Received: 9 November 2021 | Revised: 13 December 2022 | Accepted: 28 December 2022

DOI: 10.1111/sms.14301

ORIGINAL ARTICLE

WILEY

Mental fatigue changes from regular season to play-offs in semiprofessional soccer: A comparison by training days

Jesús Díaz-García[1] | **Luca Filipas**[2,3] | **Antonio La Torre**[2,4] | **Jorge Gómez-Rivera**[1] | **Ana Rubio-Morales**[1] | **Tomás García-Calvo**[1]

[1]Faculty of Sport Sciences, University of Extremadura, Cáceres, Spain

[2]Department of Biomedical Sciences for Health, Università degli Studi di Milano, Milan, Italy

[3]Department of Endocrinology, Nutrition and Metabolic Diseases, IRCCS MultiMedica, Milan, Italy

[4]IRCCS Istituto Ortopedico Galeazzi, Milan, Italy

Correspondence
Tomás García-Calvo, Faculty of Sport Sciences, University of Extremadura, Av. of University S/N, Caceres, Spain.
Email: tgarciac@unex.es

Funding information
Goverment of Spain FPU Program, Grant/Award Number: FPU18/03660; Junta of Extremadura, Grant/Award Number: GR18102

The main purpose was to compare by each training the mental load and fatigue reported by semiprofessional soccer players comparing between regular season phase and the play-offs. Fifty-three players (M_{age} = 24.59 years) for two teams participated during the 2020/21 season. Mental load was measured with a Likert questionnaire. Mental fatigue was quantified with a Visual Analogue Scale. Four trainings were recorded each week (Monday = MD+1, Wednesday = MD-4, Thursday = MD-3 and Saturday = MD-1), with a competitive match on Sunday across 10 weeks (five dates of regular season – five dates of play-offs). A Linear Mixed Model was performed with R-studio, using the training days and the competitive phase as independent variables. The influence of time played as co-variable was also checked. Results showed MD+1 as the more mentally fatiguing day in both phases, although MD-4 were the training with higher mental load reported (p = 0.001). Comparing phases, mental fatigue was significantly higher during the play-offs (p = 0.037). With regard time played, players that did not usually play showed a decrease in mental load during the play-offs. Then, we recommend coaches to use recovery strategies for mental fatigue, avoid mentally fatiguing tasks close to competition and considerer the time played as a factor which may contribute to individual differences in player mental fatigue.

KEYWORDS
applied sporting practice, cognitive fatigue, longitudinal, mental load, real soccer matches, soccer demands

1 | INTRODUCTION

Soccer, like most intermittent team sports, is a complex sport, with multiple factors contributing to successful performance.[1] One of the factors which has attracted a great amount of scientific attention is fatigue,[2] where a special interest on neuromuscular and metabolic fatigue has been observed.[3] However, soccer also poses high demands on the brain.[4] Indeed, soccer may be mentally as well as physically fatiguing.[5] Mental fatigue is a psychobiological state caused by prolonged brain demanding activity reflecting both psychological-subjective and biological alterations.[6] The symptoms of mental fatigue depend on each athlete specifically, as Russell et al.[7] showed in a qualitative study that checked how athletes perceived mental fatigue, although several studies have shown that induced mental fatigue courses subjectively with increased feelings of mental fatigue, behaviorally with cognitive or reaction

time impairments and physiologically with changes in the electroencephalogram signal or an activation of the parasynthetic activity.[8,9] It has been well defined that mental fatigue significantly impair soccer performance.[10,11] Indeed, it has been showed that mental fatigue courses in soccer players with a decrease in physical efforts, which seems to be caused by a mental fatigue-associated increase in the physical exertion,[12] higher impairments in shooting and passing performance,[12,13] or a trend of mentally fatiguing players to stay in close proximity to their teammates, resulting in poor dispersion across the pitch.[1] Therefore, it is not surprising that researchers have recently focused their attention towards mental fatigue.

Soccer game scenarios imply vigilance, decisions making, emotions or constantly processing information causing mental fatigue in soccer players.[11] Mental fatigue may impair soccer physical[12] and technical-tactical performance.[1,13,14] Therefore, controlling and limiting the presence of mental fatigue may be important for enhancing soccer performance.[15] Mental fatigue is not however limited to competition.[16] Indeed, the authors reported higher perceptions of mental fatigue during the preparation camps when compared with competitions in netball players. It may be caused by the intentional stress induced during preparation camps to know how players respond during competitions in presence of mental fatigue and the intentional individualization of programming aspects to minimize mental fatigue close to competition as recovery, coaching approach or scheduling. However, this finding remarks the importance to routinely monitor mental fatigue during training and competition and the importance of coaches to manage mental fatigue. For example, the use of more or less mentally fatiguing tasks[17,18] may determine the training adaptations to mental fatigue and its effects. To control and manipulate mental fatigue adequately, more information is however needed to understand how mental fatigue could evolve along a longitudinal competitive season. It has been previously checked over two full netball seasons.[19] The authors concluded that mental fatigue significantly fluctuate across a season, and that mental fatigue differs from physical fatigue, tiredness, stress, mood and motivation. This information remarks the importance of include mental fatigue as independent measure; coaches can use this information to adapt the mental exigences of the tasks to the state of mental fatigue of the players or to decide to use or not use strategies to counterattack mental fatigue. The evolution of mental fatigue over time has been also checked along a professional padel competition,[20] where consecutive matches are played. These authors concluded that play professional padel matches significantly increase mental fatigue, but the state of mental fatigue was significantly higher before the second match of the day when compared with the first match of the day. This study also suggests that a night of normal sleep post-matches countermeasure the state of mental fatigue. This adds information for coaches about the measure and management of mental fatigue during the tournament. Specifically, in soccer would be interesting to compare between different season phases, as playoff or a regular league with similar practical applications.

Due to the lack of researches on this aspect in team sports, experts have raised the importance of investigating the longitudinal evolution of mental fatigue.[21] Few studies have analyzed mental fatigue during a longitudinal period in soccer. Abbott et al.[22] showed that during a full-competitive season professional under-23 soccer players reported to be mentally fatigued for 2 days following a match. This finding was confirmed also by Thompson et al.[5] in an English elite-academic soccer players. Although these studies were performed in a very specific contexts and teams a low completion rate was observed, suggesting the need for replication with greater data consistency and number of athletes. Based on all this information, coaches should perhaps try to reduce the cognitive exigence of their training tasks for 48 h after matches searching for a well recovery of mental fatigue. Although, it could depend on other contextual variables as the result of the previous match, due to significant lower levels of mental fatigue reported 48 h after a won match compared to a lost one.[22] The authors also reported that mental fatigue was higher during the early- and mid-season phase than during the late-season phase of the regular season, although, an increase in the percentage of match winnings in the late-season phase by the team analyzed could explain these results.

1.1 | The present study

The information about the longitudinal evolution of mental fatigue may help coaches to know the state of mental fatigue of their players and perform a correct management of this subtype of fatigue. Abbott et al.[22] and Thompson et al.[5] described the recovery of the mental fatigue after a competitive match. However, less is known about how mental fatigue evolves across the rest of the microcycle after a competitive match. This information may allow a further analysis about typical manifestations of mental fatigue in soccer players.

