Analysis of professional soccer players in competitive match play based on submaximum intensity periods

Eduardo Caro Corresp., 1, 2 , **Miguel Ángel Campos-Vázquez** 3, 4 , **Manuel Lapuente-Sagarra** 5, 6, 7 , **Toni Caparrós** 1, 8

1 Universitat de Barcelona, Barcelona, Spain
2 Neftchi Baku, Baku, Azerbaijan
3 Department of Sports and Informatics, Cadiz CF, Cadiz, Spain
4 Universidad Pablo de Olavide, Sevilla, Spain
5 FC Barcelona, Barcelona, Spain
6 Department of Physical Education and Sport , University of Basque Country, Vitoria-Gasteiz, Spain
7 Smart Performance & Sport Science,, Cambrils, Spain
8 GRACE Research Group, National Institute of Physical Education of Catalonia (INEFC), Barcelona, Spain

Corresponding Author: Eduardo Caro
Email address: educarobalada@gmail.com

The main objective of this study is to analyse sub-maximum intensity periods (SubMIP's) manifested by professional soccer players during official matches (number of events and time spent in each event), according to the player position, match halve and match. **Methods**: We collected a total of 247 individual records of 14 players using Global Positioning System (GPS) during 15 official league matches (Azerbaijan Premier League 2019–20). We calculated both the number of SubMIPs events and the time each player spent in the SubMIPs zone (threshold of 85% MIP). **Results**: The statistical analysis showed significant differences between the individual variables in the number of events and in the time spent by the player above the threshold in distance covered at speed >19.8 km/h (HSR), distance covered at speed >25.2 km/h (Sprint), acceleration density (AccDens), mean metabolic power (MetPow), metres per minute (Mmin) and high metabolic load distance >25.5 W/kg (HMLD). Differences were also found according to the playing position in MetPow, Mmin and between halves in AccDens, MetPow, Mmin. In the clustering based on the time spent by the player in SubMIPs, three main groups were described: 1) the centroid was located in lower values in each of the variables; 2) there were an accentuation of the AccDens variable; 3) all the variables, except AccDens, were accentuated. **Conclusions:** Main differences with regard to SubMIPs are related to player's individual physical performance and not to position. However, player's position could act as an attractor and show significance differences during matches .

Analysis of professional soccer players in competitive match play based on submaximum intensity periods

[1,2] Edu Caro, [3,4]Miguel Ángel Campos-Vázquez, [5,6,7]Manuel Lapuente-Sagarra, [1,8] Toni Caparrós

[1] National Institute of Physical Education of Catalonia, University of Barcelona.

[2] Nefcthi futbol klubu, Baku, Azerbaijan

[3] University Pablo de Olavide, Sevilla, Spain

[4] Department of Sports and Informatics, Cádiz CF, Spain

[5] Department of Physical Education and Sport University of Basque Country, Vitoria-Gasteiz, Spain

[6] FC Barcelona, Barcelona, Spain

[7] Smart Performance & Sport Science, Cambrils, Spain

[8] GRACE Research Group, National Institute of Physical Education of Catalonia (INEFC), center of Barcelona, Spain

ID ORCID:

[1] 0000-0002-7823-4478

[2] 0000-0003-4888-0329

[3] 0000-0003-2491-0247

[4] 0000-0002-5169-1935

Corresponding Author:

Edu Caro

Jaime Abril, 32, A1, Viladecans, Barcelona (08840)

Email address: educarobalada@gamil.com

The authors declare no conflict of interest.

Abstract

The main objective of this study is to analyse sub-maximum intensity periods (SubMIP's) manifested by professional soccer players during official matches (number of events and time spent in each event), according to the player position, match halve and match.

Methods: We collected a total of 247 individual records of 14 players using Global Positioning System (GPS) during 15 official league matches (Azerbaijan Premier League 2019–20). We calculated both the number of SubMIPs events and the time each player spent in the SubMIPs zone (threshold of 85% MIP).

Results: The statistical analysis showed significant differences between the individual variables in the number of events and in the time spent by the player above the threshold in distance covered at speed >19.8 km/h (HSR), distance covered at speed >25.2 km/h (Sprint), acceleration density (AccDens), mean metabolic power (MetPow), metres per minute (Mmin) and high metabolic load distance >25.5 W/kg (HMLD). Differences were also found according to the playing position in MetPow, Mmin and between halves in AccDens, MetPow, Mmin. In the clustering based on the time spent by the player in SubMIPs, three main groups were described: 1) the centroid was located in lower values in each of the variables; 2) there were an accentuation of the AccDens variable; 3) all the variables, except AccDens, were accentuated.

Conclusions: Main differences with regard to SubMIPs are related to player's individual physical performance and not to position. However, player's position could act as an attractor and show significance differences during matches.

Keywords: *Soccer, Global Positioning System, Maximum Intensity Period, External Load, Performance, Cluster Analysis*.

Introduction

Knowledge of players' activity during competitive match play is vitally important for subsequent prescription of specific training (1). For this purpose, the use of global positioning systems (GPS) offers us valid and reliable information (2,3) on distance and other derived variables (4), enabling us to study and monitor training and match play (5,6).

