If we look at the information, data indicate that these players have only made a 4% of passing error throughout the season. That is to say, when the ball left their feet, in some way that we still do not know, it reached one of their teammates.

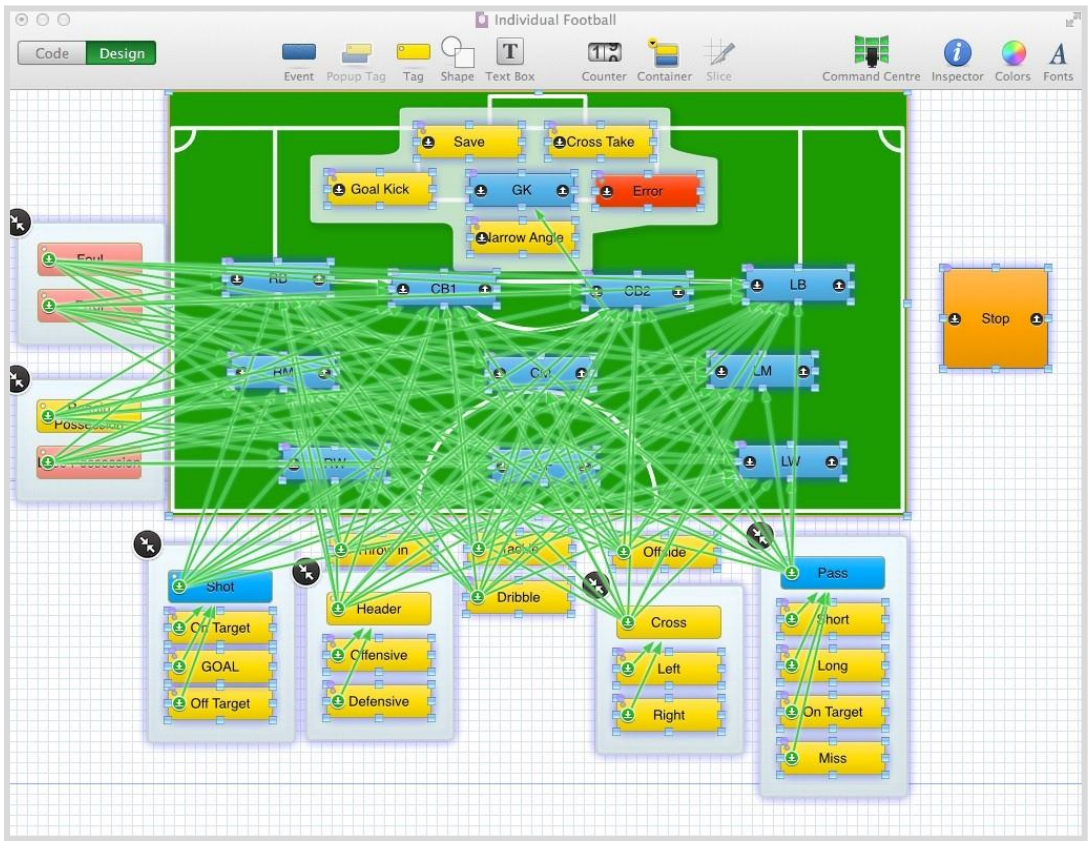
If this analysis is performed by an analyst of the club, surely the statistics would not be so favourable, and this concept (pass) would be divided into many other concepts, for example, passes under pressure, in starting zone, in finishing zone, air, ground, threaded through, tactically wrong, etcetera.

What are the data that these companies offer us useful for? An analyst who wants to analyse all the passes of a player does not have to watch all the game, he simply selects all of the passes of the game and then the analyst tags or discards according to his criteria. In order to perform this work, platforms like the one we see in figure 20 or, most usually, video analysis *software* are used. Within the latter, we can find a great variety in the market with its strengths and limitations thanks to the review conducted by Bustamante and Burillo (2016). For example, Nacsport, *software* aimed at coaches that has the advantage of

customizing tags to catalog preference actions. FootballLab is the centralized system that combines several *software* applications, *hardware* and maintenance service. It is specific for football and has a powerful user administration and security system. Besides, it has, for example, online video analysis and the possibility of associating metadata (name, description, tags) to the video clips. DVSport Fastbreak use our customizable and scalable tool that adjusts to the needs and budgets of every user. Among other functions it allows customizing data and generating graphs and reports and the option *frame by frame slow motion*, telestrator and support for multiple monitors.

