Module 1. Physical and tactical demands in basketball from videos to local positioning systems

BARÇA
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Unit 1.1 Physical and tactical demands in basketball from videos to local positioning systems

This course is composed by four modules. In the first one, we will try to answer the following question: What kind of physical demands do players support in basketball matches? To this end, we will inquire into the physical and tactical demands, using videos and local positioning systems. Our approach will constantly monitor the relation between the conditional or physical structure and the tactical or cognitive one. Establishing this relation is one of the most important aspects to better understand performance.

In relation to videos and inertial systems (IMU) and local positioning systems (LPS), we will give a vision from the usage of time motion analysis in basketball, relying on video camera analysis systems, until getting to technology that allows local positioning for learning about basketball physical demands, whether in training and/or matches or competitions. Later on, on module 2, we will talk about IMU application for quantifying and interpreting physical demands in basketball.

Technology advance, since some time, has given the chance to use small devices in vests on the back of each of the players, in order to learn about the different variables physical demands represent when in training sessions or matches. In module 3, we will move on dealing with the application of positioning systems, whether global (outdoor sports) and/or local, in order to quantify and interpret physical demands in basketball. Afterwards, we will describe the meaning of each one of the concepts and the way in which we can apply them to optimize performance and to try to prevent injuries. Finally, in module 4, we will describe most frequent injuries (types and mechanisms) in basketball and maximum demand scenarios, a very recently developed concept that is becoming more and more important in collective sports.

Maximum demand scenarios imply using a new method that is differentiated from traditionally applied methodology to quantify physical demands (based on the usage of external load average values), since they describe peak demands in the match or competition. We will elaborate on these topics in the following pages.

Before developing the module central concepts, we cannot forget to express our pride for the recent World Championship achieved by the Spanish national team in the competition during September 2019 in China. In brilliantly performed championship, the Spanish team got a gold medal after defeating the powerful Argentinian national team, with players like Scola or Campazzo, great European and global basketball referents, which explains the significance of this second medal for the history of basketball in Spain.

In order to continue with this introduction, we will go back a few years, more precisely to the moment in which there were Spanish basketball stars and FC Barcelona players like Juan Antonio San Epifano, "Epi", De la Cruz and Chicho Sibilo (who passed away recently). If we observe anthropometry, these players´ physical appearances are far from being the same as the current elite players. Nowadays, players like Rakim Sanders, Adam Hanga or Brandon Davies stand out because of their privileged physical appearances. If we go further, I propose you to do the same with NBA players. You can look at Julius Erving and Kareem Abdul-Jabbar bodies and, on the other hand, you can look at Dwight Howard or LeBron James impressive physical structures.

Figure 1: Physical differences among basketball players in different periods

Source: own creation.

Basketball is a sport that is practiced in the whole world and it has a special acceptance in the United States and in a great part of Europe. The International Basketball Federation was created in 1932, with 450 million members included in 213 federations (Harmer, 2005).

Basketball is a complex and dynamic sport (Baker, Core and Abernethy, 2003) in which it is essential to make decisions linked to explosive multidirectional actions. It is also an intermittent sport, with challenging physiological and neuromuscular demands that require high intensity, low intensity and recovery series (McInnes, Carlson, Jones and McKenna, 1995; Ben Abdelkrim, El Fazaa and El Ati, 2007). It implies using energy through two systems: aerobic and anaerobic (Hoffman, Tenenbaum, Maresh and Kraemer, 1996; Klusemann, Pyne, Foster and Drinkwater, 2012).

Jumping and sprinting could be crucial actions for scoring in basketball. These physical demands are important during the whole match and, specially, in particular actions like shots ending in a basket (with layups or shots on two legs) to score, either by a fast break or against one or some opponents in a positional move, to get a slam dunk or a jump shot. Therefore, using physical qualities that are part of the player's conditional structure, like power, speed, agility and aerobic condition are included and necessary in the game development (Hoffman, Fry, Howard, Maresh and Kraemer, 1991; Hoffman, 1996). Physical demands, at the same time, are going to be conditioned by rules, which will have an influence in the actions produced in the match, in its duration and in the density established (ratio between work time and rest time or rest time produced in between the actions).

Modern basketball has become a synonym for increasing in physical demands in the game. Currently, it demands a better fitness condition, e.g. an empowerment of the players´ conditional structure (Ben Abdelkrim, 2007; Sallet, Perrier, Ferret, Vitelli and Baverel, 2005). Studies carried out in the period between 1994 and 2004 in the French basketball league (Cormery, Marcil and Bouvard, 2008) included anthropometric analysis and a test for physical conditional assessment (using the test in ergometer cycles twice a year in each of the ten seasons analyzed). In the results, they differentiated numbers by the positions players were in (point guards, forwards or centers), which led to a conclusion that anthropometry changes in relation to game position. That is, there were significant differences among players that played as point guards, forwards or centers.

Figure 2: Anthropometric differences according to basketball players' position

Anthropometric	Guard (26)	Forward (51)	Centre (22)	A
Age (years)	25 (1.2)	25 (0.8)	23 (1.7)	NS
Height (cm)	185 (0.01)*	200 (0.01)*	207 (0.02)*	A
Weight (kg)	82.3 (1.66)*	95.9 (1.15)*	111 (2.42)*	A
Fat (%)	13.7 (0.51)	13.5 (0.35)	14.1 (0.74)	NS

Data are presented as mean (SE). Column A: group effect (guard versus forward versus centre) showing a significant main effect only ($p<0.05$).
*Averaged difference in a group when compared with the other groups (guard versus forward versus centre).

Source: adapted from Cormery, 2008.

At the physiological level, in the ergometer cycle test, guards showed bigger oxygen consumption, getting to 54 ml/kg/min, in comparison to 45 ml/kg/min for forwards or 41 ml/kg/min for centers.