Previous studies (7) have analysed the physical activity profile of professional soccer players in competitive match play, reporting the information as mean values (for example, metres per minute or metres sprinted per minute). However, owing to the intermittent nature of play in team sports (8,9), these mean values may underestimate the demands to which soccer players are subjected in certain phases of play (10), and if they are used as an intensity benchmark in designing training activities this could lead to insufficient preparation of players (1). For this reason, in recent years there has been a great increase in research on maximum intensity periods (MIPs), which can be identified as the phases of play in which players show the highest level of conditional exertion. MIP analysis therefore offers us useful information on the maximum demands on athletes (11). The characteristics of these periods have been analysed in match play (12,13), and positional differences have also been evaluated (14–16). In addition, recent research has compared the exertion of these periods in various training activities with that displayed by soccer players in competitive matches (17,18). In these studies, a range of criterion variables, time windows (14,15,17,18) and methods of analysis (10) are used to calculate MIPs, always obtaining higher values when the time window used is smaller (12,16). Moreover, it seems clear that the demands on athletes are underestimated when segmental analyses are used instead of rolling average techniques (13,19) and that these MIPs seem to be context-dependent (16,20,21).

One of the limitations that arise when calculating MIPs is that they refer to a single event (period) that occurs during play, and therefore do not provide information on time periods during the match when exertion was high, but not maximal. For this reason, it seems useful to undertake an analysis of the external load that soccer players accumulate in these sub-maximum intensity periods (SubMIPs), since they could be related to the levels of fatigue shown in matches (22). Analyses of this kind have previously been performed with internal load variables, such as heart rate (23), or with other types of methodology that analyse the external load in match play in different ranges of intensity (1). Moreover, the characteristics of SubMIPs have recently been studied in other team sports such as rugby, Australian rules football (24) and futsal, both in competitive match play (25) and trainings (26).

The main objective of this study is to analyse SubMIPs manifested by professional soccer players during official matches (number of events and time spent in each event), according to the player position, match halve and match.

Methods

Subjects

This study was conducted with 14 professional male soccer players (weight: 73.74 ± 5.92 kg, height: 1.79 ± 0.05 m, age: 23.86 ± 3.58 years), all members of the same team competing in the Azerbaijan Premier League. We analysed 15 official league matches played during the 2019–20 season. All matches were played in the afternoon, with an interval of at least 5 days between them, with similar microcycles (Table 1).

INSERT TABLE 1

The playing formation used by the team in competitive matches was 1-5-3-2 and players were grouped according to their playing position, as central defenders (CD) (n = 76 records), wide defenders (WD) (n = 50 records), midfielders (MF) (n = 62 records) and forwards (FW) (n = 59 records).

In the analysis, the records of players who participated for less than 45 minutes per half were excluded, as were subjects who did not fulfil the requirement of playing in at least 3 matches, thereby avoiding atypical values (26). Those who did not play in the same position throughout these matches were also excluded. We thus obtained a total of 337 individual records, of which 247 met the inclusion criteria.

The people involved in the study gave their written permission to use their data for academic purposes. These data were processed following the criteria of the 13th Informed Consent Declaration of Helsinki (27) and their use was approved by the ETHICS COMMITTEE FOR CLINICAL RESEARCH OF THE CATALAN SPORTS COUNCIL witch number 035/CEICGC/2021.

Instruments

The players used a GPS device (STATSports APEX ProSeries®, Northern Ireland) every day to monitor the external load accumulated in both training sessions and competitive matches. These devices, which operate at a sample rate of 10 Hz configurable to 18 Hz, also include a 600 Hz accelerometer, a 400 Hz gyroscope and a 10 Hz magnetometer: with a weight of 62.7 g. and dimensions of 44 x 84 x 20 mm. Recent studies have analysed the validity and inter-unit reliability of these devices, reporting an error of 1%–2% for the total distance and maximum speed in team sports (3). The players wore the device on their upper back, between their shoulder blades, in a vest specially designed for the purpose. The subjects were used to wear the device (3,28). Furthermore, to ensure appropriate inter-device reliability, the players used the same GPS in all the recordings (29), while the data processing and management were performed by the same person, who had a high level of relevant knowledge and experience.

Procedure

Devices were activated 15 minutes before the start of the match (3). In addition, proper connection was checked using the brand's live app (STATSports Apex Live®) during the recordings. Subsequently the raw data from each of the halves of the matches was exported through the manufacturer's software (STATSports® 3.0.03112), using a Microsoft Excel spreadsheet (Microsoft®, Redmond, WA, USA). These recordings were filtered at 10 Hz using a 4th order dual-pass Butterworth filter. The 1-minute MIP in each half was then calculated for each player in each of the variables analysed: distance covered at speed >19.8 km/h (high-speed running: HSR), distance covered at speed >25.2 km/h (Sprint), acceleration density (AccDens), mean metabolic power (MetPow), metres per minute (Mmin) and high metabolic load distance >25.5 W/kg (HMLD), as in previous studies (15,18,30,31). In addition, we applied a threshold of 85% of the individual mean of the 3 highest MIPs shown by each participant, in order to delimit the range of activity performed in the SubMIP zone (25). Finally, we calculated both the number of SubMIPs events and the time each player spent in the SubMIPs zone in each match.

