Padel Scientific Journal, Vol. I (2023) 7-22, ISSN: 2952-2218

https://doi.org/10.17398/2952-2218.1.7

HOW DOES MENTAL FATIGUE INFLUENCE COGNITIVE PROCESSES DURING PADEL COMPETITION? A PRELIMINARY STUDY OF GENDER DIFFERENCES

CÓMO INFLUYE LA FATIGA MENTAL EN LOS PROCESOS COGNITIVOS DURANTE LA COMPETICIÓN EN PÁDEL? ESTUDIO PRELIMINAR DE LAS DIFERENCIAS DE SEXO

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Recibido: 29/06/2022 Aceptado: 30/11/2022

ABSTRACT

Purpose: To quantify the evolution of mental fatigue during an official padel competition. Also, to test the influence of gender on mental fatigue, and the correlation between fatigue, effort perceptions and motivation. **Method:** Mental load and fatigue, motivation and ratio of perceived exertion of 18 semi-professional padel players (11 males, Mage = 33.68, SDage = 8.36, and 7 females, Mage = 30.70, SDage = 2.36) were quantified with Likert's scales after three official matches. Repeated measures of ANOVA, with gender like a co-variable, pairwise comparisons when significance was detected and paired *t*-test when significance was not detected were performed. Pearson's test was performed to clarify the relation between variables. **Results:** A significant main effect in repeated measures appears for mental fatigue, without gender differences (F = 8.85; p = .02 in males; F = 5.70; p = .03 in females). This main effect has not been observed for mental load neither effort perception in both genders. Bivariate correlations also suggested that higher levels of mental fatigue and motivation increased the effort perceptions. **Conclusion:** Playing successive padel matches produced an accumulation of mental fatigue that increased the subjective feelings of mental fatigue. This only occurs between matches played the same day. Players with higher levels of motivation showed higher effort perceptions. They might imply more physical and cognitive resources during matches.

Keywords: fatigue, motivation, psychology, recovery.

Introduction

Padel is a doubles racket sport with similar tennis' rules and the same scoring system played inside an enclosed glass and metal court of 10x20 meters with side and back walls that can be used during the game (Courel-Ibáñez et al., 2017). The impact of this sport around the world is growing, due to an important evolution in the number of players has been observed in European and American countries like Spain, Portugal, Sweden, Italy, England, Belgium, Brazil or Argentina (International Padel Federation [FIP], 2020). Indeed, the studies published about padel have significantly increased, where the conditional (Castillo-Lozano & Casuso-Holgado, 2017; Hoyo-Lara et al., 2007) and the technico-tactical (Courel-Ibáñez et al., 2017; Escudero-Tena et al., 2020) competition demands of this sport have nicely been described. However, to our knowledge there are no studies that have analysed the possible role of mental aspects during padel's competitions.

Padel requires repeated short bouts of high-intensity efforts interspersed

with higher times of rest that could cause physical fatigue (García-Benítez et al., 2018). Padel also implies complex tactical decisions to resolve competition problems by selecting the most appropriate solutions at high speed in an unpredictable environment (Courel-Ibáñez et al., 2017), a process that implies mental effort. The mental effort necessary to solve the aims of the task has been defined as mental load (García-Calvo et al., 2019), and it has tested that prolonged and/or intense periods of high mental effort could produce mental fatigue. Therefore, padel's players likely experience mental fatigue during competition. Mental fatigue is a psychobiological state with subjective (i.e., increased feelings of tiredness or decreased in motivation), behavioural (i.e., declined in reaction time) and physiological consequences in humans (i.e., alteration in brain activity) that might decrease the physical and psychomotor skills involved in performance, and accompanied by increases in the perceived physical fatigue (van Cutsem et al., 2017). These impairments associated to mental fatigue are not mediated by the traditional systems that support the sport performance (i.e., heart rate or lactate levels), thus the role of the brain in these processes became evident (van Cutsem et al., 2020).

