4. Integrating reading

4.1 Video Analysis Characterization. Advantages and Disadvantages of Video Analysis

4.1.1 Practicality of Use

The use of methods in order to assess the training load allows us to keep an optimal control of the physiological variables involved during training and competition. According to Hopkins (1991), the training of athletes can be evaluated by four methods: retrospective questionnaires, daily training sheets, physiological monitoring and direct observation. Training questionnaires and daily training sheets represent the cheapest option, but they have some drawbacks, such as the difficulty of collecting data and processing it in an ordered reference system. For this reason, physiological monitoring, together with the data provided by direct observation, should constitute, in team sports, the main components in the planning of training cycles.

Monitoring is important in this type of sports since the physiological load is not determined by cyclical gestures and is easily quantifiable. The constant changes in rhythm, accelerations, decelerations, jumps and kicks make it necessary to keep an exhaustive control of the load from objective and high precision parameters, and not simply from the observation of the coach, assistants or perception of the players. However, this will also have great added value.

There are various methods to evaluate physical demands in sports. Normally, these consist of recording the type, intensity, frequency and duration of the actions of the match, such as running, jumping, changing direction, accelerating, etc. For this, two main methods are used: a) video analysis systems and b) global positioning system (GPS).

Video analysis, as we know it today, brings great tactical value to the study and the decision-making in sports.

Even so, video analysis has shortcomings compared to other analysis systems and, depending on the objective pursued, it will have advantages or disadvantages compared to other sports performance analysis systems.

Figure 1: Video analysis in football

Source. [Untitled image about video analysis in football]. (n.d.). Retrieved fromhttp://www.hollandfootballuniversity.com/wp-content/uploads/videobericht.jpg

4.1.2 Times and Work Routines

Generally, the coaching staff, when planning a week, agree with the video analyst on the training sessions they want to record (all the training sessions, only some, part of some, etc.), although in most cases, all group training sessions performed by the team are recorded.

During training, the video analyst can perform two functions: recording and tagging the images. The recording can be on a fixed plane or following a player, a group of players or the game.

The tagging of the images is done through specific software that ingests the video signal from the video camera on a computer. The video analyst tags the actions that take place through a keypad that can be operated by means of the mouse with keyboard or tactile short cuts, as we can see in the example in figure 2.

Figure 2: Short cut keys for different actions in the OPTA Client System software

Source: Liu, Hopkins, Gómez and Molinuevo, 2013, p. 805.

