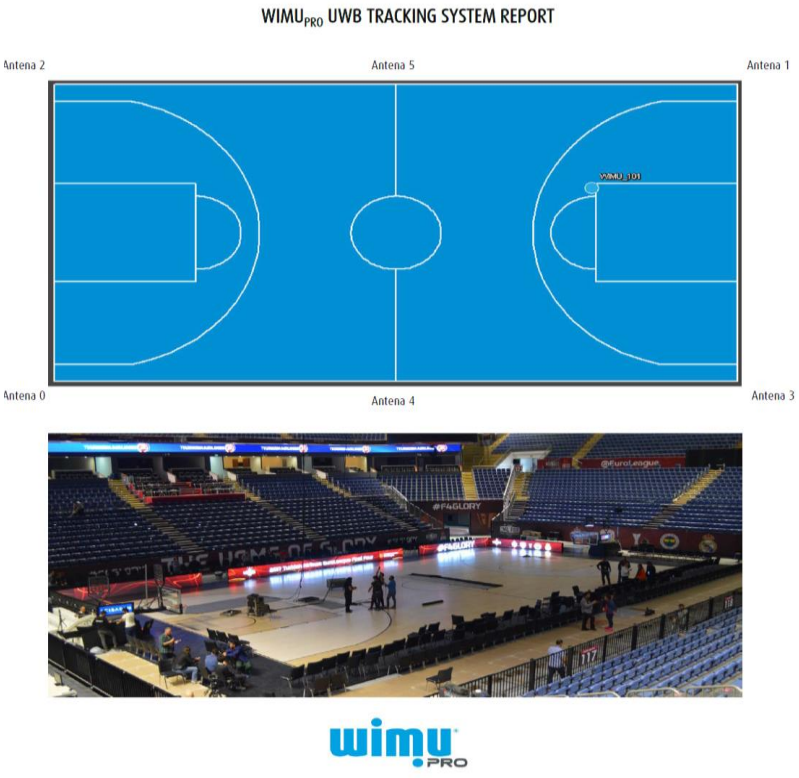
Module 3. Application of positioning systems (global and local) to quantify and interpret physical demands in basketball

Unit 3.1. Application of positioning systems (global and local) to quantify and interpret physical demands in basketball

So far, we have analysed the data retrieved from the information provided by camera motion analysis systems, inertial systems. Currently, technology also allows us to use positioning data. Technological advances make it possible to monitor the indoor court. These data have improved validity and reproducibility in relation to GPS. It is known that tracking systems may be local or global. The global ones use satellites: the clearest example is the typical GPS that can be used on any device, in our car or on our mobile phones, to find out the route we have to take. Local tracking systems, however, through ultra-wide band (UWB) technology, use antennas to get the satellites into the basketball court.

Figure 1: Local tracking system



Source: Author's production.

A signal that reaches the receivers carried by players on the playing court is emitted. This signal returns to the antenna, so that the player's location can be known at all times through triangulation.

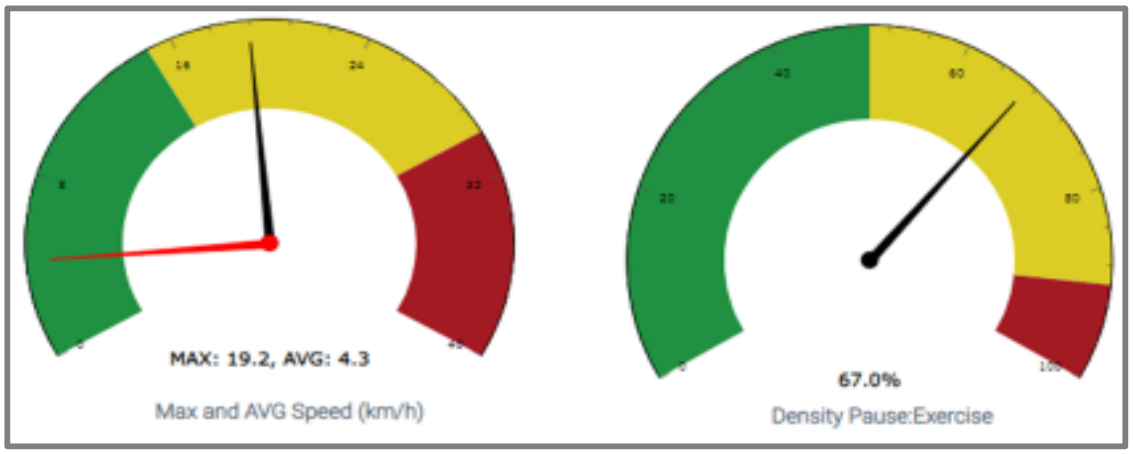
Therefore, LPS (Local Position Systems) are capable of showing the location while there are no obstacles that interrupt the passage of the signal to and from these antennas. Therefore, they allow real-time monitoring of an object or a person (in this case a basketball player) in a certain area. Nowadays, local (LPS) and global (GPS) tracking systems can also be linked with WIMUs. For example, the technology used at F.C. Barcelona includes both types of technology. Different studies have quantified the physical demands from various variables such as the distance covered, the running speed, or the number of sprints (in football and rugby, as well as other outdoor sports). These systems are based on knowing the location, that is, the position of the player. This knowledge is the source of all the other physical demands; thus, a precise understanding of the position will thoroughly determine the quality of those data.

It is essential to know the reproducibility of such devices. In their 2018 publication, Bastida Castillo, Gomez Carmona, De la Cruz Sánchez and Pino Ortega have demonstrated that the ones used at Football Club Barcelona possess high reproducibility. This offers peace of mind when using them on a daily basis.

These systems offer metric data such as distance, speed, acceleration, etc. They provide us with three types of data, namely absolute values, relative values in relation to the maximum, and other relative data related to time. For example, if someone has run 3.5 km in a game, it is not the same to have run them in 20 or 30 minutes. That is, this absolute data is divided by the elapsed time, which results in a normalized value related to time.

Another data that is interesting to know is the density in a training session (work time / break time). All these data are analysed and can be accessed very quickly.

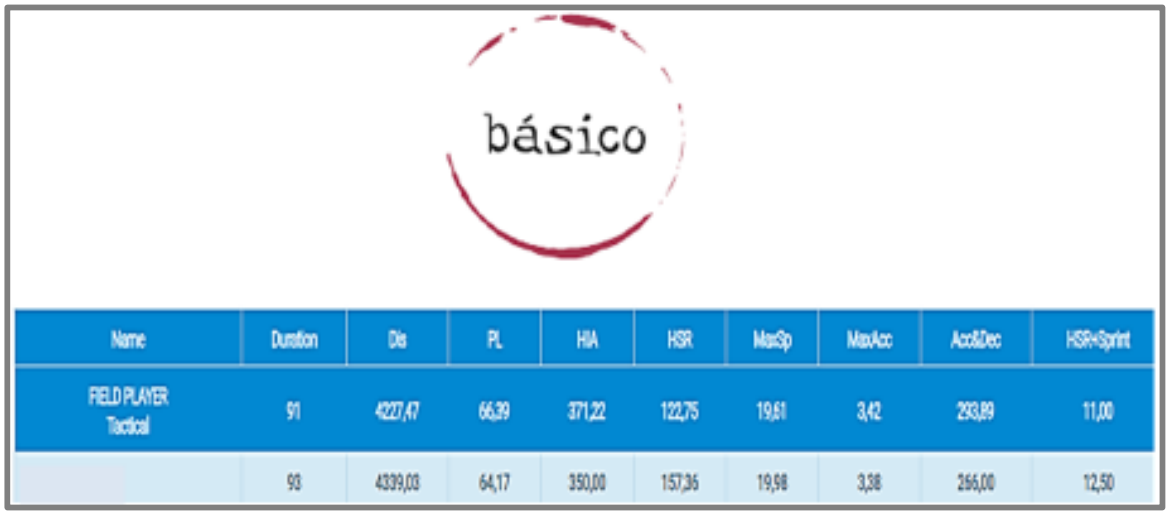
Figure 2: Density in a training session



Source: Author's production.

Out of this analysis we may also obtain different variables that should appear in a short (basic) report: the distance covered, the player load, high intensity actions, high intensity speed greater than 18 km / h, the maximum speed, the maximum acceleration, the number of accelerations and decelerations greater than 2 m / s^2, the number of times the athletes have exceeded 18 km / h and the number of sprints.

Figure 3: Basic report

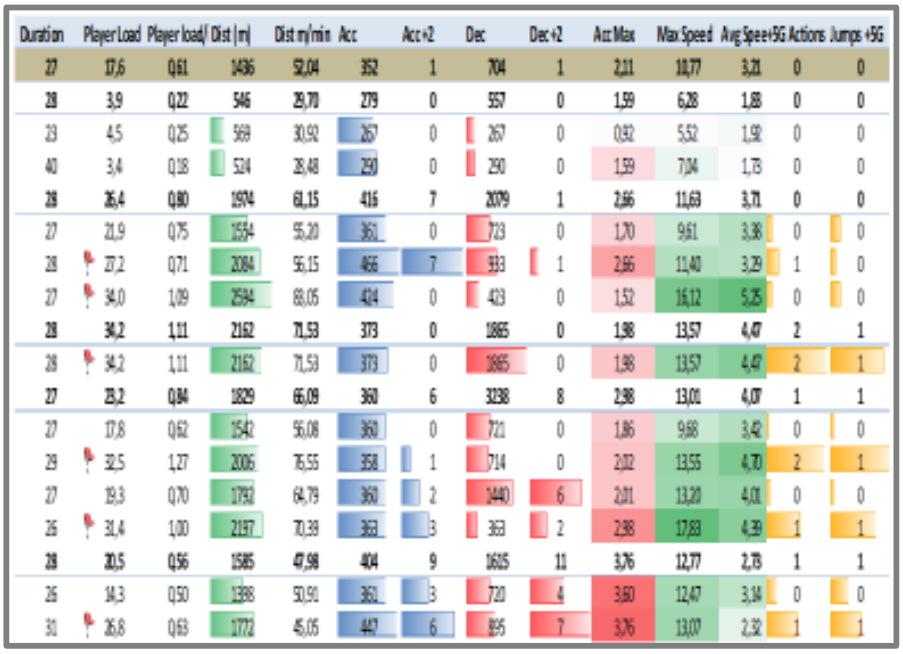


Name	Duration	Dis	PL	HIA	HSR	MaxSp	MaxAcc	Acc&Dec	HSR+Sprint
FIELD PLAYER Tactical	91	4227,47	66,39	371,22	122,75	19,61	3,42	293,89	11,00
	93	4339,03	64,17	350,00	157,36	19,98	3,38	266,00	12,50

Source: Author´s production.

On the other hand, an extended report includes more data. In this case, some of the variables expressed in terms of absolute value in the first report are expressed in terms of relative values with respect to time in the second report. Such would be the case of distance. The first report may inform that an athlete has covered 4km in a training session and the following report may add that he has maintained a speed of 55 m / min in the training performed. The same applies for total accelerations. There should also be included here the number of jumps (both in absolute value and in relative value per minute), amd the number of lateral impacts that the player has supported, among other variables.