Figure 3: VO2Max differences according to basketball players´ game positions

	Guard (26)	Forward (51)	Centre (22)	A
Power				
VT (W/kg)	2.84 (0.10)*	2.19 (0.06)	2.24 (0.13)	A
RCP (W/kg)	3.45 (0.10)*	2.86 (0.05)	2.75 (0.14)	A
Max (W/kg)	4.11 (0.11)*	3.56 (0.06)	3.31 (0.11)	A
Ventilatory				
VT (ml/min/kg)	37.5 (1.2)*	29.3 (0.7)	28.5 (1.2)	A
RCP (ml/min/kg)	45.1 (1.4)*	36.5 (0.6)	34.3 (1.3)	A
$\dot{V}O_2$max (ml/min/kg)	54.0 (1.6)*	45.50 (0.7)*	41.7 (1.1)*	A
$VT_{\%VO2}$max	68.3 (1.6)	64.0 (1.57)	68.5 (1.7)	NS
$RCP_{\%VO2}$max	84.3 (1.7)	80.0 (1.0)	83.8 (1.5)	NS
IsoBuff (ml/min/kg)	8.4 (0.6)	8.4 (0.8)	7.0 (0.8)	NS
HHV(ml/min/kg)	9.2 (1.2)	9.2 (0.5)	6.7 (0.8)*	A
RelFB	16.4 (1.59)	22.7 (1.5)	20.7 (1.2)	A
Cardiac				
HR_{rest} (beats/min)	60 (2.3)	60 (1.3)	64 (2.8)	NS
HR_{VT} (beats/min)	152 (2.6)	144 (2.4)	138 (2.6)	NS
HR_{RCP} (beats/min)	166 (1.8)	164 (1.5)	156 (2.9)	NS
HRmax (beats/min)	183 (1.6)	179 (1.3)	175 (2.0)	NS

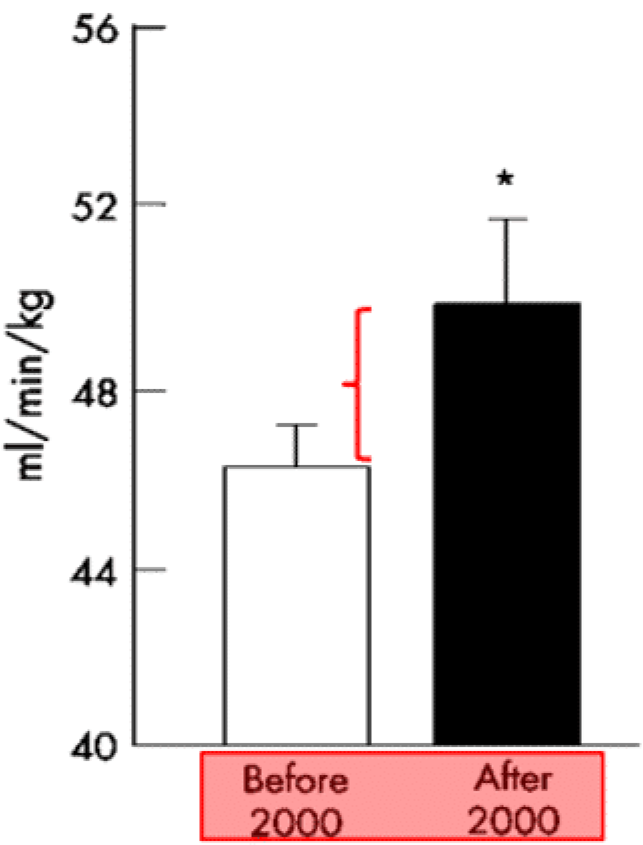
Data are presented as mean (SE). Column A: group effect (guard versus forward versus centre) showing a significant main effect only ($p<0.05$).
*Averaged difference in the group when compared with the other groups (guard versus forward versus centre).
HHV, hypocapnic hyperventilation; IsoBuff, isocapnic buffering; NS, non-significant; RelFB, relative buffering capacity.

Source: adapted from Cormery, 2008.

We can conclude then that there are differences among positions, not only in physiological parameters, but also in other analyzed variables.

This study´s main goal was to compare if there were changes since modifications included in the year 2000 regulations (for example, going from 30 seconds possessions to 24 seconds possessions, as well as time reduction in passing half court when in ball possession). In a very brief summary, VO2max was established in 45 ml/kg/min before the year 2000 and it was changed to more than 49 or 50 ml/kg/min since the year 2000. This variation coincides, as we said before, with changes in regulations and it shows the corresponding increase for physiological demands.

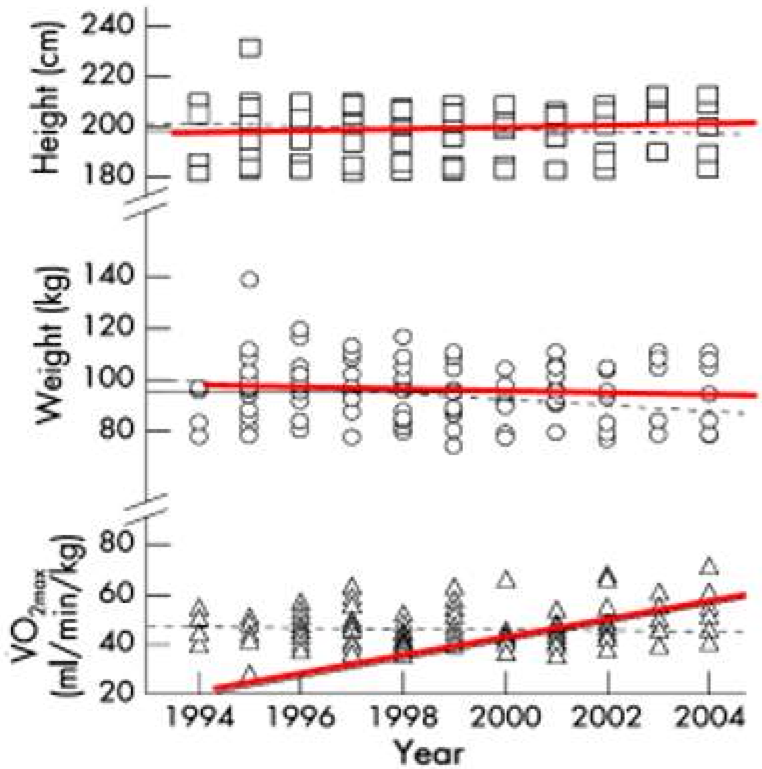
Figure 4: VO2Max differences in basketball players before and after the year 2000



Source: adapted from Cormery, 2008.

Another piece of data to highlight is that since the year 2000 players´VO2max exponentially rose. To sum up, athletes' physiological profile was modified increasing their physical condition. The study also highlights that players showed a tendency to slightly gain weight and increase height in those ten years. In the same way, the VO2 max showed a rising tendency in the decade analyzed.