Anyway, there is still some confusion when using this kind of systems by coaches and athletes, so standardizing transmission protocols, standardizing measurement techniques and data structuring becomes indispensable, the same as care about information management, since ethical issues come into play when sharing athletes' personal data (Bustamante and Burillo, 2016).

Figure 19: Video analyst's manual tagging panel



Source: Own elaboration based on the Wyscout software, 2016.

Figure 20: Tagging multiple players at the same time

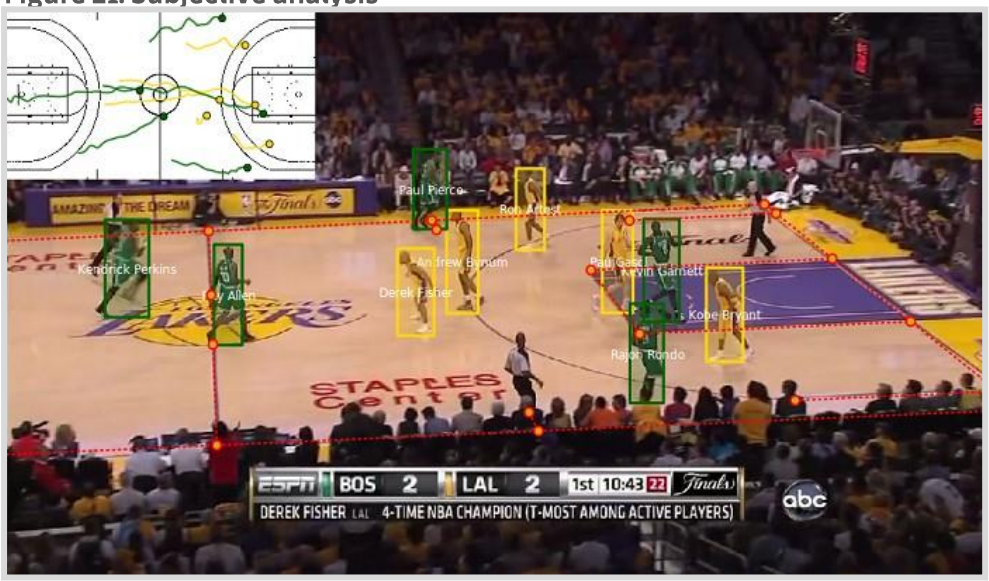
Source: Screenshot of tagging multiple players at the same time (Sportscode, 2015, https://www.sporttech.biz/sportscode).

2.2.2 Objective intervention in the game or training

As already mentioned in previous topics and units, it is difficult to objectify the game or even the training. The intervention of subjective analysis becomes necessary, since there is a lack of objective data that can be connected with subjective analyses.

In the coming years, we will start to see experiences supported by *machine learning* or automatic learning. *Machine learning*, that comes from computer science through artificial intelligence, develops techniques that allow machines or computers to learn.

Figure 21: Subjective analysis



Source: Rogez, 2012. p. 4.

These concepts that may seem abstract are very easy to understand through examples.

Imagine there is a coach who detects there is a defender that continuously separates from his teammates and produces errors in the defensive system that later lead to goal opportunities for the opponents. To analyse that situation, he will assign the analyst to show him, through video, when that situation is produced. Today, only an analyst can do that action subjectively. Now, if the XY position of all of the players and the ball is available, what the analyst analyses may become an algorithm that serves to analyse by itself a game and provide the objective data to a subjective situation, identifying automatically the situations requested by the coach.

If this situation has been understood, we hope that this one can also be understood. If after a season or several seasons, a machine is fed with all the subjective analysis of a coaching staff, with its own criteria, and all the videos of the games are added and, also, all the geolocation data of the ball and the players, the machine can learn and create algorithms that objectify the objective.

Experiences of this kind will start to be usual in the coming years.

Contrary to what may be thought, this type of work is not going to replace the work of the video analyst, simply, it is going to provide them with more data and more time so that they can offer better solutions to the coaching staffs of the teams and free them from routine work that does not add value and that can be done by machines.

Figure 22: Analysis booth

Source: Outside of the Boot, 2015, http://outsideoftheboot.com/2015/09/24/insight-into-data-analysis-in-football/

2.2.3 Relationship between tactical behaviour and moment of the game, week, season

Video analysis acquires great relevance when it is used to study collective tactics. This does not mean that it is analysed collectively, since individual tactical performance is what configures the collective tactics of a sports team.