Abbott et al.[22] also answered to the differences between parts of the regular season in the mental fatigue reported by players. Many soccer leagues (e.g., England Championship, Spanish Second Division...) are characterized by the presence of play-offs in the last part of the season, where the best teams of the regular season play a range from two to five eliminatory matches to promote

to a high-level league. Know how mental fatigue change from the regular season to a play-off phase could also allow coaches to adapt the training mental exigences to the mental fatigue-levels of their players. This information seems of importance due the importance of play-offs which determine the promotion/not promotion (i.e., performance) to a higher category, based on the negative effects that mental fatigue causes on soccer performance and the special cognitive (i.e., players play vs. the best players of the season, which may increase the cognitive complexity) and emotional (i.e., monetary rewards, personal recognition) that play-offs may cause. To the best of our knowledge, no previous studies have answered this research question in soccer. Other study has investigated the longitudinal evolution of mental fatigue along different parts of the season in netball,[19] but it has not been previously checked in soccer.

Also, researchers agree about the existence of individual characteristics influencing the specific mental fatigue reported by each player.[15] However, information about what variables influences the interindividual differences in mental fatigue reported between different members of the team is currently lacking. The study analyzed time played as interindividual variable among players. From a conditional viewpoint it has been well defined that a higher time played results in more physical fatigue.[3] No previous studies have analyzed the effects of this variable on mental fatigue. A higher time played may results in higher times of cognitive efforts, although, players provided with less playing time may experience negative emotions. Then, due to it is difficult to anticipate the effects of this variable on mental fatigue and it is mandatory that coaches decisions results in there is players with higher and less time played, this variable may be of interest.

Therefore, the main purpose of the present study was to explore potential differences in mental fatigue perceived by players between the regular season and play-offs comparing by trainings. Also, the present study explored the influence of time played in the interindividual differences for mental fatigue between the players of the team.

2 | METHODS

2.1 | Experimental design

All procedures were approved by the local research ethics committees and follow the ethical principles for medical research involving human subjects set by the World Medical Association Declaration of Helsinki. Participants were provided with written instructions outlining the studies procedures but were not informed of their aims.

Considering the purpose of this study, a total of 10 weeks of trainings with a competitive match in each week of each team were analyzed. The decision to analyze 10 weeks was based on the idea to analyze the same number of play-offs and regular season matches. Play-off's phase implied a total of five matches in that season. Therefore, the previous 5 weeks (i.e., last five matches of the regular season) before starting the play-offs were also analyzed. Match days (MDs) were always on Sunday. Regarding weeks training sessions, both teams performed four training sessions per week (Monday = MD+1; Wednesday = MD-4; Thursday = MD-3; and Saturday = MD-1). Training organization, type, and number of tasks per training were the same between the two phases of the season. Only tactical information (i.e., based on the previous and the following match) differed between phases of the season. Researchers have a meeting with the staffs of the teams before the first training of each week. In the start of the project, we agree to decide an established number of four tasks (10 min the first and second tasks, 15 min the third and fourth tasks) preceded by 10 min warm-up in each training. All these tasks were possession games with the same rules in the two teams, in agreement with the coaches. The content was based on the previous result and the next match. Players conducted the mental load and mental fatigue questionnaires using a laptop, tablet, or mobile phone within 10 min following the completion of the training session. The chronological explanation of the procedure is reported in Figure 1.

Participants were encouraged to sleep at least 7 h per night and asked to have a similar meal during the study. All the trainings and measures were conducted at the same time of the day (the timeframe of the trainings was 9 p.m.–11 p.m).

To improve metacognition, mental load, mental fatigue and RPE were previously defined to players. Indeed, a previous familiarization with the concepts and scales was performed. Mental load was defined as the cognitive and emotional efforts that players must to perform to achieve the purpose of the tasks.[17] For this variable, an example of "nothing effort perceived" may be a very easy cognitive task where also the possibilities to success are high. This may be a 2×1 task where only are 1 teammate (i.e., one possibility of decision) and 1 rival (i.e., only one attentional focus in defenders) with numerical superiority, meanwhile, an example of "maximum possible effort perceived" may be the contrary 5×6 situation. Mental fatigue is defined as a psychobiological state caused by prolonged periods of demanding cognitive activity. Descriptors previously reported by athletes were showed to the players. RPE was defined as the ratio of physical exertion perceived by players. An example of "nothing effort perceived" may be a typical possession game (usually named "rondo") where

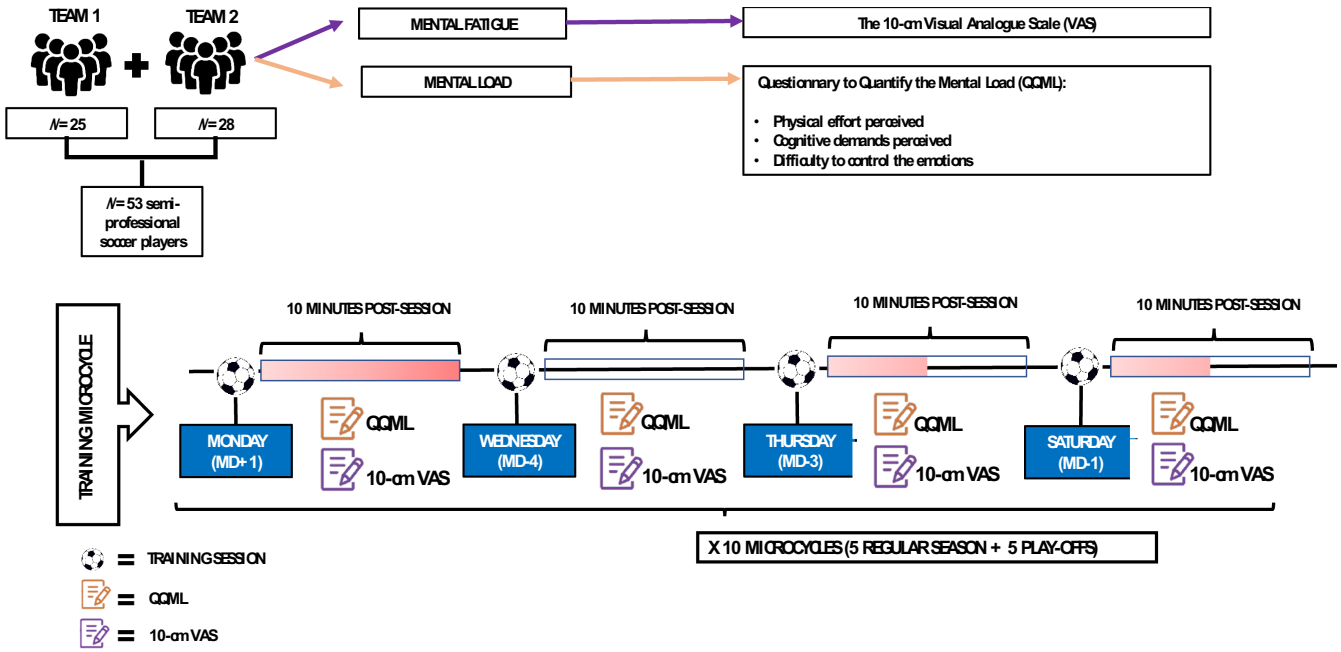


FIGURE 1 Chronological explanation of the measures and variables obtained.

attackers are situated as a circle and only the defenders situated in the center of the circle have the highest range of movement. On the contrary, an example of "maximum possible effort perceived" may be a 5×6 tasks in a high dimension pitch.

