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## ORIGINAL

### HIGH INTENSITY EFFORTS DURING COMPETITION IN PROFESSIONAL FOOTBALL

### ESFUERZOS DE ALTA INTENSIDAD DURANTE LA COMPETICIÓN EN EL FÚTBOL PROFESIONAL

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#### ABSTRACT

The aim, of this work was to quantify the number and duration of the very high-speed running and sprinting events (VHSRS) and the recovery interval between them in 36 first and second division professional soccer players. The players were monitored through GPS devices during two official matches.

The average duration of the EMAVS was  $2.58 \pm 0.44$  seconds with an average interval between them of  $107.07 \pm 67.00$  s. The mean heart rate (HR) during the EMAVS was  $164.92 \pm 12.39$  p.p.m., reaching 85% of the maximum HR. No

significant differences were found between the duration of the VHSRS, the intervals between them and the HR reached ( $p \leq 0.05$  in all cases), with great individual variability.

The use of the duration of the EMAVS, the recovery times and the HR reached during them, would be very useful to design the interval training in football.

**KEY WORD:** interval training; sprint, soccer, football, performance, high-speed running

## RESUMEN

El objetivo de este trabajo fue cuantificar el número y duración de los esfuerzos de muy alta intensidad y esprint (EMAVS) y el intervalo de recuperación entre ellos en 36 futbolistas profesionales de primera y de segunda división. Los jugadores fueron monitorizados a través de dispositivos GPS durante dos partidos oficiales.

La duración promedio de los EMAVS fue de  $2,58 \pm 0,44$  segundos con un intervalo medio entre los mismos de  $107,07 \pm 67,00$  sg. La FC media durante los EMAVS se situó en  $164,92 \pm 12,39$  p.p.m., alcanzando el 85% de la FC máxima. No se encontraron diferencias significativas entre la duración de los EMAVS, los intervalos entre ellos y la FC alcanzada ( $p \leq 0,05$  en todos los casos), con gran variabilidad individual.

La utilización de la duración de los EMAVS, los tiempos de recuperación y la FC alcanzada durante los mismos, serían de gran utilidad para diseñar los entrenamientos interválicos en el fútbol.

**PALABRAS CLAVE:** entrenamiento interválico; sprint, fútbol, rendimiento, carrera de alta velocidad

## INTRODUCTION

Success during competition depends to a great extent on the physical performance of the football players. A number of studies have been carried out to assess such performance. Today, however, more specific methods are needed in order to evaluate their physical abilities (Juárez-Toledo, Domínguez-García, Laguna-Camacho, Sotomayor-Serrano & Balbás-Lara, 2018). Nowadays, football teams take part in a high number of high-level competitions, playing numerous games in shorts periods of time. This results in high physical demands, which in turn determine performance (García-Concepción, Peinado, Paredes-Hernández and Alvero-Cruz, 2015).

The capacity of footballers to repeat intermittent very high-speed running and sprinting events ( $\geq 19,8$  km / h) (VHSRS) (Bishop, Girard and Mendez-Villanueva, 2011; Rampinini et al., 2007) is one of the variables that may help determine their performance, given that the decisive plays of the game are

made during these high-intensity events (Bishop et al., 2011; Buchheit, Simpson and Mendez-Villanueva, 2013; Girard, Mendez-Villanueva and Bishop, 2011; Stolen, Chamari, Castagna & Wisloff, 2005; Wragg, Maxwell & Doust, 2000). When the periods between VHSRS events last >60 s, the capacity to repeat the effort required does not diminish (Bishop and Claudius, 2005; Duffield, King & Skein, 2009). However, when they last <60 s, player performance can be negatively affected and the level of intensity required by that action may not be achieved (Bishop, Edge, Davis & Goodman, 2004; Girard et al., 2011). These events account for just 0.5-3% of a footballer's activity during a match (Buchheit, Mendez-villanueva, Simpson & Bourdon, 2010; Stolen et al., 2005), but their unpredictability may occasionally result in insufficient time for complete recovery. The capacity to repeat them will depend upon players' oxidative metabolism, the capacity to resynthesise deposits of phosphocreatine 11-13, neuromuscular factors such as muscular excitability, the adequate transmission of nervous impulses, and the recruitment of muscular fibres (Bishop et al., 2011; Gantois et al., 2017; Haseler, Hogan and Richardson, 1999; Rodriguez-Fernandez, Sanchez Sanchez, Rodriguez-Marroyo, Casamichana & Villa, 2017).