It has been tested that acute increases of mental fatigue values decrease the ball speed and the accuracy of the shoots in table-tennis' players (le Mansec et al., 2018). It is also demonstrated that mental fatigue impairs the capacity to perform specific motor skills in racket sports (Kosack et al., 2020), the physical performance through increases in the efforts' perception (van Cutsem et al., 2017) and the cognitive performance (van Cutsem et al., 2020). Although there is evidence that high levels of motivation could counterattack the negative effects of mental fatigue (Herlambang et al., 2019; McMorris, 2020), this previous information clearly indicates a negative influence of mental load and fatigue might be present on padel performance as well.

The effects of mental fatigue on padel performance must be analysed both from an acute and chronic point of view, due to padel competitions imply successive matches in the same day or during consecutive days. A previous study has showed that feelings of mental fatigue could affect participants during an hour before mental activity have finished, while the negative effects of mental fatigue on reaction times remained 15 minutes following its application (Junior et al., 2020). This residual effect could negatively affect the performance in players that have more than a game per day, a very common situation during semi-professional competitions and qualified rounds in professional tournaments that coaches should take into consideration. However, no studies have quantified the evolution of mental fatigue during a competitive week (Russell et al., 2019). Also, padel coaches frequently train

both males and females players. Previous studies have tested that there are no differences between males and females in mental fatigue's effects (Jaydari-Fard & Lavender 2019; Lopes et al., 2020). However, it has not been tested in racket sports. Indeed, a previous study had suggested that the mental load reported at the beginning of the tasks was higher in untrained females than males (Lopes et al., 2020), which in a padel match may cause a different evolution of mental aspects between genders. Indeed, If the mental fatigue or mental load perceptions were different between gender, the training strategies and the coaching during competition would be different for males and females, with important practical applications at trainings and competitions.

This previous information triggered the interest to measure the mental fatigue during a padel competition. Therefore, the main objective of the present study was to quantify the evolution of mental fatigue during a padel official competition. The differences per gender were also analysed in this evolution. A secondary objective of the present study was to test the relation between mental load, mental fatigue, ratio of perceived exertion and motivation.

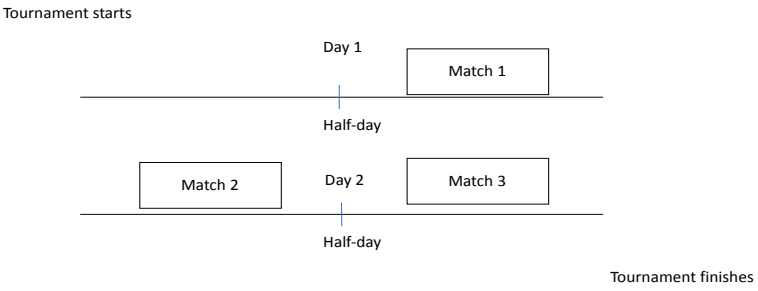
We hypothesized that a residual effect of mental fatigue would increase the subjective feelings of mental fatigue in successive matches (*Hypothesis 1)*, according to the results of Junior et al. (2020). Also, based on Jaydari-Fard & Levender (2019), and Lopes et al. (2020) we hypothesized that no differences between male and females' players on mental fatigue were reported (*Hypothesis 2)*. Finally, we hypothesized that higher values of mental fatigue would increase the effort perceptions (*Hypothesis 3A)* based on van Cutsem et al. (2017), while higher values of motivation would increase the effort and fatigue perceptions (*Hypothesis 3B)* based on Herlambang et al. (2019).

Material and Methods

Participants

A priori G∗Power 3.1 analysis was used to calculate sample size requirements (Faul et al., 2009). Power analysis indicated that the sample size required was at least of 14 participants, resulting in a power of 0.75 (α = 0.05, f = 0.25). Eighteen Spanish semi-professional padel players (11 males, Mage = 33.68, SDage = 8.36, and 7 females, Mage = 30.70, SDage = 2.36), according to Swann et al. (2015) participated in this study. All participants had a minimum experience of five years playing padel. Also, they practiced padel almost three days per week, with a training regime of at least 3 hours by week. A specific criterion to participate was that they had to play three matches at a Spanish national padel competition in 2019 with the next schedule: Day one = 1 game per day, previous quarter-final round in the afternoon; day two = 2 games per day, previous semi-final in the morning and previous final in the afternoon.