2.2 | Sample

A total of 53 male players (M_{age} = 24.6 years) of two Spanish semiprofessional soccer teams (N Team A = 25, M_{age} Team A = 22.3 years; N Team B = 28 M_{age} Team B = 24.9 years) participated in this study. All participants had a minimum of 10 years of training experience and competed in the Spanish third division during the 2020–2021 season.

2.3 | Instruments and outcomes

2.3.1 | Questionnaire to quantify the mental load

We used the Questionnaire to Quantify the Mental Load (QQML) with the purpose to quantify the perceived mental exigence caused by each training or match in these soccer players.[23] This questionnaire is composed by three items: Ratio of Perceived Exertion (RPE; How much physical activity was required?), cognitive demands (How much cognitive effort was required?) and difficulty to control the emotions (How difficult is control the emotions?). The range of responses of each item was in the format of Likert's Scale (0–10), where 0 was nothing, effort perceived and 10 was the maximum possible effort perceived.

2.3.2 | Visual Analogue Scale for mental fatigue

The 10-cm Visual Analogue Scale (VAS) was used to quantify the subjective feelings of mental fatigue reported by players, where 0 was no mental fatigue perceived' and 10 was the maximum possible degree of mental fatigue perceived. This subjective measure of mental fatigue has been used in several studies that quantify mental fatigue in sport activities.[24,25] Subjects were asked to indicate the perceived level of mental fatigue placing a mark on the VAS 10-cm line. The left side of the scale indicated "not at all," while the right side indicated "maximum."

To clarify it, both VAS and QQML were 2×10 points scales. The 10 mm VAS has come from the 100 mm VAS. In the present study, this adaptation from 100 to 10 mm in VAS was performed because researchers thought that the use of 2×10 points scale is easiest for players when compared with use 1×10 points scale and 1×100 point scale. The main different in the application of these scales was that VAS was presented as a sliding scale from 0 to 10, meanwhile, in the QQML players had to select a specific number from 1 to 10. This was performed because researchers used the original functioning of the scales, but in future studies the presentation of the scales in the same form may be better for players.

TABLE 1 Mental load and MF reported by each training. A comparison between regular season and play-offs

			Regular season scores by training days			
Variables	**RS**	**Play-off**	**MD+1**	**MD-4**	**MD-3**	**MD-1**
RPE	5.31 ± 0.14	4.97 ± 0.11**	4.79 ± .18$^{b,c***;d*}$	6.40 ± .18^{a,c,d***}	5.52 ± .18^{a,b,d***}	4.28 ± .20$^{a*;b,c***}$
Cognitive load	5.24 ± 0.14	5.29 ± 0.12	4.42 ± .19^{b,c***}	6.07 ± .19^{a,d***}	5.81 ± .18^{a,d***}	4.45 ± .20^{b,c***}
Emotional load	4.98 ± 0.18	5.10 ± 0.12	4.43 ± .22^{b,c***}	5.77 ± .22^{a,d***}	5.39 ± .22^{a,d***}	4.11 ± .24^{b,c***}
Mental fatigue perceived	3.87 ± 0.18	4.09 ± 0.11	4.37 ± .21^{c*,d***}	4.20 ± .21^{c*,d***}	3.77 ± .21^{a,b*}	2.86 ± .22^{a,b***}

Note: RS = Regular season; a = Significative differences compared to MD+1; b = Significative differences compared to MD-4; c = Significative differences compared to MD-3; d = Significative differences compared to MD-1. *Inter-phases comparison per day*: e = Significative differences between MD+1 of regular season and MD+1 of play-offs phase; f = Significative differences between MD-4 of regular season and MD-4 of play-offs phase; g = Significative differences between MD-3 of regular season and MD-3 of play-offs phase; h = Significative differences between MD-1 of regular season and MD-1 of play-offs phase; *Inter-phases comparison between days*: i = significative differences in MD+1 to MD-4 change between regular season and play-off phase; j = significative differences in MD-4 to MD-3 change between regular season and play-off phase; k = significative differences in MD-3 to MD-1 change between regular season and play-off phase; l = significative differences in MD-4 to MD-1 change between regular season and play-off phase; m = significative differences in MD+1 to MD-3 change between regular season and play-off phase; n = significative differences in MD+1 to MD-1 change between regular season and play-off phase.
*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.

2.3.3 | Time played by players

Researchers performed the next codification of the time played: 0 = players that did not play any minute in the last match; 1 = players that played <45 min. in the last match; 2 = players that played more than 45 min. in the last match.

2.4 | Data analysis

Data were analyzed with R-studio.[26] A linear mixed model (LMM) was performed using lme4,[27] to test the differences in mental load and mental fatigue perceptions between seasons-phases by each training. LMM lets analyze data with a hierarchical structure in nesting units and has demonstrated its ability to cope with unbalanced and repeated-measures data. Mental load and mental fatigue were recorded after each training and each training/week were nested for a specifical season phase. Training days (i.e., MD+1, MD-4, MD-3, MD-1) and season phase (i.e., regular season or play-offs) were included as independent variables in the analysis. Mental load and mental fatigue reported were the dependent variables. Firstly, a general comparison of the medium values for mental load and mental fatigue between phases were performed. Secondly, an intra-phase comparison of the mental load and mental fatigue perceptions was performed between different training days into the same phase (i.e., MD+1 vs. MD-4 vs. MD-3, vs. MD-1, all of these during regular season or play-offs phases). Finally, an interphase comparison of mental load and mental fatigue perceptions for each day between phases (i.e., MD+1 of regular season vs. MD+1 of play-offs; MD-4 of regular season vs. MD-4 of play-offs...) was performed. All these analyses were also performed including teams as independent variable to test the variability between teams. We only showed the fixed factors in the present study. On the other hand, researchers included the time played by players as co-variable (as previously exposed and coded) to test the effect of time played on mental load and mental fatigue according to each training and season phase. Significance was set at *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

3 | RESULTS

Table 1 shows the mental load and mental fatigue reported by semiprofessional soccer players during the regular season and the play-off phases. With regard general scores, significantly higher mean scores in RPE were reported during regular season with respect to the play-offs ($p < 0.01$). On the contrary, no significantly higher mean scores in mental fatigue, cognitive and emotional efforts was observed in the play-offs compared to the regular season. With regard trainings into the same phase, similar results were observed in the regular season and the play-offs. Specifically, significant changes were found between all training days for mental load and mental fatigue in both phases. MD-4 was identified by players as the most mentally demanding training, followed by MD-3, MD+1 and MD-1 ($p < 0.001$ when compared MD-4 with MD-3, MD+1 and MD-1). However, MD+1 was identified as the most mentally fatiguing training, followed by MD-4, MD-3 ($p = 0.03$ when compared with MD+1 and MD-4) and MD-1 ($p < 0.001$ when compared with MD+1