Figure 5: VO2Max increase in basketball players since the year 2000



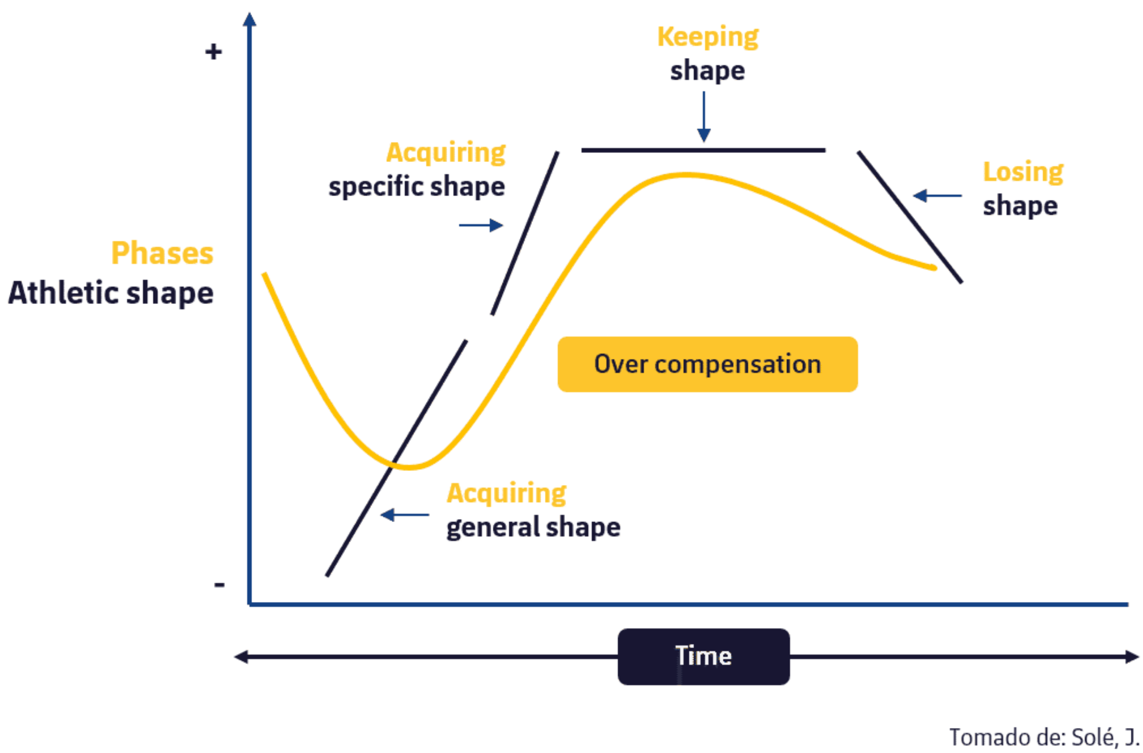
Source: adapted from Cormery, 2008.

In conclusion and as we pointed out in course 1, we should learn about the physical demands in basketball, mainly because of two reasons: to optimize our team performance by training and to establish the relation of these demands (together with other factors) with injuries and/or sickness players suffer.

Monitoring basketball players' physical demands has been a topic of interest, for a long time already, for sport scientists and for coaches. Knowledge about physical demands, their control, their valuation and assessment are important to optimize sports and to prevent injuries. That is why, besides studying the physiological variables, (for example, the VO2Max in the study in the first division French league we observed before) we should learn about the external load (besides the internal response to game) basketball requires.

Another important point when we talk about sport performance is the concept of athletic shape that is the players´ optimal state or predisposition, basketball players in this case, for them reaching the best possible performance in competition events (matches). Inside athletic shape we could acknowledge different stages. The first phase is about acquisition in a general way, the one that will give players the basic requirements that would later allow them to achieve the specific athletic shape in relation to typical basketball demands. Then, the phase for keeping the shape follows. Once that level is specifically reached, it should be kept during the competitions period. These adaptations would be based initially in Seyle's model (General Adaptation Syndrome, 1976) that determines the over compensation that could be achieved in relation to training and/or competition stimulus and to rests or recovery in between them. The last phase is the one in which the athletic shape is lost; it is related to the end of the season when players will lose part of their shape, so for the next season they will have to recover their optimal state to deal with the next competition or competition season.

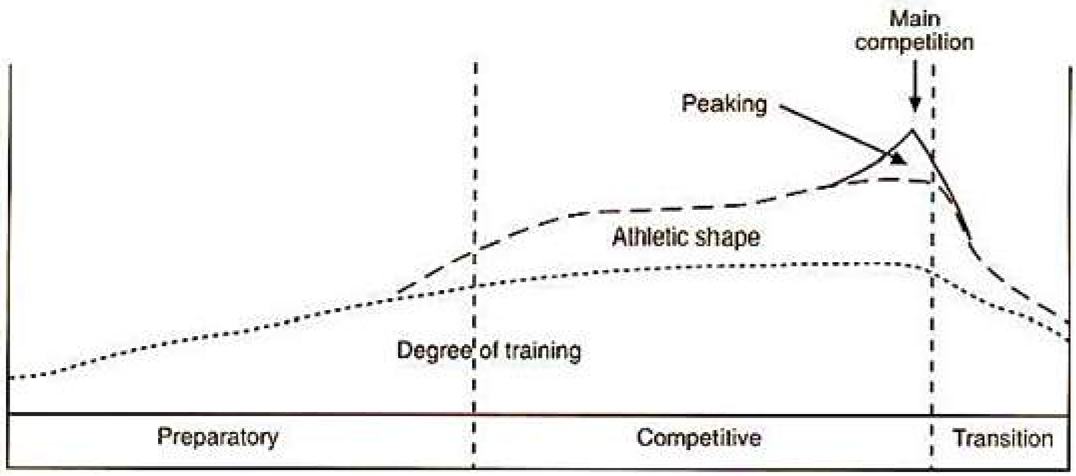
Figure 6: Athletic shape phases



Source: adapted from Solé, 2002.

In relation to periodization, Bompa (2009) differentiates three phases: the preparatory phase, the competitive phase and the transition phase. In the competitive phase, players progressively improve their shape until they reach their peak performance, right before the competition they have to hold.

