Application of intermittency to GPS raw data

The objective and processes of this course are fundamentally practical; the aim is to describe examples of specific data analysis interventions in a plausible context of a sport scientist, justify the usefulness of the type of analysis in the specific framework and state the steps to achieve the proposed objective. The video material will show how to develop the code that will allow you to comply with the steps described in this document.

In the first case study, we will look at the analysis of intermittency, an inherent characteristic in sports in which actions carried out at high speeds, including accelerations and decelerations, are interspersed with moments of low intensity or variable pauses (Lapuente Sagarra & Campos Vázquez, 2018a). This characteristic is shared by a large number of sports of a non-continuous nature.

As we know, one of the main objectives of scientific research and knowledge of sport is to analyse the conditional demands of sport. With this analysis as a starting point, we will be able to perform appropriate interventions to prepare our athletes according to their profile and demands. Additionally, monitoring and detecting changes in these values is essential to making adjustments throughout the season or in specific periods.

These analyses, which usually use tools such as GPS devices, have highlighted characteristics such as the average values during a competitive event of the sport in question and they have also dealt with the periods of maximal and submaximal intensity. These analyses, although valid and providing insighful information for later use, are dubiously related to the aforementioned "intermittency". When we talk about intermittency we refer to the analysis first proposed by Manuel Lapuente. This approach aims to focus on the analysis of actions and pauses; therefore, it is a very detailed analysis of each event that occurs on the game in order to determine how each of the characteristics of the actions and pauses affect the conditional demand of the sport and each of its players.

As defined by Lapuente Sagarra and Campos Vázquez (2018a), during intermittent exercise, the increase in physical demands can occur due to increases in the duration or intensity of the actions or by a decrease in the intensity or increase in intensity at times of pause. From the above description, we can pinpoint two conditioning factors in each of the elements (actions and pauses) that describe intermittency.

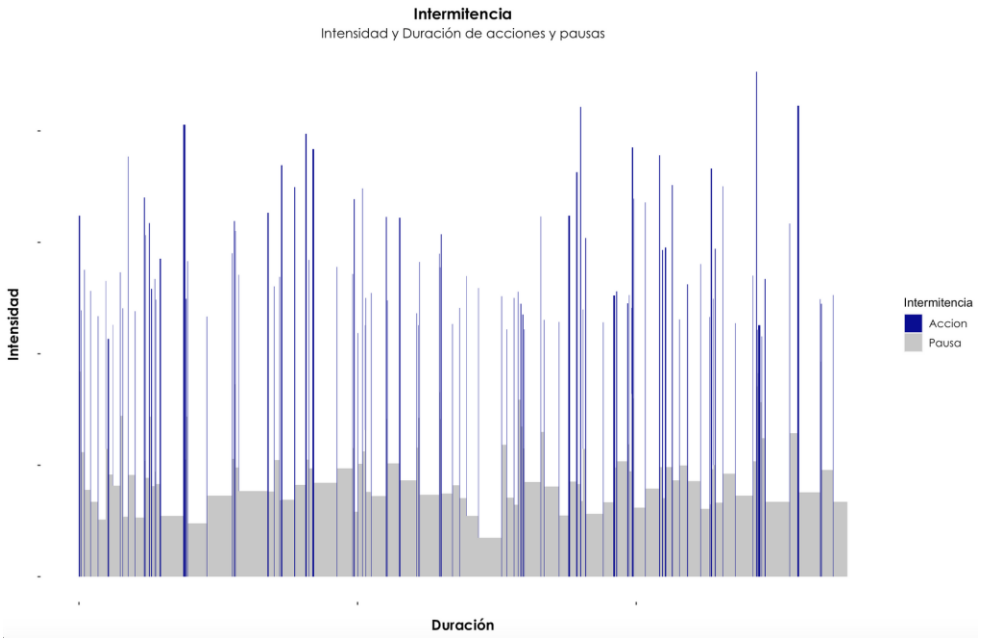
- Action
    - Duration.
    - Intensity.
- Pause
    - Duration.