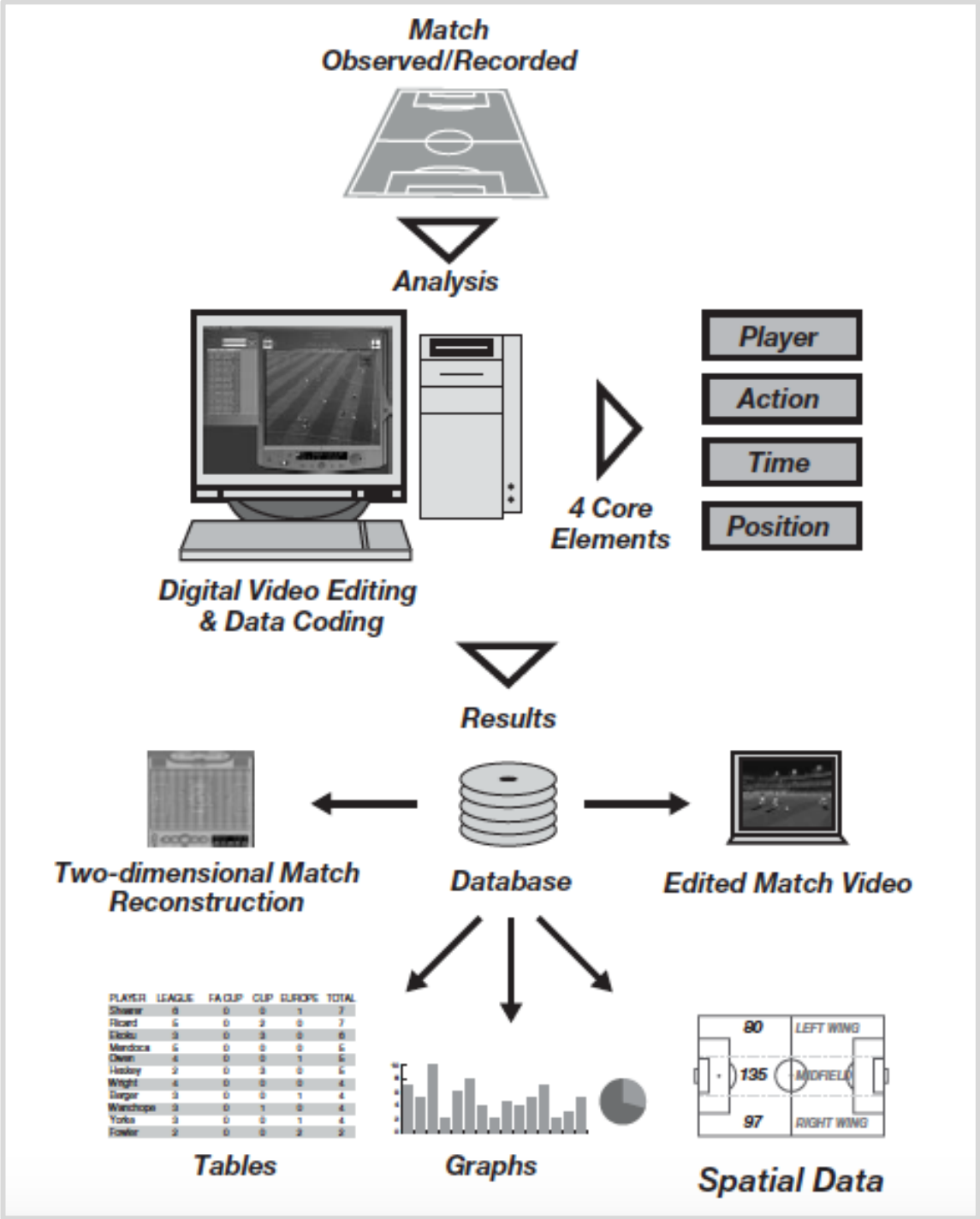
Once the training finishes, the most intense work of the video analyst begins since the coaches want to see some phases of the work done in practice. If the images have been labelled during training, this makes the coach's job easier since he/she can go very quickly to consult whatever he/she wants (for example, all the actions of a player, all losses of ball possession of any player, etc.).

Tagging can also be a collaborative task in which various coaches enrich the video file with their own tags.

If the video analyst carries out his/her work with quality, he/she plans the events he/she wants to tag at the beginning of the season, and agrees with the coaches, conditioning coach and physical trainers that a very rich qualitative and quantitative audiovisual database will be managed.

But the most advanced and resourceful coaching staffs are able to communicate in real time from different areas of the stadium. In this way, a coach located in the stands can receive the video tagged in real time by the video analyst located in the area of the master camera. The same file can be sent to the locker room to be reviewed at half-time by the coaching staff and it can even be shown to the players.

Figure 3: Computerized match analysis process



Source: Carling, Williams and Reilly, 2005, p. 37.

4.1.3 Internal and External Load Indicators

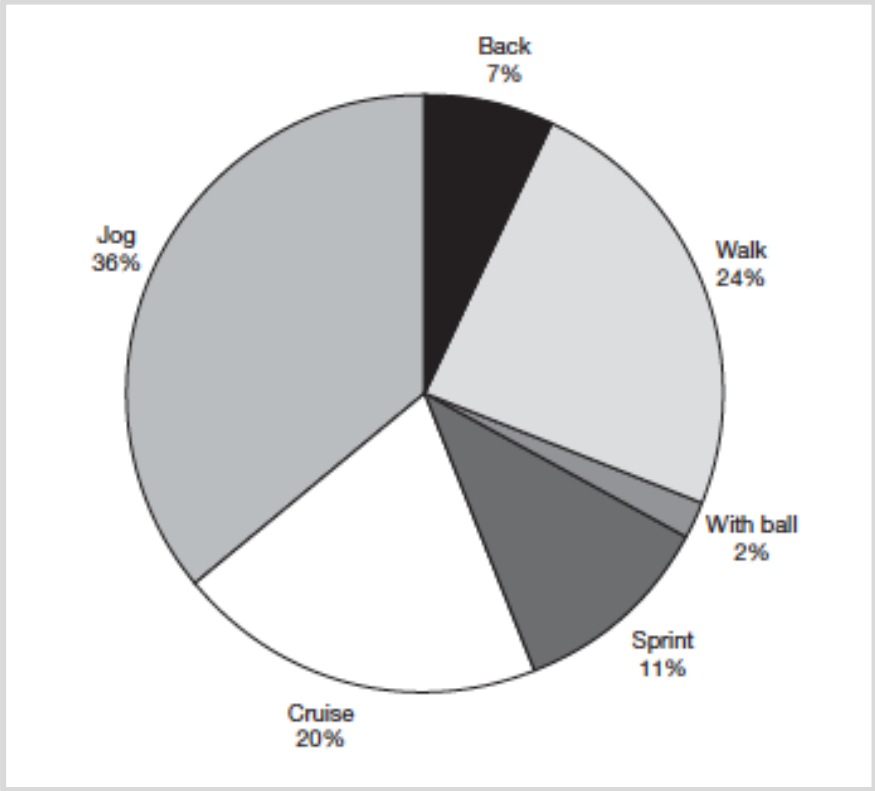
When we refer to the concept of training load, we must understand it as the set of psychobiological demands (internal load) that result from training activities (external load). These concepts, then, allow us to distinguish between the activities that constitute the training unit, that

