

# Differences of intermittency characterization during competitive matches: average values vs periods of maximum intensity

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## Headline

**D**uring football matches moderate and high-intensity actions are performed (1) interspersed with pauses of variable duration and intensity (2). Despite the evident intermittent nature of competition matches, there are still few studies that have analysed the characteristics of the actions and pauses that occur during competition (3). In addition, the vast majority of descriptive studies that have analysed the conditional demands of competition matches to date have usually reported average intensity values (4) (e.g. relative distance: m/min in 45–90-minute matches), limiting our knowledge of the exertion during the most intense phases of the competition (5).

**Aim.** The main objective of this research was to compare the characteristics of the actions and pauses (duration and intensity) when analysing average 45-minute durations of competition matches with data obtained when analysing the periods of maximum intensity of the matches (MIP, temporary window of 3 minutes), using the metabolic power as a signal of intensity of the player's activity.

## Methods

**Athletes.** This study involved 31 professional players (6 central defenders, 7 lateral defenders, 4 midfielders, 7 wide midfielders, and 7 strikers) belonging to 3 different teams (2 teams from the Spanish 2nd Division League and 1 team from the United Arab Emirates 1st Division League). The players were monitored both in official competition matches (5 matches, 58 individual records) and in friendly matches (10 matches, 136 individual records). All subjects were previously informed of the purpose of the study and provided their informed consent following the indications of the Declaration of Helsinki.

**Methodology.** All players were monitored during matches with GPS devices (10 Hz STATSports Viper, Ireland). Subsequently, the recorded data were downloaded through STATSports Viper software (v.2.7.1.83) and exported to a Microsoft Excel spreadsheet for analysis. The Viper STATSports device operates at a sampling frequency of 10 Hz and has shown good levels of reliability and validity for distance measurements and velocity peaks (6). The GPS unit was housed in a bib that the players wore on the torso, which allows the device to be in a fixed and stable position in the upper part of the back (between the scapulae). To be included in the analysis, each player must have been monitored in at least 2 games. The range of games monitored per player was 2–6.

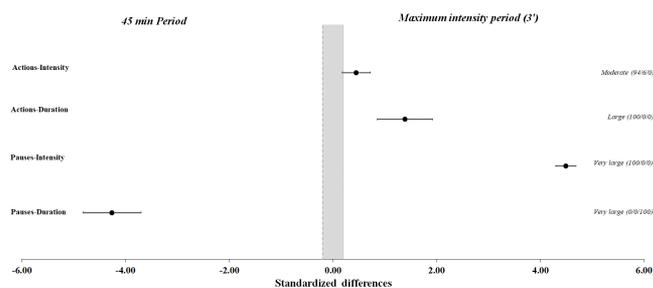
The intensity signal chosen to evaluate the intermittency was metabolic power (7,8), which represents a proposal to estimate the players' instantaneous energy needs per unit of time based on the energy cost of his activity and the speed

demonstrated at each moment. Metabolic power is proposed as a more accurate way of calculating the intensity because its calculation integrates both the speed and acceleration that the player demonstrates at each moment, instead of considering them separately. Nevertheless, metabolic power presents some limitations such as the underestimation of the energy demands of soccer-specific drills, particularly during recovery phases (8,9).