Some authors report that professional footballers have a greater ability to exert maximum efforts than lower-level footballers (Andersson, Randers, Heiner-Moller, Krstrup and Mohr, 2010; Impellizzeri et al., 2008). This might help determine the category in which a footballer could compete (Gabbett and Mulvey, 2008). Maximal-intensity interval training has also been said to improve the abilities of team-sports players (Taylor, Macpherson, Spears and Weston, 2015). However, for any specific application of interval training (IT) it is necessary to take into account the sports concerned, the duration of the interval between VHSRS events and the individual characteristics of the athletes themselves (Viana et al., 2018).

Thanks to the use of new technologies in football, it is now possible to perform a comprehensive analysis of the physical and technical and tactical demands during competition. The use of GPS devices with integrated accelerometers and heart rate (HR) monitors provides insight into volume and intensity variables both during competition and during training. Nonetheless, many studies describe averaged parameters without really knowing what happens between high-intensity periods (Bradley, Di Mascio, Peart, Olsen & Sheldon, 2010; Buchheit et al., 2013; Di Salvo, Gregson, Atkinson, Tordoff & Drust, 2009; Impellizzeri et al., 2008). Knowing this would result in training programmes that take into account the duration of high-intensity periods and the mean recovery time between them. Due to the lack of this information, the aim of this study was to record the number and duration of VHSRS performed by footballers from Spain's top and second division during competition. The secondary aim of this study was to compare the number and duration of VHSRS events between top-division and second-division players and between the different playing positions.

## MATERIALS Y METHODS

### Study design

This work was designed as a comparative, cross-sectional case study (evidence level III). Given its non-invasive nature, and the importance of the data obtained with respect to player performance, no ethics committee approval was required. All data were treated anonymously, and the study subjects knew only their own results. All subjects provided their informed consent to be included, in keeping with the principles of the Helsinki Declaration regarding research on human subjects.

### Procedures

Thirty-six male professional football players were involved in the study—21 from Spain's top division and 15 from Spain's second division (age  $24.3 \pm 2.9$ , height  $180.0 \pm 0.07$  cm, weight  $75.13 \pm 7.59$  kg). They all volunteered to participate. The data were collected during matches selected randomly among those played by their teams. A total of 72 data records were gathered.

All the teams involved followed similar training schedules: five weekly training sessions plus a match. The weekly plan was established as follows: compensatory/recovery session the day after the game, rest, three tactical training sessions, and an activation session the day before competition. The footballers were grouped according to the division they played in and their playing position, i.e. defenders ( $n = 8$  top-division players and 6 second-division players), midfielders ( $n = 9$  and 5, respectively) and forwards ( $n = 4$  and 4, respectively).

The players were monitored during the matches using a GPS device (GPSports EVO 10 Hz, Canberra, Australia) with integrated accelerometer (100 Hz). This device was placed on a vest between the scapulas and it also featured a sensor that recorded the HR. The following data were collected: the number of VHSRS events performed at  $\geq 19.8$  km/h, the duration of each of them, the interval between them and the HR attained during the VHSRS events. For a player's data to be used, he had to have been on the pitch for at least 80 min. All data were collected in September (the first month) of the 2017-2018 season.

### *Statistical analysis*

The Kolmogorov-Smirnov test was used to confirm that the quantitative variables showed a normal distribution. ANOVA was performed to detect differences associated with division and tactical position. Bonferroni post hoc multiple comparison testing was performed to identify significant differences. Significance was set at  $p < 0.05$ . All calculations were performed using SPSS v.21.0 software for Windows

## RESULTS

Table 1 shows the mean results for the VHSRS-associated variables recorded with respect to division and tactical position.

No difference was seen between first and second division players in terms of their height ( $180.0 \pm 0.07$  cm vs.  $180.4 \pm 5.7$  cm [ $p > 0.01$ ]), weight ( $75.13 \pm 7.59$  Kg vs.  $77.4 \pm 5.9$  Kg [ $p > 0.01$ ]), or age ( $24.36 \pm 2.93$  years vs.  $26.2 \pm 3.76$  years;  $p > 0.01$ ) (Table 1).