Figure 4: Extended report



Duration	Player Load	Player load/	Dist (m)	Dist m/min	Acc	Acc +2	Dec	Dec +2	Acc Max	Max Speed	Avg Speed +5G	Actions	Jumps +5G
27	17,6	0,61	1436	52,04	352	1	704	1	2,11	18,77	3,21	0	0
28	3,9	0,22	546	19,78	279	0	557	0	1,59	6,28	1,68	0	0
23	4,5	0,25	569	30,92	267	0	267	0	0,92	5,52	1,92	0	0
40	3,4	0,18	524	28,48	250	0	250	0	1,59	7,04	1,73	0	0
28	26,4	0,80	1974	61,15	416	7	2079	1	2,66	11,63	3,71	0	0
27	21,9	0,75	1554	55,20	361	0	723	0	1,70	9,61	3,36	0	0
28	27,2	0,71	2084	56,15	466	7	933	1	2,66	11,40	3,29	1	0
27	34,0	1,09	2584	88,05	424	0	423	0	1,52	16,12	5,25	0	0
28	34,2	1,11	2162	71,53	373	0	1865	0	1,98	13,57	4,47	2	1
28	34,2	1,11	2162	71,53	373	0	1865	0	1,98	13,57	4,47	2	1
27	23,2	0,84	1829	66,09	360	6	3238	8	2,98	13,01	4,07	1	1
27	17,8	0,62	1542	55,08	360	0	721	0	1,86	9,68	3,42	0	0
29	32,5	1,27	2006	76,55	358	1	714	0	2,02	13,55	4,70	2	1
27	19,3	0,70	1792	64,79	360	2	1440	6	2,01	13,20	4,01	0	0
26	31,4	1,00	2157	70,39	363	3	363	2	2,98	17,83	4,39	1	1
28	20,5	0,56	1585	47,98	404	9	1615	11	3,76	12,77	2,73	1	1
26	14,3	0,50	1388	50,91	361	3	720	4	3,60	12,47	3,14	0	0
31	26,8	0,63	1772	45,05	447	6	895	7	3,76	13,07	2,32	1	1

Source: Author's production.

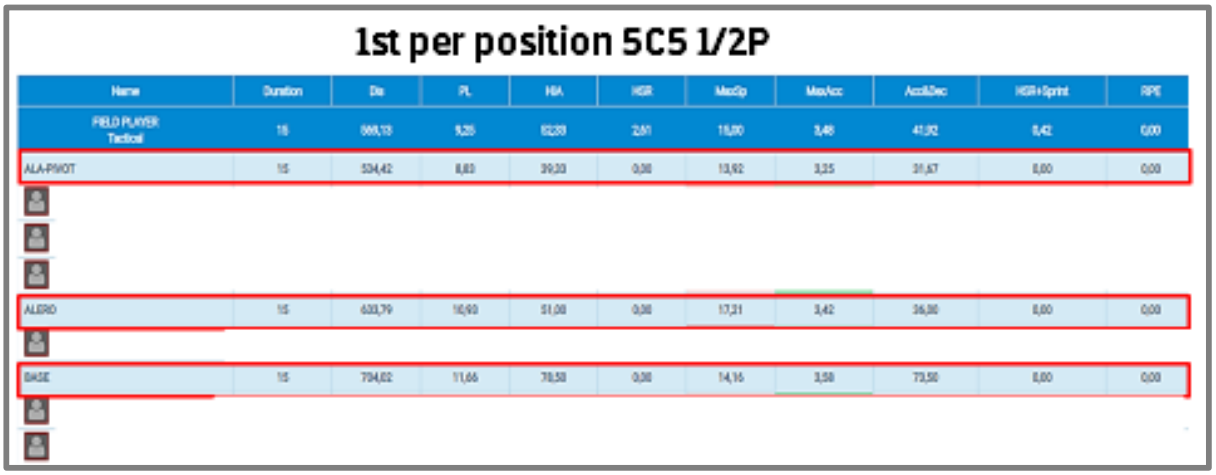
All these data are important *per se*, but if they are taken into account by position and individually, they acquire even greater rigour and relevance. Therefore, the reports that we obtain from the LPS data after each training session allow us to compare the data by position and by the task each one has carried out.

For example, 5 vs. 5 on mid-field for 15 minutes. Analysing this task through the basic report (figure 5), we will focus on the distance covered by the centres (534 meters) compared to the forwards (633 meters) and the point guards (704 meters). Through this simple data, a difference between the athletes' physical demands depending on their playing position can be observed. When considering other variables, we will get to similar scenarios.

In this case, the player load obtained in the task would be 8.83 for the centres, 10.93 for the forwards and 11.66 for the point guards.

Regarding high intensity distance, in this case it is the same for all positions, since it was in the middle of the field and there was no high intensity distance covered surpassing 18 km / h.

Figure 5: Basic 5vs5 task report at mid-court



Source: Author's production.

Another example: if we take the basic report based on our training sessions (Figure 6), a power forward player covered a total distance of 5677 m in a training session. And another player in the same position covered 3001 meters. If we now analyse two forwards, one covered 6057 meters and the other, 3409 meters.

Figure 6: Basic comparison report between players who occupy the same position

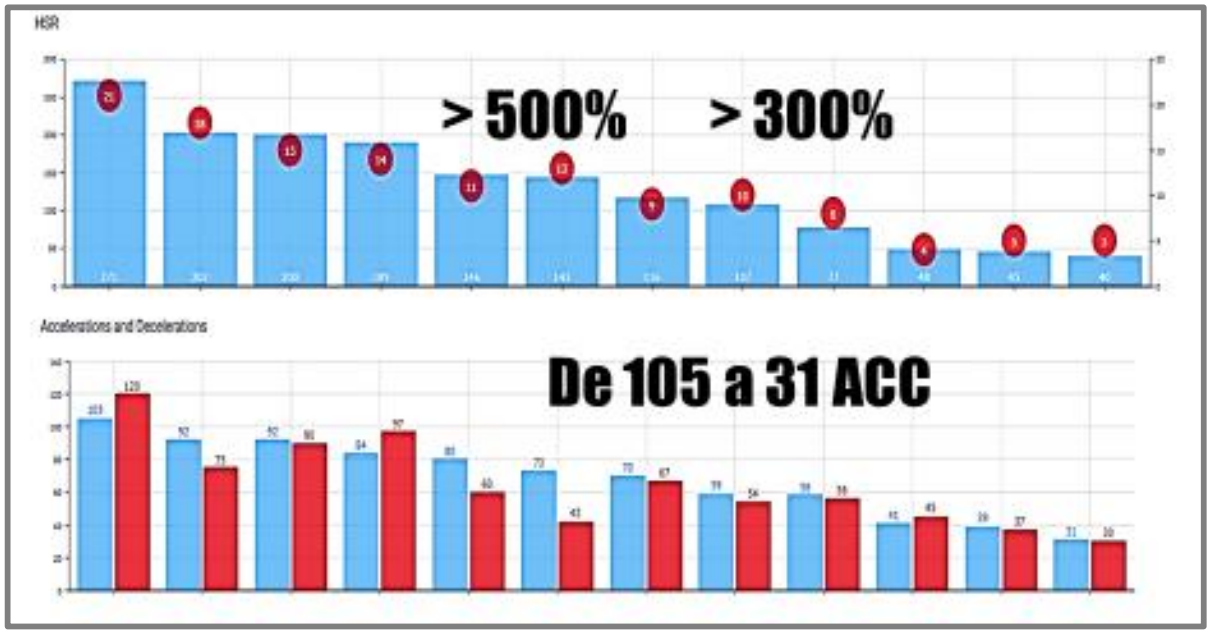
Source: Author's production.

These data are highly relevant to understand the importance of control of training loads. Therefore, it is important to know the data by position, as well as the individualized data. The information in this case is from a session that was used to give more load to the players who had played less in the previous game and therefore the players who had played more got a lower load. For this reason, we can see that, for example, one power forward covered 5,600 m and another player in the same position covered practically half

of that measure (3,000 m). Both types of information are important, to monitor by position and individually.

In this way, when we analyse training sessions, for example, we can see that there are differences among the players. Regarding the variable of distance greater than 18 km / h, Figure 7 shows that in this session a player covered 271 m at more than 18 km / h, while the player who covered the least was only 40 m to high intensity. This represents a relevant percentage, which in this case reaches a 500% difference between the player who covers the highest intensity distance and the player who covers the least. And when considering high intensity accelerations and decelerations, a similar situation occurs. The chart goes from the player who had the highest intensity requirements - in terms of accelerations and decelerations, 105 in total - to another player that had 31.

Figure 7: Distance covered by individual players in a training session



Source: Author's production.

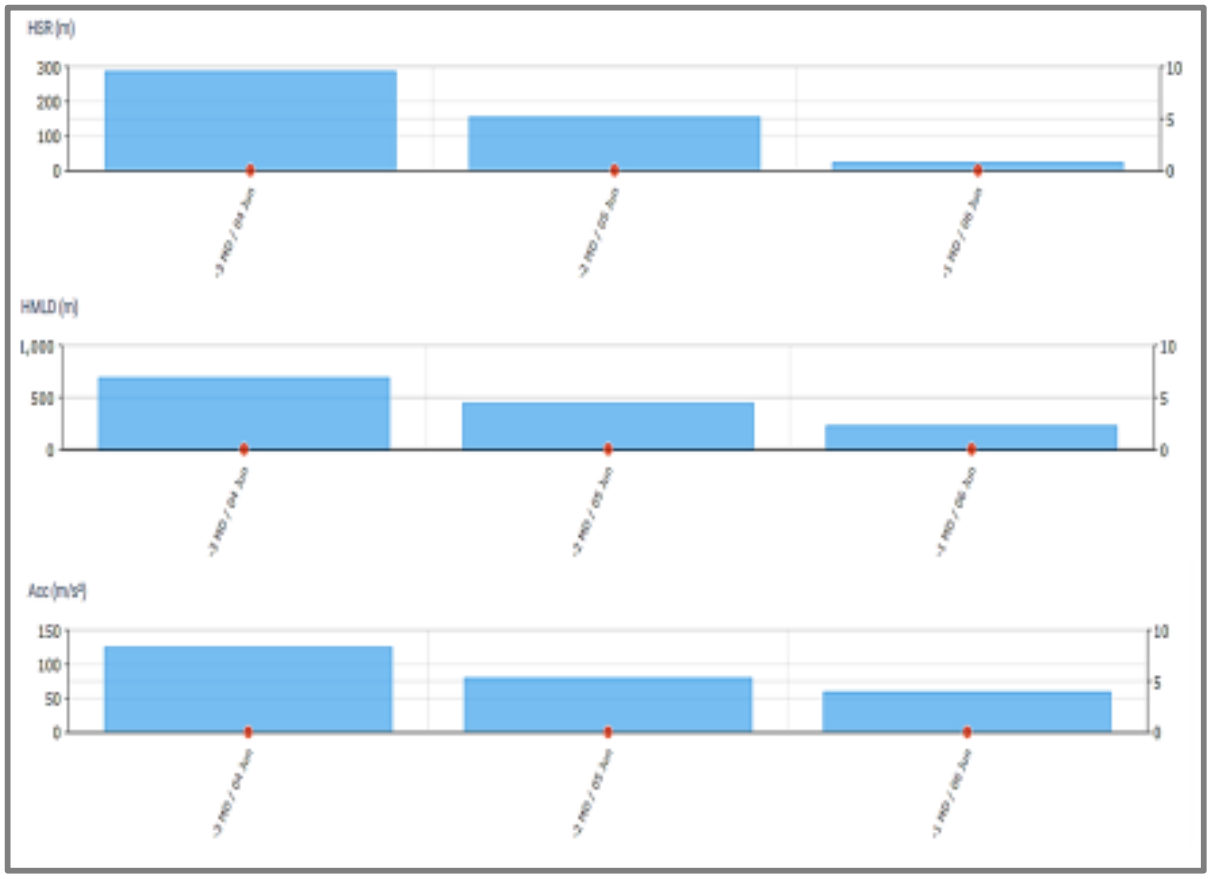
Another important aspect is the analysis of the data in relation to the game. That is, what happens the day before the game, two days before, the day after the game, etc. This data will also be important for the establishment of load dynamics, analysing the different variables. Surely the behaviour of the distance variable will not be the same as the behaviour of high intensity accelerations and decelerations. This case is an example of a micro cycle: Monday was a post-game day (rest), on Tuesday 2905 m were covered, on Wednesday 3,036 m, on Thursday, 3,670 m, on Friday 3,564 m, the day before the game 2059 m were covered and on Sunday the game took place. This is a case of a micro cycle in which there was only one game.