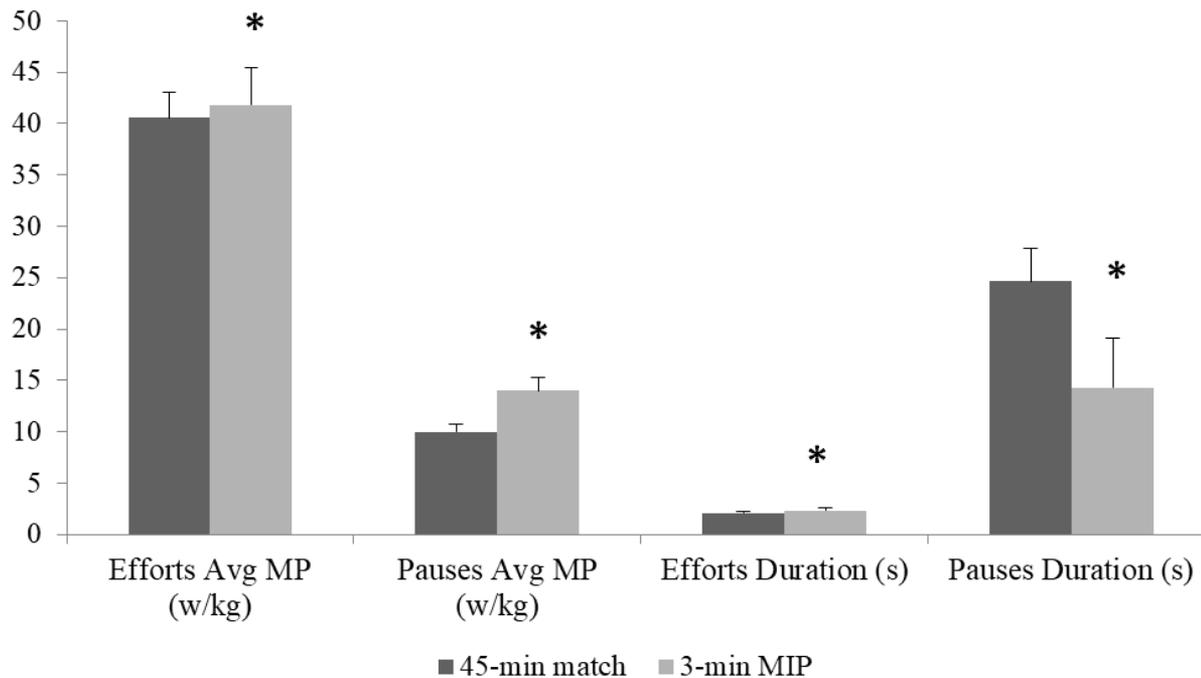
For the characterization of intermittency, we identified the two types of events that essentially comprise it: actions and pauses. The actions were identified when the metabolic power exceeded the threshold of 25.5w/kg and remained above it for at least 1 second, while the pauses were identified as the phases in which the previous criterion was not met (10,11).

The duration and average intensity of the actions and pauses were evaluated in periods of 45 minutes (1st or 2nd part of the competition matches). The duration and average intensity of 3-minute periods in which the requirement based on the average metabolic power was the highest in the match (maximum intensity period, MIP: worst-case scenarios) were also evaluated through rolling average procedures (5). This duration was selected because it has been suggested that 3-min all-out exercise could be used to establish VO<sub>2</sub> peak (12), and also because it is one of the typical durations of different high intensity drills (10). Besides, a recent publication has reported a significant decrement in metabolic power values from 1 to 2-minutes maximum intensity periods in soccer matches (due probably to the rapid depletion of the immediate phosphagen stores of energy), with a smoothing decrement between 2-5 minutes periods (13).

**Statistical analysis.** The results are presented as mean  $\pm$  standard deviation (SD). In addition to the analyses for statistical significance, possible differences in duration and intensity of actions and pauses between average 45-min periods and 3-min MIP were analysed for practical significance using magnitude-based inferences (14). The data were log-transformed before analysis to reduce non-uniformity of error. The effect size (ES)



**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.



**Fig. 2.** Average duration (actions and pauses) and average metabolic power (action and pause intensity) in 45-min match periods and 3-min maximum intensity periods in professional soccer players. \* Substantial effect (>75%). MP: metabolic power; Avg: average; MIP: maximum intensity period.

was determined, and the threshold values for Cohen’s statistics were trivial (0.0–0.19), small (0.2–0.59), moderate (0.6–1.1), large (1.2–1.9), and very large (> 2.0) (15). Probabilities were also calculated to establish whether the true (unknown) differences were lower, similar, or higher than the smallest value or the difference (0.2 multiplied by the between-subject SD, based on Cohen’s effect size principle). The qualitative descriptors proposed by Batterham and Hopkins (15) were used to interpret the likelihood that the true effect could be harmful, beneficial, or trivial: <1%, almost certainly not; <5%, very unlikely; <25%, unlikely/probably not; 25%–75%, possibly/possibly not; >75%, likely/probably; >95%, very likely; >99%, almost certainly. If the chances of having higher or lower values than the smallest worthwhile difference were both >5%, the true difference was assessed as unclear. A substantial effect was set at >75% (16).

## Results

The results of the comparisons between the 45-minute periods and the MIPs for the duration and intensity of actions and pauses can be seen in Figures 1 and 2. Although there were substantial differences (>75%) in all the comparisons (Figure 2), the magnitude of the effects was always higher in the comparisons relative to the characterization of the pauses (Figure 1). Thus, the differences between the 45-minute periods and the MIPs for the intensity and duration of the actions were moderate (likely) and large (almost certainly), respectively, while the differences in both the intensity and the duration of the pauses between both periods analysed were very large (almost certainly).