Statistical analysis

A central trend descriptive analysis was performed, subsequently analysing the normality of the variables studied with the Shapiro-Wilk test. In view of the non-normality of the sample, we analysed the possible independence of the variables with the Kruskal-Wallis test and the possible specific relationships between the groups using a post-hoc analysis with Dunn's test (32). In order to explore the possible distribution of physical demands in homogeneous groups, a cluster analysis was performed. To determine the number of clusters, a hierarchical cluster analysis (HCA) was performed, standardizing the sample values (Z-score) beforehand. The variables were clustered in the groups obtained using the k-mean method. Once the clusters had been established, possible associations were determined with an ANOVA analysis (33). The Z-score was used as the criterion to establish the value of the dimensions as high, moderate or low. Values between –0.5 and +0.5 standard deviations (SDs) around the standardized mean were considered moderate, scores greater than +0.5 SDs high and scores below –0.5 SDs low. (33). The statistical analysis was performed with SPSS software (Statistics for Windows version 25, IBM Corp., NY, USA). The significance level in all cases was $p < .05$.

Results

The results are shown as mean plus/minus standard deviation, the highest average values in number of events and time above the threshold were found in the AccDens and Mmin variables, and the lowest values in Sprint (Table 2).

Those who exceeded the threshold in the HSR variable on the most occasions and for the longest time were MF and WD; by contrast, CD showed the lowest values in number of events and time above the threshold in the HSR, Sprint and HMLD variables. WD had the highest number and duration values in Sprint and HMLD. MF showed higher values than the other positions in number of events and time spend above the threshold in the AccDens variable, as opposed to FW, who had the lowest values in this variable. In the MetPow and Mmin variables WD were those with the lowest time and duration values. The position that showed the highest values in these two variables was MF. The average values for number of AccDens events and duration of Mmin proved to be the highest in the first half of the match, and the values for number of Sprint events and duration in HSR were the lowest during the second half (Table 2).

INSERT TABLE 2

The statistical analysis showed significant differences between the individual variables in the number of events in HSR (Z = 27.805, p = .01), AccDens (Z = 51.733, $p < .001$), MetPow (Z = 74.44, $p < .001$) and Mmin (Z = 66.751, $p < .001$) and in the time the player spent above the threshold in the same variables (HSR: Z = 26.7, p = .014; AccDens: Z = 49.455, $p < .001$; MetPow: Z = 68.868; $p < .001$; Mmin: Z = 63.655, $p < .001$) (Table 3). Significant differences were also observed between the variables according to the playing position for number of events in MetPow (Z = 35.742, $p < .001$) and Mmin (Z = 38.725, $p < .001$) and the time above the threshold in these variables (MetPow: Z = 34.607, $p < .001$; Mmin: Z = 38.775; $p < .001$) (Table 3). Similarly, differences were found between halves in number of events for AccDens (Z = 5.797, p= .016), MetPow (Z = 7.402, p =.007), Mmin (Z = 6.05, p = .014) and time above the threshold in these variables (AccDens: Z = 8.611, p =.003; MetPow: Z = 8.068, p = .005; Mmin: Z = 8.602, p = .003). Only were found differences between matches for events and time of Mmin (Z = 30.971, p = .006, Z = 32.582, p = .003) and in time of MetPow (Z = 26.513, p = .022) (Table 3).

INSERT TABLE 3

The subsequent post-hoc analysis showed differences between MF and FW in AccDens time ($Z = 1.838$; $p = .033$), and also differences between CD and FW in MetPow, both in number of events ($Z = -2.144$; $p = .016$) and in duration ($Z = -1.822$; $p = .034$). It also showed differences between WD and FW in number of events ($Z = -4.215$, $p < .001$) and duration ($Z = -3.923$, $p < .001$), between MF compared to CD and WD in number of events ($Z = 3.637$, $p < .001$ and $Z = 5.58$, $p < .001$ respectively) and their duration ($Z = 3.653$, $p < .001$ and $Z = 5.593$, $p < .001$ respectively), and between MF and FW in time above the threshold ($Z = 1.699$, $p = .045$), but not in number of events. In the Mmin variable the analysis showed differences between MF compared to CD and WD in number of events ($Z = 4.042$, $p < .001$ and $Z = 5.465$, $p < .001$ respectively) and duration ($Z = 4.023$, $p < .001$ and $Z = 5.521$, $p < .001$ respectively). Analysing this same variable we find differences with respect to CD compared to WD and FW in number of events ($Z = 1.906$, $p = .028$ and $Z = -2.977$, $p = .001$ respectively) and events duration ($Z = 1.983$; $p = .024$ and $Z = -2.879$, $p = .002$ respectively) and also between WD and FW in number of events ($Z = -4.493$, $p < .001$) and events duration ($Z = -4.477$, $p < .001$).

Analysing the first and second halves by post-hoc analysis, we can see differences both in the number of events of AccDens, MetPow and Mmin (Z = 2.408, p = .008; Z = 2.721, p = .003; Z = 2.46, p = .007 respectively) and in time above the threshold in these same variables (Z = 2.934, p = .002; Z = 2.84, p = .002; Z = 2.933, p = .002 respectively), values for the first half being higher than for the second.

In the clustering based on the time spent by the player in SubMIPs, three main groups were described (Figure 1). In the first, the centroid was located in lower values in each of the variables. In the second, an accentuation of the AccDens variable was observed, and in the third and final cluster it could be seen that all the variables, except AccDens, were accentuated (Table 4). When these clusters are compared to the positions used for the analysis, we can see behavioural tendencies during match play. CD and WD were respectively 60.5% and 66% inclined to belong to the third cluster. MF tended to show behaviour clustered in the second group in 48% of the events analysed, while FW were distributed in all three

INSERT TABLE 4

INSERT FIGURE 1

The ANOVAs revealed significant differences between the three clusters ($p < 0.01$), and the Levene F value indicated significant differences between the three clusters for each variable analysed ($p < 0.01$). The sampling adequacy measure was KMO = 0.64, for $X^2 = 537.0$ and $p = .00$ (34).