DIVISION	Playing position	No. of VHSRS	Duration of VHSRS event	Interval between VHSRS events (s)	HR (bpm)
1 <sup>st</sup>	D (n = 8)	25.36±6.41	2.59±0.40	109.41±28.10	164.40±10.92
	M (n = 9)	30.61±6.91	2.56±0.38	126.84±143.02	165.45±15.43
	F (n = 4)	31.57±6.05	2.80±0.37	85.14±17.89	163.10±6.48
2 <sup>nd</sup>	D (n = 6)	25.56±8.52	2.35±0.53	105.33±28.36	174.74±9.90
	M (n = 5)	27.35±9.28	2.57±0.54	64.75±8.18	160.66±14.07
	F (n = 4)	42.25±6.85	2.66±0.28	108.82±44.98	165.22±6.41
<b>Total</b>	n = 36	28.35±8.35	2.58±0.44	107.07±67.00	164.92±12.39

**Table 1:** Average number and duration of intermittent VHSRS events, their duration and interval between them. Heart rate (HR) during VHSRS events in top and second-division players, and by playing position.

### *Number of VHSRS events, their duration, and the interval between them*

No significant differences were observed between top-division and second-division players regarding the duration of the VHSRS events (Figure 1) or the interval between them (Figure 2), ( $p > 0.05$  in both cases).

Second-division forwards performed a higher number of VHSRS events compared with top-division forwards ( $p = 0.025$ ). Regarding the other playing positions, no significant differences were seen in the number of VHSRS events between top and second-division players ( $p > 0.05$ ) (Figure 3).

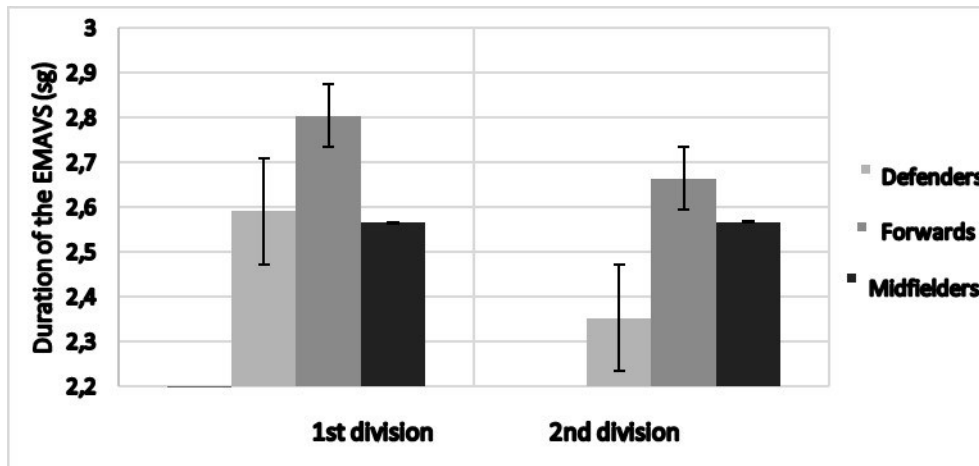


Figure 1: Duration of VHSRS events in first and second-division players, by playing position.