- Intensity.

The sport we work in will have specific intermittency particularities, but this analysis allows us to standardize its description and clearly spot the elements which have a greater impact on each of our players. In a sport like football, in which variability is very high, the interaction between actions and pauses (and their respective durations and intensity) will be highly influenced by the context of the game, teams that have a greater number of interruptions due to their game model or specific positions on the field, which have a more continuous performance than others. However, in individual sports of an intermittent nature such as tennis, some of the characteristics of intermittency are conditioned by the regulations. The duration of breaks is an example of this, since the recovery time between points is limited by the regulations.

In both cases, intermittency analysis allows us to determine the player's behaviour in terms of actions and pauses, and to spot the moments of the game in which there are changes in each of the elements.

Figure 1. Intermittency



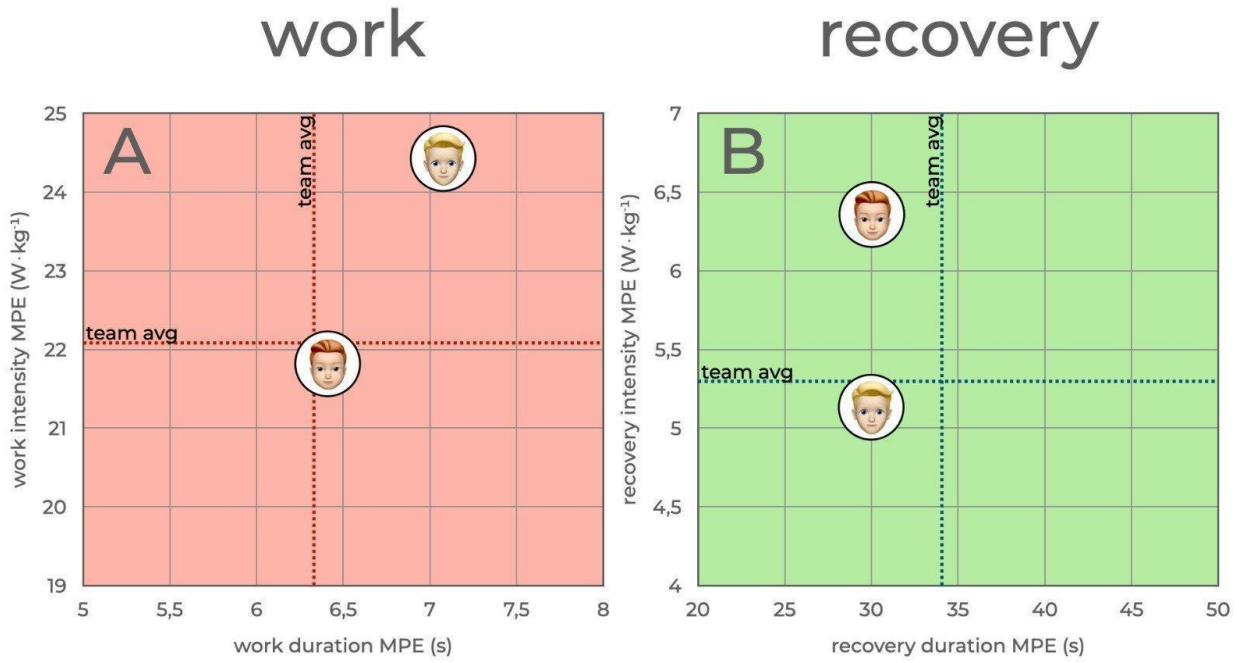
Source: Author's own production

The figure represents 45' of a football match by displaying actions and pauses, rather than a continuous speed signal. We can see that each of the actions (blue lines) are interspersed with the pauses (gray lines); we can also appreciate the intensity and duration of each of these phases

- the intensity is represented by the height of the lines or bars and the duration by their amplitude. The higher the intensity, the higher the line, whether action or pause, and the longer the duration, the wider the bar. We can see phases where a greater number of actions are accumulated (blue lines closer together) with other phases of the game where pauses are predominant (wider gray bars and fewer actions).