Play-off scores by training days				Inter-phases per day	Inter-phases between days
MD+1	MD-4	MD-3	MD-1		
$4.53 \pm .19^{b,c,d***}$	$5.92 \pm .20^{a,d***}$	$5.84 \pm .20^{a,d***}$	$3.64 \pm .19^{a,b,c***}$	$^{**}{}_{h}$ $^{*}{}_{f}$	$^{**}{}_{j,m}$
$4.56 \pm .20^{b,c***}$	$6.13 \pm .20^{a,d***}$	$6.15 \pm .20^{a,d***}$	$4.39 \pm .20^{b,c***}$		
$4.52 \pm .23^{b,c***}$	$5.92 \pm .24^{a,d***}$	$5.91 \pm .23^{a,d***}$	$4.13 \pm .23^{b,c***}$	$^{*}{}_{g}$	
$5.24 \pm .22^{b**;c,d***}$	$4.61 \pm .22^{a,d***;c**}$	$4.01 \pm .22^{a,d***;b**}$	$2.41 \pm .22^{a,b,c***}$	$^{***}{}_{e}$ $^{*}{}_{f,h}$	$^{***}{}_{n}$ $^{**}{}_{l}$ $^{*}{}_{k,m}$

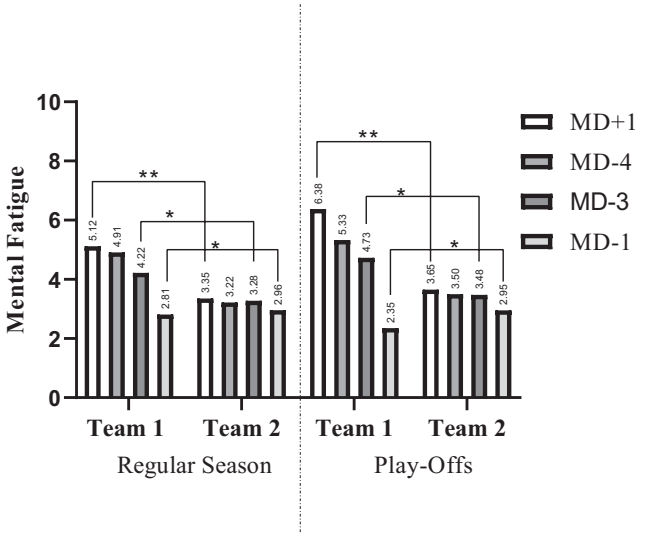


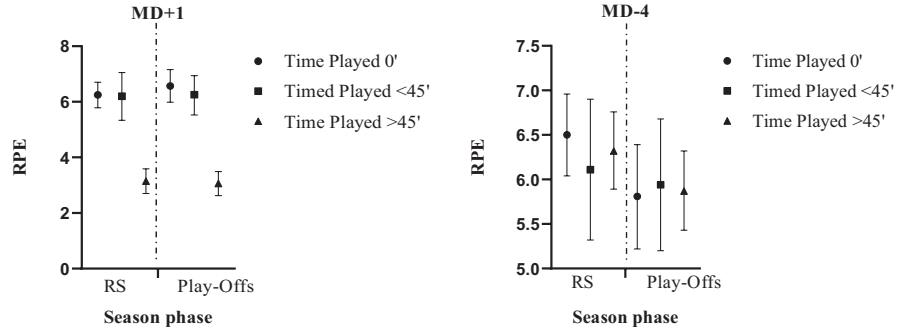
FIGURE 2 Combined effects of team × season phase × training days on mental fatigue.

and MD-4). With regard the same training day between different phases, significantly higher RPE scores were observed for MD-4 ($p = 0.03$) and MD-1 ($p < 0.01$) in the regular season compared to the play-offs. Also, mental fatigue was higher in MD-1 in the regular season than in the play-offs ($p < 0.001$). On the contrary, significantly higher emotional efforts in MD-3 ($p = 0.04$) and significantly higher mental fatigue in MD+1 ($p = 0.04$) and MD-4 ($p = 0.04$) were reported in the play-offs than in the regular season. The inter-phases comparison between days checked the existence of significative differences between two different training/weeks comparing regular season and play-offs. According to these results, differences in RPE from MD-4 to MD-3 ($p < 0.01$) and from MD+1 to MD-3 ($p < 0.01$) between phases were found, where the highest differences between trainings appear in the regular season. Moreover, changes for mental fatigue from MD+1 to MD-1 ($p < 0.001$), from MD-4 to MD-1 ($p < 0.01$), from MD-3 to MD-1 ($p = 0.03$) and from MD+1 to MD-3 ($p < 0.03$) were higher in the play-offs phase than in the regular season.

Figure 2 showed the variability between teams on mental fatigue. No significant changes in the mental load reported were observed between teams (only, a significant higher cognitive effort [$p = 0.01$] on MD-1 reported by Team 1). No significant combined effect of team × season phase × training day was observed. Figure 2 shows that although the mental fatigue reported by the Team 1 was higher in most of the cases ($p = 04$ on MD-3; $p = 03$ on MD-1; $p < 0.001$ on MD+1), the tendency of the two teams in both phases was similar.

Figures 3–6 shows the changes from regular season to play-offs phase exploring the influence of time played by players on RPE (Figure 3), cognitive efforts (Figure 4), emotional load (Figure 5) and mental fatigue (Figure 6) before each training.

No significant changes were observed on RPE in MD+1, MD-4 and MD-3 between season phases according to time played. That is, when compared players that played the same range of minutes (i.e., 0, <45 or >45 min) between the two different phases, no significant differences were observed on RPE in these days. In MD+1, players that played 0 or <45 min showed significant higher values of RPE ($p < 0.001$) than the players that played >45 min, but it was similar both in regular season and play-offs. In MD-4 and MD-3, the values of RPE did not show significant differences between players in both phases similarly.



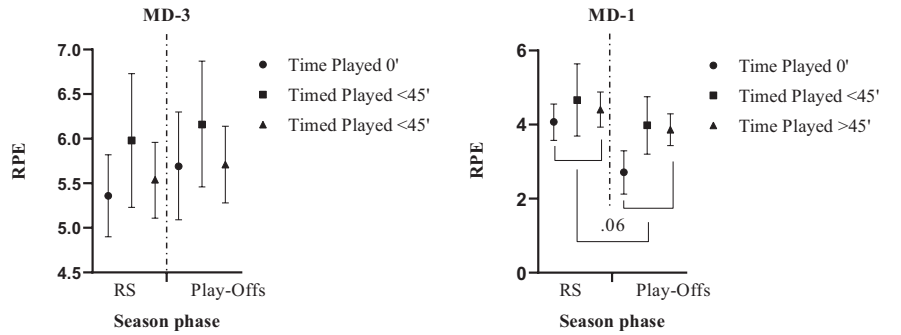
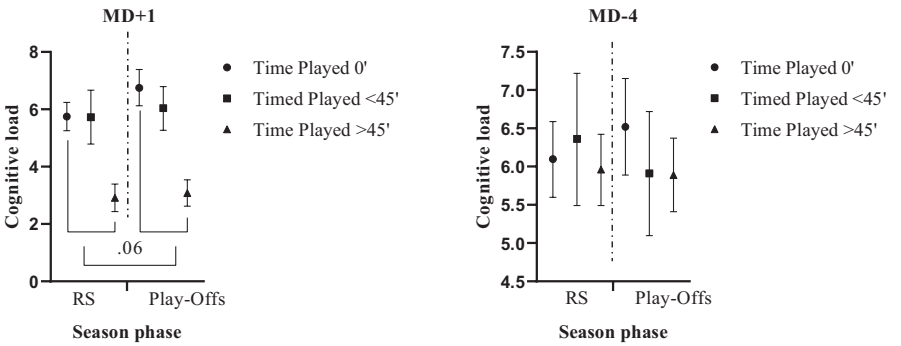


FIGURE 3 RPE reported by each training. A comparison between RS (Regular Season) and play-offs according to time played.