Figure 1.- *Temporal distribution of the matches played*



Instruments

Questionnaire to Quantify the Mental Load. To quantify the mental load the Questionnaire to Quantify the Mental Load (QQML) in sports was used (Díaz-García, González-Ponce, et al., 2021). This questionnaire is composed by four items: physical effort perceived (How much physical activity was required?), cognitive demands (How much cognitive effort was required?), difficulty to control the emotions (How difficult is control the emotions?), and pressure caused by the interdependence level (How much affective effort was required?). The range of responses of each item were in format of Likert's

Scale (0-10), where 0 was the minimum effort perceived and 10 was the maximum possible effort perceived.

VAS fatigue. The 10-cm Visual Analogue Scale (VAS) was used to quantify the 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 (Arney et al., 2019). Participants 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".

RPE. The Rating of Perceived Exertion (RPE) was measured to know the internal values of physical fatigue reported by players. The participants were instructed to report the level of physical fatigue they experienced in a format of Likert's Scale (0-10), where 0 was the minimum effort perceived and 10 was the maximum possible effort perceived (van Cutsem et al., 2020).

Motivation. How motivated was the last match? Was also asked. The range of responses of this item were in format of Likert's Scale (0-10), where 0 was the minimum and 10 was the maximum level possible. It was used in previous studies about padel and cognitive and motivational variables (Díaz-García et al., 2021).

Procedures

All participants were informed about the objectives of the study and signed a participation-agreement according to the Local Ethics Committee. Also, the data were treated according to the ethics and privacy of the *American Psychology Association*.

The national federation approved the request of the researchers to start this study. Therefore, the researchers contacted players to explain the aims of the study and asked about their intention to participate. Next, the researchers explained to all the players the items of the questionnaire (by an online meeting) and they sent a link from the participants to access all questionnaires. During the competition, the researchers emphasized (in person) to the players the importance of answering the questionnaires as soon as possible after they finished their matches, in a maximum range of 30 minutes after matches finished.

Data analysis

To analyse the data, the SPSS 25.0 statistical programme was used. Data was showed as Mean ± Standard Deviation. The Shapiro-wilk normality test was performed, showing normal distribution for the mental fatigue, mental load, RPE and motivation. Sphericity was verified by Mauchly's test; when the assumption of sphericity was not met, the significance of *F* ratios was adjusted with the Greenhouse-Geisser procedure. Also, the Levene's test was used for evaluating the homogenising the variance. Repeated measures of ANOVA were used to compare values of these dependent variables for each after-match time point (three matches). To detect an effect of the fatigue and load measures during the competition we also performed paired samples t-test between each pair of matches. The gender was included like co-variable, to tested possible differences between males and females' players in the evolution of the dependent variables. Follow-up pairwise comparisons were performed when significance was detected. A paired *t*-test was performed between matches and genders when significance was not detected in the repeated measures. An analysis of the bivariate correlation through the Pearson's test was performed between mental fatigue, mental load, ratio of perceived exertion and motivation in each match. Statistical significance was set at $p < .05$.

Results

The evolution of mental fatigue, mental load, physical exertion and motivation during the competition by gender were showed in Table 1.

Table 1

Evolution of mental aspects and RPE during competition. Differences per gender.