Below there is a representation of the intermittency analysis of two different players and their average values (average intensity and duration of pauses and actions during the match) compared to the team's average. In this way, it is possible to represent different player profiles which will need specific training interventions.

Figure 2. Two-player intermittency



Source: [No-title image about two-player intermittency]. (2021). https://shorturl.at/gh7FI

Lapuente Sagarra and Campos Vázquez (2018b) analysed the characteristics of intermittency in periods of maximal intensity (MIP), which we have seen in previous modules, to determine which of the characteristics of intermittency has the greatest influence on the increase in conditional demands. We could think that, considering that the MIPs are a single value (average metabolic power value for 3 minutes, for example), the predominant characteristic in these phases is that

the intensity of the actions has increased. However, the authors found that the most important difference between the average intermittency characteristics of the match (average duration and intensity of the actions and the duration and average intensity of the pauses) and the MIP is the duration of the pauses, i.e. a decrease in this aspect, as can be seen in the figure below. This reflects that players in the higher intensity phases of the match perform actions of slightly higher intensity, but the fundamental characteristic that increases the conditional demand is that the rest between actions is much lower, which results in a higher density of actions.

With these results, we can see direct applications in our training prescription as we have information to modify our tasks or exercises, and to replicate what occurs in those more intense phases. Not only will we need to increase the intensity of the actions, but we should also make sure that the duration of the pauses is shorter.

Figure 3. Intensity and duration of actions and pauses

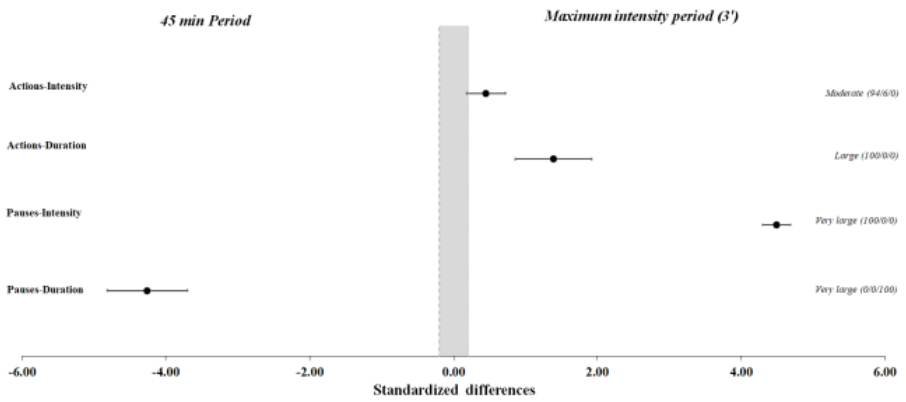
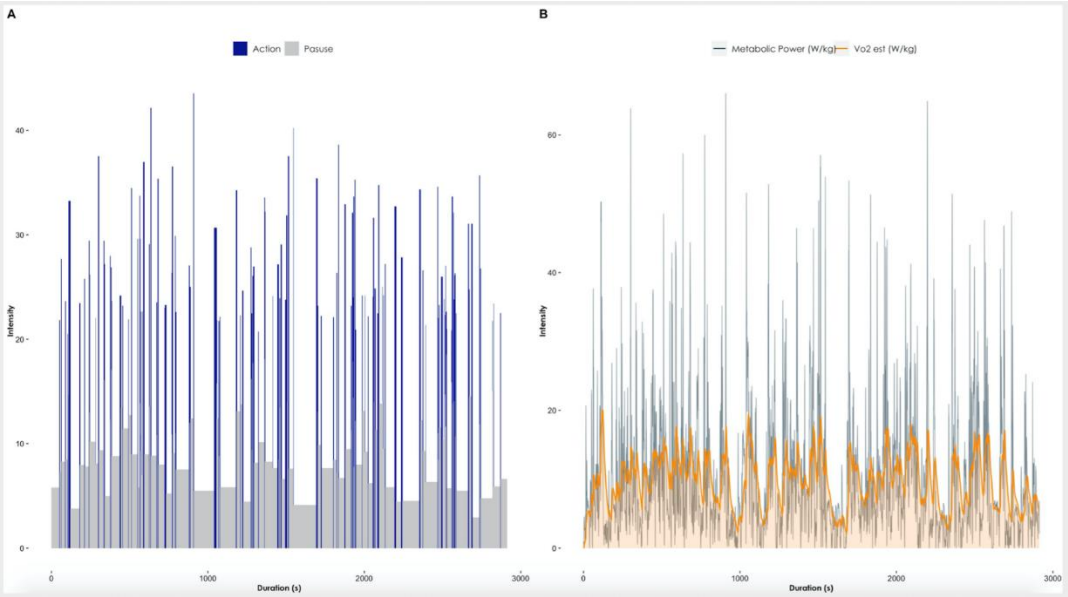