As for the data of accelerations greater than 2 m / s^2 (considering the same micro cycle), there was no training session on Monday, but 191 high intensity actions were performed

on Tuesday. On Wednesday there were 247, 112 the following day, 212 two days before the game and the day before the game there were 122 high intensity accelerations and decelerations. As for the relative data, in this example, the distances of 48 m / min, 52 m / min, 57 m / min and 46 m / min appear in the load dynamics of that micro cycle.

If we take the data from last season, in an Endesa League playoff week, we can see (Figure 8) the High Speed Running (HSR) variables, that is, high intensity distances at more than 18 km / h. Here we find more than 200m in the -3MD (three days before the match), which decrease to approximately 120m in the -2MD (two days before the match) and then less than 30m. -1MD (one day before the game). Another variable is the High Metabolic Load (HMLD), which offers a measure that represents total high-intensity activity, since it includes both high-speed running over 18 km / h and high-intensity acceleration actions. And in relation to accelerations and decelerations, in this case they decreased from -3MD to -1MD, following the same dynamics as the other two variables.

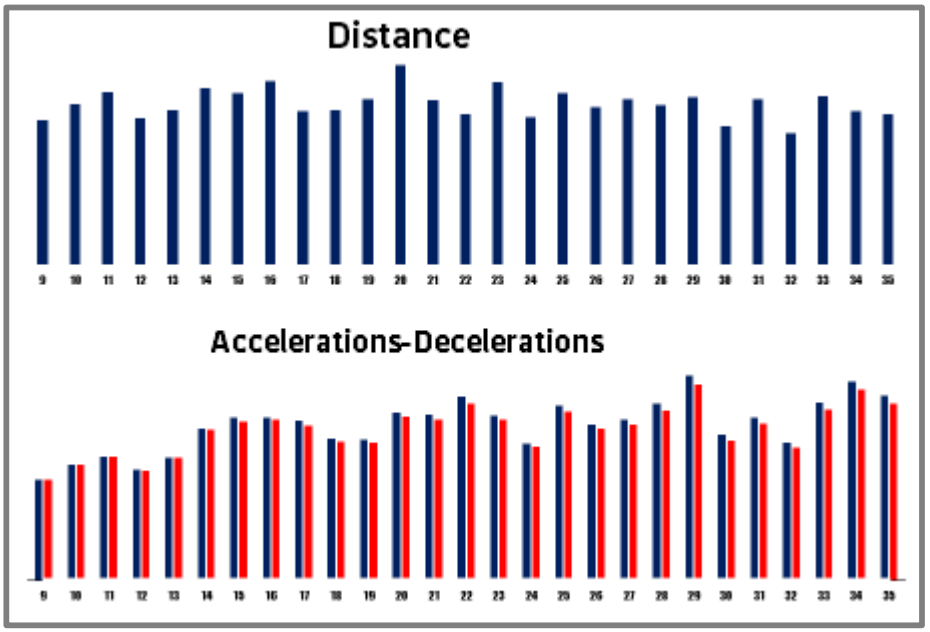
Figure 8: Distance covered data using the High Speed Running variable



Source: Author´s production.

Another way to carry out such examinations is by monitoring all these variables but per micro cycle, which in this case coincides with the week. In this way, the load dynamics of each of the weeks can be scrutinized, for example, regarding the distance variable or the acceleration and deceleration measure.

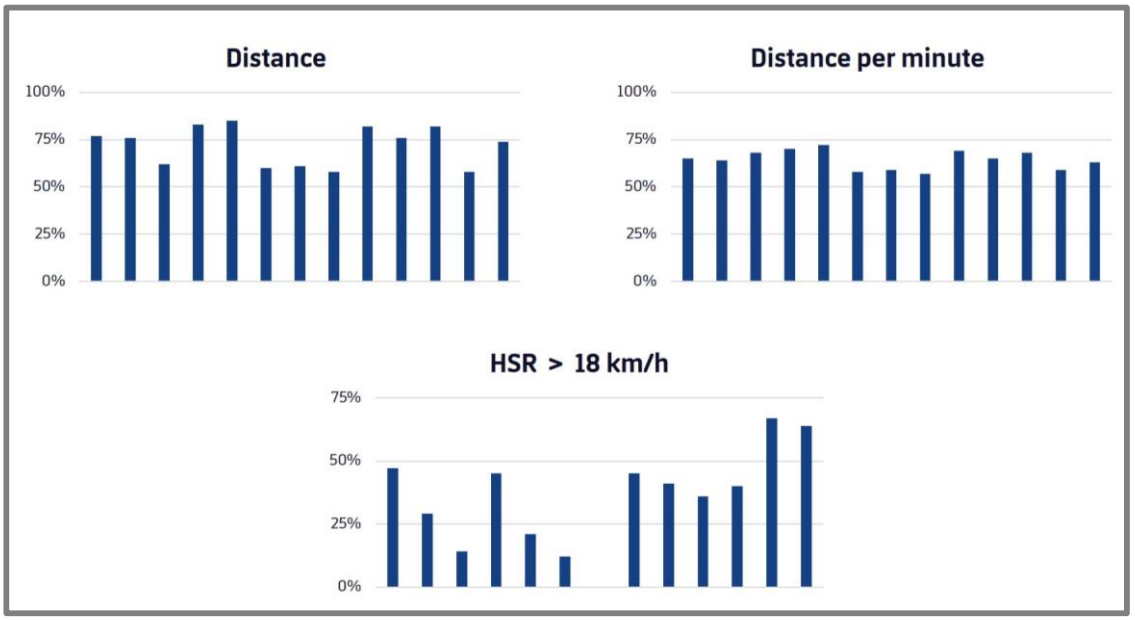
Figure 9: Monitoring per micro cycles



Source: Author's production.

It is also interesting to know the magnitude of these training demands regarding the game. Thus, for instance, for each player the physical demand related to the game is established. And this can be established with respect to the distance variable, the distance per minute, or the distance covered to high intensity over 18 km / h.

Figure 10: Each player's physical training demand related to the game

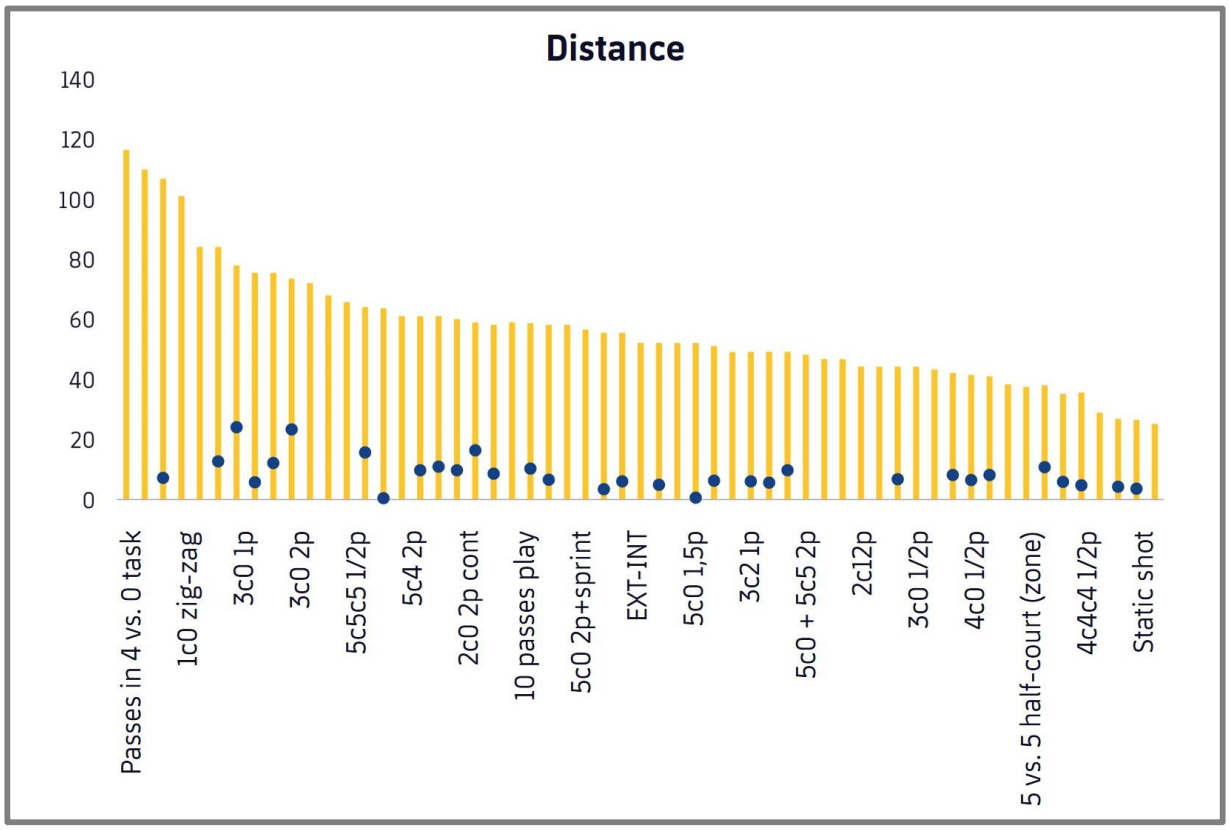


Source: Author's production.

As could be done with the WIMU (inertial measurement unit), a set of exercises can be established based on the different variables obtained in each of the tasks that are most used in training.

So, maybe, for example, when we did a 4 versus 0 job with fast transitions or 3 versus 0 braids, either on one or two courts, it was when we reached the most distance per minute.