Discussion

The most important findings of this study are as follows: (I) the largest differences in physical demands based of SubMIPs in competitive matches are individual (HSR, AccDens, MetPow and Mmin); (II) there are differences between positions, between halves and between matches in the number of SubMIP events and the duration of these events in different variables; (III) the largest differences between positions are found in the MetPow and Mmin variables, while the differences between halves are most evident for AccDens, MetPow and Mmin; (IV) physical demands are not determined solely by a player's position, although this could act as an attractor in their playing profile during matches.

Recent research (1) analysed the percentage distribution of intensity compared to MIP 1', concluding that the average data in this distribution were much lower that the MIP 1' values, especially for high-intensity exertion (9%–19%). This type of analysis has also been considered in sports such as rugby and Australian rules football (24), as well as in much more closely related sports such as futsal, both in match play and in training (25,26). The study cited (25) showed that high-intensity (80%) and very high-intensity (90%) exertions in competition were lower in high-speed actions (in this case only HSR) (0.17 ± 0 in both categories) and higher in distance variables (3.17 ± 2.32 and 0.75 ± 0.35 respectively) and acceleration variables (2 ± 1.12 and 0.67 ± 0.55 respectively), similarly to the results obtained in our study, although we do not treat the latter variable in the traditional way but rather as acceleration density. However, a comparison between the study by Illa et al. (2020) and our work should be interpreted with caution, because of the differences between the two sports (especially with regard to the number of players participating and the playing space).

To the best of our knowledge, this is the first study to date that has analysed the number of events and the time spent in SubMIP zones in professional soccer matches. The most notable results show significant differences ($p < .01$) between individuals in HSR, AccDens, MetPow and Mmin events, as well as in the duration of each. These results suggest that we should consider the physical demands of players in competitive match play individually, also extrapolating this to training sessions.

The differences in physical demands between positions in match play have been extensively studied with classical variables analysis using absolute speed thresholds (35,36) and individual relative thresholds (37) or with analysis of MIPs in various time windows (15,30). Regardless of the method used, all these studies showed significant differences between positions. In our study, analysing of SubMIPs, we found significant differences in the AccDens variable (only in its duration), which was higher in midfielders than in forwards. The greatest differences between positions occur in the MetPow and Mmin variables in number of events (Table 3), except between MD and FW, who obtained significantly higher values compared to CD and WD, and the values were higher in wide than in CD. Differences between the values for MF compared to FW were only significant in MetPow duration. These differences could be partially explained by position-dependent nature in soccer (15,30,35–37); indeed, using individualized threshold values for the SubMIP based on the MIP for each player, we can find significant differences between positions in the number of events and the time in SubMIP.

The results obtained show higher values in the first half than in the second for AccDens, MetPow and Mmin, in number of events (Table 3), with no significant differences between halves in the other variables analysed. Previous studies also showed differences between halves when performing an analysis using classical variables, a lowering of total distance (36) and a reduction of the distance covered in various speed ranges in the second half (38), though not systematically. Moreover, when MIPs were analysed, differences were found in variables such as average metabolic power, and these differences were more evident when the time window analysed was larger (12). Despite the apparent reduction in physical performance in the second half shown by these studies, we should treat this information with caution, as the reduction in performance could be a result of the players' accumulated fatigue, but it could also be due to the reduction in useful playing time (39) or other reasons.

On the other hand, there were almost no differences in of SubMIPs when a comparison was made between matches. Significant differences were only apparent in the duration of MetPow and in number of events and duration of Mmin. This is contrary to what is reported in previous studies that have analysed the same phenomenon from a traditional perspective, where greater differences are shown, especially in metres covered at high intensity. (40). The individualization of the thresholds for analysis of the number of events and duration could explain this absence of differences between matches.

Clustering produced three major behavioural groups. In group one, the centroid of all the variables was in a lower range that in the other groups and we found 20%–30% of players of all positions, suggesting that players who, for various reasons, have not undergone great conditional exertion during a match are located here. In group two, where midfielders tend to be found, the AccDens variable was accentuated, probably because they are the players who perform the highest number of actions during match play and because of the nature of those actions. Finally, in group three the other variables (HSR, HMLD, Sprint, Mmin, MetPow) were accentuated relative to the other two groups. CD and WD tended to be located in this group, probably owing to high competitive demands in the case of WD and low MIP values in the case of CD. FW were distributed among the three groups.

An important factor to take into account when interpreting the results is the methodology used to calculate SubMIPs. In our study, the average of the three highest MIPs for each of the variables was individual, and therefore so were the thresholds for the SubMIP. This means that a player who obtains higher maximum peaks in a specific variable will have higher SubMIP thresholds than another player with lower MIP values, giving different possibilities in the relationship between MIP and SubMIP, depending on the variable and the player's physical demands during the match. On this context, there are players with high MIP and many SubMIP events, for example, WD in HSR, or both low values like CD in Sprint as the nature of their position requires them to use or not certain demands. Players with lower MIP and higher SubMIP periods (such as CD in AccDens, probably because of the low SubMIP threshold) and players with high MIP and low SubMIP, are rarely able to exceed the SubMIP range, either due to the low frequency with which the actions are requested or due to the very high threshold at which these actions are found.