Fig. 1. Standardized mean differences for intensity and duration of actions and pauses between 45-min periods and maximum intensity periods (3') in professional soccer players. Dark grey area represents the smallest worthwhile change.

Source: Lapuente Sagarra & Campos Vázquez, 2018 b.

Another justification for this approach can be seen in the following figure, which shows the relationship between intermittency characteristics and the estimation of oxygen consumption (orange area) based on the work of Osgnach and di Prampero (2018). We can see how the player's intermittent behaviour conditions their oxygen consumption. Phases of the game where there is a higher density of actions and greater intensity are followed by an increase in that intensity indicator.

Figure 4. Relationship between intermittency and oxygen consumption



Source: Author's own production.

How to apply intermittency analysis using RStudio

First, we need to determine whether there is a need for this type of analysis. Its usefulness as a method of analysis of conditional demands has been justified in the previous paragraphs, so the second criterion to consider is whether these analyses are already part of the technology available to sport scientists. To respond to this question, we must look at which commercial brands of GPS devices provide us with this information. Currently, this analysis is not enabled by all GPS devices. In addition, as we will see in the criteria below, although all brands provide information on events or actions at high intensity, there are limitations in the software to consider what is defined as an action or event.

Thus, for our context, if we consider that intermittency analysis can add value to our load control methodology, RStudio is presented as a tool that allows us to efficiently perform this analysis.

Taking into account the description of intermittency, there are a series of criteria to consider, most of which can be modified by the sport scientist to adjust the analysis model to the specific context.

- Action
    - Intensity signal: we nned to choose which intensity signal to use to determine efforts or actions. Depending on the characteristics of the sport we are

analysing, the variable may be different (metabolic power, speed, acceleration, etc.).
    - Threshold: from the intensity in the chosen variable we determine that an action occurs.
    - Minimal duration: how long the intensity above the threshold must be maintained in order to be considered an action. Again, this value may vary (0.5 seconds, 1 second, etc.) depending on the sport or intensity signal chosen.

- Pauses
    - The rest of the moments in which the action criteria are not met will be classified as pauses.
    - Time between actions: It should be noted that, due to the nature of efforts in some sports, it is possible for the player to have an intensity above the threshold of more than 1 second but to momentarily lower this threshold and then to surpass the threshold once more. We have to determine the interval of time in which we consider that the decrease in intensity is a pause or part of the same action.

As we can see, based on their definition, some of these criteria are part of other analyses carried out during the course, such as periods of maximal or submaximal intensity. These analyses were carried out based on the raw data provided by the GPS devices, therefore, the intermittency analysis will start from that same point. Please note the considerations when dealing with raw data, filtering and calculating corresponding variables.