		Match 1		Match 2		Match 3		Evolution	
Variables		Males	Females	Males	Females	Males	Females	Males	Females
Mental fatigue	*M*	6.45	5.29	4.27	3.43	7.27	6.86	*F* = 8.85;	*F* = 5.70;
	SD	±2.25	±2.05	±2.15	±1.40	±1.10	±2.04	*p* = .02*	*p* = .03*
	t(*p*)	-1.17 (.28)		-.84(.37)		.41(.58)		(a, c)	(a, c)
Mental Load	*M*	6.18	5.10	6.50	5.10	6.16	5.25	*F* = .08;	*F* = .36;
	SD	±2.28	±2.85	±2.49	±2.03	±2.17	±3.22	*p* = .86	*p* = .71
	t(*p*)	-1.08(.39)		-1.39(.25)		-.91(.48)			
RPE	*M*	5.91	4.43	6.00	4.00	5.45	4.57	*F* = .16;	*F* = .43;
	SD	±2.34	±2.87	±2.49	±2.16	±2.46	±3.65	*p* = .83	*p* = .66

	t(*p*)	-1.48(.25)		-2.00(.10)		-1.12(.31)			
	M	7.07	6.73	7.20	5.00	7.18	4.86	*F* = .05;	*F* = .07;
Motivation	*SD*	±2.54	±3.58	±2.68	±2.26	±2.31	±2.48	*p* = .89	*p* = .87
	t(*p*)	-.28(.78)		-2.13(*)		-2.02(*)			

Note. *$p < .05$. a = significant differences between Match 1 and Match 2; b = significant differen-ces between Match 1 and Match 3; c = significant differences between Match 2 and Match 3.

A significant main effect was found in the repeated measures for mental fatigue when compared the three competition matches. The pairwise comparison showed that mental fatigue reported was significantly higher in the Match 1 than in the Match 2 in both genders ($p < .01$ in males; $p = .02$ in females), meanwhile mental fatigue was significantly lower in the Match 2 than in the Match 3 ($p < .001$ in males; $p < .001$ in females) in both genders. The mental fatigue reported after the Match 3 was higher than in the Match 1, although no significant differences were observed ($p = .79$ in males; $p = .87$ in females). No significant differences were observed between genders in the mental fatigue of each match, although the mental fatigue reported in the Matches 1, 2 and 3 were higher in males. No significant main effects were observed in the repeated measures for mental load and RPE. The *t*-test showed no significant differences in these variables from Match 1 to Match 3 ($p = .36$ for mental load; $p = .42$ for RPE), from Match 2 to Match 3 ($p = .43$ for mental load; $p = .57$ for RPE), neither from Match 1 to Match 3 ($p = .29$ for mental load; $p = .49$ for RPE). No significant differences in each match were also observed between genders for mental load and RPE, meanwhile, the mental and physical effort perceptions had no influence on the effort perceptions of successive matches. No significant main effect was observed for motivation levels in the repeated measures. The *t*-test showed that motivation values of all matches were higher in males. Significant differences were observed in Matches 2 ($p = .04$) and 3 ($p = .05$) between males and females. Also, a significant decrease was observed in females' motivation from Match 1 to Match 3 ($p < .01$), without significant changes in males' players.

The results about the correlation between mental fatigue, mental load, RPE and motivation were showed in Table 2.

Table 2

Relations between mental fatigue, mental load, RPE and motivation values.

	Match 1				Match 2				Match 3			
Variables	1	2	3	4	1	2	3	4	1	2	3	4
Mental fatigue	-	-	-	-	-	-	-	-	-	-	-	-
Mental Load	.46*	-	-	-	.34	-	-	-	.59*	-	-	-
RPE	.17	.64*	-	-	.17	.85*	-	-	.50*	.88*	-	-
Motivation	.35	.62*	.27	-	.41*	.82*	.74*	-	.33	.16	-.01	-

Note. *p < .05; 1 = Mental fatigue; 2 = Mental Load; 3 = RPE; 4= Motivation

There is a significant correlation between mental fatigue and mental load in Matches 1 (p = .02) and 3 (p = .01), without significant correlations in Match 2 (p = .34). Also, mental fatigue and RPE showed significant correlations in Match 3 (p = .03), but not in Matches 1 (p = .41) and 2 (p = .43). Motivation showed significant correlations with mental load in Matches 1 (p = <.001) and 2 (p = <.001), RPE in Match 2 (p =. <.001) and mental fatigue in Match 2 (p = .04).