is to say, the external load, and the degree of demand that they represent for the human organism, that is to say, the internal load (González Badillo and Ribas Serna, 2002).

Each of these concepts has different indicators that help control the load that they both define. There are many indicators and each professional uses one indicator or another depending on their knowledge, culture and preference. Generally, these indicators are combined algorithmically to generate key performance indicators (KPI).

When talking about external load, it could be defined as the measurement of any parameter related to speed, pace, distance, acceleration, jump, power, impact, strength measurement, etc.

Figure 4: Relative distances covered by field players, in different activity categories, during a football match



Source: Carling, Williams and Reilly, 2005, p. 91.

When it comes to internal load, we talk about how the organism of athletes responds to a determined effort. In this way, the indicators used to measure this concept are related to metabolic parameters linked to the intensity of physical effort: heart rate, oxygen consumption, lactate concentration, among others.

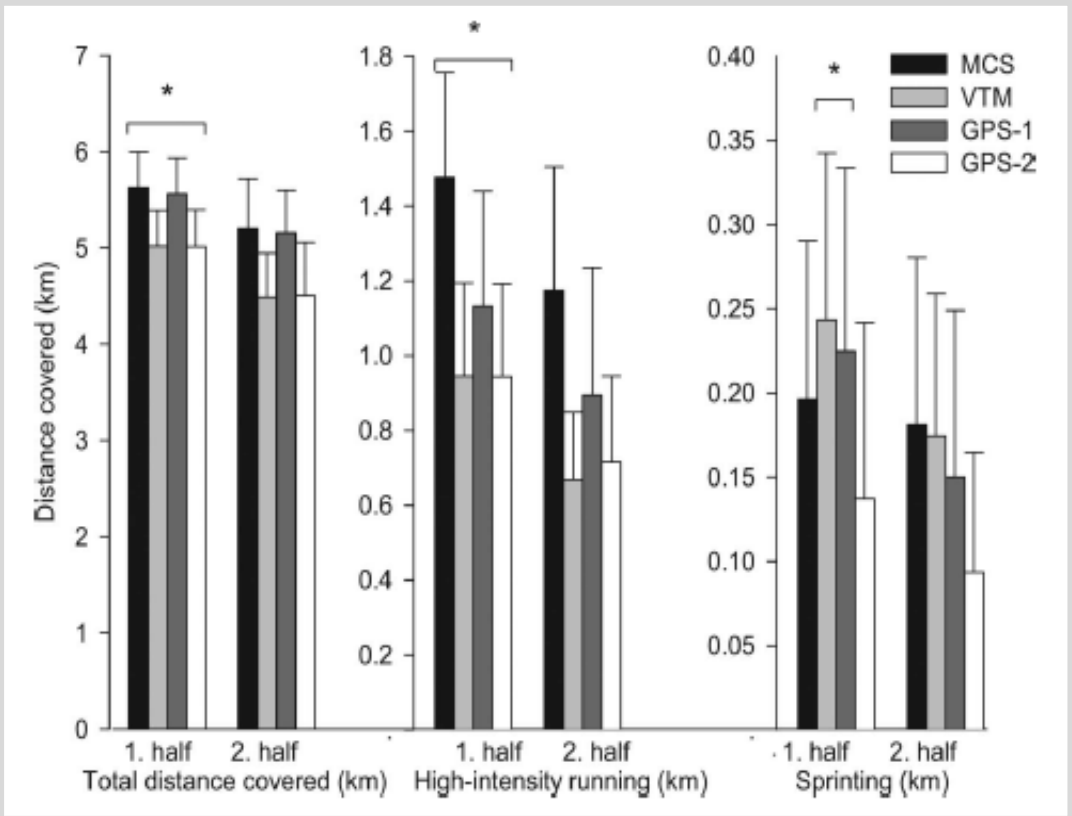
Video analysts of coaching staffs are focused on the analysis of tactical concepts of teams. If they use simple image capture systems, these do not generate any type of data or information beyond the purely audiovisual one which, subjectively, the video analyst enriches with his work.