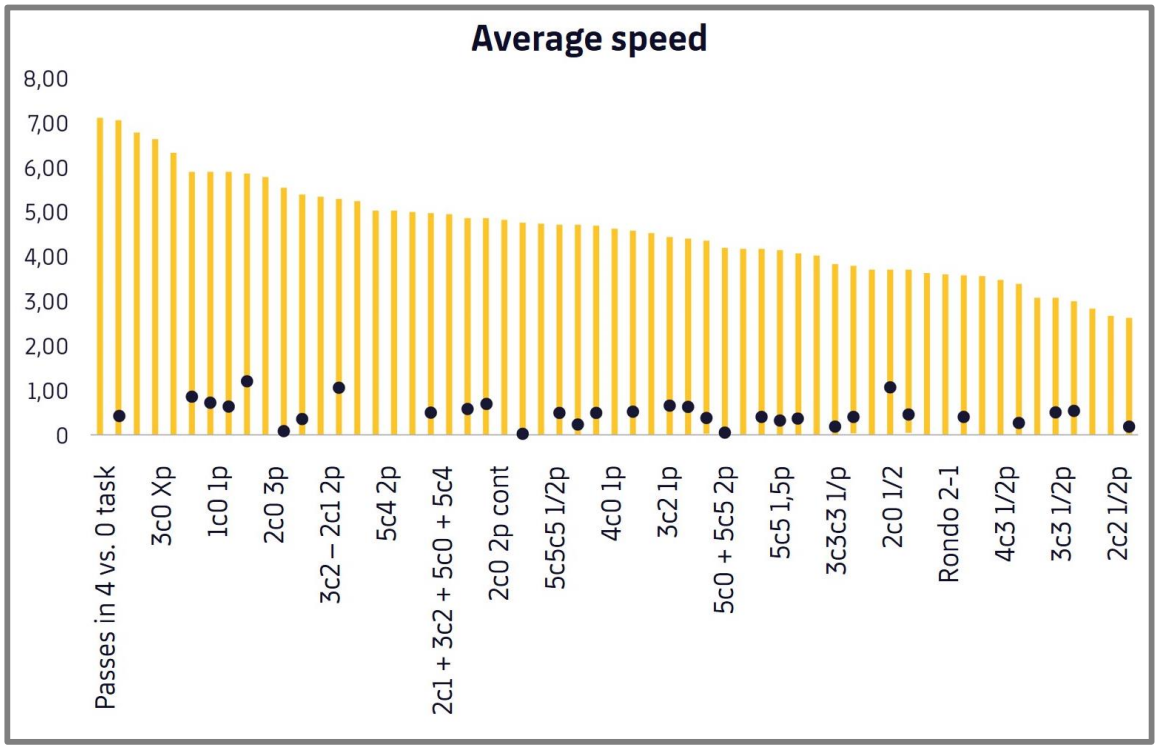
Figure 11: Analysis of the distance covered in different training tasks



Source: Author's production.

If we analyse the average speed of the tasks, as mentioned above, the transitions working on 4 vs. 0 with one or more than one court and 3 vs. 0 show the highest average speed in the task, followed by the superiority tasks. In this case, for example, the following sequences take place: 3 vs. 2, 3 vs. 1, and an exercise that included 5 vs. 5, 2 vs. 1, plus 3 vs. 2, plus 5 vs. 0, plus 5 vs. 4. The sequences were performed one after another. These exercises were the ones that produced the highest average speed.

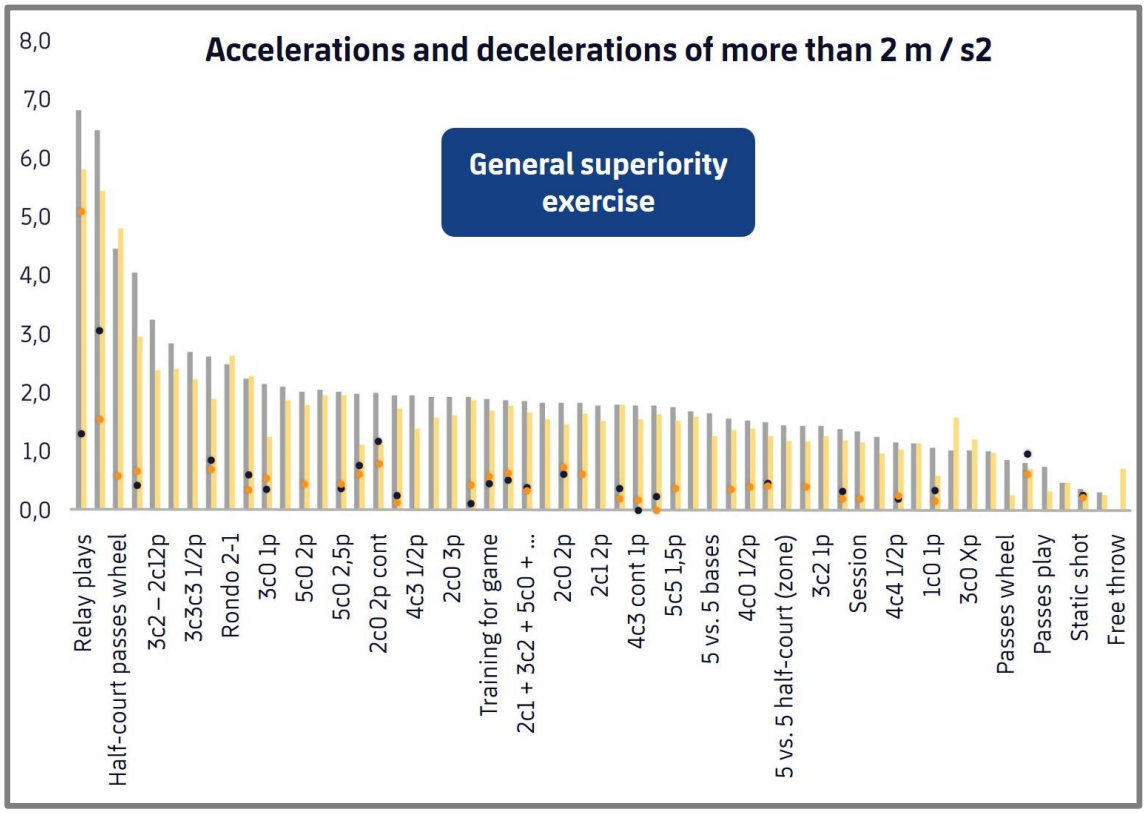
Figure 12: Analysis of average speed in different training tasks



Source: Author's production.

In another classification we use accelerations and decelerations of more than 2 m / s^2. The exercise that produced the most high-intensity accelerations and decelerations was precisely an exercise that included a general relay race in groups. That generated a large number of movements since the two teams competed to win. In addition, a high number was obtained in the tasks that presented superiorities and also in the 3 against 3 task.

Figure 13: Analysis of accelerations and decelerations in different training tasks



Source: Author's production.

In the following section a series of data of 4 versus 4 played on 2.5 courts will be thoroughly discussed. They include an attack to a ring, a transition with an attack to the other ring and return to finish the task in the ring where the exercise started. Thus, in a summarised and general way - taking the average by positions and by player - in the basic report the distance they covered was 804 m; the player load was 12.43; the high intensity actions were 84; the HSR distance was 82.46; the maximum speed was 19.69 m; the maximum acceleration was 3.62 m / s^2; the number of accelerations and decelerations was 40 and the number of high intensity distance, including the sprint was 7.25.

Figure 14: Basic report of a 4 vs. 4 task on two and a half courts

Name	Duration	Dis	PL	HIA	HSR	MaxSp	MaxAcc	Acc&Dec	HSR+Sprint	RPE
FIELD PLAYER Tactical	14	803,89	12,43	84,00	82,65	19,72	3,52	53,42	7,25	0,00
ALA-PIVOT	14	869,40	12,08	66,67	99,15	19,69	3,27	40,00	7,67	0,00
	14	979	13	73	146	20.0	3.41	40	10	0
	14	953	13	60	96	19.5	2.80	37	8	0
	14	677	11	67	56	19.5	3.61	43	5	0
ALERO	14	693,60	11,56	75,00	76,73	19,28	3,41	45,00	6,00	0,00
	14	694	12	75	77	19.3	3.41	45	6	0
BASE	14	792,77	12,79	87,00	50,99	19,31	3,72	57,50	5,00	0,00
	14	715	11	73	28	19.0	4.06	48	3	0
	14	871	14	101	74	19.6	3.39	67	7	0
ESCOLTA	14	725,16	10,27	70,33	64,75	19,74	3,63	51,67	6,00	0,00
	14	754	10	66	63	19.8	3.58	46	6	0
	14	773	10	60	39	19.0	3.21	47	3	0
	14	648	10	85	93	20.5	4.09	62	9	0

Source: Author's production.

Let us look into another task during the season, in this shooting exercise (in which the player has to get a series of baskets on the half court while his partner bounces), we get on average 434m from all positions and players, a 7.42 player load, 64 high intensity actions, 0 HSR, a maximum speed of 11.3 m / s, a maximum acceleration of 3.3 m / s^2, 49 accelerations and decelerations and 0 sprint actions.

Figure 15: Basic report on a shooting task at half court

Name	Duration	Dis	PL	HIA	HSR	MaxSp	MaxAcc	Acc&Dec	HSR+Sprint	RPE
FIELD PLAYER Tactical	8	434,58	7,42	63,92	0,00	11,37	3,30	49,25	0,00	0,00
ALA-PIVOT	8	470,87	7,52	41,00	0,00	11,83	3,10	32,33	0,00	0,00
	8	442	6	18	0	9.3	2.69	15	0	0
	8	458	7	37	0	12.1	2.91	22	0	0
	8	513	10	68	0	14.1	3.71	60	0	0
ALERO	8	542,80	8,88	71,00	0,00	10,68	3,45	69,00	0,00	0,00
	8	543	9	71	0	10.7	3.45	69	0	0
BASE	8	474,11	9,35	103,00	0,00	13,58	3,67	64,00	0,00	0,00
	8	563	12	135	0	13.5	3.97	100	0	0
	8	385	7	71	0	13.7	3.38	28	0	0
ESCOLTA	8	438,25	6,55	70,33	0,00	11,85	3,44	50,33	0,00	0,00
	8	406	7	94	0	11.5	3.65	59	0	0
	8	362	4	14	0	9.6	2.31	9	0	0
	8	546	8	103	0	14.5	4.35	83	0	0

Source: Author's production.

Can the two tasks (4 vs. 4 on 2.5 courts and shooting) be compared? Obviously not. So, in terms of what characteristic can we compare these two tasks? In terms of the duration of each task. In other words, these data are relative to the time that each task has lasted. In this way, we will have access to the following data. The 4 vs. 4 on 2.5 courts encompassed 57 m / min. As for the player load, it was 0.89; and there were 6 high intensity actions per

minute. Regarding high intensity distance, it was 5.89 m / min; top speed and acceleration obviously did not vary; the number of accelerations and decelerations was 2.86 per minute and the number of HSR and sprint was 0.52. In comparison to the standard shooting data, there is a distance of 54.25 m per minute, a player load of 0.93; there are 8 high intensity actions per minute, no HSR, maximum speed reaches 11.3, maximum acceleration is 3.3, the number of accelerations and decelerations is 6.13, and the number of high intensity speed actions and sprints is 0.

Figure 16: Comparison of two training tasks in relation to duration

57,43	0,89	6,00	5,89	19,69	3,62	2,86	0,52
Distance	PL	HIA	HSR	Maximum speed	MAX acc	nº ACC DEC	HSR + Sprint

54,25	0,93	8,00	0,00	11,3	3,3	6,13	0,00
Distance	PL	HIA	HSR	Maximum speed	MAX acc	nº ACC DEC	HSR + Sprint

Source: Author's production.

Hence, when comparing the two tasks (pay attention to the type of shooting task, which could completely modify the results) the variables of distance, player load and maximum acceleration are similar. But if we examine the number of high intensity accelerations over 2 m / s^2 we see that in the shooting task there are 6.1, compared to 2.9 in the 4 vs. 4 task. These data may orient the recommendation to use one or the other task depending on the objective, the conditional and physiological approach, the session and the day that session is carried out regarding the game.