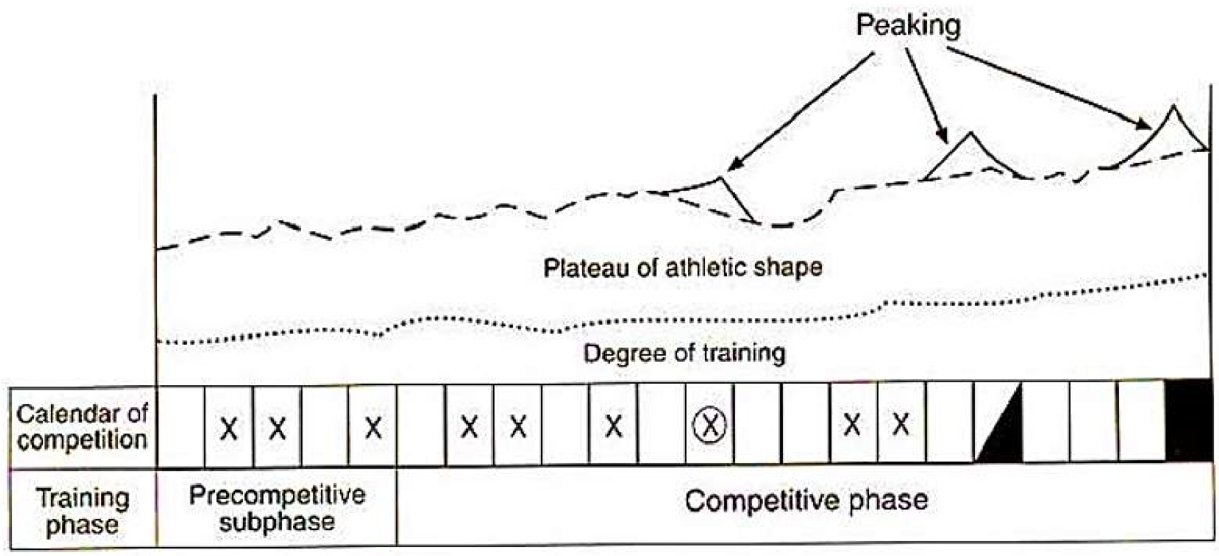
Figure 7: Periodization in sport training



Source: Bompa, 2009

This is very typical in individual sports. For example, if an athlete has to run the 100 meters in the Olympic Games, he/she will train to achieve his/her peak in that competition. But we all know that, in basketball, calendars include a match, two and even three per week. Thinking, for example, about a playoff in the Liga Endesa that is played in June, it makes no sense to apply the formula that consists in reaching the best possible performance, since it would leave out players during the competition. Therefore, we should think about a different approach, for example, another proposal made by Bompa himself illustrated in figure 8. There we can see a proposal to apply during the competitive phase where different shape peaks appear. That is, we see the ways to reach high shape states during the competitive phase without getting to a peak. We will be able to apply this concept to basketball, adapting it to the needs in the week and in the competitive calendar for the whole season, trying to achieve those high shape peaks in some players, and trying to keep them in as many microcycles as possible in matches played during the whole competition.

Figure 8: Second proposal for periodization in sport training



Source: Bompa, 2009.

Then, in order to improve physical fitness state in individual sports such as cycling or athletics, we could start with periodization based mainly in the Bompa's proposal we saw in figure 7, but in order to achieve an athletic shape in team sports, basketball in particular, we should think about something different.

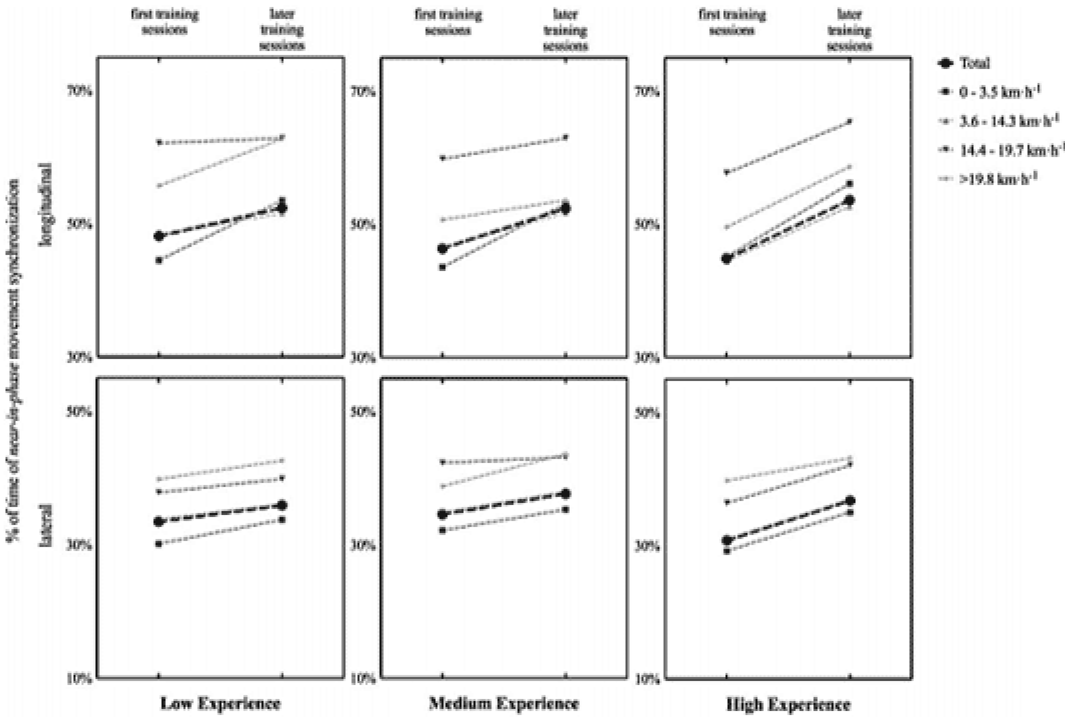
Athletic shape in team sports exceeds the monitoring of physiological parameters like heart rate, lactate level or the VO2Max (decisive in different methods in individual sports). It is productive, then, to continue developing ideas that could contribute to get a better understanding of athletic shape in basketball.

Initially, athletic shape should be understood as a harmonious unit that represents all components (physical, technical, tactical and mental components included) that are part of the predisposition for achieving the best possible performance. It is about using all the structures that are part of the basketball player, that is, the cognitive (tactical), the coordinative (technical), the conditional or physical, the psychological, the emotional-volitional, the bioenergetic and the creative-expressive and it is about creating synergy among them in order to optimize performance altogether. We will go deeper on these aspects later on.

In basketball, pre-season´s main goal is to get the necessary athletic shape to be able to play the matches during the competitive season. Here we should consider two dimensions: the individual athletic shape and the collective athletic shape. The individual could be in a very high level, but it may not be so useful in the collective level and vice versa. Other dimensions to take into account are the athletic shape in relation to the rivals, and the athletic shape in relation to the moment in the season (Seirul-lo, 1986).

A recent research by Folgado, Goncalves and Sampaio (2018) allows for advancing more in quantification (with scientific base) in the collective athletic shape (the second one in Seirul-lo´s proposal). The work analyses the way in which the tactical, physical and physiological performance is modified during preseason in elite football. To this end an 8-against-8-plus-goalkeeper situation was studied and it was repeated from the first week until the last one in the preseason. They used positioning systems, GPS in this case, and a non-lineal methodology to analyze data obtained through these devices. This methodology includes the analysis by entropy, which is a way of analyzing time signals typical in non-lineal methodologies (complex dynamic systems). It could be observed that the distance covered in more than 18 km/h and the sprints kept stable when comparing all the training sessions in the preseason. Nevertheless, using entropy to analyze data that we could relate to length and side movements, we found out that players' synchronization improved in an 8% and a 7% in each movement respectively. These results allow for better understanding what the athletic shape is about, e.g., the way players improved their communication and coordination in the field. This is not a minor detail, since teams should be able to response together and in a coordinate way to different situations in each of the matches played. The sport success has a lot to do with identifying and interpreting the most important aspects of the game in a similar and quick way.