However, there are more sophisticated systems that use audiovisual technology, manage to keep track of the players and even the ball, and provide useful data. These data is related to external load of the players. Even today, the industry has still not managed to develop commercial products that offer data on the internal load of players through audiovisual technology.

Not all external load data offered by these systems has a high level of reliability. Data on general distance covered are fairly similar to reality. As speed and acceleration increase, these systems have more trouble providing this information since they work with positioning error margins that are key when it comes to detecting high speed intensities.

Currently, there is no consensus on the gold standard method for the validation of distance covered measurements of video analysis systems (Randers, Mujika, Hewitt, Santisteban, Bischoff, Solano, Zubillaga, Peltola, Krustrup and Mohr, 2010). Randers *et al.* (2010) compared the pattern of activity and development of fatigue in the same football match of second and third division of Spanish football. They used an analysis system based on activity pattern (time-motion analysis), a semi-automatic camera system and two GPS systems, 5 Hz (GPS-1) and 1 Hz (GPS-2). The four systems showed a greater distance covered at high intensity during the first 15 minutes and a shorter distance at high intensity during the last 15 minutes of play, with a reduction of 46 ± 19%, 37 ± 26%, 50 ± 26%, and 45 ± 27%, for the semi-automatic time-motion system, GPS-1 and GPS-2 systems, respectively. These results indicate that the four systems are capable of detecting similar decreases in performance during a football match and that they can be used to study induced fatigue by a match. However, the authors of this work proposed that caution be used when comparing different levels of physical performance between samples evaluated with different measurement systems. This comparison will most likely lead to misinterpretations.

Figure 5: Total distance covered, total distance at high intensity and total distance covered in sprint, during a second and third division football match in Spanish football



Source: Randers et al., 2010, p. 178.

4.1.4 Validity and Usefulness of Obtained Data

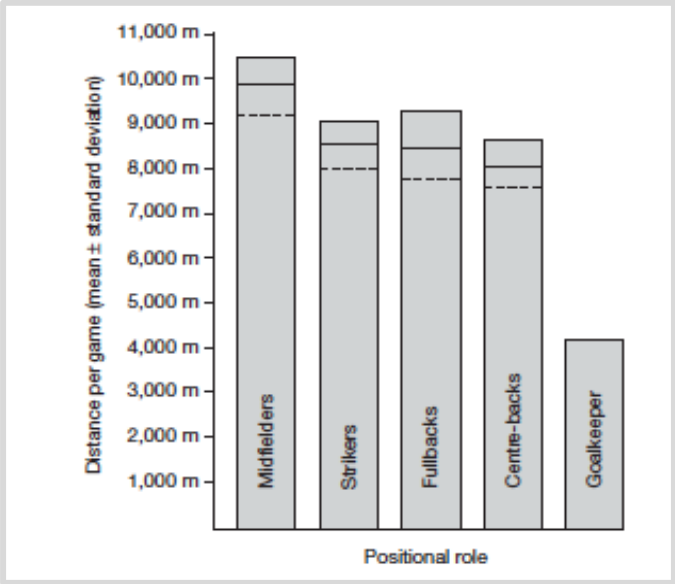
The data produced from the treatment of audiovisual information by video analysts is of great qualitative value because it is based on subjectivity, and this subjectivity is based on the knowledge of coaches.

In this sense, the usefulness that this data have for the coaching staff is of great value, since it will allow analysing individual and group performance in accordance with the tactical principles that are used. For example, a company offering data on correct passes made by a team or a player is often a type of information that does not help much. That is because, for a team, a good pass will be the one that connects a player with another from the same team without evaluating if there was a better option or if it was the most appropriate for that specific situation.