It is important to bear in mind that an athlete's conditional demands in competitive play, and consequently the MIP attained, is multifactorial (20). This is why the average of the three highest MIPs for each player in each variable was taken, so as to minimize the possible noise that may be caused in the MIP by context (25). Given that players exceed the SubMIP theshold approximately 0.2 times per half in HSR, Sprint and HMLD, we can see that MIP analysis from a non-dynamic perspective, analysing matches independently, may underestimate the real maximum capacities of our athletes. An analysis over the course of different matches and training sessions may offer us a view closer to the real maximum demand of players.

In this respect, it could be useful to standardize the criteria for obtaining SubMIPs and explore this field in greater depth so as to obtain more detailed knowledge of player's physical demands from this new perspective, with the aim of providing valid and reliable tools for designing training and analysing their conditional performance in competitive match play.

However, main limitations of this study were the sample size (a single professional team) and the number of matches analysed, so these results should be interpreted according to this specific competitive context.

Conclusions

In conclusion, the analysis of the SubMIP in professional soccer players during official matches shows individual-dependent differences in the variables HSR, AccDens, MetPow and Mmin. There are also differences between positions in MetPow and Mmin; AccDens, MetPow and Mmin for halves; and MetPow and Mmin for matches. Therefore, we can conclude that physical demands are not determined solely by a player's position, although this could act as an attractor in their playing profile during matches.

PRACTICAL APPLICATIONS

Just as the use of MIP for monitoring load and analysing match play has brought about a change in training design, the use of SubMIPs to discover and quantify the physical demands of professional soccer players may be a useful tool that could help to optimize players' performance.

Bearing in mind the individual differences in the characteristics of SubMIPs during match play in professional soccer, it seems appropriate to individualize training according to the profile of each player and to the relationship of MIP to SubMIP profiles, as this could be an indicator of the physical demand required and whether this leads to the desired adaptations in the athletes.

REFERENCES

1. Riboli A, Esposito F, Coratella G. The distribution of match activities relative to the maximal intensities in elite soccer players

2. Harper DJ, Carling C, Kiely J. High-Intensity Acceleration and Deceleration Demands in Elite Team Sports Competitive Match Play: A Systematic Review and Meta-Analysis of Observational Studies. Sport Med [Internet]. 2019;49(12):1923–47. Available from: https://doi.org/10.1007/s40279-019-01170-1

3. Beato M, Coratella G, Stiff A, Iacono A Dello. The validity and between-unit variability of GNSS units (STATSports apex 10 and 18 Hz) for measuring distance and peak speed in team sports. Front Physiol. 2018;9(SEP).

4. Gabbett TJ. The training-injury prevention paradox: Should athletes be training smarter and harder? Br J Sports Med. 2016;50(5):273–80.

5. Casamichanan D, Castellano J, Calleja-Gonzalez J, San Roman J, Castagna C. Relationship between indicators of training load in soccer players. 2013;27(2):369–74.

6. Gómez-Díaz AJ, Pallarés JG, Díaz A, Bradley PS. Cuantificación de la carga física y psicológica en fútbol profesional: Diferencias según el nivel competitivo y efectos sobre el resultado en competición oficial. Rev Psicol del Deport. 2013;22(2):463–9.

7. Suarez-Arrones L, Torreño N, Requena B, Sáez De Villarreal E, Casamichana D, Barbero-Alvarez JC, et al. Match-play activity proile in professional soccer players during oficial games and the relationship between external and internal load. J Sports Med Phys Fitness. 2015;55(12):1417–22.

8. Johnston RD, Gabbett TJ, Jenkins DG. Applied sport science of rugby league. Sport Med. 2014;44(8):1087–100.

9. Johnston RD, Black GM, Harrison PW, Murray NB, Austin DJ. Applied Sport Science of Australian Football: A Systematic Review. Sport Med [Internet]. 2018;48(7):1673–94. Available from: https://doi.org/10.1007/s40279-018-0919-z

10. Whitehead S, Till K, Weaving D, Jones B. The Use of Microtechnology to Quantify the Peak Match Demands of the Football Codes: A Systematic Review. Sport Med [Internet]. 2018;48(11):2549–75. Available from: https://doi.org/10.1007/s40279-018-0965-6

11. Lord C, Blazevich AJ, Abbiss CR, Sciences H. A Reduction in Match-to-match Variability Using Maximal Mean Analyses in Sub-elite Soccer Authors. 2020;1–6.

12. Casamichana D, Castellano J, Diaz AG, Gabbett TJ, Martin Garcia A. The most demanding passages of play in football competition: A comparison between halves. Biol Sport. 2019;36(3):233–40.

13. Campos-Vázquez MA, Lapuente-Sagarra M. Análisis de las diferencias posicionales en el perfil competitivo de potencia metabólica en futbolistas profesionales. 2018;

14. Delaney JA, Thornton HR, Rowell AE, Dascombe BJ, Aughey RJ, Duthie GM. Modelling the decrement in running intensity within professional soccer players. Sci Med Footb [Internet]. 2018;2(2):86–92. Available from: https://doi.org/10.1080/24733938.2017.1383623

15. Martín-García A, Casamichana D, Gómez Díaz A, Cos F, Gabbett TJ. Positional differences in the most demanding passages of play in football competition. J Sport Sci

Med. 2018;17(4):563–70.