Figure 9: Results of players´ movement synchronization in preseason



Source: Folgado, 2018. p. 8.

Another aspect that this publication highlights is that players get in shape at different rhythms. The study showed that veteran athletes got a collective athletic shape more quickly than the ones who were not veterans. Figure 9 shows three differentiated groups of players: low experience, medium experience and high experience. According to the entropy analysis, the synchronization slope is a lot steeper in expert players than in non-experienced ones. Because of this, it is important to differentiate between the individual athletic shape and the collective team athletic shape. We should identify and quantify which are the most adequate indexes to establish the athletic shape. For this purpose, we can use general tests that allow for analyzing and learning about athletic shape in particular: the conditional structure one. This way, for example, if we want to learn about the players´ aerobic resistance level, we can make an intermittent test that measures the maximum aerobic power. Nevertheless, the most common athletic shape in basketball is the collective one and, therefore, the level showed in the game is the one that should help to identify it. The best test will then be the analysis of training sessions and the competition itself. Besides, players´ age and the moment in which they are in their athletic life have a lot to do with the time they need to get their athletic shape.

Sometimes we do not speak the same language with players and/or trainers or the coaching staff. Coaches should clearly communicate the ways to get a series of goals. We should be able to transmit information easily and coherently, trying to get close to coaching staff's way of thinking and training. In this sense, I propose a series of concepts that will be beneficial to reach our conditional goals.

- Transition situations: quick actions in which there is no total defense organization and which are useful to generate advantages in attack.
- Mid court situations (positional game).
- Situations in which there might be long attacks and when they might require a possession of 20 seconds or more to complete the attack.
- Inbound passes or entry passes and plays that emerge after a timeout.
- Type of defense situations, when we attack against an individual defense or against the zone defense.
- Press crossover against a full court press defense situation.

Below, we will add different tactical actions for the completion of attack plays (although they could happen any time). We can differentiate types of plays according to how they are completed:

- ☐ **Set shots:** typical play in which a player throws to the basket from the three-point line. Different movements are made until a pass is received and the player has to receive the ball and throw it to the basket.
- ☐ **Screen and roll:** the player doing the screen goes to the basket; he/she receives the pass and completes the action.
- ☐ Transition with completion, thanks to a quick offensive transition.

- **Low post:** the ball gets to the player in the frontcourt near the basket and said player manages to complete the play.

- **Cut:** another player who does not have the ball cuts in direction to the basket and manages to complete the play thanks to another partner.

- Offensive rebounds with tip shot.

- **Isolation:** team partners enlarge the court making room for the player to complete the play.

- **Come off the screen through one, two or more screens: it pretends to get the player receiving with certain advantage, in such a way that he/she could shoot without opposition**.

- Handoff.

- Direct screen with the player who received the screen completing the play.

- The last group includes the rest of play completions that are not mentioned inside the previous ones.

We can also talk about the different types of actions like receiving and shooting. This is: released or defended, shot over dribble on half court (including all shots after dribble) and shots over dribble in relation to the completion distance from the basket.

Below, you will find data related to different ABC and Euroleague teams.

13% of time devoted to plays corresponds to transitions. Specifically, 11 possessions in transition are produced, scoring 14 points. While the positional game in half court supposes the 87% of the resting time, with 74 average possessions by match that supposes 74 points scored.

The baseline constitutes the 6% of plays, producing 5 possessions and 4 points scored on average. In relation to wings, they imply the 8%, with 6 possessions and 6 points scored on average.

13% of plays after a timeout correspond to ten possessions and nine points scored.

As regards the percentage of different types of completions, the 21% corresponds to set shots, 19 possessions and 20 points scored. The direct screen and roll of the player with the ball implies the 20%, 14 possessions and 12 points. Transitions the 13%, 11 possessions and 14 points. The direct screen and roll of the screener comprehends the 10%, 8 possessions and 9 points scored. Low post plays represent the 8%, 7 possessions and 8 points. Cuts include the 7%, 6 possessions and 7 points. Offensive rebounds 5%, 5 possessions and 5 points scored. Isolations, the 5%, 4 possessions and 4 points scored. Coming off the screen occupy the 5%, 4 possessions and 3 points. Handoff 3 %, 2 possessions and 2 points scored. Other types would include 3% of time, with 6 possessions and 3 points.

Physical demands quantify stimuli supported by players in matches. In order to analyze them effectively, we should take into account the absolute values and also relative data in relation to time. This way, we will learn about the conditional requirements our players should meet and we will be able to relate them to technical-tactical elements.