The validation of this type of data is carried out by the coaching staff of each team and is often linked to the professionalism and trust that the coaches and the organization have in the video analyst.

As seen in previous topics, the most complex video analysis systems are capable of offering data on the external load of the players. The usefulness of this data is of great value, since it allows comparing and quantifying the competitive training loads of the players. That the data is useful does not mean that its validity or reliability is very high. It is useful because it is available, but it is necessary to know that there are errors of greater or lesser magnitude caused by two different aspects: the first, the technology used, which must still evolve to be more precise; the second, the professionalism and skill of the company that provides the data.

Figure 6: Distance covered in a match according to the playing position



Source: Carling, Williams and Reilly, 2005, p. 6.

The main problems of this data are related to:

- Ball tracking in football. The size of the playing field, the distance of the position of cameras and the small dimensions of the mobile are factors that greatly complicate the accurate ball tracking.
- High intensity or speed. From the tests and studies that have been carried out, it is observed that when the players reach maximum accelerations or high speeds, the calculation of these distances has significant errors.

4.2 Relationship between video analysis and other monitoring methods

4.2.1 Video analysis and heart rate monitoring

The responses of the autonomic nervous system can provide us with very useful information about functional adaptation of the organism to physical exercise (Aubert, Seps and Beckers, 2003).

The pattern of heart rate (HR) response to changes in intensity during continuous and intermittent exercise is, however, significantly different. This can lead to differential adaptations of the autonomic nervous system in athletes who practice one type of sport or another (Ostojic, Markovic, Calleja-Gonzalez, Jakovljevic, Vucetic and Stojanovic, 2010).

On the other hand, it is desirable to know if the heart rate can be useful as a parameter to assess the effort profile in intermittent sports. Given this, Ben Abdelkrim, Castagna, El Fazaa and El Ati (2010) have observed that the response of the HR was greater in a group of basketball players of international level compared to players of national level. The highest level of a group of athletes can, therefore, be associated with greater cardiovascular stress and thus with a greater HR response. These authors concluded that HR represents a highly useful index for assessing physiological global stress during a match, although this variable may be easily influenced by others, such as anxiety or stress (Tumilty, 1993), nutritional status, and temperature (Gilman, 1996).

When evaluating the effort profile in homogeneous groups, the results can be contradictory. For example, in rugby, Coutts, Reaburn and Abt (2003) observed that there were no significant differences in the mean HR between the first and second half of a semi-professional match. However, Helgerud, Engen, Wisloff and Hoff (2001) observed, in football, that the highest zones of HR were greater in the first half compared to the second, and even this response accentuated after a period of high-intensity interval training of 8 weeks.

The mean HR values in football could be around 160-170 beats per minute (bpm), and oscillations between 160-190 ppm could occur. Therefore, it is reasonable to think that the aerobic system is requested as a priority (90% of energy) during matches (Bangsbo, 1994) and to find mean HR values of 85% and maximum HR of 98% (Bangsbo, Mohr

and Krustrup, 2006; Krustrup, Mohr, Ellingsgaard and Bangsbo, 2005), which warns about of the high physiological load that the players bear during competition.

Heart rate is a variable of internal load that, in order to be measured, requires that there is contact of the monitoring system with the skin of the person we want to control. In the world of sports, until a few years ago and even today, the most common thing is to measure the heart rate through electrodes that are on a band which is placed on the athlete's chest.

In recent years, technology has evolved towards less invasive and less uncomfortable solutions for sports practice.

One of the latest technological solutions that have been presented is the Apple smartwatch. The technology used is called photoplethysmography which is the same that is used in medical procedures to perform volumetric measurements of the organs and which is based on the use of light-sensitive photodiodes to detect the amount of blood flowing.

Although most of these solutions have, as supports, monitors located on the wrists of athletes, there are already experiences of locating both the electrodes and the optical sensors in smart shirts that are less invasive for the athlete.

The fact that technology has advanced towards optical sensors suggests that, perhaps in the future, these remotely located sensors will be able to detect this variable and some others, such as lactate. Perhaps a single camera like the one used today to capture images can be the support for taking variables of internal and external load. These are just hypotheses.

4.2.2 Video Analysis and GPS

As on many other occasions throughout history, the name of a technology has been used to name a product, concept or matter. We have become accustomed to hearing about GPS as a tool to control the internal and external load of athletes when, in reality, GPS (Global Position System) is just a technology developed by the United States Department of Security, which serves to geolocate objects on Earth through the triangulation of signals received by a series of satellites located in space. GNSS (Global Navigation Satellite System) is exactly the same technology, but developed by the former Soviet Union. Currently the European Union has an ongoing project called Galileo and it is basically the same as GPS and GNSS.