Figure 17: Analysis of four variables in two training tasks

Source: Author's production.

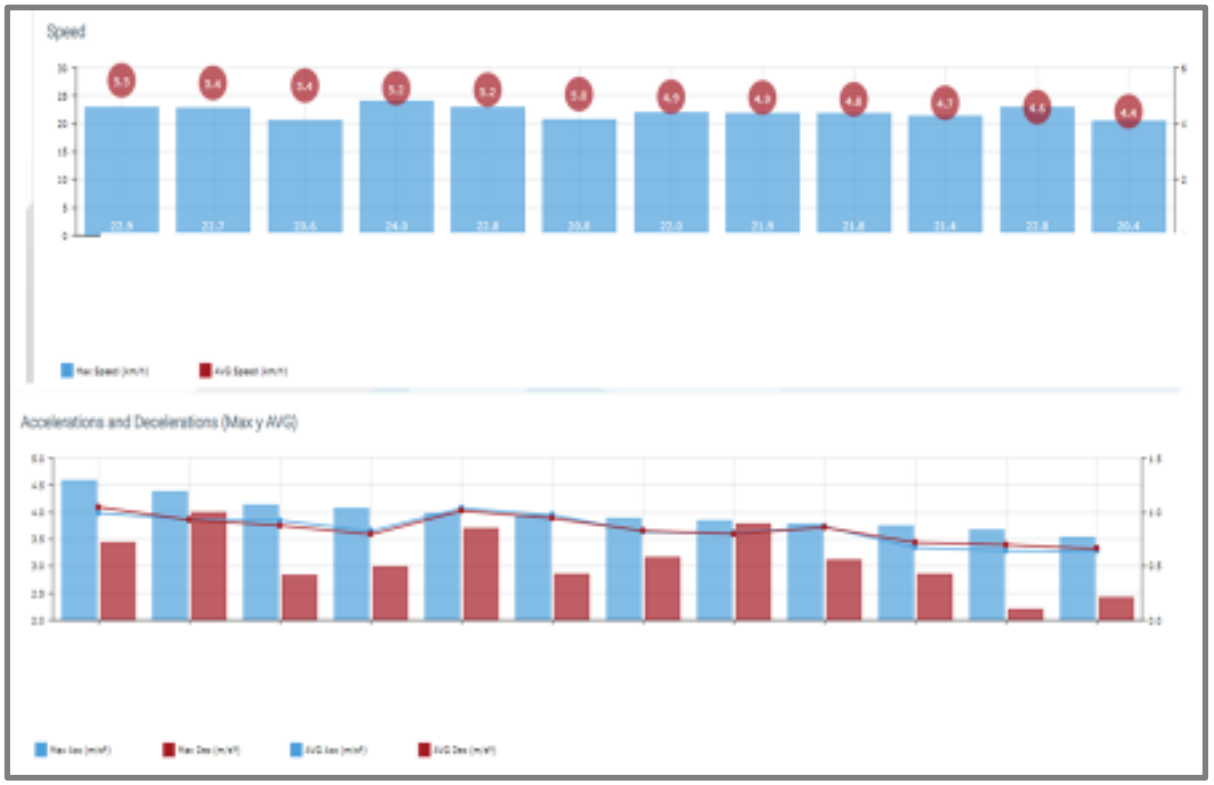
The last data in relation to these two tasks is that, while in the shooting exercise 0 m were covered out of over 18 km / h, in the 4 vs. 4 task 5.9 m / min were reached.

Efficiency and effectiveness are two aspects that should also be taken into account. Efficiency has to do with carrying out the task and achieving a goal with the least possible resources (energy); efficiency entails achieving the goal that has been set. In other words, a person can perform a task effectively, but it is also important to be efficient, too. Therefore, it is essential to combine, analyse and optimize performance in terms of both external load - for example, distance covered - and efficiency.

Another interesting fact arises, for example, from the individualization of a task carried out without the ball, in which different lines are crossed on the court. When analysing the management of the distance covered that each individual player has done, we arrive to singular results. This means that there are players who have produced different numbers of high intensity accelerations and decelerations. This is particularly interesting because, in general, high intensity decelerations in some tasks do not exceed high intensity accelerations. However, in this task there were players who achieved a greater number of decelerations compared to high intensity accelerations, which would be a perfect stimulus to prepare players to withstand high intensity requirements in slow-down phases, in which they tend to suffer from muscle injuries.

This task was unspecific: since there was no ball, there was no decision-making. However, if we compare it to a task such as the 4 vs. 4 task previously analysed, we can see that the number of players was the same, and there was no difference between the number of high intensity decelerations and high intensity accelerations. This may justify the fact that some physical trainers, at specific times require the performance of a series of unspecific tasks to prepare the players to withstand what the game imposes on them, so that the demand of the training task is superior to the demand in the game, in this case, in high intensity decelerations.

Figure 18: Analysis of variables in 4 vs. 4 tasks



Source: Author's production.

It is very important to know that, in order to control this situation, we need to quantify not only the demands imposed on training, but the demands that the players endure in the games. That is precisely the starting point on which to base the training from a conditional aspect point of view. That is, we need to prepare our players based on what they need in competition, which should be measured.

In the following paragraphs there is a revision of a series of articles that serve as a guide for what happens in competitions. In the article published by Vázquez-Guerrero, Jones, Fernández-Valdés, Morás, Reche and Sampaio (2019a) the data was taken in the context of a Euroleague sub-18. In this case 94 elite male players participated in the research. The average age was 17.4. The average height was 1.99 m, while body mass was 87.1 kg. Eight teams representing six different countries participated. The number of players that were considered in the analysis were: 35 point guards, 42 forwards and 17 centres. A descriptive, non-experimental design was performed to examine the differences between the physical demands for each position. Physical activity was evaluated following Realtrack's local positioning system. The championship was played based on the FIBA rules. The warm-up, which was required by protocol, took an average of 15 minutes in the 13 games. The championship lasted four days. The demands were quantified only when the players competed on the. Warm ups, the time when the players were on the bench and the interval between quarters were excluded from quantification.

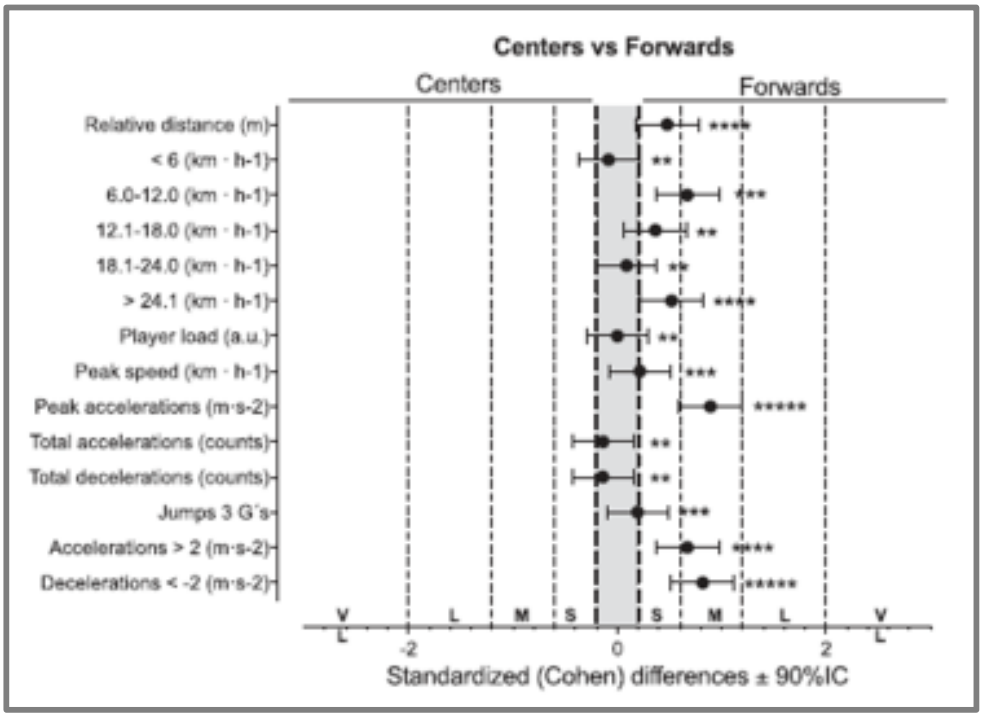
The selection criteria were that the players had not suffered any injuries during the game and that they had played at least five minutes in that game. A total of 266 observations were included: 104 related to the point guards, 119 to forwards and 43 to centres. The result of the tournament determined two team levels and another level was also established depending on the game. That is, three levels were established according to who played against whom: when the two teams were among the best in the category, when both were among worst and when it was a mixed combination. The variables analysed were the relative distance, the total distance in the game by time, the relative distance in speed zones under 6 km / h, jogging from 6 to 12 km / h, race from 11 to 18 km / h, high intensity race from 18.1 to 24 km / h and the sprint over 24.1 km / h, the player load, the maximum speed and the maximum acceleration got during the game, the number of total accelerations and decelerations, the number of jumps over 3G and the number of high intensity accelerations and decelerations, in this case considered over 2 m / s^2. As a summary, the total distance covered by the centres was 68.2 m, that of the forwards was 72.6 m and that of the point guards was 74.4 m. Regarding accelerations over 2 m / s^2, the centres withstood 1.6 high-intensity accelerations, the forwards, 1.9, and the point guards, 2. The player load we was about 1.4. In this case, it was the same for forwards, point guards and centres.

Once these data were collected, a cluster analysis was carried out. The clusters, by means of a statistical analysis, show the data in different groups and then the explanation, that is, why this classification appears as such, must be sought. In this case, the clusters enabled the identification of three responses of physical demands classified as low, medium and high, which encompassed 37.4%, 52.8% and 9.8% of the cases.

In this way, the high intensity accelerations, the high intensity decelerations and the maximum accelerations, as well as the total distance covered were the variables that had the highest prediction to generate these clusters and differentiate between low, medium or high demands of analysed requirements.

Subsequently, another statistical analysis was also carried out, in which significant differences were appreciated in relation to different variables. Regarding the forwards and the centres, there were significant differences in the accelerations and decelerations in the acceleration peak.

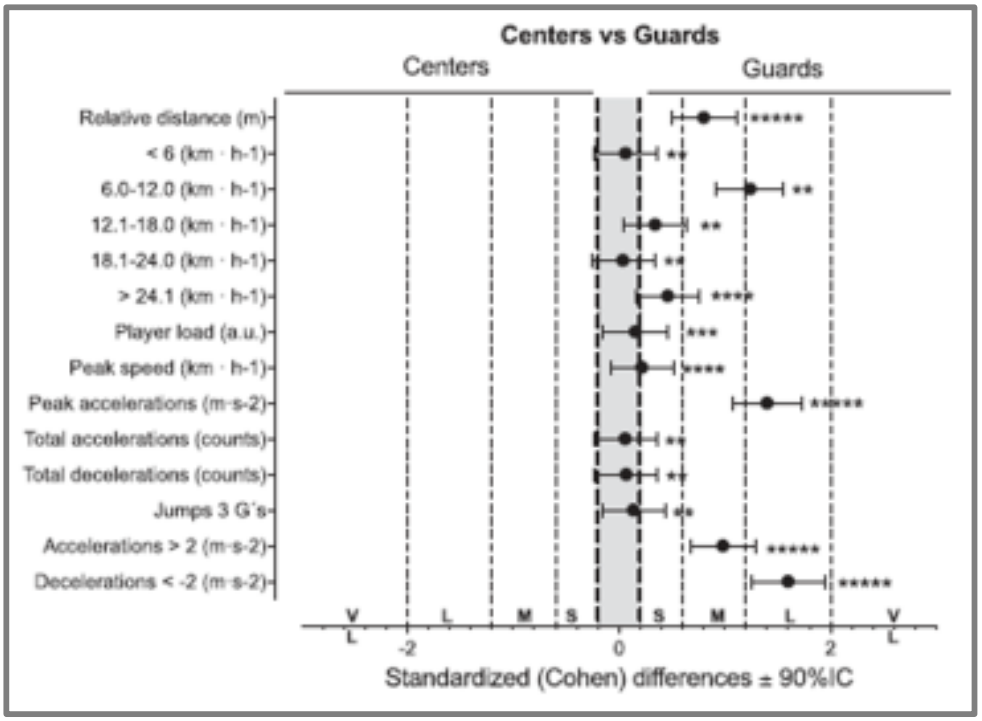
Figure 19: Comparison between forwards and centres



Source: Vázquez-Guerrero, 2019.