16. Oliva-Lozano JM, Rojas-Valverde D, Gómez-Carmona CD, Fortes V, Pino-Ortega J. Worst case scenario match analysis and contextual variables in professional soccer players: A longitudinal study. Biol Sport. 2020;37(4):429–36.

17. Martín García A, Castellano J, Méndez Villanueva A, Gómez Díaz A, Cos F, Casamichana D. Demands of Ball Possession Games in Relation to the Most Demanding Passages of a Competitive Match. J Sport Sci Med [Internet]. 2020;(January 2019):1–9. Available from: http://www.jssm.org

18. Martin Garcia A, Castellano J, Diaz AG, Cos F, Casamichana D. Positional demands for various-sided games with goalkeepers according to the most demanding passages of match play in football. Biol Sport. 2019;36(2):171–80.

19. Cunningham DJ, Shearer DA, Carter N, Drawer S, Pollard B, Bennett M, et al. Assessing worst case scenarios in movement demands derived from global positioning systems during international rugby union matches: Rolling averages versus fixed length epochs. PLoS One. 2018;13(4):1–14.

20. Novak AR, Impellizzeri, Franco M. Trivedi A, Coutts AJ, McCall A. Analysis of the worst-case scenarios in an elite football team: Towards a better understanding and application. Sport Sci. 2021;

21. Riboli A, Semeria M, Coratella G, Esposito F. Effect of formation, ball in play and ball possession on peak demands in elite soccer. Biol Sport. 2021;38(2):195–205.

22. Schimpchen J, Gopaladesikan S, Meyer T. The intermittent nature of player physical output in professional football matches : An analysis of sequences of peak intensity and associated fatigue responses. Eur J Sport Sci [Internet]. 2020;0(0):1–21. Available from: https://doi.org/10.1080/17461391.2020.1776400

23. Aşçı A. Heart Rate Responses during Small Sided Games and Official Match-Play in Soccer. Sports. 2016;4(2):31.

24. Johnston RD, Thornton HR, Wade JA, Devlin P, Duthie GM. The Distribution of Match Activities Relative to the Maximal Mean Intensities in Professional Rugby League and Australian Football. J Strength Cond Res. 2020;Publish Ah(May).

25. Illa J, Fernandez D, Tarragó JR, Reche X. Most demanding passages in elite futsal: An isolated or a repeat situation? Apunt Educ Fis y Deport. 2020;(142):80–4.

26. Illa J, Fernandez D, Reche X, Carmona G, Tarragó JR. Quantification of an Elite Futsal Team's Microcycle External Load by Using the Repetition of High and Very High Demanding Scenarios. Front Psychol. 2020;11(October):1–10.

27. Fortaleza. Declaración de Helsinki de la AMM - Principios éticos para las investigaciones médicas en seres humanos. 2013;

28. Gimenez JV, Garcia-Unanue J, Navandar A, Viejo-Romero D, Sanchez-Sanchez J, Gallardo L, et al. Comparison between Two Different Device Models 18 Hz GPS Used for Time-Motion Analyses in Ecological Testing of Football. Int J Environ Res Public Health.

2020;17(6):1–9.

29. Jennings D, Cormack S, Coutts AJ, Boyd LJ, Aughey RJ. Variability of GPS units for measuring distance in team sport movements. Int J Sports Physiol Perform. 2010;5(4):565–9.

30. Di Mascio M, Bradley PS. Evaluation of the most intense high-intensity running period in english FA Premier League soccer matches. 2013;27(4):909–15.

31. Delaney JA, Cummins CJ, Thornton HR, Duthie GM. Importance, reliability, and usefulness of acceleration measures in team sports. J Strength Cond Res. 2018;32(12):3485–93.

32. López-Roldán P, Fachelli S. Metodología de la investigación social cuantitativa. Universidad Autónoma de Barcelona. 2015.

33. Izquierdo DG, Ceballos ID, Ramírez Molina MJ, Vallejo EN, Díaz JD. Risk for eating disorders in “high”- And “low”-risk sports and football (soccer): A profile analysis with clustering techniques. Rev Psicol del Deport. 2019;28(4):117–26.

34. Morissette L, Chartier S. The k-means clustering technique: General considerations and implementation in Mathematica. Tutor Quant Methods Psychol. 2013;9(1):15–24.

35. Mallo J, Mena E, Nevado F, Paredes V. Physical Demands of Top-Class Soccer Friendly Matches in Relation to a Playing Position Using Global Positioning System Technology. J Hum Kinet. 2015;47(1):179–88.

36. Di Salvo V, Baron R, Tschan H, Calderon Montero FJ, Bachl N, Pigozzi F. Performance characteristics according to playing position in elite soccer. Int J Sports Med. 2007;28(3):222–7.

37. Abbott W, Brickley G, Smeeton NJ. Physical demands of playing position within English Premier League academy soccer. J Hum Sport Exerc. 2018;13(2):285–95.

38. Rampinini E, Coutts AJ, Castagna C, Sassi R, Impellizzeri FM. Variation in top level soccer match performance. Int J Sports Med. 2007;28(12):1018–24.