At present, there are three technologies to control the internal and external load of athletes:

- Systems based on technologies of geolocational recognition by satellite technologies (GPS).
- Systems based on technologies of geolocational recognition by radio frequency (RFID).
- Systems based on technologies of geolocational recognition by optical systems (ROC).

> Load control technology by GPS (the most widely used today), has a great advantage that resides in its ability to be used anywhere in the world without the need to carry control logistics at a specific site to process the information. . The positional information is transmitted to the satellite which transmits it back to the data analysis centre that can be anywhere in the world. This means that, in contrast to video or microprocessor tracking, match performance can be more easily analysed. However, like everything, it also has its disadvantages: a) the subjects must carry the tracking device, b) some of the current systems demonstrate a flaw in their portability, since they are heavy and large and, therefore, they cannot be used by players during competition matches, c) the device requires the use of batteries, which can run out quickly, d) such systems do not function properly in football stadiums and they are influenced by the temperature and configuration of the playing field, e) the GPS are still relatively expensive, f) analysis is often restricted to one positional measurement per second. This means that they have a limitation in the analysis of accelerations, decelerations and changes of direction. (Carling, Williams and Reilly, 2005).

FIFA has made a proposal to name all of these systems as Electronic Performance and Tracking Systems (EPTS). From now on, when we refer to all these systems we will do so as EPTS.

Figure 7: Use of GPS technology in football

Source: Sport, 2015, https://www.sport.es/es/noticias/barca/gps-nueva-arma-luis-enrique-4024452

It is important not to confuse concepts and to clarify that the video analysis worked on in this course has to do with the more tactical analysis of competition and training. Even so, we cannot ignore that the solutions tend to hybridize and, in this section, we can observe the very specific case of a solution that was born with the vocation of helping coaches and that currently serves physical trainers to monitor the load in competition: the systems based on technologies of geolocational recognition by optical systems.

Studies that have attempted to compare data have reached two conclusions. The first, that there are great differences depending on the company that offers the data through optical technology; and the second, that greater differences are observed when the variables to be measured have to do with high-intensity external load values and accelerations.

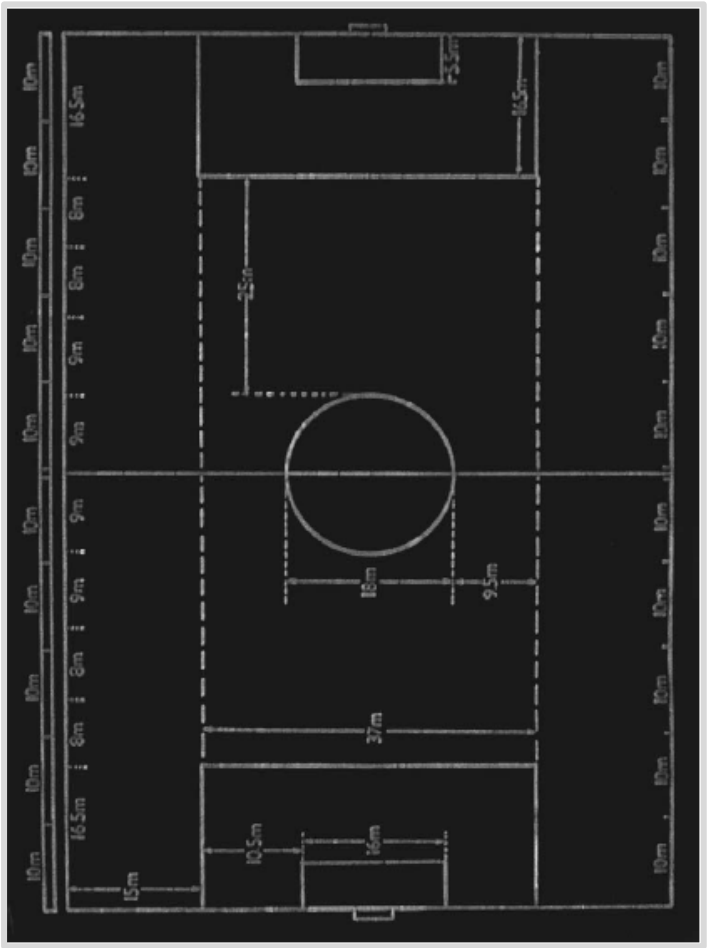
4.2.3 Video analysis and manual control of competition statistics