## Discussion

The main objective of this research was to assess the possible differences in the variables that characterize the intermittency, between the average data obtained in 45-minute game periods and 3-minute periods of higher exertion during competition (worst-case scenarios). The results reflect very large differences in the characterization of the pauses (duration and intensity) during competition between the average 45-minute period and the 3-min MIP. These results can have great relevance and practical application for the design of tasks.

It is well known that during competition, efforts of varying duration and intensity occur interspersed with pauses of incomplete recovery, which causes an intermittent dynamic of efforts throughout the match. However, the global values of the game may not be adequate to evaluate the characteristics of the most demanding phases of the competition. Recent publications have been able to verify how the maximum demands during matches vary according to the time periods evaluated, with higher values when the demands are analysed in smaller temporal windows (13,17). For example, Delaney et al. (13) recorded distance/min values that ranged between  $\approx 175$  m/min and  $\approx 125$  m/min for temporary windows of 1 and 10 mins, respectively, and metabolic power values of  $\approx 18$  w/kg and  $\approx 12$  w/kg in the same time windows, always using rolling average techniques.

Knowledge of the peak intensity achieved during competition allows coaches to adequately prepare athletes for these demands through an appropriate training methodology (13). During the intermittent exercise, higher exertion demands can come either from increases in the duration or intensity of the actions or from decreases in the duration (or increases in intensity) of the pauses. Therefore, it is necessary to know how the intermittency is demonstrated during the most demanding phases of the competition in order to have specific references

and to be able to replicate those scenarios during the training tasks. To date, no information has been published regarding possible differences in the characteristics of the intermittency between average match recordings and data obtained during 3-min MIPs. With the data obtained in this study, it can be affirmed that the characteristics of the pauses significantly condition the exertion experienced by players during the MIP. Thus, while the average duration of the actions in the matches ranged between 2.1 seconds (45-min match) and 2.3 seconds (3-min MIP) [ES: large], the average duration of the pauses decreased from 24.7 seconds (45-min match) up to 14.3 seconds (3-min MIP) [ES: very large]. It must be noted that due to the nature of the game, when periods as long as 45 minutes are analysed, these include breaks that occur during games due to the fact that the ball is not being played (rules infractions, injuries, etc.). However, the presence of these phases is usually less when analysing short periods of time such as a 3-minute MIP. On the other hand, the average intensity of the actions was 40.6 w/kg for 45-min matches and 41.8 w/kg for 3-min MIPs (ES: moderate), while the average intensity of the pauses ranged from 10.0 w/kg (45-min matches) to 14.0 w/kg (3-min MIPs) [ES: very large]. It therefore seems evident that the exertion increase during the 3-min MIP occurs mainly as a consequence of a change in the characteristics of the pauses.

In this context, it is important to analyse up to what point and to what extent the intrinsic characteristics of the game and its phases, and/or the acute fatigue that accumulates during these brief (3-min) periods of time analysed are responsible for the differences found during intermittency demonstration. It is possible that both factors are inseparable. Therefore, coaches and trainers should take this information into account in designing the training tasks and subsequently controlling the effectiveness of them. Players should experience specific training stimuli that favour their adaptation to the demands that will later be encountered during competition, taking into account the relationship between the intrinsic characteristics of the game and the essential conditional support to tolerate fatigue (not only) of conditional character that these phases of the game suppose for each player.

### Practical Applications

- It should be proposed situations during training sessions that allow players to demonstrate a greater number of actions per unit of time to replicate periods of highest conditional exertion, as well as situations in which the intensity of the pause phases is higher, which allows players to maintain a high activity rate during the task.
- When proposing training tasks that focus on developing the ability to tolerate and reproduce the phases of higher conditional exertion, the maximum intensity of actions is not an essential requirement to keep in mind.
- When designing the training tasks and in order to have proper references to functionally control the intermittency of the target pursued, it should be taken into account the duration of the tasks and the period of time on which the conditional adaptation is sought, instead of taking as a reference the average values (intensity and duration of actions and pauses) obtained during 45-min.

### Limitations and future directions

- The data included in this report are only representative of the analysed sample, which included 1st and 2nd division teams of different leagues and both friendly and official matches. It is possible that both the team's sporting level

and the type of competition played may have constrained the demonstration of the intermittency, so it would be helpful to analyse the characteristics of the actions and pauses taking both variables into account.

- The results show information for the average requirement of the higher conditional exertion phases of competition, identified in 3-min periods. It would also be interesting to know the maximum registers that characterize the intermittence and evaluate them in different time windows (for example from 30 seconds to 10 minutes), to have information for the worst-case scenarios that the players undergo in competition matches.

### Dataset

Dataset available on SportPerfSci.com

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