39. Rey E, Casáis L, Lago C, Lago J. Superando el mito de la fatiga en el fútbol. Influencia del tiempo efectivo de juego sobre la distancia recorrida por futbolistas de elite. Futbolpf Rev Prep Física en el Fútbol. 2011;54–62.

40. Oliva-Lozano JM, Muyor JM, Fortes V, McLaren SJ. Decomposing the variability of match physical performance in professional soccer: Implications for monitoring individuals. Eur J Sport Sci [Internet]. 2020;0(0):1–29. Available from: https://doi.org/10.1080/17461391.2020.1842513

Table 1(on next page)

Records of training during the research period

Table 1: Records of training during the research period

	TD	HSR	VHSR	m/min	Acc	Dcc
MD+1	4918.11 ± 694.52	157.16 ± 84.01	33.01 ± 51.23	72.68 ± 10.42	51.02 ± 16.07	42.87 ± 18.31
MD+1 Rec.	1935.23 ± 308.44	73.25 ± 68.08	8.96 ± 15.32	66.79 ± 14.57	2.43 ± 2.36	2.03 ± 2.31
MD-4	5120.06 ± 835.23	216.62 ± 193.25	26.71 ± 37.59	64.60 ± 13.31	46.03 ± 15.77	32.11 ± 14.63
MD-3	5716.80 ± 903.00	227.38 ± 113.72	45.77 ± 41.81	69.65 ± 9.07	55.85 ± 16.72	47.10 ± 16.39
MD-2	4173.90 ± 847.73	135.57 ± 124.77	21.42 ± 33.89	62.59 ± 11.67	40.57 ± 12.04	30.06 ± 11.76
MD-1	2767.18 ± 563.17	69.77 ± 71.64	8.10 ± 16.35	54.32 ± 7.74	31.71 ± 11.73	22.99 ± 10.60

MD + 1 (Day after the match compensatory work), MD + 1 Rec. (Day after the match recovery work), MD-4 (4 days before the next match), MD-3 (3 days before the next match), MD-2 (2 days before to the next match), MD-1 (1 day before to the next match)

Table 2 (on next page)

Mean and standard deviation of 247 events recorded during the 15 games, differentiated by position and halves

Table 2: Mean and standard deviation of 247 events recorded during the 15 games, differentiated by position and halves.

Position	**CD**			**WD**			**MF**			**FW**					
Half	1st n=39	2nd n=37	□ n=76	1st n=29	2nd n=21	□ n=50	1st n=35	2nd n=27	□ n=62	1st n=36	2nd n=23	□ n=59	1st n=138	2nd n=109	1st and 2nd n=247
	Mean ±SD	*Mean ±SD*	*Mean ±SD*	*Mean ±SD*	*Mean ±SD*	*Mean ±SD*	*Mean ±SD*	*Mean ±SD*	*Mean ±SD*	*Mean ±SD*	*Mean ±SD*	*Mean ±SD*	*Mean ±SD*	*Mean ±SD*	*Mean ±SD*
# HSR	0.103	0.162	0.132	0.276	0.190	0.240	0.286	0.185	0.242	0.278	0.130	0.220	0.23	0.167	0.202
	0.307	0.374	0.34	0.455	0.402	0.431	0.519	0.483	0.502	0.566	0.458	0.527	0.471	0.421	0.45
Duration HSR	0.151	0.284	0.216	0.429	0.305	0.377	0.436	0.240	0.35	0.384	0.233	0.325	0.341	0.266	0.308
	0.460	0.665	0.57	0.725	0.660	0.694	0.805	0.632	0.736	0.766	0.809	0.78	0.699	0.681	0.691
# Sprint	0.077	0.135	0.105	0.172	0.238	0.2	0.200	0.111	0.161	0.222	0.130	0.186	0.165	0.148	0.158
	0.270	0.347	0.309	0.384	0.539	0.452	0.473	0.320	0.413	0.422	0.344	0.393	0.392	0.382	0.387
Duration Sprint	0.150	0.262	0.205	0.328	0.461	0.384	0.376	0.218	0.307	0.363	0.250	0.319	0.299	0.287	0.294
	0.528	0.673	0.602	0.731	1.046	0.87	0.900	0.628	0.791	0.713	0.661	0.69	0.723	0.742	0.73
# AccDens	2.692	1.946	2.329	2.207	1.619	1.96	2.657	2.259	2.484	1.694	1.696	1.695	2.324	1.907	2.142
	2.028	1.393	1.777	1.521	1.284	1.442	2.057	2.086	2.062	0.822	1.146	0.951	1.729	1.532	1.655
Duration AccDens	3.385	2.011	2.716	2.617	1.751	2.254	3.657	2.683	3.234	2.013	1.749	1.91	2.938	2.073	2.56
	3.352	2.279	2.943	2.278	2.080	2.217	3.437	3.030	3.277	1.286	1.858	1.525	2.813	2.374	2.66
# MetPow	1.513	1.108	1.316	0.759	0.905	0.82	2.714	2.000	2.403	2.194	1.348	1.864	1.835	1.343	1.619
	1.144	1.430	1.298	1.091	1.546	1.289	1.808	1.664	1.769	1.582	1.191	1.491	1.595	1.505	1.572
Duration MetPow	2.007	1.400	1.712	0.975	1.125	1.039	3.591	2.572	3.148	2.734	1.617	2.299	2.379	1.686	2.076
	1.560	1.789	1.698	1.391	1.895	1.606	2.389	2.109	2.311	1.971	1.395	1.84	2.077	1.876	2.017
# m/min	1.615	1.459	1.539	1.000	0.952	0.98	3.286	2.222	2.823	2.667	1.870	2.356	2.18	1.639	1.943
	1.330	1.966	1.661	1.363	1.284	1.317	2.052	1.847	2.021	1.882	1.359	1.73	1.885	1.737	1.838
Duration m/min	2.242	1.825	2.04	1.433	1.187	1.33	4.405	2.860	3.733	3.497	2.408	3.073	2.944	2.084	2.568
	1.844	2.536	2.203	2.293	1.630	2.026	2.614	2.520	2.667	2.441	1.750	2.246	2.537	2.278	2.46
# HMLD	0.231	0.243	0.237	0.345	0.333	0.34	0.371	0.222	0.306	0.333	0.130	0.254	0.317	0.231	0.279
	0.536	0.495	0.513	0.614	0.483	0.557	0.598	0.506	0.561	0.478	0.458	0.477	0.552	0.485	0.525
Duration HMLD	0.300	0.347	0.323	0.446	0.521	0.477	0.487	0.284	0.399	0.480	0.1830.6	0.365	0.424	0.33	0.383
	0.707	0.705	0.702	0.800	0.768	0.78	0.783	0.683	0.743	0.712	33	0.693	0.744	0.697	0.724