With these criteria and the data collected during training sessions and matches, we will be able to modify the data in order to detect the events. The outline of the process is as follows:

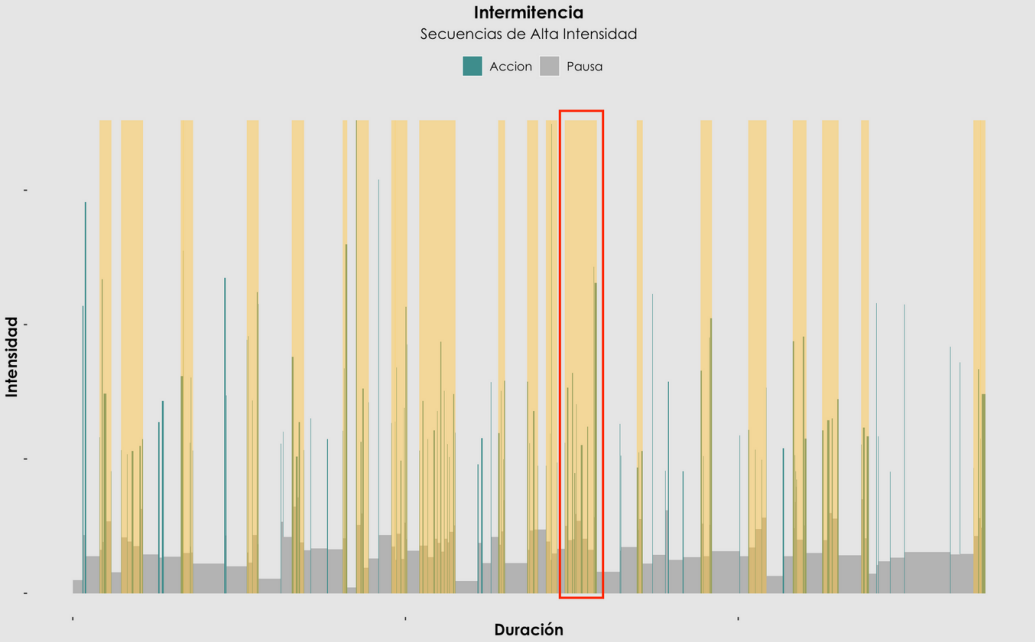
- Import the data to be analysed.
- Filter the intensity signal to reduce noise (extreme or highly fluctuating data).
- Calculate derived intensity signals (metabolic power, acceleration).
- Define the criteria for determining actions (Intensity and duration).
- Apply these criteria to the derived intensity signal.
- Repeat the process for pauses.

By following these steps, we will have the description of each of the actions and pauses of the imported data. From this point onwards, the specific analyses can be carried out (average intermittency values of the match, profiles, intermittency analysis in the MIPs, etc.).

Alternative analyses derived from intermittency

One of the analyses to perform from the intermittency data is the description of the high-intensity sequences. These sequences are also referred to as high intensity burst. This is an analysis parallel to periods of maximal intensity, as it aims to describe phases in which the player performs multiple actions (above a certain intensity) with a reduced time between them (Carling et al. 2012).