Something very similar occurs when comparing centres and point guards, although the magnitude of these differences were higher in high intensity slow-downs and the peak of accelerations of the point guards with respect to the centres.

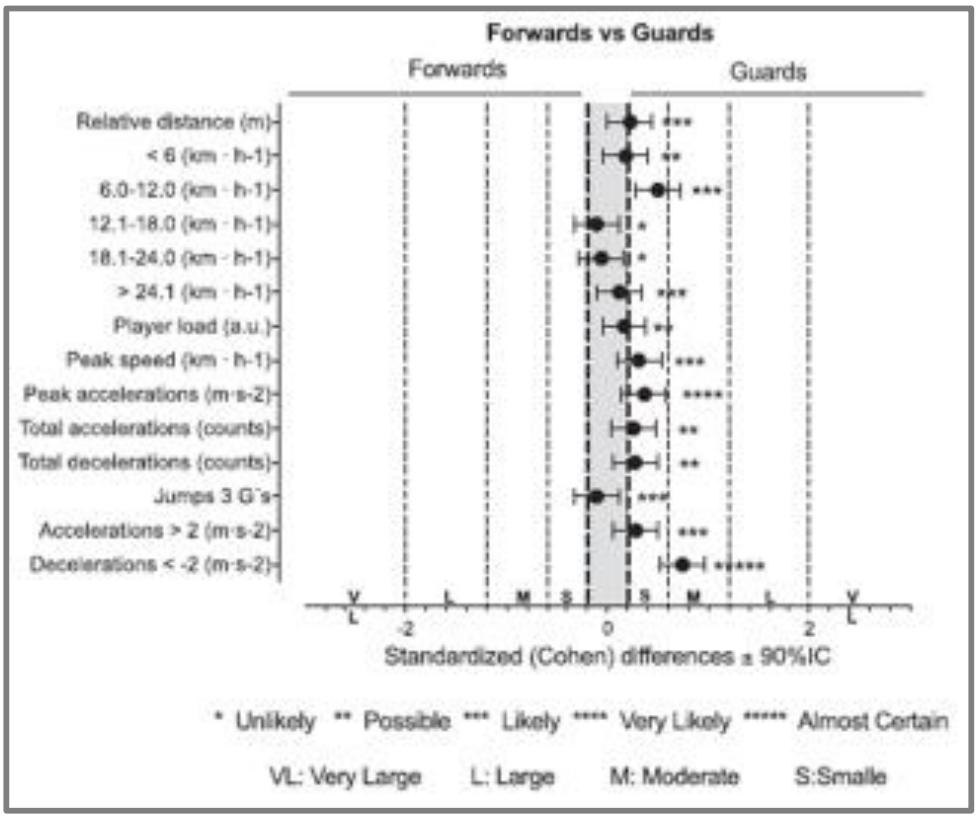
Figure 20: Comparison between centres and point guards



Source: Vázquez-Guerrero, 2019.

And finally, some very small differences were found between point guards and forwards. The only difference found in relation to moderate magnitude was the decelerations established among point guards and forwards.

Figure 21: Comparison between forwards and point guards

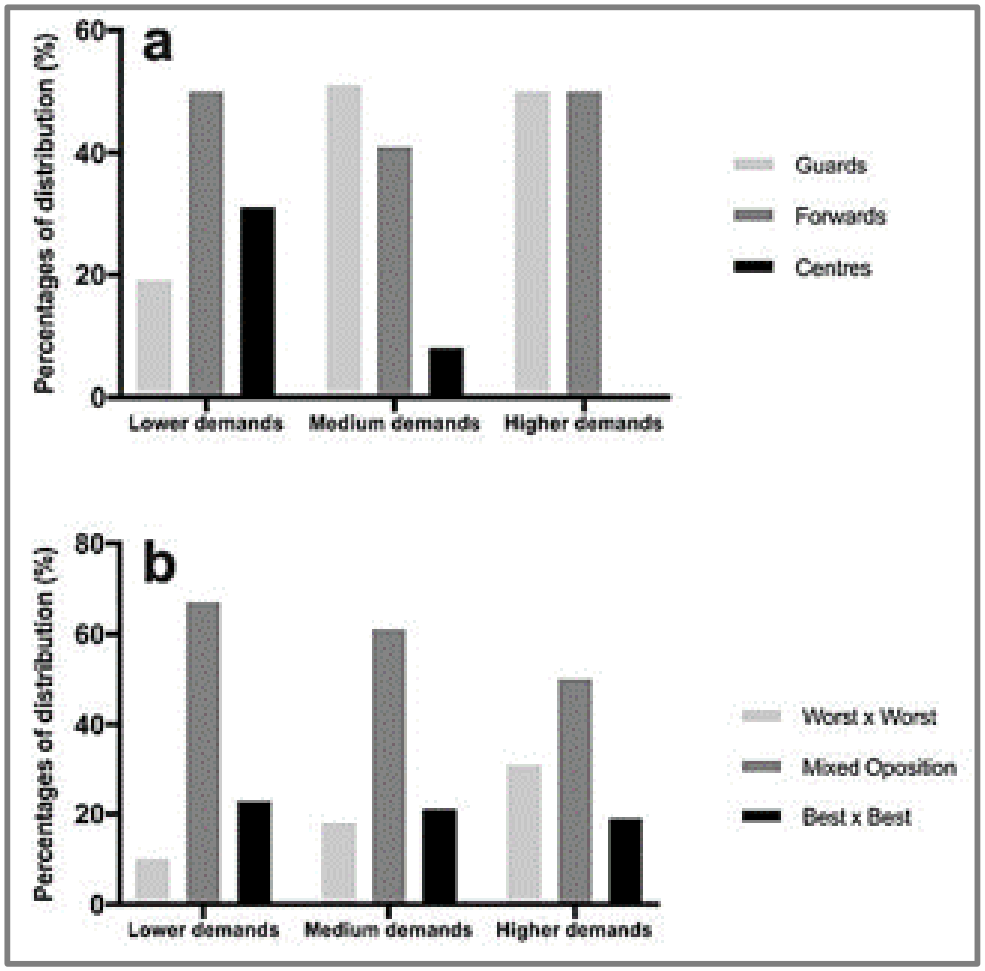


Source: Vázquez-Guerrero, 2019.

It becomes clear that the point guards have covered a relative distance greater than the centres and the forwards. The forwards, in turn, have covered a greater relative distance than the centres. And the distance covered at more than 24 km / h was greater for the forwards and point guards than for the centres. Forwards and point guards had higher peak accelerations than centres. And the forwards and the point guards had more accelerations and decelerations of 2 m / s^2 than the centres.

The type of games was significant, that is, games between the worst rivals tended to generate greater physical demands, while the activity withstood in games in which the best teams faced each other, tends to be equally distributed among the three groups.

Figure 22: Comparison of different variables related to positions (a) and opposing teams levels (b)



Source: Adapted from Vázquez-Guerrero, 2019.

The main conclusions of the study were that there is a difference between positions, types of games and types of teams. The centres experienced lower physical demands related to the number of high intensity accelerations, decelerations and the peak acceleration compared to the guards.

Moreover, each team had a different activity profile. As for the practical applications of this study, the researchers arrived to the conclusion that the style of play and the actions to overcome the opponent may influence offensive actions through transitions, counter-attacks and more organized tactical actions such as direct blocks, face to face or indirect blocks.

Physical demands are influenced by the positional role depending on the specific actions performed on the court. Centres, for example, have shown fewer physical demands than forwards and point guards. What is more, cluster analysis enables the creation of guidelines to assist and adjust fitness programs and to understand the effects of contextual variables in these guidelines.

The following article we will discuss is based on the same Euroleague tournament previously analysed (Vázquez-Guerrero, Fernández-Valdés, Jones, Moras, Reche and Sampaio, 2019. b). Their main objectives were to describe the physical demands during the game quarters and to establish a series of thresholds. In this way they were able to establish, for example, that in the first quarter, the point guards have covered a distance of 80 m / min; in the second quarter, 73.91 m / min, in the third quarter, 76.81 m / min and in the fourth quarter, 70 m / min. This means that the distance covered by the point guards has decreased regarding each quarter in which they have participated, and the same progression occurs for the rest of the positions.

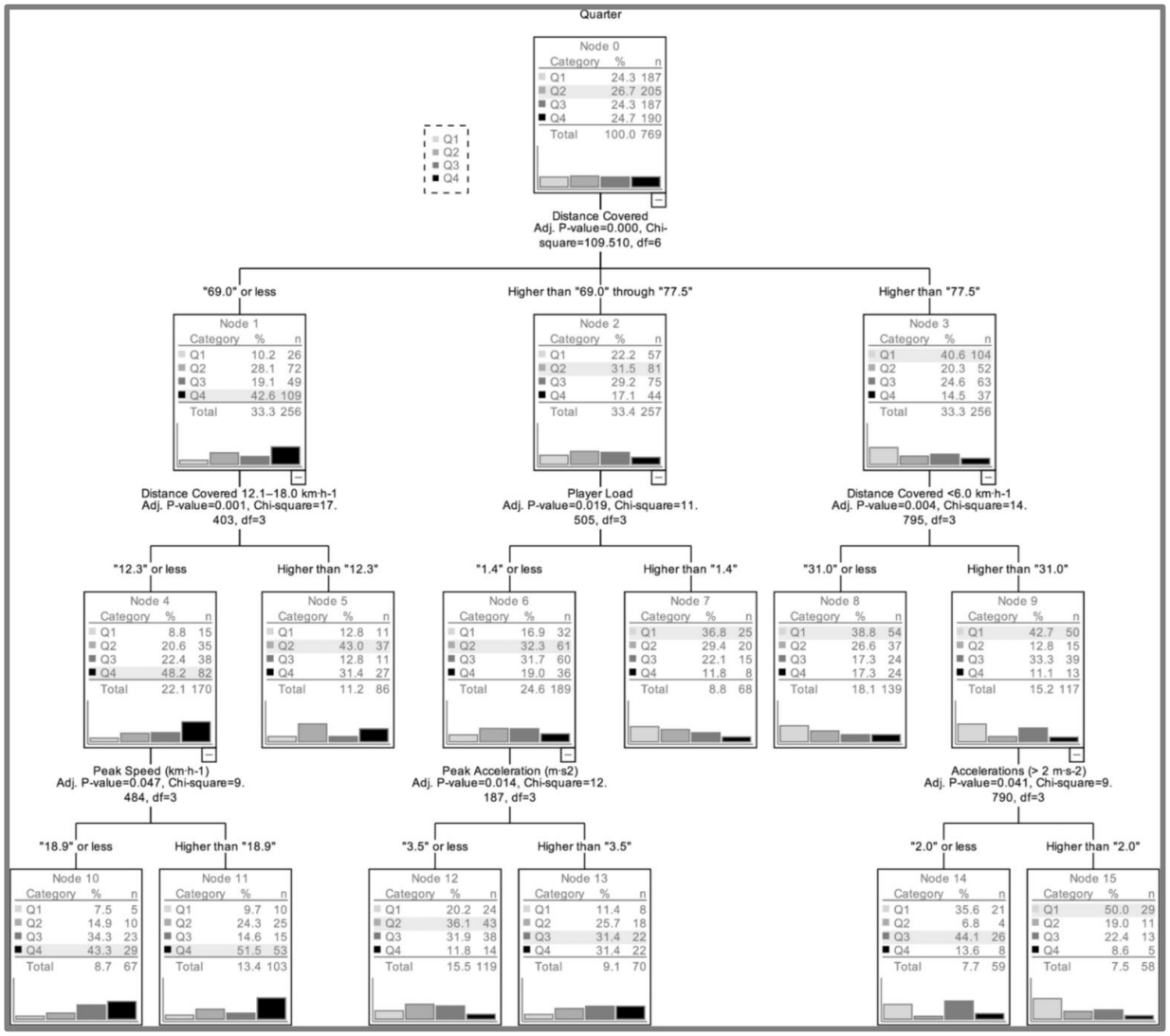
Figure 23: Physical demands of forwards, centres and guards during game quarters