When a coaching staff designs a season, it not only works on conditional topics, but of course there is a tactical content that should be programmed based on the coaching staff, the he players' knowledge, the competitions that must be faced, etcetera.

All the tactical content is distributed in microcycles, mesocycles, moments of the season, according to rivals and competitions. When trying to establish a way of playing on a team, all the content that is offered to the group must be measured somehow to know if this is done correctly or not.

This measurement can be done subjectively in training sessions and in games, as it happens most of the times, or objectively, through the use of geolocation technology. But the final format that all this study has is video analysis. Consequently, it is very important to have the adequate tools to carry it out and the professionals qualified and aligned with the coach so that the measurement, if subjective, adjusts to what is looked for.

Figure 23: Technique revision

Source: Lineout Coach, 2015, https://thesneakytester.com/category/the-workplace/

According to every coaching staff and the video analysis results, feedback given to the players individually or collectively varies substantially. There is no defined model, a better or worse model, but it depends on many variables that are determined according to the ability and preference of each coaching staff.

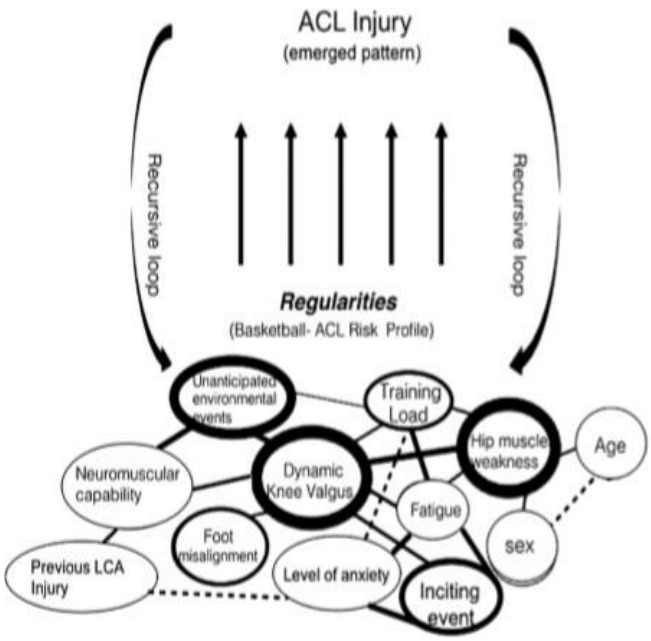
Video analysis is the most important technique you have when analysing tactically a team, whether your own or the rival.

2.2.4 Relationship between tactical behaviour, physical performance, injury

Often physical performance analysis and injury analysis are performed, in an isolated and individualized way, without taking into account the ecosystem in which these actions take place. A training session is not the same as a game, a friendly game as a final, just as a maximum intensity and linear sprint of an athlete on a training field is the same as a sprint of similar characteristics in the dispute of a ball with an opponent in a game or in a training session, with a

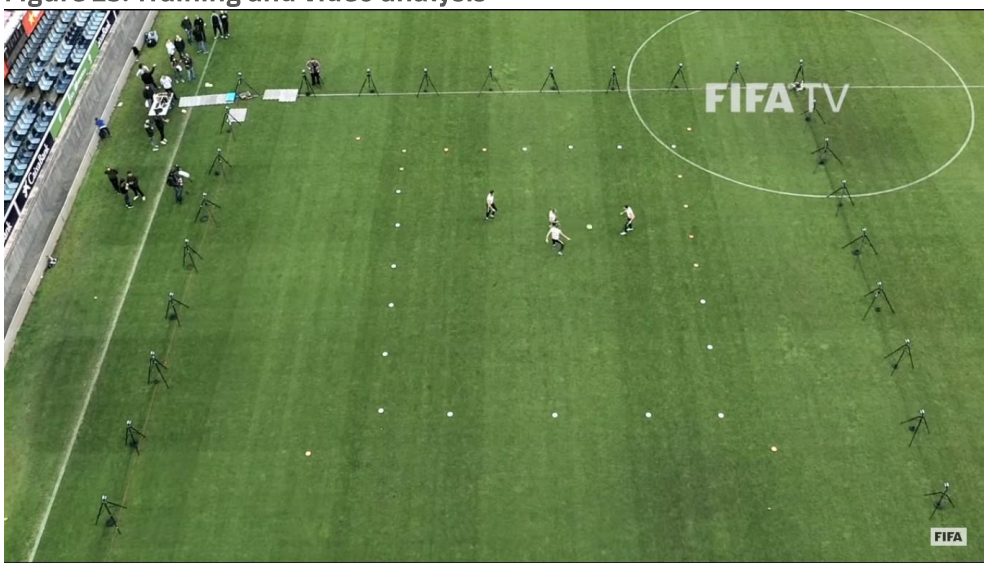
cognitive, emotional and socio-affective load that we do not know, since sports injuries do not arise from a combination of isolated and predictive factors, but are the product of a complex multifactorial network of determinants, which may be linked to each other linearly or not. Based on this, we need to position ourselves in the complex systems approach, where small changes in some determinants can lead to great consequences, even unexpected, since this approach is dynamic and open, in which there are recursive loops and complex interactions between units, spontaneously organized. Complexity assumes that prediction is based on probability and not on direct causality (Bittencourt, Meeuwisse, Mendonça, Nettel-Aguirre, Ocarino and Fonseca, 2016). We can see an example of this complex determinant network for a specific injury in figure 24.