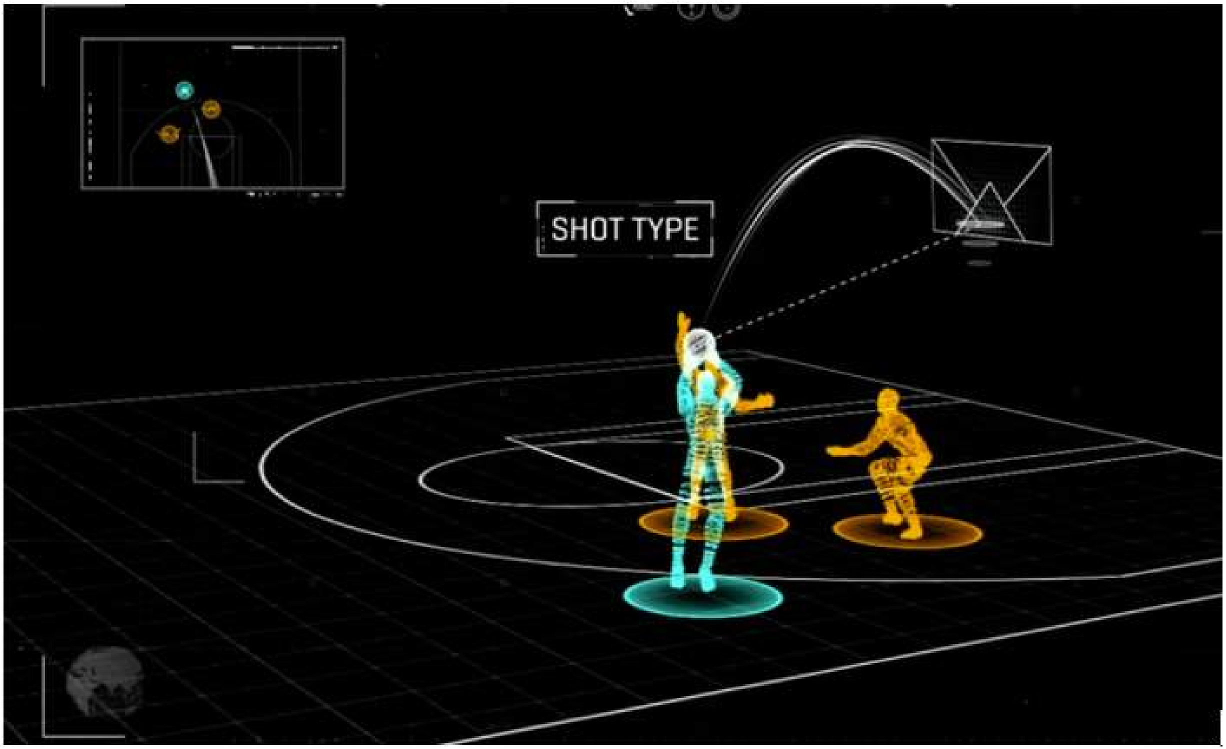
In order to learn about these physical requirements, the first resource was time motion by video analysis, based on video cameras (Ben Abdelkrim, Castagna, El Fazzaa and El Ati, 2010; Ben Abdelkrim, Castagna, Jabri, Battikh, El Fazaa and El Ati, 2010; Abdelkrim, 2007; Hulka, Cuberek and Svoboda, 2013; Klusemann, Pyne, Hopkins and Drinkwater, 2013; Scanlan, Dascombe and Reaburn, 2011). The recording of data by this method could vary depending on the system used, even though it is usual to follow similar procedures: using fixed cameras in the hall or in portable tripods.

Figure 10: Multi cameras system for analyzing time motion

Source: [Untitled image about multi cameras system for analyzing time motion] (2019). Recovered from https://medium.com/analytics-vidhya/data-science-the-science-of-moving-dots-in-basketball-and-shot-value-5f66e791476b

Players' monitoring by video analysis has been very important in the most important league, the NBA, in which you can follow each player and every ball movement during all matches, all the teams included. These systems are able to detect players on the court by video screenshots, and later, files are analyzed by software that digitalizes images and compile relevant information.

Figure 11: Digitalization of video analysis images



Source: [Untitled image about digitalization of video analysis images]. (2015). Recovered from https://www.sporttechie.com/tracking-basketball-players-can-help-society-move-forward/

Data can vary according to the software and the analyst needs; however, as a norm, speed, distance, movement duration and frequency are the variables that are most studied in these analyses (McInnes, Carlson, Jones and Mckenna, 1995). This way, taking previous basketball scientific bibliography as a base, they establish different movement or physical activities patterns. Stand or walk would be the first pattern, which includes any situation in which the walking speed is not exceeded. There are no differences, in this case, between being still and walking or among different walking intensities. It also includes actions in which the player is in a defensive position, but motionless (McInnes, 1995; Ben Abdelkrim, 2007; Ben Abdelkrim, 2010) and actions in which multidirectional movements happen at 1 m/s, when the player is not in defensive position (Scanlan, 2011; Scanlan, Dascombe, Reaburn and Dalbo, 2012).

Another pattern would be jogging or low speed running; here walking without hurry is included (McInnes, 1995; Ben Abdelkrim, 2007; Ben Abdelkrim, 2010; Klusemann, 2013) and the multidirectional movements done in speeds of 1.1 m/s to 3 m/s, when the player is not in a defensive position (Scanlan, 2011; Scanlan, 2012).

In another block of patterns we find the moderate speed forward or backward sprint, which demands a higher speed than the one used for jogging or moderate hurry, without approaching to an intense movement level (McInnes, 1995, Abdlekrim, 2007; Ben Abdelkrim, 2010); the multidirectional sprint with consecutive movements, one leg support included, with fly phases and without double-support phases (Narazaki, 2009); and multidirectional movements of 3.1 m/s to 5 m/s, when the player is not in a defensive position (Scanlan, 2011; Scanlan, 2012).

High speed sprint that includes from 5 m/s to 6.66 m/s (Ben Abdelkrim, 2010; Janeira, 1998).

- **Sprint or high speed run:** it is carried out forwardly at a very high intensity. It is characterized by a maximum or very close to maximum effort (McInnes, 1995; Ben Abdelkrim, 2007; Ben Adbelkrim, 2010) and a multidirectional movement faster that 7 m/s, when the player is not in a defensive position (Scanlan, 2011; Scanlan, 2012).

- **Shuffling movement at low intensity:** generally lateral or backward, athletes dragging their feet, it is characterized for being executed at slow rhythm and in an erect body position (McInnes, 1995; Ben Abdelkrim, 2007; Ben Abdelkrim, 2010); multidirectional movement in a defensive position slower than 2 m/s (Scanlan, 2011; Scanlan, 2012), and any feet action that it is not walking or running, for example, pivot or crossover step slower than 1.67 m/s (Ben Abdelkrim, 2010; Delextrat, Badiella, Saavedra, Matthew, Schelling y Torres-Ronda, 2015).

- **Shuffling movement at moderate intensity:** moderate feet rhythm, generally in erect position and without approaching an intense shuffling movement (McInnes, 1995; Ben Abdelkrim, 2007; Ben Abdelkrim, 2010), and any feet action different to walking, running or running doing turns or crossover steps, executed to speeds of 1.67 m/s to 2.5 m/s (Ben Abdelkrim, 2010; Delextrat, 2015).

- **High intensity shuffling movements:** they are quick feet movements, generally in bending position (McInnes, 1995, Ben Adbelkrim, 2007, Ben Abdelkrim, 2010). Any multidirectional movement carried out in defensive position at speeds faster than 2 m/s (Ben Abdelkrim, 2010; Delextrat, 2015), and any feet action different to walking or running, like turns or crossover steps that are executed at speeds faster than 2.5 m/s (Ben Abdelkrim, 2010; Delextrat, 2015).

- **Jumps:** time from the beginning of the jump action until the landing completion (McInnes, 1995; Ben Abdelkrim, 2007; Ben Abdelkrim, 2010). Any type of movement by which players initiate a jump action and lift their feet from the ground (Scanlan, 2011; Scanlan, 2012); they could be jumps performed on one leg or both (Narazaki, 2009).