Physical demands	Quarters	Center	Forward	Guard
distance covered	Q1	73.45 ± 12.97	78.91 ± 10.09	80.46 ± 7.57
	Q2	69.10 ± 7.97	71.90 ± 9.03	73.91 ± 8.93
	Q3	68.95 ± 9.45	71.98 ± 11.23	76.81 ± 8.46
	Q4	64.24 ± 8.50	69.15 ± 13.87	70.00 ± 9.89
< 6 (km · h^{-1})	Q1	30.12 ± 4.66	29.84 ± 3.41	30.30 ± 3.06
	Q2	29.52 ± 3.58	28.95 ± 3.40	28.94 ± 2.86
	Q3	31.44 ± 3.89	30.23 ± 3.96	30.69 ± 3.07
	Q4	29.64 ± 3.90	28.92 ± 2.81	29.27 ± 2.98
6.0–12.0 (km · h^{-1})	Q1	26.26 ± 5.83	28.97 ± 4.88	30.13 ± 4.82
	Q2	22.48 ± 3.99	25.01 ± 4.65	27.57 ± 4.93
	Q3	23.06 ±4.77	24.88 ± 5.54	28.27 ± 4.40
	Q4	22.00 ±3.98	24.07 ± 6.01	25.55 ± 5.40
12.1–18.0 (km · h^{-1})	Q1	14.42 ± 5.38	16.64 ± 5.22	16.73 ± 4.20
	Q2	14.69 ± 4.91	15.19 ± 4.54	14.74 ± 4.04
	Q3	12.54 ± 3.86	14.60 ± 4.52	14.99 ± 4.34
	Q4	10.80 ± 3.67	13.93 ± 7.58	12.92 ± 4.46
18.1–24.0 (km · h^{-1})	Q1	2.56 ± 1.34	3.24 ± 2.05	3.14 ± 1.71
	Q2	2.38 ± 1.45	2.64 ± 1.74	2.45 ± 1.50
	Q3	1.85 ± 1.56	2.21 ± 1.51	2.72 ± 1.48
	Q4	1.77 ± 1.71	2.14 ± 1.92	2.17 ± 1.60
> 24.1 (km · h^{-1})	Q1	0.08 ± 0.19	0.22 ± 0.34	0.16 ± 0.35
	Q2	0.03 ± 0.12	0.11 ± 0.24	0.22 ± 0.41
	Q3	0.06 ± 0.18	0.06 ± 0.19	0.15 ± 0.29
	Q4	0.03 ± 0.09	0.09 ± 0.24	0.10 ± 0.24

Source: Adapted from Vázquez-Guerrero, 2019.

This Figure shows the evolution of each of the requirements by position per quarter. These include player load, peak speed, peak acceleration, and the number of accelerations and decelerations over 2 m / s^2. One of the novel aspects of this publication is the classification in the form of a tree depicted in Figure 24. Different nodes are established in this classification. The first quarter is represented by nodes 7, 8 and 15, which greatly influence the distance covered over 69 m / min, as well as the distance covered under 6 km / h and accelerations over 2 m / s^2. However, the last quarter of the games was very different and was defined mainly by nodes 10 and 11, which were defined by a large influence of the distance under 69 m and the distance covered from 21.1 to 18 km / h. Note that the second quarter was better described by the distance covered between 69 and 77.5 m, while the player load was less than 1.4.

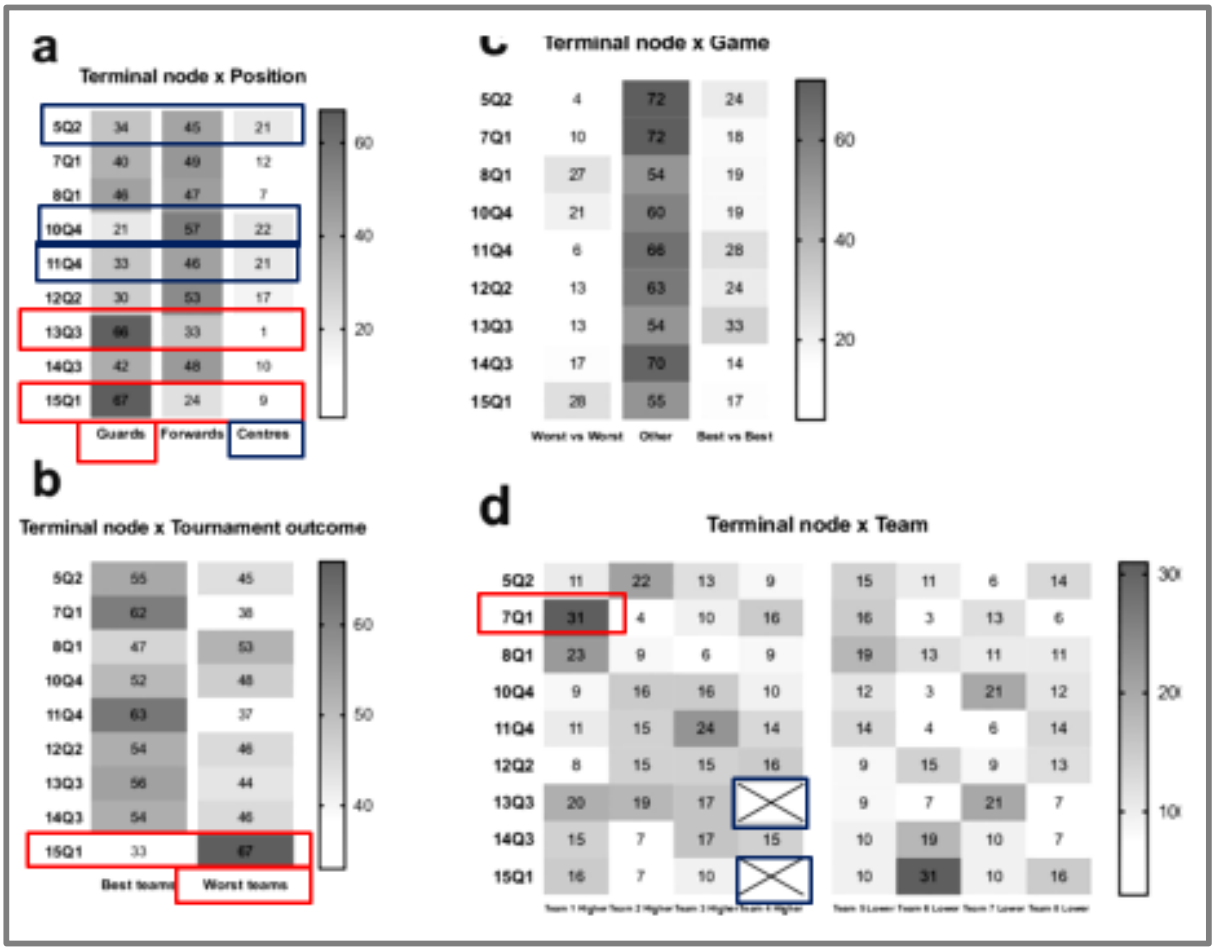
Figure 24: Tree-shaped classification



Source: Vázquez-Guerrero, 2019.

Another novel tool provided by this article was the distribution percentage of all the cases listed in the nodes. Analysing each position, it becomes clear that the passes were particularly active in nodes 13 and 15, which correspond to the first and third quarters. In contrast, the centres were more active in nodes 5, 10, and 11, which correspond to the second and the last quarter. In contrast, the result of the tournament shows that the worst teams were particularly active in node 15, which was more related to the activity of the first quarter; this means that the worst teams experienced more physical demands in the first quarter. As for the type of game that were analysed, the article shows that the games of the best teams were more related to the activity emphasized in the third and fourth quarters, while the games of the worst teams against one another seem to be more related to the demands of the first quarter. Finally, it was possible to identify different team profiles. For example, team 1 was particularly prominent in node 7. In relation to the activity of the first quarter, team 4 was not present at node 13 or 15.

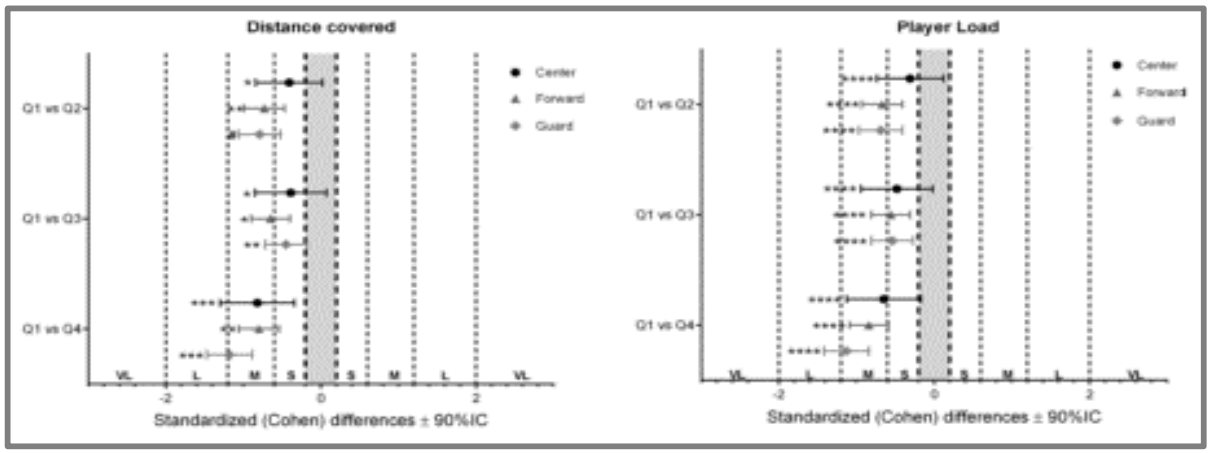
Figure 25: Distribution percentage by nodes



Source: Adapted from Vázquez-Guerrero, 2019.