Figure 24: Determinant network for an ACL injury in basketball athletes



Source: Bittencourt et. al., 2016. p. 1313

Figure 25: Training and video analysis



Source: Screenshot of Electronic Performance Tracking Systems Validation Study (FIFA TV, 2019, https://www.youtube.com/watch?time_continue=157&v=bMY6C_tLEAQ)

Video analysis helps to contextualize the situations our athletes live. This, far from simplifying analysis, shows us the complexity in which sports develop, and based on this complexity and with all the collected information, better decisions can be made.

Figure 26: High intensity sprint in context

Source: Martín, 2013, http://www.elespectador.com/deportes/futbolcolombiano/lionel-messi-les-habria-buscado-pelea-jugadores-del-rea-articulo-402184

Increasingly, physical performance analysis *software* like those provided by EPTS companies allow video to be incorporated to see under what circumstances efforts are developed.
Moreover, physicians, physiotherapist and rehabilitation specialists enter video analysis to be able to produce better

diagnoses and design better prevention and rehabilitation protocols. This does not mean that they have to register and analyse the videos on their own. Maybe better work structures should be organized, in which video analysts, through collaboration and cooperation, provide video and analysis sources. In a way that the professionals that are part of an organizational structure of a team can benefit from all of the resources.

Figure 27: Video analysis resources

Source: Reel, 2016, https://www.linkedin.com/pulse/experiential-screen-combining-ipad-pro-myplayxplay-turning-reel

References

Balsalobre-Fernández, C., Glaister, M. and Lockey, R. A. (September 14, 2015). The validity and reliability of an iPhone app for measuring vertical jump performance. *Journal of sports sciences, 33*(15), 1-6.

Balsalobre-Fernández, C., Tejero-González, C., del Campo- Vecino, J. and Bavaresco, N. (2014). The concurrent validity and reliability of a low-cost, high-speed camera-based method for measuring the flight time of vertical jumps. *The Journal of Strength & Conditioning Research*, *28*(2), 528-533.

Bharatkumar, A., Daigle, K., Pandy, M., Qin, C. and Aggawrwal, J. (1994). Lower limb kinematics of human walking with the medial axis transformation. *Proceedings of IEEE workshop on Motion of Non- Rigid and Articulated Objects*, 70-76.

Bittencourt, N.F.N., Meeuwisse W.H., Mendonça L.D., Nettel- Aguirre, A., Ocarino, J.M. and Fonseca, S.T. (2016). Complex systems approach for sports injuries: moving from risk factor identification to injury pattern recognition—narrative review and new concept. *Br J Sports Med.*, 50, 1309-1314.

Bustamante, A. and Burillo, P. (2016). *Management and performance analysis in basketball: a systematic review of software Retos, 29,* 72-78.

Clark, R., Paterson, K., Ritchie, C., Blundell, S. and Bryant, A. (03/14/2011). Design and validation of a portable, inexpensive and multi-beam timing light system using the Nintendo Wii hand controllers. *Journal of Science and Medicine in Sports*, *14*(2), 177-82.

Damsted, C., Oestergaard Nielsen, R. and Henrik Larsen, L. (2015). Reliability of video-based quantification of the knee and hip angle at foot strike during running. *International Journal of Sports Physical Therapy*, *10* (2), 147-154.