The monitoring of the effort profile during the competition was carried out, at first, by means of a technique known as video analysis based on the pattern of activity or movement (time-motion analysis), such as the one developed by Reilly and Thomas (1976). The use of these methods allowed valuable observations to be made, but their complexity and, especially, the time required to encode, analyse and interpret the data constituted great barriers for the adoption of these methods by sports teams (James, 2006). Furthermore, the original techniques were restricted to a single player and were therefore quite limited in

practicality.

Over the past decades, technological advances have allowed the introduction of more sophisticated performance analysis systems that are currently used in elite football. These are based on simultaneous analysis of all the players in a relatively short period of time and provide a valuable information base that can positively affect the daily practice of the coaches (Carling, Bloomfield, Nelsen and Reilly, 2008).

Figure 8: Schematic map of the field where marks are used to determine distances



Source: Carling, Williams and Reilly, 2005, p. 5.

Sports video analysis software offers a wide range of solutions that allow each action that happens in real time to be tagged making it possible to create a subjective analysis of the training or the match that is analysed dynamically.

The analysis in real time allows any concept to be collected quantitatively and, at the same time, to be linked to a moment in the time line, which favours the contextualization of any statistical concept.

Through very simple configuration windows, templates can be created for analysis, which allow configuring tools that can create very complete code window libraries according to the knowledge, experience and aesthetic sense of video analysts. These libraries will not only be friendly and aesthetic, but they can also be very efficient, since several statistical concepts can be associated and linked at the same time with just one click.

All the marks or tags that are made are stored in a series of tag tables, reference database, audiovisual classifiers, statistical windows and time lines, all linked to each other, which allow very complete analyses.

The statistics window is a spreadsheet with the ability to make complex calculations extracted from the marks that are made in the code windows and that are collected in a time line. This statistics window allows performing mathematical and logical operations. Besides, it is very flexible as its rows and columns can be moved, added, deleted and these can present the result in hundreds of shapes and scripts that can be copied and pasted into other cells.

It is also possible to use coding applications independent of any software, which allow exporting the data worked in .csv or .xml format, among others.

Likewise, video analysis software also allows the export of data to third parties through different formats and according to the tool that must be ingested.

4.2.4 Video analysis and intervention in training

All the analysis that is carried out during training sessions and matches aims to know what happens, in order to improve processes and behaviours that lead teams and athletes to increase their sports performance.

The effort profile indicates a player's contribution to the team's total effort. The intensity can be expressed as the total distance covered, which determines, *grosso modo*, the energy used in the match. The distance covered represents the global effort profile and can, in turn, be discriminated in discrete actions of each player throughout the game. Actions can be classified according to type, intensity, duration and frequency. Thus, effort-pause rates can be calculated and this can be used to adapt demands to the players training program. This is very useful for evaluating the physical fitness of players. For example, the

distance covered in a match is highly related to laboratory measurements of the players' maximum oxygen consumption (VO2 max). Performance profiles can help to increase individual weaknesses, such as susceptibility to fatigue, observed by a drop in the effort profile towards the end of the match, or the need for a greater recovery after series of high-intensity exercises (Carling, Williams and Reilly, 2005).

When it comes to the intervention that video analysis has in training, we always talk about intervention during the course of this, that is to say, video analysis in real time and intervention during training.

During training, everything that is recorded through video cameras as well as what is analysed in real time can be shown through different platforms. The easiest thing is to show it through computers, smartphones, tablets or laptops that the coaching staff has during training.

Figure 9: Performance analysis data dumped onto a smartphone

Source: [Untitled image about performance data in smartphone]. (n.d.). Retrieved from https://www.oliversport.co.uk/rds-bluetooth-badminton-rackets/

There are other solutions that are more innovative supported by technological evolution and the needs of each sport. Perhaps one of the first experiences in this regard could be seen at the Sant Cugat del Vallés High Performance Centre with the Olympic synchronized swimming team more than ten years ago. The swimmers, after performing an exercise, could watch the video of what they had done and receive corrections from their coaches.

There are studies that estimate the performance of an athlete in more than 15% improvement if they receive feedback in live video format and are able to repeat the exercise again to correct errors, than if the feedback is received after the session and you have no chance to repeat the exercise until the next training session.