Number of actions (#) and duration of these (minutes) when the threshold of 85% of the maximum values previously stipulated is exceeded.
Centre-defenders (CD), Wide-defenders (WD), Midfielders (MF), Forwards (FW).

Figure 1

Groups based on the time the players are in % > the 85% threshold

Figure 1. Groups based on the time the players are in % > the 85% threshold

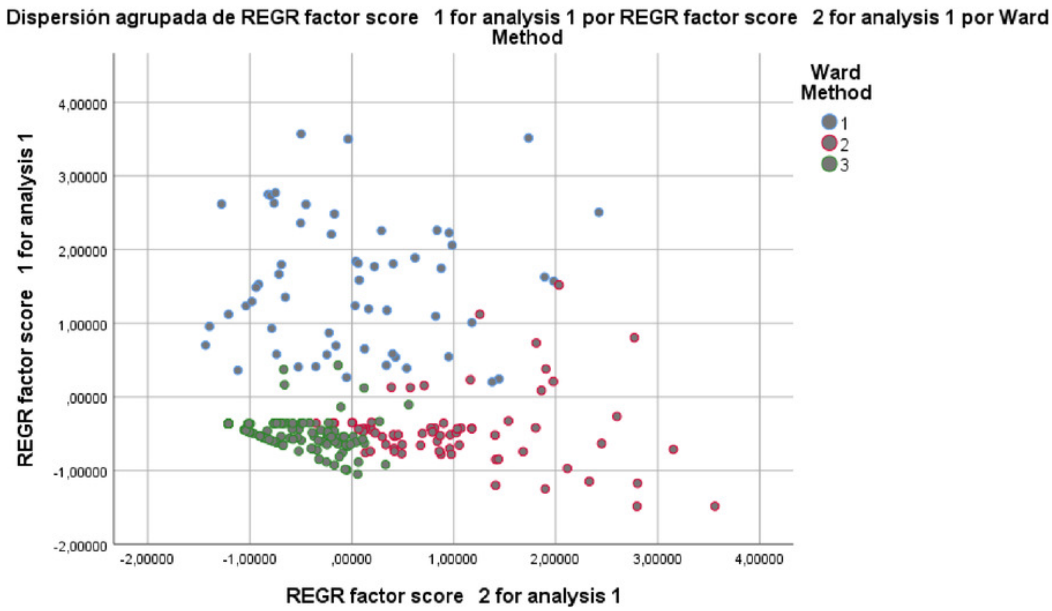

Table 3(on next page)

Kruskal-Wallis Test

Table 3 Kruskal-Wallis Test

Variable	Factor	Individual	Position	Halves	Match
# HSR	St.	27.805*	2.738	1.448	12.637
Duration HSR	St.	26.7*	2.289	1.199	13.413
# Sprint	St.	13.669	2.19	0.17	11.146
Duration Sprint	St.	12.509	1.53	0.072	10.872
#AccDens	St.	51.733**	3.533	5.797*	14.063
Duration AccDens	St.	49.455**	3.749	8.611*	16.528
# MetPow	St.	74.44**	35.742**	7.402*	22.723
Duration MetPow	St.	68.868**	34.607**	8.068*	26.513*
#m/min	St.	66.751**	38.725**	6.05*	30.971*
Duration m/min	St.	63.655**	38.775**	8.602*	32.582*
#HMLD	St.	15.968	1.73	1.637	22.072
Duration HMLD	St.	14.293	1.593	1.376	21.147

*p<.05; **p<001

Table 4(on next page)

Clustering centroid in each of the variables for each group

Table 4. Clustering centroid in each of the variables for each group

	1	2	3
Duration HSR	0.1425	0.1910	0.6550
Duration Sprint	0.2072	0.1899	0.5047
Duration AccDens	1.2321	6.4361	2.0658
Duration MetPow	0.7794	2.0697	4.1712
Duration m/min	0.9601	2.5699	5.1593
Duration HMLD	0.1772	0.3435	0.7416