Devan, N. (User). (Tuesday, September 8, 2015) *Biomechanics - Analysis of a Football Free Kick* [Dailymotion]. Taken from http://www.dailymotion.com/video/x35n7de

Egan, C., Verheul, M. and Savelsberg, G. (2007). Effects of experience on the coordination of internally and externally timed football kicks. *Journal of Motor Behaviour*, *39*(5), 423-432.

Ekman, P., and Friesen, W. (1969). The Repertoire of Nonverbal Behaviour: Categories, Origins, Usage and Coding. *Semiotics, 1*, 49- 98.

Fifa TV. (2019). Electronic Performance Tracking Systems Validation Study. Taken from https://www.youtube.com/watch?time_continue=157&v=bMY6C_tLEAQ

Isokawa, M. and Lees, A. (1988). A biomechanical analysis of the instep kick motion in football. In Science and football. E and FN Spon, *8*(2), 449-455.

[Untitled image about a player's pitch occupation in a game]. (2016). Taken from https://www.pinterest.com/pin/128211920617998015/

Lees, A., and Nolan, L. (1998). The biomechanics of football: A review. *Journal of Sports Sciences* 16, 211-234.

Lees, A. and Nolan, L. (2002). Three-dimensional kinematic analysis of the instep kick under speed and accuracy conditions. *Science and football IV*, 16-21.

Lineout Coach. (2015). *Lineout Coach*. Taken from https://thesneakytester.com/category/the-workplace/

Liu, H., Hopkins, W., Gómez, A. M. and Molinuevo, S. J. (2013). Inter-operator reliability of live football match statistics from OPTA Sportsdata. *International Journal of Performance Analysis in Sport, 13*(3), 803-821.

Martín, A. (January 31, 2013). Lionel Messi les habría buscado pelea a jugadores del Real Madrid. *El espectador* [Digital]. Taken from http://www.elespectador.com/deportes/futbolcolombiano/lionel-messi-les-habria-buscado-pelea-jugadores-del-rea-articulo-402184

Outside of the Boot. (Thursday, September 24, 2015) *Insight into data analysis in football.* Taken from http://outsideoftheboot.com/2015/09/24/insight-into-data-analysis-in-football/

Padulo, J., Vando, S., Chamari, K., Chaouachi, A., Bagno, D. and Pizzolato, F. (2015). Validity of the MarkWiiR for kinematic analysis during walking and running gaits. *Biology of sport, 32(1)*, 53-58.

Prozone. (2016). Prozone (V3.1). Prozone software screenshot. Taken on 01/15/2017. Stats LLC.

Reel, I. (January 6, 2016). *The Experiential Screen. Combining #iPad Pro and #myplayXplay - A turning point for Coaching, Video Analysis and Medical Review.* Taken from

https://www.linkedin.com/pulse/experiential-screen-combining-ipad- pro-myplayxplay-turning-reel

Reilly, T. and Williams, M. (2003). *Science and Football.* London: Psychology Press.

Rogez, Grégory. (2012). Advances in Monocular Exemplar-based Human Body Pose Analysis: Modeling, Detection and Tracking.

Smith, C., Gilleard, W., Hammond, J. and Brooks, L. (2006). The application of an exploratory factor analysis to investigate the inter-relationships amongst joint movement during performance of a football skill. *Journal of Sports Science and Medicine, 5*(4), 517-524.

Sportscode. (2015). *Home Sportscode*. Taken from http://sporttech.biz/sportscode/products/overview/

Stevens, T. G. A., De Ruiter, C. J., Van Niel, C., Van de Rhee, R., Beek, P. J., and Savelsbergh, G. J. P. (2014). Measuring Acceleration and Deceleration in Soccer-Specific Movements Using a Local Position Measurement (LPM) System. *International Journal of Sports Physiology and Performance, 9*(3), 446 - 456.
doi:10.1123/ijspp.2013-0340

Stoner, L. and Ben-Sira, D. (1981). Variation in movement patterns of professional football players when executing a long range and a medium range in-step football kick. *Biomechanics, 7*(B), 337–341.

Whittaker, E. (1904). On an expression of the electromagnetic field due to electrons by means of two scalar potential functions. *Proceedings of the London Mathematical Society, 1*, 367-372.

Wyscout. (2016). Wyscout App. Version 4. Wyscout software screenshot. Taken on 01/15/2017. Wyscout Spa - Corso Garibaldi, 32/8 16043 Chiavari (Ge), Italy - VAT n. IT01499880993 - Enfold Theme by Kriesi.