We can also analyse the comparisons between the first and second quarters, first and third and first and fourth by examining, through statistical analysis, the effect produced on variables such as distance, player load, peak speed and peak acceleration. Distance and player load, as well as high intensity accelerations and decelerations showed a general decrease in the final quarter.

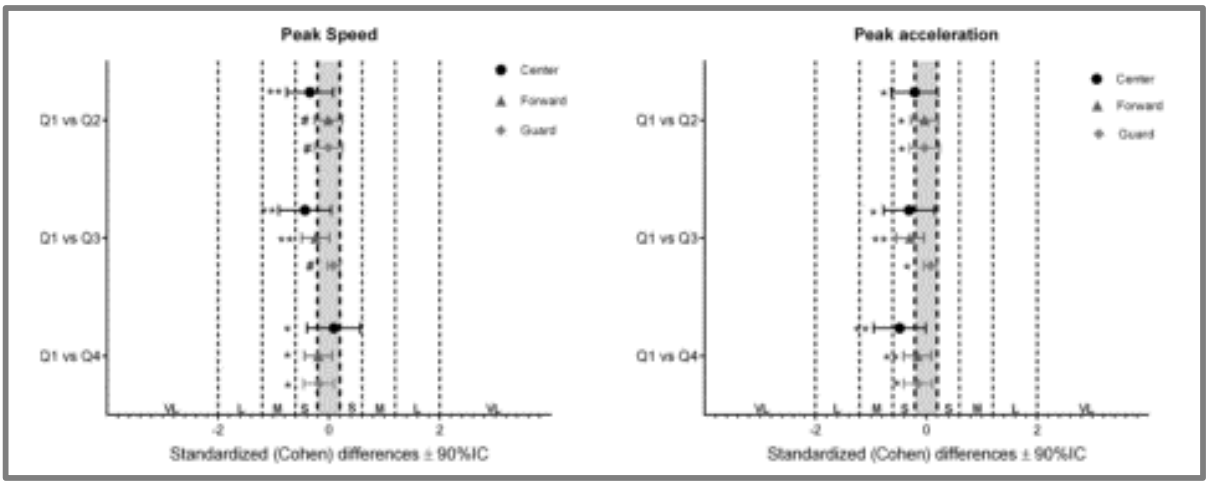
Figure 26: Comparison of distance covered and player load in different quarters



Source: Adapted from Vázquez-Guerrero, 2019.

On the other hand, the speed and peak accelerations showed only small changes, decreasing in every quarter in all positions.

Figure 27: Comparison of peak speed and peak acceleration in different quarters



Source: Adapted from Vázquez-Guerrero, 2019.

Thus, the main finding is the general decrease in physical demands such as distance, player load, and the number of high intensity accelerations and decelerations between the first and the fourth quarter in all playing positions. The results suggest that the first quarter is more physically demanding because the teams are still preparing for the game, which will likely lead to good and bad decisions and movement patterns.

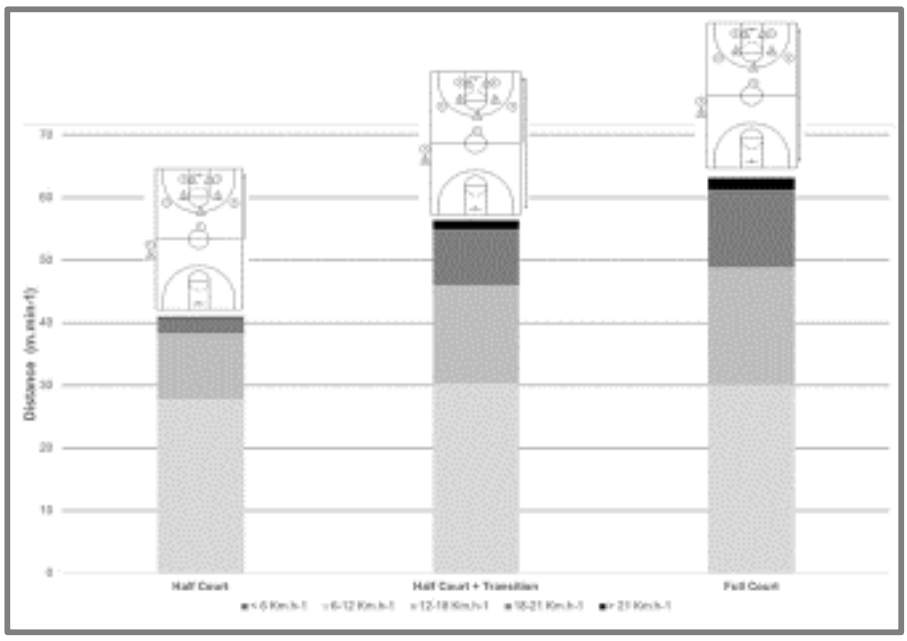
For example, in the NBA All-Star Game games, fewer mistakes are made when making decisions and deciding where to run. This may be the case because they take better and shorter routes to reach their destinations and to achieve their tactical / technical objectives. Furthermore, it is also possible that, in the last quarter, the proximity of the final decision and the result trigger an increase in the pressure experienced by the players, which results in a reduction of the risks and the rhythm of the game, and a decline in the physical demands.

Concerning applications, practices and conclusions, the results may contribute to improving the coaches' understanding of physical performance in game contexts during a tournament. There is a significant reduction in physical demands, especially between the first and fourth quarters for the different positions. The increased physical demands of the first quarter attempt to maintain high intensity to generate score differences, probably through greater rapid transitions, which may lead to shorter ball possessions. Additionally, due to the format of the tournament, teams could take advantage of the higher physical demands at the beginning of the game, since they need to win games so as to be able to successfully complete the tournament.

It is also important to show the requirements that occur in training situations of an elite team, in this case, our team F.C Barcelona, in the tasks of 5 vs. 5. For this, conditioning tasks, which are fashionable these days, are used. Reduced games are used to establish a series of conditions necessary to achieve the objective of a task - in this case in basketball or in football. In this way, most of the effects that occur, for example, when we establish space constraints in basketball - that is, playing 5 against 5 on the half court, generating a 5 against 5 encounter on the half court plus an attack on the opposite hoop or a 5 against 5 task that has a continuity of 3/4 courts - has not yet been scientifically analysed. Therefore, the objective of the article published by Vázquez-Guerrero, Reche, Cos, Casamichana and Sampaio (2018) was to determine the effects of modifying the 5-on-5 rules on the physical demands of basketball.

To achieve this, three determining factors were established - three different tasks. Five against five on half court, five against five on half court plus a transition, and game simulation on 3/4 courts. The main practical application for coaches and physical trainers is knowing that the rules established in our training tasks alter physical demands, especially regarding high intensity actions. In particular, when court dimensions are reduced, the physical demands placed on them are reduced as well. This could also be determined beforehand, since coaches normally tend to focus on correcting details in the five-on-five half-court tasks, which may generate a longer pause time in those half-court tasks. In addition, mid-court situations plus a transition and in simulation games with three or four courts, could be especially related to improving tactical purposes such as counter-attack or transitions. That is, if our game model is to play in transition or to play in counter-attack style, these tasks should obviously be present in our training sessions.

Figure 28: Distance covered in three different training tasks

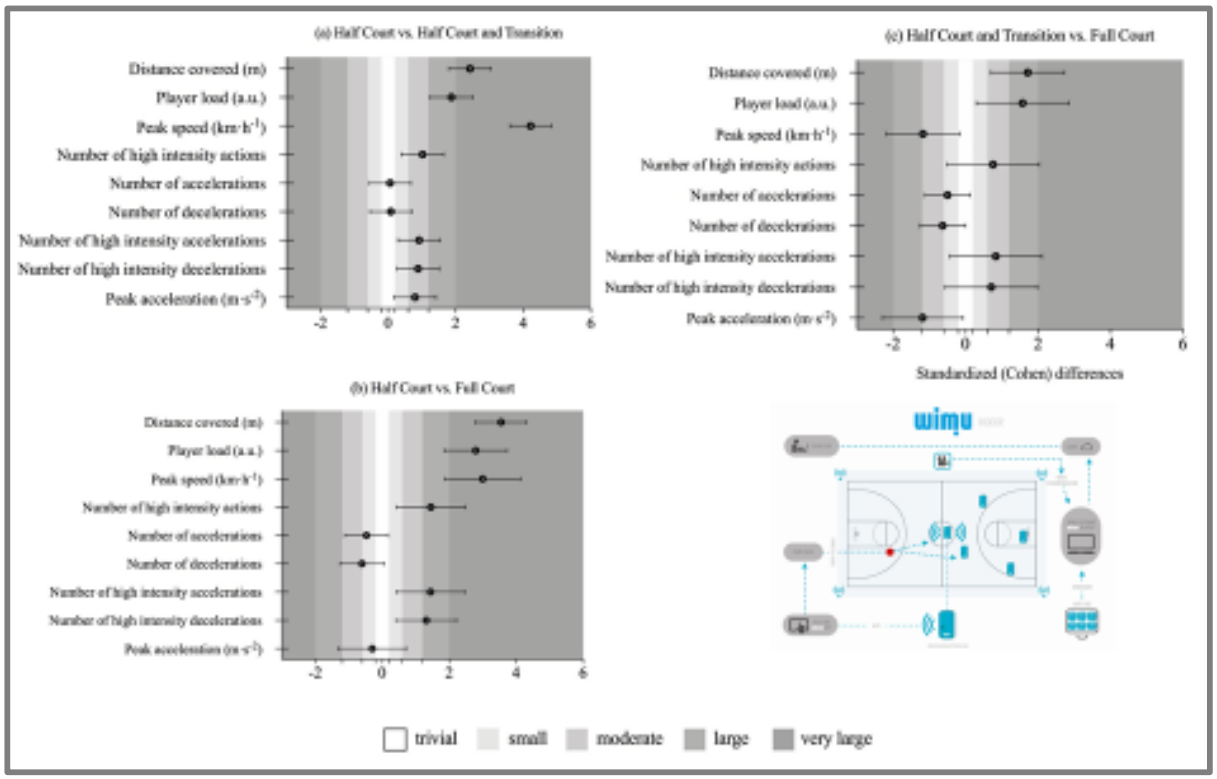


Source: Adapted from Vázquez-Guerrero, 2018.

It is important to bear this in mind when preparing the warm-up before the five vs. five task, especially if it is the first task after the warm-up). Also, when preparing the workload dynamics of the week, include this type of task one day or another, depending on the day of the game.

However, in order to train with greater demand, it is essential to keep in mind that we cannot neglect the use of half-court tasks plus an attack and the game simulation with 3/4 courts because if we only exercise the half-court physical demands may not reach the level of requirements related to the other workloads that require more space. This is why this study emphasizes the use of different dimensions of the court to achieve the highest levels of effort. The results also show higher percentages of variation coefficient for full court situations, that is, that there was more variability when we worked not only on the half court.

Figure 29: Analysis of variables in three different training tasks



Source: Adapted from Vázquez-Guerrero, 2018.

All of these studies are very important; however, it is of paramount importance to analyse the physical demands considering other factors, such as the technique and tactics involved in the task.

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