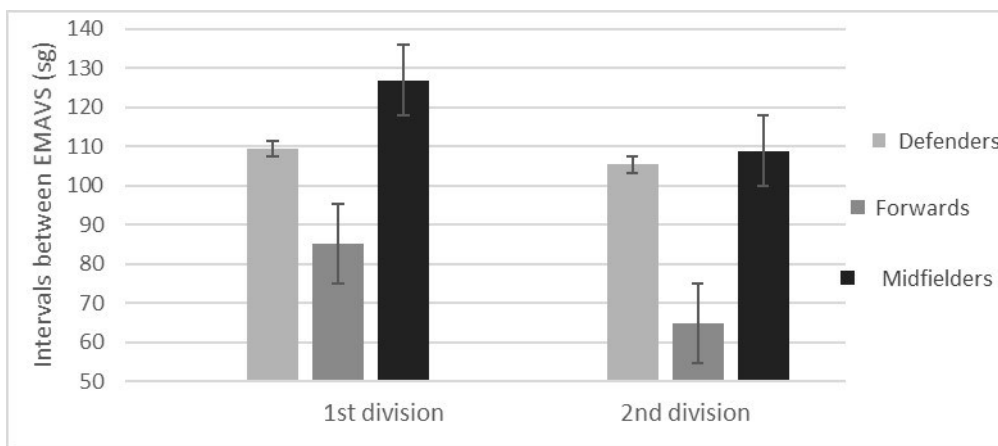


Figure 2. Intervals between VHSRS event(s) in first and second-division players, by playing position.

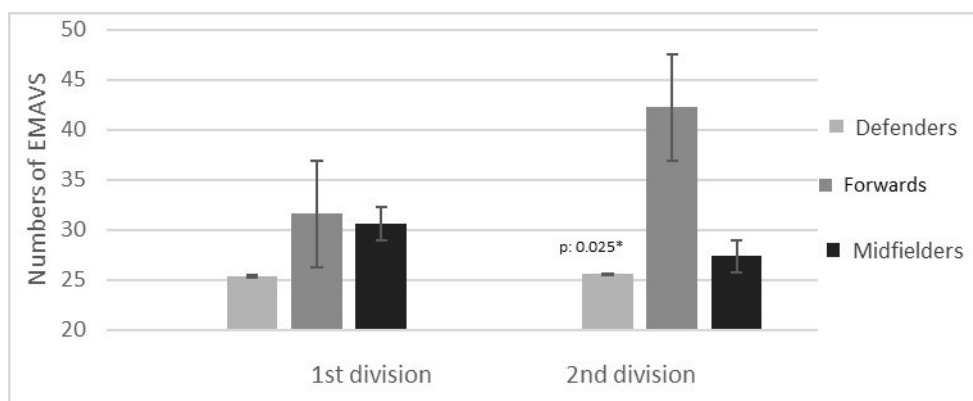
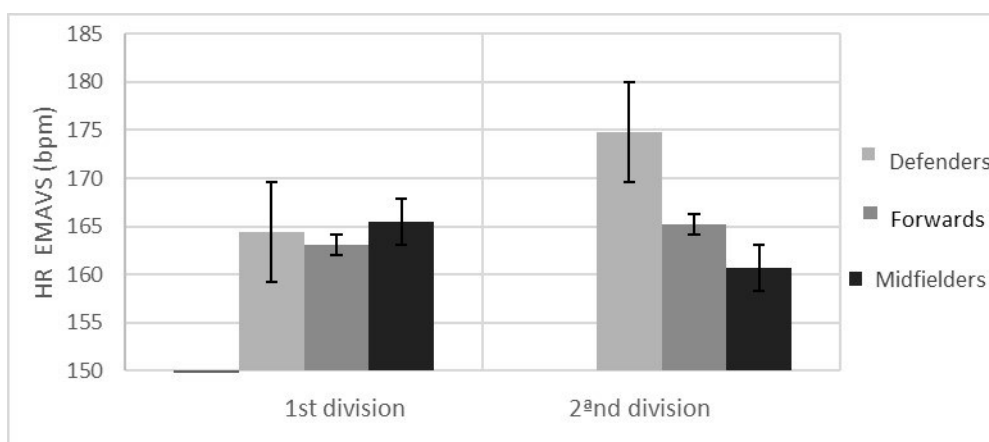


Figure 3. Number of VHSRS events in first and second-division players, by playing position.  
\*Significant differences

### Heart rate

No significant differences were seen between the first and second division players in terms of the mean heart rate reached during VHSRS events (164.50 +/- 11.7 vs. 165.50 +/- 13.44 beats per minute [bpm] respectively [ $p=0.45$ ]), or between players of different tactical position ( $p=0.13$ ) (Figure 4).



**Figure 4.** Mean heart rate (HR) during VHSRS events in top and second-division players, by playing position.

## DISCUSION

The aim of this paper was to compare the number, duration and recovery intervals of VHSRS events during competition between top and second-division footballers. The main finding of our research did not show significant differences in the analysed variables between top- and second-division players.