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Changes of direction (Conte, Favero, Lupo, Francioni, Capranica and Tessitore, 2015; Janeira, 1998).

- ***Dribling:*** any active dribbling movement in any direction (Scanlan, 2011; Scanlan, 2012; Scanlan, Dascombe, Kidcaff, Peucker, and Dalbo, 2015).

- **Passes:** it includes any type of pass (Delextrat, 2015).

- **Superior body movements:** any action in the superior part of the body that implies the elevation of one or both arms above the horizontal. These movements were analyzed simultaneously and independently from other movements (Scanlan, 2011; Scanlan, 2012; Scanlan, 2015).

- **Static execution:** it would include direct and indirect screens (Ben Abdelkrim, 2010; Conte, 2015; Delextrat, 2015).

In order to better understand the relation between m/s and km/h, we will observe the relation established among the different movement patterns:

- **Stand and walk:** less than 6 km/h = 1.69 m/s.

- **Jog:** less than 6.1 km/h until 12 km/h = 1.7 m/s to 3.34 m/s.

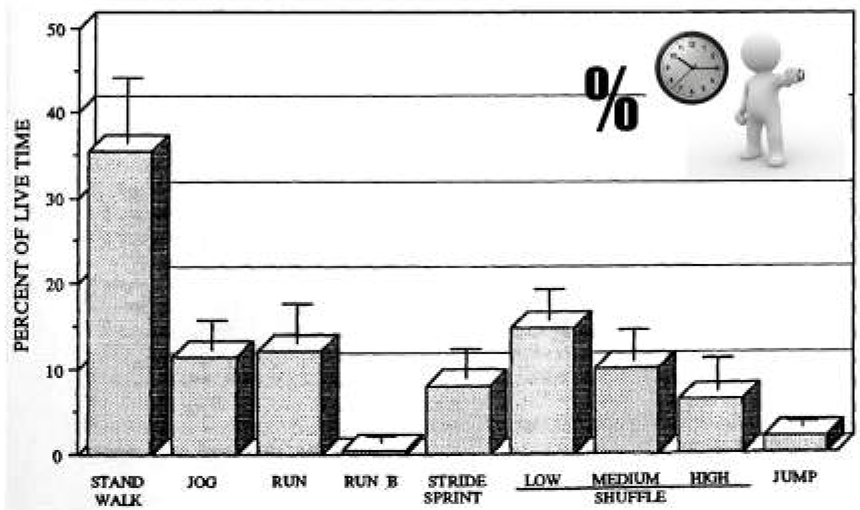
- **Moderate run:** 12.1 km/h to 18 km/h = 3.35 m/s to 5 m/s.

- **Fast run:** from 18 km/h until 24 km/h = 5.01 m/s to 6.67 m/s.
- **Sprint:** bigger than 24 km/h = 6.67 m/s.
- **Low shuffle:** less than 6 km/h = 1.69 m/s.
- **Medium shuffle:** 6.1 km/h until 9 km/h = 1.7 m/s to 2.54 m/s.
- **High shuffle:** more than 9 km/h = more than 2.5 m/s.
- **Lateral run:** more than 12 km/h = 3.34 m/s (McInnes, 1995; Ben Abdelkrim, 2010; Puente, 2017; Moras, Fernandez-Valdes, Vazquez-Guerrero, Tous-Fajardo, Exel and Sampaio, 2018).

In relation to the activity frequency, according to bibliography, an average total of 997 ± 183 actions are registered during the match. The average duration of each movement category was less than three seconds, with a change in the event every 2.2 seconds. And the average was established in 105±52 actions for high intensity actions, with an average duration of 1.7 seconds, which produced a high intensity action every 2.1 seconds during game time (without taking stops in the match into account). Relative frequencies vary between 20 and 29 movements. In relation to duration, figure 12 shows the time percentage per actions (McIness 1995). We can observe the percentages for each of the actions in the game live time, in which the ones that stand out are the patterns we have mentioned before (standing, running, high intensity running, sprinting, etc.).

Figure 12: Game live time percentages during a basketball match

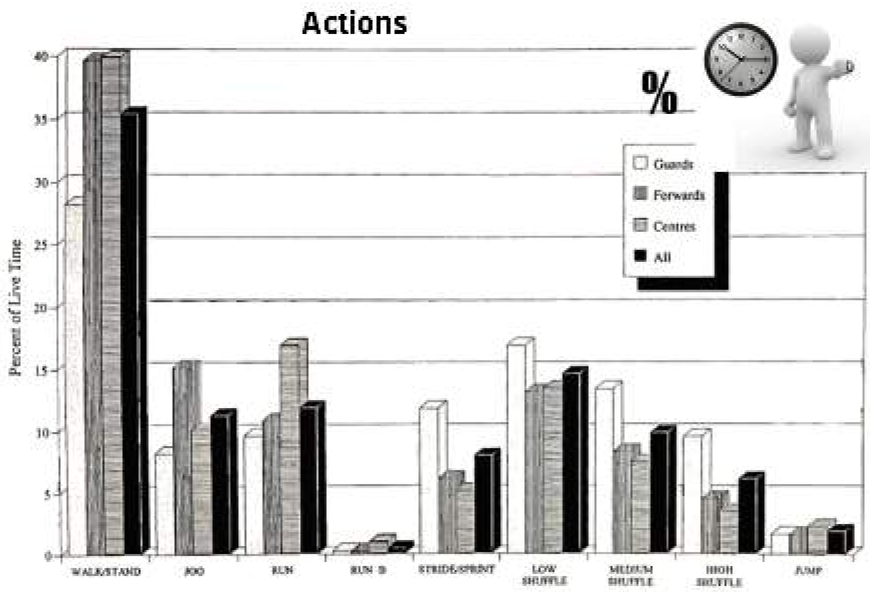
Actions



Source: adapted from McInnes, 1995.

The same author proposes the percentage of actions time duration for each of the movement patterns, established according to the different positions (guards, forwards and centers).