Figure 5. Understanding High-Intensity Sequences

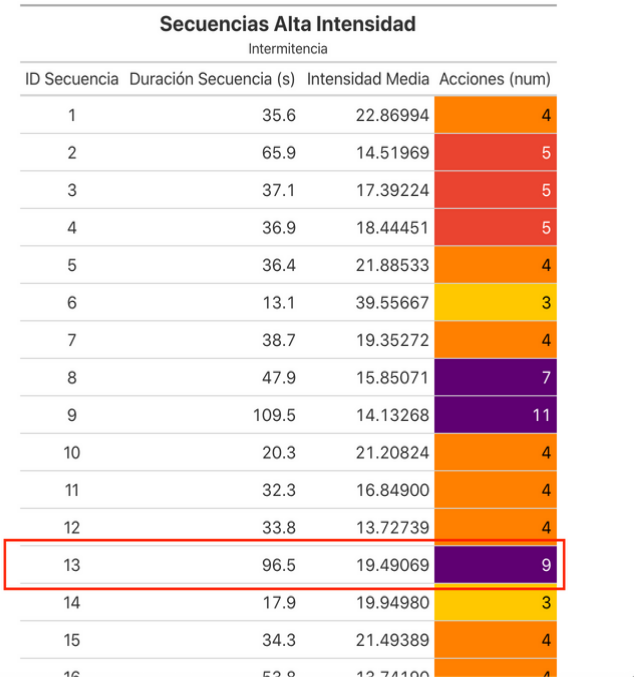


Source: Author's own production.

In the figure we can see how the high intensity burst criteria have been applied to the intermittency data. In this case, to define a high-intensity sequence, it is determined that there must be at least 3 actions, and the time between each of them is less than 20 seconds. Shaded in orange, we can see a football player's high-intensity sequences during 45' of a competitive match.

Then, as a consequence of the analysis, there is a description and a summary of each of the sequences and of one of them in particular. This exemplifies the level of detail that can be achieved with the analysis. Not only do we see the duration, number of actions, and intensity of the sequence, but if we analyse one of the sequences in particular, we can see the characteristics of each of the actions (including the properties of different metrics) and pauses. This has clear implications for training prescription, whether in directed tasks in return from injury processes or in the design of group tasks that seek to replicate the demands of the game.

Figure 6. High-Intensity Sequences



Secuencias Alta Intensidad

Intermitencia

ID Secuencia	Duración Secuencia (s)	Intensidad Media	Acciones (num)
1	35.6	22.86994	4
2	65.9	14.51969	5
3	37.1	17.39224	5
4	36.9	18.44451	5
5	36.4	21.88533	4
6	13.1	39.55667	3
7	38.7	19.35272	4
8	47.9	15.85071	7
9	109.5	14.13268	11
10	20.3	21.20824	4
11	32.3	16.84900	4
12	33.8	13.72739	4
13	96.5	19.49069	9
14	17.9	19.94980	3
15	34.3	21.49389	4

Source: Author's own production.

Figure 7. Sequence properties

Propiedades Secuencia

Secuencia número 13

AvgMetPow	MaxSpeed	MaxAcc	MaxDec	Duration	AvgHMPi	Intermitencia
28.01	3.72	1.68	0.58	1.40	6.04	Accion
12.51	3.20	0.89	−1.61	5.60	2.52	Pausa
38.31	6.19	2.37	−0.66	4.80	8.88	Accion
9.88	4.37	1.39	−1.49	10.90	2.43	Pausa
41.04	5.73	2.09	−0.73	2.60	9.49	Accion
10.04	4.43	0.92	−2.50	4.40	3.56	Pausa
22.40	3.96	1.00	0.15	2.60	3.88	Accion
14.80	3.80	0.28	−0.76	2.10	2.94	Pausa
35.16	4.69	1.74	0.46	1.20	7.65	Accion
13.47	3.78	1.57	−1.62	12.80	2.39	Pausa
27.56	5.21	1.55	−0.64	5.60	5.36	Accion
10.18	4.01	1.53	−1.39	13.60	1.57	Pausa
31.05	4.20	2.75	0.07	2.60	6.26	Accion
8.12	3.99	0.82	−1.07	16.30	1.21	Pausa
60.79	5.97	4.07	−0.68	2.30	14.02	Accion
14.19	4.69	−0.45	−2.02	1.50	7.93	Pausa
57.75	8.89	2.40	−2.74	6.20	15.08	Accion

Source: Author's own production.

References

Carling, C. A., Le Gall, F., & Dupont, G. (2012). Analysis of repeated high-intensity running performance in professional soccer. *Journal of Sports Sciences*, 30(4), 325–336. https://doi.org/10.1080/02640414.2011.652655

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