Discussion

The main purpose of this study was to quantify the evolution of the mental fatigue and efforts perceptions reported by players during an official semi-professional padel competition, and, also, to test the effects of gender on this evolution. A secondary objective of this study was to test the correlation between mental load, mental fatigue, RPE and motivation. The main findings of this study showed that padel matches have a residual effect of mental fatigue that increase the subjective mental fatigue reported by players in the next matches', only when players play more than 1 game per day and without effects between consecutive matches played at different days. This residual effect appeared both in males and females padel players without

significant differences. This residual effect was not found mental load, motivation and RPE. A significant difference was observed in motivation values between genders, with higher values in males. Also, the bivariate correlation showed that higher levels of mental fatigue could increase the effort perceptions of participants, meanwhile higher levels of motivation increased their effort and fatigue perceptions although this mechanism could be limited in presence of higher levels of mental fatigue.

The *Hypothesis 1* indicated that exists a residual effect of mental fatigue on successive matches' levels of mental fatigue. According to the results of the present study, this residual effect exists when padel players participate in more than 1 match per day. The presence of this residual effect is reinforced by the quantification of the RPE, mental load and motivation, due to these variables have not significant differences between matches. Thus, they could depend on each match characteristics (duration, environmental conditions…). Padel matches imply complex tactical environment (Courel-Ibáñez et al., 2017), therefore, padel matches could produce mental exertion. In a previous study, Junior et al. (2020) reported higher levels of mental fatigue reported after a Stroop Task for 15 minutes after the Stroop Task had finished. The present study shows that padel competitions produce mental fatigue, meanwhile the residual effects of this mental fatigue increased the mental fatigue reported in consecutive matches played the same day although the time between matches is higher than one hour. The mechanism that produces this phenomenon remains unknown (Ishii et al., 2014), although the extracellular adenosine could be an underlying variable that could explain this effect (Smith et al., 2019). Thus, the time necessary to avoid the physiological causes of mental fatigue could cause this residual effect. The effects of mental fatigue on padel performance and the benefits of caffeine or creatine's ingestion on mental fatigues' residual effect have to be proved (van Cutsem et al., 2018; van Cutsem et al., 2020) in future studies.

On the contrary, this residual effect of mental fatigue has not been observed between different days. The Match 2 (day two at the morning) shows the smallest reported values of mental fatigue, while the Match 3 (the only that has a previous match in the same day) shows the higher values of mental fatigue. With regard Match 1, some contextual factors as travels or studies could also increase the levels of mental fatigue in athletes, although no previous matches were played during the day (Thompson et al., 2020). One possible explanation is that the recovery of mental fatigue may happen after certain time of recovery (the recovery time between matches 1 and 2 was higher than this value between matches 2 and 3). Other possible explanation

of this no residual values of mental fatigue between days could be the effects of sleep on mental fatigue (Ishii et al., 2014; Russell et al., 2019). High quality of sleep could decrease the mental fatigue, the anxiety and the stress values, due to a decrease in the cognitive processes. Therefore, the no residual effect of mental fatigue between matches played at different days might be explained by a higher recovery time or the influence of the sleep. In future studies, experts have to test the effects of the sleep quality on mental fatigue recovery.

The *Hypothesis 2* indicated that there are no differences between males and females on mental fatigue levels during matches. The results of this study have tested this affirmation, due to no gender's differences were observed in mental fatigue values between competition matches. These results agree with the information provided by Jaydari-Fard & Levender (2019), and Lopes et al. (2020). These authors tested the effect of mental exertion task on mental fatigue reported by participants of both genders, and no differences between genders were observed. Based on these results, coaches that train players for both genders have to take account equally the evolution of mental fatigue during the competition, as it was described in the previous paragraph.