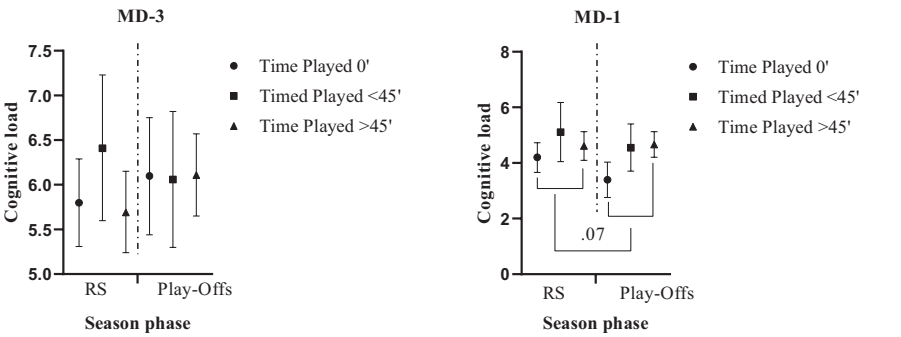


FIGURE 4 Cognitive load reported by each training. A comparison between RS (Regular Season) and play-offs according to time played.

On the contrary, a nearly significant change occurred on RPE between season phases in MD-1 ($p = 0.06$). In this case, all players showed a similar RPE in MD-1 during the regular season. Differently, players that played 0 min showed a significant decrease ($p = 0.02$) on this variable when compared with players that played <45 and >45 min in the play-offs season.

No significant changes were observed on cognitive load in MD-4 and MD-3 between season phases according to time played. The cognitive load reported by players on these days was similar for all players similarly in both phases. On the contrary, a nearly significant change on cognitive load between season phases was observed in MD+1 ($p = 0.06$ in players that played >45 min) and MD-1 ($p = 0.07$ in players that played >45 min). Specifically, in MD+1, cognitive load was significantly higher ($p < 0.001$) in players that played 0 and <45 min than in players that played >45 min.

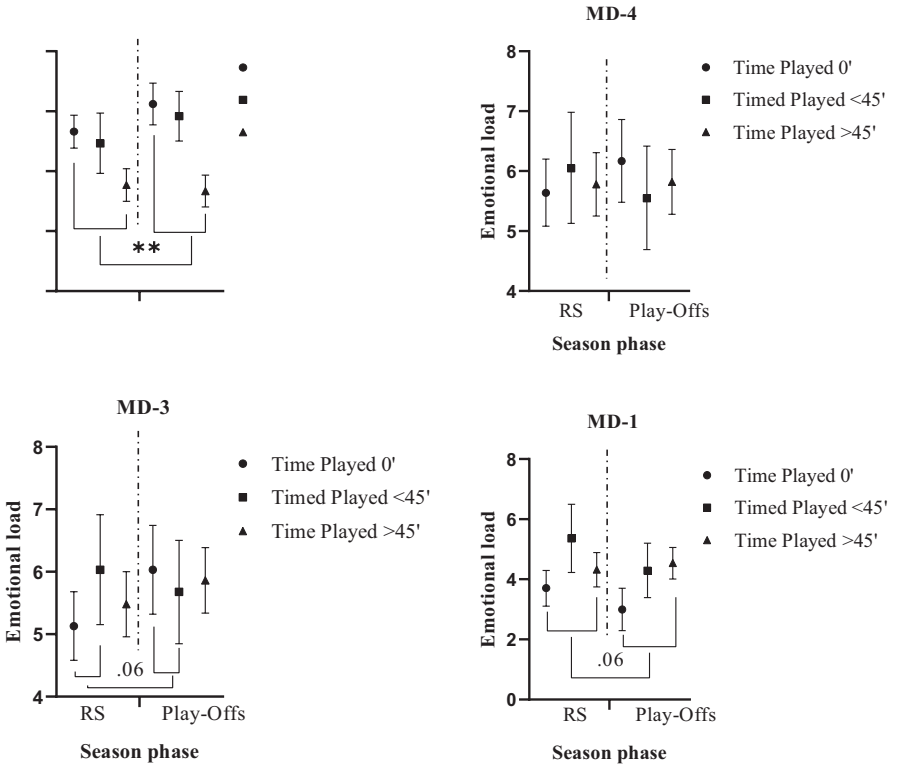


FIGURE 5 Emotional load reported by each training. A comparison between RS (Regular Season) and play-offs according to time played.

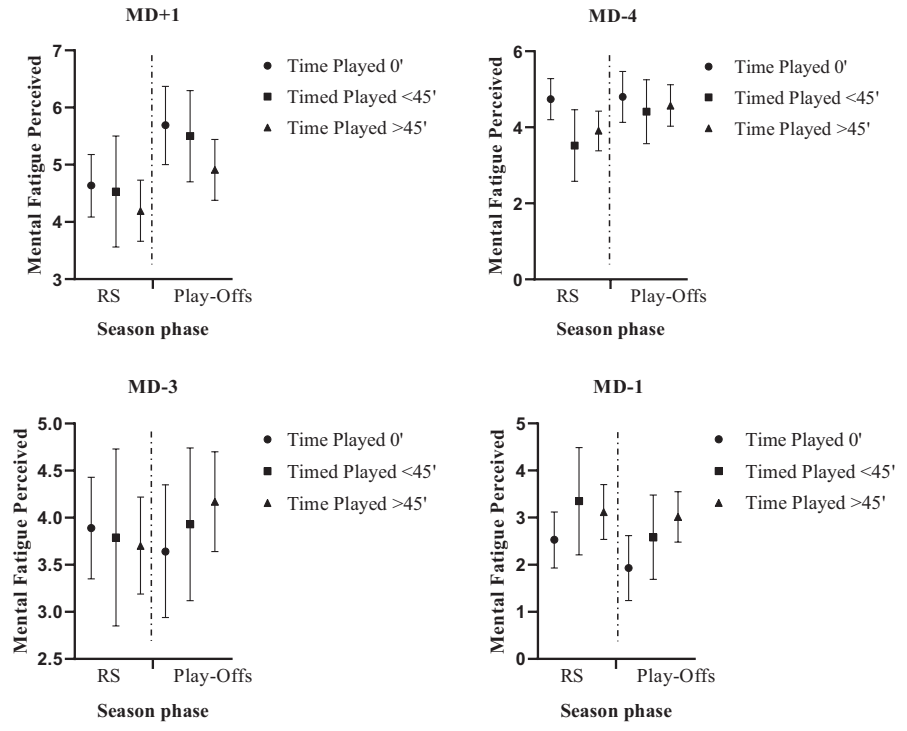


FIGURE 6 MF reported by each training. A comparison between RS (Regular Season) and play-offs according to time played.