Figure 13: Percentage of actions time duration for each of the movement patterns established according to the different game positions

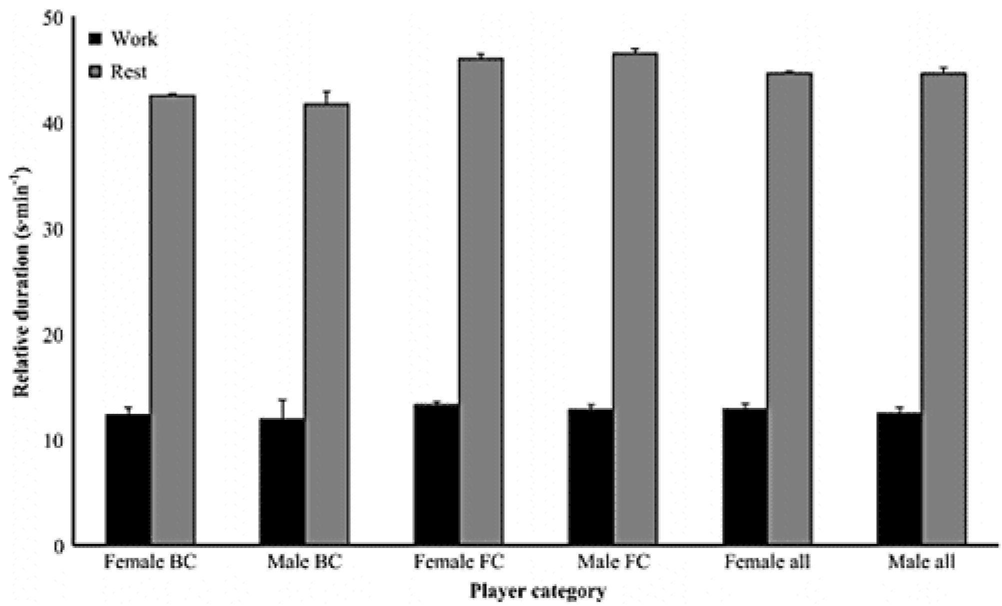


Source: adapted from McInnes, 1995.

Besides, we can see a significant decrease in time for intense activities in the last quarter (Ben Abdelkrim, 2007), so the time devoted to high intensity actions in the first quarter was bigger than in the rest. This supposed an increase in duration for low intensity activities (stand, walk or jog) during the second part.

Differences between male and female basketball players in relation to game time ratio and rest time are almost insignificant.

Figure 14: Game time ratio and rest time in male and female basketball players



Source: Scanlan, 2015. p. 623.

We can also make reference to work time and rest time established in different time ranges, relying on a publication by Colli and Faina's (1987) in which they established periods from 1 to 10 seconds, from 11 to 20, from 21 to 30, from 31 to 40, from 41 to 50, that is, every 10 seconds, until getting to more than 120 seconds, not only for game time but also for rest.

Table 1: Work and rest time duration in basketball

Duration (Seconds)	Game		Rest	
	Frequency	Percentage	Frequency	Percentage
1 - 10	34	5.4	36	5.7
11 - 20	141	22.5	153	24.4
21 - 30	108	17.2	114	18.2
31 - 40	76	12.1	57	9.1
41 - 50	43	6.8	66	10.5
51 - 60	45	7.1	60	9.6
61 – 70	37	5.9	45	7.1
71 - 80	25	4.0	36	5.7
81 - 90	30	4.8	6	1.0
91 - 100	11	1.7	15	2.4
101 - 110	23	3.7	9	1.4
111 - 120	21	3.3	3	0.5
>120	33	5.3	3	0.5
	627		603	

Source: Colli, 1987.

An analysis of ten matches played on the National Collegiate Athletic Association (Conte, Tessitore, Smiley, Thomas and Favero, 2016) concludes that 65% of game time was less than 40 seconds, that is, the 65% of actions before rest lasted less than 40 seconds. In relation to rest times, actions lasting less than 40 seconds represented the 51.7 % of the total.

Figure 15: Analysis of ten matches played in NCAA

< 40"
65,1%

< 40"
51,7%

	Live Time (%)						Stoppage Time (%)					
	Game	1st half	2nd half	χ^2	p-value	Cramer's V	Game	1st half	2nd half	χ^2	p-value	Cramer's V
1-20 s	38.5	33.5	43.0				28.3	32.7	24.5			
21-40 s	26.6	28.4	24.9				23.4	22.8	23.9			
41-60 s	15.6	17.6	13.8	7.015	0.135	0.103 (Small effect)	23.8	21.5	26.0	5.71	0.222	0.094 (No effect)
61-80 s	11.2	11.2	11.2				8.3	7.6	8.8			
>80 s	8.2	9.3	7.2				16.2	15.5	16.8			

Source: adapted from Conte, 2016.

Another interesting piece of information in this article is the density that was established between game time and rest time. In competitions the number was 0.71, whereas in training matches the ratio was 1.38. This data was very interesting because it clearly shows that requirements, in relation to density in this case, were a lot more demanding in training, due to the longer rests established in matches.

Figure 16: Game and rest time

	Mean	Median
Game	0.71 ± 0.08	0.73
Defensive drill	0.75 ± 0.23	0.65
Offensive drill	0.80 ± 0.17	0.78
Scrimmage *	1.38 ± 0.48	1.21

Note: *indicates a statistical difference compared to games [adj-p= 0.012, r= -0.789 (large effect)], defensive [adj-p= 0.024, r= -0.629 (large effect)] and offensive [p= 0.018, r= -0.664 (large effect)] drills

Source: adapted from Conte, 2016.

From here, it is easy to relate periodization concepts, programming and training session and competition requirements with the main goal to optimize performance and to have a positive influence in injury prevention, at the same time.

Figure 18 shows the time percentage in different ranges in the analysis of our team participation in the Euroleague.

Figure 17: FC Barcelona professional basketball team game and rest time data in the Euroleague

Match	
INTERVALS WORK	
	Percentage
0 – 10"	12%
10 – 20"	21%
20 – 30"	18%
30 – 45"	21%
45 – 60"	9%
1 – 2"	16%
+2"	2%

Match	
INTERVALS REST	
	Percentage
0 – 10"	3%
10 – 20"	32%
20 – 30"	25%
30 – 45"	12%
45 – 60"	7%
1 – 2"	16%
+2"	6%

Source: own creation.

Taking different publications into account, distance can vary between 4.4 km and 7.5 km (average of 5 and 6 kilometers) during a match. We are talking about information taken from video analysis. Another important piece of information is that the average distance covered before the year 2000 was 4.542 m, whereas the average distance in different publications after the year 2000 is 6.679 m. This data seems inconsistent, in some occasions and after comparing different publications. Let´s analyze these examples: according to studies cited here, point guards exerted more physical demands than forwards and centers (Hulka, Cuberek y

Svoboda, 2013); point guards and centers ran less than shooting guards, power forwards and centers (Oba y Okuda, 2008); point guards and shooting guards covered more distances than the centers and small forwards (Scanlan, 2011; Scanlan, 2012; Scanlan, 2015). Technological advances have allowed us to analyze this data from another perspective. We will go deeper on this later on. For the time being, and as a summary, we can highlight that the different studies by Ben Abdelkrim's group show an increase in physical demands in men and women's basketball teams since regulations changed.

CONTINUE

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