Mental load, RPE, motivation and mental fatigue values are higher in males players compared to female ones. Previous studies suggested that the mental effort is influenced by the specific characteristic of each task (Herlambang et al., 2019; Ishii et al., 2014). However, no previous study suggested differences in the difficult of the padel matches between males and females. Thus, a possible explanation is that these differences between genders could be caused by the importance that players give to the results (ego or extrinsic motivation). This assumption was based in the high punctuation that male's players reported in motivation, while females decrease the motivation values during the tournament. The high extrinsic motivation of males' players on padel competitions have previously been reported by Courel-Ibañez et al. (2018). Herlambang et al. (2019) tested the effects of the extrinsic motivation in the impairment produced by a mental exertion task. These authors reported that higher levels of motivation could increase the importance that participants give to the tasks, thus higher levels of motivation imply higher efforts and, also, an increase in the fatigue values. The results of the present study suggested that male players have higher values of extrinsic motivation, and it implies higher values of efforts and fatigue. Although more studies are needed to test this affirmation, the coach's strategies during the games should be different between genders to optimize the subjective measures of motivation and their influence on load and fatigue.

The *Hypothesis 3A* indicated that higher levels of mental fatigue induced higher levels of effort. This study provides no support for this assumption, due to the lack of higher values of physical and mental load reported in presence of mental fatigue. A previous study has tested that the acute increase of mental fatigue levels impairs the physical performance in endurance's sports by the increases in the effort perceptions (van Cutsem et al., 2017). Only in the Match 3 the present study shows similar results to these authors. One possible explanation is the difference between sports in the assimilation of mental fatigue (Russell et al., 2019). This is the first study that has tested this hypothesis in racket sports. Endurance sports produce incremental efforts that finish with exertion. These sports could have the capacity to obtain a negative influence of mental fatigue on physical performance. However, the mental and physical demands of padel competitions are different. Padel competitions could need several successive matches to produce a certain level of mental exertion that increase the physical effort perception. Thus, this relation between mental fatigue and an increase in the effort perception might be present only when padel players play more than one match per day.

Finally, the *Hypothesis 3B* indicated that higher levels of motivation increased the effort perceptions reported by players. The results of the present study suggested that higher levels of motivation could increase the effort perceptions. Herlambang et al. (2019) supported that participants with higher levels of motivation increase the effort perception tolerance to decrease the impairments that mental fatigue causes on accuracy and performance. Thus, players with higher level of motivation probably give more importance to padel matches and they showed higher implications that increased the effort perceptions. Therefore, motivation strategies and management of motivation by coaches seem to reveal important variables for future padel studies, with important practical applications.

Conclusions

According to the results showed in the present study, the authors concluded that the mental fatigue induced by a padel match on players has a residual effect that increases the levels of mental fatigue reported in the next matches played in the same day without genders differences. Also, we can conclude that this residual effect was not found for the mental load, motivation and the RPE. There are evidences that male players have higher values of motivation and that higher levels of motivation increase the efforts perceptions.

Practical applications

The present study suggests the presence and accumulation of mental load and fatigue during padel tournaments. Then, it seems necessary that players and coaches know strategies to counterattack the accumulation of mental load and fatigue and its possible negative effects on performance. Firstly, the management of the training load may be an important question for this purpose. Coaches should avoid the presence of mentally fatiguing trainings nearly competitions to avoid the presence of mental fatigue immediately before tournaments. But it would be nice that players train under mentally fatiguing conditions far of competitions to train the tolerance versus mental fatigue and its effects. Secondly, players may use ergogenic aids as caffeine or creatine during competitions to counterattack mental fatigue (van Cutsem et al., 2018).

Funding details:

This research was supported by an FPU PhD candidate grant (Ministry of Education, Culture and Sports) to Jesús Díaz-García (FPU18/03660).

Ethics:

This study received the approved of the local Ethics Committee (protocol number: 93/2020).

Disclosure statement

The authors report no conflict of interest.

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