This was similar in both phases, however, the cognitive load reported by players that played 0 min was nearly significantly higher ($p = 0.06$) in play-offs when compared with the regular season. With regard MD-1 non-significant differences were observed between groups of players in this variable during the regular season, On the opposite, during the play-offs phase, players that played 0 min showed a significant decrease in this variable on MD-1 ($p = 0.01$) when compared with players that played <45 or >45 min.

No significant changes were observed on emotional load in MD-4 between season phases according to time played. A significant change ($p = 0.01$) in the emotional load between groups of players were observed on MD+1 from regular season to play-offs. Specifically, a significant increase from regular season to play-offs on this variable

was observed in players that played 0 min ($p = 0.03$), while no significant changes were observed in players that played <45 and >45 min. On MD-3, a nearly significant difference ($p = 0.06$) was observed between phases. Specifically, in MD-3 during the regular season the smallest values of emotional load were reported by players that played 0 and >45 min. On the contrary, these players showed the highest values in this variable during the play-offs. A significant increases were observed in the emotional load on MD+3 from regular season to play-offs ($p = 0.03$ in players that played 0 min and $p = 0.04$ in players that played >45 min). With regard MD-1, a nearly significant change between groups of players were observed ($p = 0.06$), due to players that played >45 min showed significant higher values of emotional load during the regular season than during the play-offs ($p = 0.01$).

No significant changes were observed in mental fatigue between season phases for any training according to time played. All groups of players showed a non-significant increase on mental fatigue reported from regular season to play-offs in MD+1. Similar values of mental fatigue reported were observed in all groups of players on MD-4 and MD-3 in both season phases. On MD-1, a small decrease in this variable were observed from regular season to play-offs in all groups of players.

4 | DISCUSSION

The main purpose of the present study was to test possible differences in mental load and mental fatigue perceptions between training of two different phases of the season (i.e., the last 5-weeks of the regular season and the 5-weeks of the play-offs) in semiprofessional soccer players. The main findings of the study were: (1) semiprofessional soccer players identified MD-4 and MD-3 as the more mentally demanding trainings of the weeks, (2) despite it was not identified as the more mentally demanding training, MD+1 was identified as the more mentally fatiguing training of the week in both phases, (3) in general, semiprofessional soccer players identified the trainings of the play-offs phase as more mentally fatiguing than the trainings of the regular season (with a special interest in the higher values of mental fatigue reported in MD+1 and MD-4 during the play-offs compared to the regular season), (4) no differences were observed in the tendencies of mental fatigue between phases when compared the two teams, although a significant difference in the quantity of mental fatigue was observed between trainings.

To the best of our knowledge, this is the first study that have analyzed longitudinally the evolution of the mental load and mental fatigue along competitive weeks in soccer. As we explained before, the first finding of the present study was that semiprofessional soccer players identified MD-4 and MD-3 as the more mentally demanding trainings of the weeks. The presence of higher values of mental load after MD-4 and MD-3 compared to MD-1 and MD+1 suggests that mental fatigue may be consciously organized and prevented to avoid high levels of mental fatigue nearly the official matches. Previous authors have highlighted the importance not to use mentally fatiguing tasks the days previous to competitions.[15] It seems important also before soccer competitions, based on the negative effects that have been associated to mental fatigue in soccer.[10] Coaches should consider this information to avoid the use of mentally fatiguing tasks 24 h after a competitive match, in order not to impair the recovery from mental fatigue. Based on the results of the present study, coaches tried to decrease mental load and mental fatigue from the main training days (i.e., MD-4 and MD-3 in this study) to the trainings nearly to MD. Previous studies have demonstrated this phenomenon for other physical variables as total distances.[28] To the best of our knowledge this is the first study that have showed this for mental fatigue. As it was previously indicated, there are a lot of constraints that may help coaches to organize the mental demands of their trainings according to their purposes (see the Section 6.2 for more information about it).

The second finding was that despite it was not identified as the more mentally demanding training, MD+1 was identified as the more mentally fatiguing training of the week in both phases. These results are in accordance with previous findings reported by other studies; semiprofessional soccer players also identified MD+1 as the most mentally fatiguing day.[5,22] According to the results of the present study, this phenomenon occurs both in the regular season and the play-offs. Based on the mental load reported by soccer players after each training, mental fatigue after MD+1 may reflect the absence of a full recovery in the mental fatigue caused by the last match, due to this training was not defined as high mentally fatiguing by players. The mental and emotional demands of soccer game scenarios were defined previously, ant this study confirms that soccer lead in a state of mental fatigue that remain increased 24 h after the match has finished.

The third finding was that semiprofessional soccer players identified the trainings of the play-offs phase as more mentally fatiguing than the trainings of the regular season. This is the first study that check it on soccer, however, the result of the present study supports the findings of another previous study that study the longitudinal evolution of mental fatigue during two full netball seasons.[19] As explained in the introduction, this study concluded that mental fatigue significantly fluctuates across a season, similarly to the changes observed in this study from regular season to play-offs. The significantly higher values of

mental fatigue reported after MD-1 in the regular season may suggest that coaches tried to decrease the presence of mental fatigue before play-offs matches. It may seem easy to understand, due to the performance during play-offs determining the promotion or not. However, the results reported after MD+1 and MD-4 indicate that it may exist intrinsically factors associated to play-offs that could increase the feelings of mental fatigue in semiprofessional soccer players. This affirmation is based in the absence of significant differences in mental load between phases, meanwhile mental fatigue was significantly higher after MD+1 and MD-4 in the play-off phase. Therefore, we cannot explain these highest values of mental fatigue by a consequence of the training load. It could be caused by a consequence of the emotional efforts that players may have during the play-off phase, influenced by the rewards that it could obtain in case to promote. It could be also an accumulation of mental fatigue along the season.[15] In both cases, based on these results, coaches should considerer a special attention to mental during the play-off phase, where an excessive accumulation of mental fatigue may determinate promotion or not. As Russell et al.[21] explained, performance competitions outcomes are determined by very small margins of difference, therefore, reducing the impact of mental fatigue on performance has potential to be significant.

Other important finding of the study is the non-observed differences in the tendencies of mental fatigue between phases when compared the two teams, although a significant difference in the quantity of mental fatigue was observed between trainings. It remarks the needed to individualize the management of the mental fatigue in each team and players. In this regard, coaches and players may be also carefully in the specific associated-mental fatigue to other contextual factors: on one hand, Thompson et al.,[5] concluded that more research is needed to know if associated-factors to play soccer matches as travels, interviews and other external factors as works elicit mental fatigue in adult soccer players; on the other hand, Russell et al.[7] reported that athletes and coaches think that environment, over-analysis or experience mediated mental fatigue and its effects. All this information highlights the needed to individualize mental fatigue and its management in each player.

A secondary purpose of this study was to check the effect of time played on the mental fatigue reported in each training comparing between the regular season and the play-offs. The main findings were: (1) in MD-1, players that played 0′ significantly decrease their RPE from the regular season to play-offs, (2) players that played 0′ significantly change their cognitive exigences reported from the regular season to the play-offs in MD-1 (increase) and MD+1 (decrease), (3) players that played 0′ significantly increase their emotional exigences in MD+1 during play-offs compared to the regular season, meanwhile they also significantly decrease their emotional exigences in MD-4 and MD-1 causing significant differences with respect the other groups of players and (4) no changes in the behavior of the mental fatigue from the regular season to the play-offs were observed in any of the groups defined.