Secondarily, the description of this type of effort and the physiological response may allow for interval trainings specifically designed to improve VHSRS events. During a football match, players perform an average of  $28.35 \pm 8.35$  VHSRS events lasting  $2.58 \pm 0.44$  s, with a mean interval between them of  $107.07 \pm 67.00$  s and a mean HR of  $164.92 \pm 12.39$  bpm. No significant differences were found between top and second-division players or between players in different playing positions in terms of the duration of VHSRS events, the duration of the intervals between them or the HR reached during these efforts. Likewise, no differences have been observed with regards to playing positions, with the exception of second-division forwards. Individual variations in these data and information on two assessment criteria—the duration of the efforts and the heart rate values during these efforts—would allow for the design of individual interval training sessions in which a player's target heart rate should be 85% of his maximum heart rate during maximal-intensity efforts, with recoveries of maximum 107 s. These data would vary throughout the season, in accordance with the data gathered during the games.

The number of VHSRS events in men's and women's football has been reported by other authors (Bradley et al., 2010; Di Salvo et al., 2009; Gabbett, Wiig & Spencer, 2013; Ingebrigtsen, Dalen, Hjelde, Drust & Wisløff, 2015). However, to this day, no study has linked the heart rate to the duration of the efforts, or to the recovery duration between such efforts, nor have they compared the results between professional footballers in different categories. The duration of VHSRS events was similar to what other authors have reported for other European top division leagues (Bradley et al., 2010; Di Salvo et al., 2009; Ingebrigtsen et al., 2015) and higher than the values reported for less competitive leagues (Ingebrigtsen et al., 2015). Contrary to the results in this study, all the above-mentioned authors found positional differences in the duration of the VHSRS events, with fewer VHSRS performed by midfielders.



Based on these positional differences, position-based groups could be created for interval training. However, the goal of performing data measurements during competition would be to establish individual training intensities, and HR could also be used to this end.

HR is a commonly used variable when monitoring internal training load. (Alexandre et al., 2012). Some authors have reported differences in the HR recordings between games played by footballers from different divisions (Proietti et al., 2017), but we have not found any study describing the HR behaviour during the intervals between VHSRS events, or in players in different playing positions. The recorded HR were approximately 85% of the theoretical maximum HR, similarly to what has been reported by other authors (Bloomfield, Polman and O'Donoghue, 2007; Bradley et al., 2009; Dellal et al., 2008; Stolen et al., 2005). However, a solid relationship between heart rate and performance has never been established (McLaren et al., 2018). Therefore, some authors recommend using different variables when planning interval training (Viana et al., 2018). Measuring the efforts and recovery durations between such efforts during a match provides useful information when planning this kind of interval training.

The use of the term "high-intensity" to define maximal and supramaximal efforts is highly controversial. For this study, we have considered efforts performed at over 19.8 km/h (Bishop et al., 2011; Bradley et al., 2010; Rampinini et al., 2007) in order to cover all high-intensity efforts and describe the internal load using the HR.

The players' HR during a match has only been useful to monitor their internal response in specific trainings for conditional performance improvement. Fitness coaches must be provided with information regarding internal load (HR) and external load parameters (number and duration of VHSRS events) with the objective of knowing the demands of such trainings and comparing those stimuli with those performed during competition.

Regarding the limitations of the study, we acknowledge that it is a descriptive study in which a small number of matches were analysed. Future research should analyse a higher number of games in order to find out whether there are positional and between-category differences. It is also worth mentioning that the number of maximum efforts that a player can perform during a game also depends on their individual physical fitness (strength, resistance to fatigue, etc.) at the time of the study, as well as on weather conditions, the characteristics of the pitch, or the formation of the team. Lastly, the data obtained were collected during the first month of competition in order to be used as an initial assessment. It would be advisable to further evaluate such parameters at different times of the season.

## **CONCLUSIONS**

No significant differences were found in the number or duration of VHSRS events, the intervals between them, or the mean HR reached during such



events between top-division and second-division players, or among players in different playing positions. Only forwards performed a higher number of VHSRS events. This information (duration of and recovery from efforts) may prove extremely useful in planning interval trainings aimed at improving this variable.

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