From that experience, many other ways of showing video during training are evaluated, such as the use of video markers in halls or stadiums, adapted mobile devices, etc.

Technology must be at the service of coaches and athletes, but sports, games and, above all, athletes are the main protagonists of the process.

References

Aubert, A. E., Seps, B. and Beckers, F. (2003). Heart rate variability in athletes. *Sports Medicine*, *33*(12), pp. 889-919.

Bangsbo, J. (1994). Energy demands in competitive soccer. *Journal of Sports Sciences*, *12*, pp. 5-12.

Bangsbo, J., Mohr, M., and Krustrup, P. (2006). Physical and metabolic demands of training and match-play in the elite football player. *Journal of Sports Sciences, 24*(7), pp. 665-674.

Ben Abdelkrim, N., Castagna, C., El Fazaa, S. and El Ati, J. (October 2010) The effect of players' standard and tactical strategy on game demands in men's basketball. *Journal of Strength & Conditioning Research, 24*(10), pp. 2652-2662.

Carling, C., Bloomfield, J., Nelsen, L. and Reilly, T. (2008). The role of motion analysis in elite soccer: contemporary performance measurement techniques and work rate data. *Sports Medicine*, *38*(10), pp. 839-862.

Carling, C., Williams, A. M., and Reilly, T. (2005). *Handbook of soccer match analysis. A systematic approach to improving performance*. London and New York: Rotledge.

Coutts, A., Reaburn, P. and Abt, G. (February 2003). Heart rate, blood lactate concentration and estimated energy expenditure in a semi-professional rugby league team during a match: a case study. *Journal of Sports Sciences*, *21*(2), pp. 97-103.

Gilman, M. B. (1996). The use of heart rate to monitor the intensity of endurance training. *Sports Medicine, 21*(2) pp. 73-79.

González Badillo, J. J., and Ribas Serna, J. (2002). *Programación del entrenamiento de la fuerza*. Barcelona: INDE

Helgerud, J., Engen, L. C., Wisloff, U. and Hoff, J. (November 2001). Aerobic endurance training improves soccer performance. *Medicine & Science in Sports & Exercise*, *33*(11), pp. 1925-1931.

Hopkins, W. G. (1991) Quantification of training in competitive sports. Methods and applications. *Sports Medicine, 12*(3), pp. 161-183.

[Untitled image about video analysis in football]. (n.d.) Retrieved from

http://www.hollandfootballuniversity.com/wp-content/uploads/videobericht.jpg

[Untitled image about performance data in smartphone]. (n.d.) Retrieved from https://www.oliversport.co.uk/rds-bluetooth-badminton-rackets/

James N. (2006). The role of notational analysis in soccer coaching. *International Journal of Sports Science, 1*(2), pp. 185-198.

Krustrup, P., Mohr, M., Ellingsgaard, H. and Bangsbo, J. (2005). Physical demands during an elite female soccer game: importance of training status. *Medicine & Science in Sports & Exercise, 37*(7), pp. 1242–1248.

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), pp. 803-821.

Ostojic, S. M., Markovic, G., Calleja-Gonzalez, J., Jakovljevic, D. G., Vucetic, V. and Stojanovic, M. D. (March 2010) Ultra short-term heart rate recovery after maximal exercise in continuous versus intermittent endurance athletes. *European Journal of Applied Physiology*, *108*(5), pp. 1055-1559.

Reilly, T., and Williams, M. (2003). *Science and Soccer*. London and New York: Taylor and Francis Group.

Reilly, T. and Thomas, V. (1976). A motion analysis of work rate in different positional roles in professional football match play. *Journal of Human Movement Studies, 2*(2), pp. 87-97.

Randers, M. B., Mujika, I., Hewitt, A., Santisteban, J., Bischoff, R., Solano, R., Zubillaga, A., Peltola, E., Krustrup, P and Mohr, M. (2010). Application of four different football match analysis systems: A comparative study. *Journal of Sports Sciences*, *28*(2), pp. 171-182.

Sport (17 March, 2015). *El GPS, el nuevo arma de Luis Enrique*. Retrieved from https://www.sport.es/es/noticias/barca/gps-nueva-arma-luis-enrique-4024452

Tumilty, D. (1993). Physiological characteristics of elite soccer players. *Sports Medicine, 16*(2), pp. 80-96.