The interpretation of the levels of mental fatigue after sport situations may be difficult by the interaction between different factors as engagement.[15] Engagement may be a difficult situation during soccer trainings in usual substitutes or players that did not played minutes frequently. This situation was reflected in the results of the present study. As explained, the finding revealed that players that played 0′ significantly decrease their RPE, cognitive, and emotional exigences during different trainings in the play-offs phase compared to the regular season. Usually, these impairments occurred on MD-1 or MD+1, which suggests an effect of time played on engagement. More information is needed to test the relation between these variables. However, these results suggest that time played could be a potential variable to considerate in the state of art of the mental fatigue caused by soccer. In the same form, season phase could appear as an important factor in this topic. Coaches should considerer this information to optimize the levels of mental fatigue in most of their players. This may be difficult based on the individual differences between players.

All this information remarks the importance that coaches should give to mental fatigue. Firstly, we like to remark the importance of include measurements of mental fatigue in training and matches.[19] It allows coaches to know the state of their players and perform a correct planification and management of mental fatigue consequently. Secondly, it highlights the needed to planify and manage the mental fatigue caused by trainings (see the Section 6.2 for more information about how mentally fatiguing different soccer trainings and constraints are). In a general approximation to the concept, coaches should use non-mentally fatiguing constraints nearly the matches (i.e., MD-1) to avoid the presence of high levels of mental fatigue and its effects on performance, but also, coaches should use mentally fatiguing constraints in the main-development trainings of the week (i.e., MD-4 or MD-3) to train the resistance to mental fatigue and its effects.[16] Thirdly, coaches and players should identify other factors that may influence on the mental fatigue of the players (e.g., travels, other jobs, high-difficult matches or interviews[5]). If needed, coaches and players should know that mental fatigue and its effects may be counterattacking by ergogenic aids as caffeine (acute effect) or creatine (chronic effect), music, or motivation.[29]

5 | PERSPECTIVE

The present study can also be extended from a theoretical and practical perspective. From a theoretical viewpoint, this work represents the first study that have investigated changes in mental fatigue across training days in soccer athletes. Also, a comparison between season phases was performed. This knowledge responds to the demands of several highlighted researchers in the topic of mental fatigue in application to high-performance sporting practice. These researchers suggested the needed to quantify the evolution of the mental fatigue in longitudinal studies.[10,21] Indeed, this study has been performed from an ecological perspective, which seems of importance to provide information of athletes experiences during their day to day training and competition demands.[10] This information may be of interest for coaches in the practical management of the mental fatigue. Based on the results obtained, we recommended to avoid the use of mentally fatiguing tasks on MD+1, meanwhile mental fatigue on MD+3 and MD+4 should be manipulated according to the specifics needs of the sport and team. Coaches should use soccer constraints according to the mental fatigue -specifical state of their players.[17,18] Previously, this information was available for physical fatigue only.

6 | CONCLUSIONS

The present study indicates that mental fatigue remains increased for 24 h after the match has finished. With respect the evolution of the mental fatigue during competitive weeks, the highest values of mental load during the training weeks were found in MD-4 and MD-3 in both phases, with a significant decrease in this variable nearly competitions. Comparing between phases, higher mental fatigue was reported during the play-offs than in the regular season, without significant changes in the mental load reported between season phases. With regard the influence of time played on mental demands, players that played 0′, significantly decreased their mental load during the play-offs compared to the RS, compared to those that played 45′ or more.

6.1 | Study limitations and future guidelines

The present study showed different limitations that we should consider. The main limitation of the present study is that only subjective indicator of mental load and mental fatigue were recorded. This did not include behavioral neither physiological indicator of mental fatigue. On the contrary, we like to highlight the difficult to obtain this ecological information in two different competitive teams along 10 weeks. Obtain this information may be so difficult in a real context, due to practical challenges of data collection using objective and physiological measures within the daily training and competition environment. In future studies, we are going to try to include other measures of mental fatigue as reaction time or electroencephalography.

Similarly, the presence of only two teams is another limitation of the study. To counterattack this limitation, we recorded information along a total of 10 weeks of each team. To counterattack these limitations, we tried to control all the factor that could influence on mental fatigue to check the effect of the season phase specifically. It is recommended future studies collect a complete season of data.

Another important limitation of these (and typical of ecological designs) is the difficulty to control certain aspects as food intake or schedule. The initial idea of the study included to refrain from the consumption of caffeine in the 12 h before the training and matches and to avoid creatine supplementation during the study, due to previous benefits reported by these supplements on mental fatigue and its effects.[29] However, this study was conducted in a real scenario with teams that were fighting to promote; then, based on the proved benefits of caffeine on soccer performance, it was not possible (coaches rejected it). In future studies, rather than asking participants to abstain from caffeine, suggestion would be to allow their usual habitual consumption, but record this dosage/amount/frequency and include this as a variable in analysis and interpretation. With regard the schedule, all the measures were obtained after trainings (9 p.m., as indicated in the Section 2). Besides of all the measures were obtained at the same time to counterattack it, the level of mental fatigue at this time may be also influenced by the potential tendency for mental fatigue to accumulate over a day of tasks which are cognitively demanding.

Other limitation of the study is that time played was included in ranges of minutes played. Future works should include the specific minutes played by players.

Practical applications

- The highest values of mental fatigue appear on MD+1, therefore, coaches should use mental fatigue recovery strategies or avoid the presence of mentally fatiguing task 24 h after the last match to guarantee a good recovery of mental fatigue in soccer player for the main training days (MD-4 and MD-3).
- Based on the result of the present study, coaches have strategies to consciously manipulate and organize mental fatigue. They should avoid the presence of mental

fatigue close to competitions. There are a line of studies investigating the effects of different soccer tasks constraints on mental fatigue. The authors have concluded that the active participation of the coach is more mentally fatiguing than the non-participative presence of the coach[18]; that the associated increase in the time pressure caused by start a soccer task losing results in more mental fatigue than the normal (i.e., 0–0 draw) start[30]; or that the associated-cognitive complexity caused by include a rule where certain number of different players must participate to obtain a valid goal is more mentally fatiguing that non-normal restriction conditions.[17] All this information may be used to manipulate the cognitive load of sports trainings.[31]

- Due to the presence of mental fatigue in a soccer context is inescapable, the use of training focused on the resistance to mental fatigue[32] may be also a good option to decrease the negative effect that this variable causes on soccer performance.
- Play-offs phase implies a significant increase in mental fatigue, therefore, special attention should be applied on this variable during this competitive phase.
- Coaches should considerer the time played by players to individualize the trainings and the information with respect to mental fatigue. It may allow a correct manage of mental fatigue according to the individual differences between players.

FUNDING INFORMATION

This work was supported by the Assistance to Research Groups (GR18102) of the Junta de Extremadura (Ministry of Employment and Infrastructure); with the contribution of the European Union through the European Regional Development Funds (ERDF). Also, this research was supported by an FPU PhD candidate grant from the Government of Spain (Ministry of Education, Culture and Sports) to Díaz, J. (FPU18/03660).

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

ORCID

Jesús Díaz-García https://orcid.org/0000-0002-9430-750X
Luca Filipas https://orcid.org/0000-0002-3828-9626
Ana Rubio-Morales https://orcid.org/0000-0003-1062-1989
Tomás García-Calvo https://orcid.org/0000-0002-2550-418X

REFERENCES

1. Coutinho D, Gonçalves B, Wong DP, Travassos B, Coutts AJ, Sampaio J. Exploring the effects of mental and muscular fatigue in soccer players' performance. *Hum Mov Sci*. 2018;58:287-296.
2. Silva JR, Rumpf MC, Hertzog M, et al. *Acute and Residual Soccer Match-Related Fatigue: A Systematic Review and Meta-Analysis*. Springer International Publishing; 2018:539-583.
3. Nedelec M, McCall A, Carling C, Legall F, Berthoin S, Dupont G. Recovery in soccer: part I-post-match fatigue and time course of recovery. *Sports Med*. 2012;42:997-1015.
4. Fink A, Bay JU, Koschutnig K, et al. Brain and soccer: functional patterns of brain activity during the generation of creative moves in real soccer decision-making situations. *Hum Brain Mapp*. 2019;40:755-764.
5. Thompson CJ, Noon M, Towlson C, et al. Understanding the presence of mental fatigue in English academy soccer players. *J Sports Sci*. 2020;38:1524-1530.
6. Van Cutsem J, Marcora S, De Pauw K, Bailey S, Meeusen R, Roelands B. The effects of mental fatigue on physical performance: a systematic review. *Sports Med*. 2017;47:1569-1588.
7. Russell S, Jenkins D, Rynne S, Halson SL, Kelly V. What is mental fatigue in elite sport? Perceptions from athletes and staff. *Eur J Sport Sci*. 2019;19:1367-1376.
8. Van Cutsem J, Van Schuerbeek P, Pattyn N, et al. A drop in cognitive performance, whodunit? Subjective mental fatigue, brain deactivation or increased parasympathetic activity? It's complicated! *Cortex*. 2022;155:30-45.
9. Rubio-Morales A, Díaz-García J, Barbosa C, Habay J, López-Gajardo MA, García-Calvo T. Do cognitive, physical, and combined tasks induce similar levels of mental fatigue? Testing the effects of different moderating variables. *Motor Control*. 2022;1:1-19.
10. Thompson CJ, Fransen J, Skorski S, et al. Mental fatigue in football: is it time to shift the goalposts? An evaluation of the current methodology. *Sports Med*. 2019;49:177-183.
11. Coutts AJ. Fatigue in football: it's not a brainless task! *J Sports Sci*. 2016;34:1296.
12. Smith MR, Coutts AJ, Merlini M, Deprez D, Lenoir M, Marcora SM. Mental fatigue impairs soccer-specific physical and technical performance. *Med Sci Sports Exerc*. 2016;48:267-276.
13. Badin OO, Smith MR, Conte D, Coutts AJ. Mental fatigue impairs technical performance in small-sided soccer games. *Int J Sports Physiol Perform*. 2016;11:1100-1105.
14. Filipas L, Borghi S, La Torre A, Smith MR. Effects of mental fatigue on soccer-specific performance in young players. *Sci Med Footb*. 2021;5:150-115.
15. Van Cutsem J, Marcora S. The effects of mental fatigue on sport performance. In: Englert C, Taylor I, eds. *Motivation and Self-Regulation in Sport and Exercise*. Routledge; 2021:134-148.
16. Russell S, Jenkins DG, Halson SL, Juliff LE, Kelly VG. How do elite female team sport athletes experience mental fatigue? Comparison between international competition, training and preparation camps. *Eur J Sport Sci*. 2022;22:877-887.
17. García-Calvo T, Pulido JJ, Ponce-Bordón JC, López-Gajardo MA, Costa IT, Díaz-García J. Can rules in technical-tactical decisions influence on physical and mental load during soccer training? A pilot study. *Int J Environ Res Public Health*. 2021;18:1-8.

18. Díaz-García J, Pulido JJ, Ponce-Bordón JC, Cano-Prado C, López-Gajardo MA, García-Calvo T. Coach encouragement during soccer practices can influence players'mental and physical load. *J Hum Kinet*. 2021;79:277-288.
19. Russell S, Jenkins DG, Halson SL, Juliff LE, Connick MJ, Kelly VG. Mental fatigue over 2 elite netball seasons: a case for mental fatigue to be included in athlete self-report measures. *Int J Sports Physiol Perform*. 2022;17:160-169.
20. Díaz-García J, González-Ponce I, López-Gajardo MÁ, Van Cutsem J, Roelands B, García-Calvo T. How mentally fatiguing are consecutive world padel tour matches? *Int J Environ Res Public Health*. 2021;18:9059.
21. Russell S, Jenkins D, Smith M, Halson S, Kelly V. The application of mental fatigue research to elite team sport performance: new perspectives. *J Sci Med Sport*. 2019;22:723-728.
22. Abbott W, Brownlee TE, Naughton RJ, Clifford T, Page R, Harper LD. Changes in perceptions of mental fatigue during a season in professional under-23 English premier league soccer players. *Res Sports Med*. 2020;28:529-539.
23. Díaz-García J, González-Ponce I, Ponce-Bordon JC, López-Gajardo MA, García-Calvo T. Diseño y validación del Cuestionario para valorar la Carga Mental en los Deportes de Equipo (CCMDE). *Cuad Psicol Deporte*. 2021;21:138-145.
24. Ishii A, Tanaka M, Watanabe Y. Neural mechanisms of mental fatigue. *Rev Neurosci*. 2014;25:469-479.
25. Pageaux B, Lepers R. The effects of mental fatigue on sport-related performance. *Prog Brain Res*. 2018;240:291-315.
26. R-Studio Team. *RStudio: Integrated Development for R*. RStudio; 2020.
27. Bates D, Machler M, Bolker B, Walker S. Fitting linear mixed-effects models using lme4. *J Stat Softw*. 2015;67:1-48.
28. Los Arcos A, Mendez-Villanueva A, Martínez-Santos R. In-season training periodization of professional soccer players. *Biol Sport*. 2017;34:149-155.
29. Proost M, Habay J, De Wachter J, et al. How to tackle mental fatigue: a systematic review of potential countermeasures and their underlying mechanisms. *Sports Med*. 2022;52:2129-2158.
30. Ponce-Bordón JC, García-Calvo T, López-Gajardo MA, Díaz-García J, González-Ponce I. How does the manipulation of time pressure during soccer tasks influence physical load and mental fatigue? *Psychol Sport Exerc*. 2022;63:1-22.
31. Russell S, Kelly VG, Halson SL, Jenkins DG. Cognitive load in sport. In: Salmon PM, McLean S, Dallat C, Mansfield N, Solomon C, Hulme A, eds. *Human Factors and Ergonomics in Sport: Applications and future directions. Human Factors and Ergonomics in Sport*. CRC Press; 2020:181-200.
32. Filipas L, Martin K, Northey JM, La Torre A, Keegan R, Rattray B. A 4-week endurance training program improves tolerance to mental exertion in untrained individuals. *J Sci Med Sport*. 2020;23:1215-1219.

How to cite this article: Díaz-García J, Filipas L, La Torre A, Gómez-Rivera J, Rubio-Morales A, García-Calvo T. Mental fatigue changes from regular season to play-offs in semiprofessional soccer: A comparison by training days. *Scand J Med Sci Sports*. 2023;33:712-724. doi:10.1111/sms.14301