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Psychophysiological Responses and Cognitive Performance: A Systematic Review of Mental Fatigue on Soccer Performance

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Abstract

Background: Successful performance in soccer is associated with multiple factors such as physical, technical and perceptual-cognitive performance. In contrast to physical fatigue, nowadays one of the most popular affecting factors is mental fatigue, especially in soccer.

Objectives: This systematic review aims to clarify the impact of mental fatigue intervention on psychophysiological responses and cognitive performance in soccer.

Methods: A literature review was conducted by using the keywords of "mental fatigue and soccer" and "cognitive fatigue and soccer" in the content of confined space, psychophysiological and cognitive performance in soccer within the databases of Pubmed, Scopus, Web of Science (WOS) and Sport Discuss from the 1st of January 2010 to the 31st of January 2022. Systematic searches of six databases resulted in consist of 7 studies. The study was characterized based on PICO (Population, Intervention, Comparison and Outcome) criteria.

Results: The current results showed that mental fatigue had a negative impact on psychophysiological responses, impaired cognitive performance, and decreased utilization of technical skills.

Conclusions: According to this systematic review, mental fatigue reduces performance via impairing psychophysiological responses, cognitive performance, and technical skills in soccer.

Keywords: Mental fatigue, Soccer, Psychophysiology, Cognitive Performance

1. Background

Soccer is known that requires motor skills, including changing and long-duration game structure, such as strength, aerobic endurance, agility, and physical actions consist of the sprint, change of direction, tackle, technical and tactical skills (1). Soccer players' decision-making styles are influenced by internal and external load depending on game demands, resulting in impaired cognitive ability and reduced optimal performance (2, 3). Thus, psychophysiological responses that improve performance will give insight on the unexpected mental requirements of soccer.

Fatigue is defined as exhaustion, fatigue or tiredness that reveals physical and mental activities (4-6). Long-term physical and mental tasks resulted in fatigue, a lack of energy, inhibited emotions, unwillingness, and poor cognitive function (7, 8). Mental fatigue is characterized by the inability to sustain cognitive function as a result of decreasing brain activity and mental exhaustion (6) and often leads to reduction of attention/concentration-response (9), reaction times (10) decision-making ability (11) and response accuracy (12). Considering the challenges that elite athletic performance provides to the brain, it is difficult to think of any human activity that imposes more demands on the brain (13). Mental fatigue might cause lower performance, as a result of increasing perceived effort with exposure to exhaustion (14-16). Researchers (17-19) stated that mental fatigue affected by the mental performance as well as mood and physical performance.

To perform at a high level, elite soccer players are exposed to strong pressure and intense stress, and such constraints may result in exhaustion, which may impair their performance (20). The prolonged and competitive game design of soccer matches has been shown to complicate perceptual-cognitive demands for optimal performance (3). Furthermore, despite high-intensity activities in a soccer match, players must sustain their decision-making abilities which is improving

optimal performance (21, 22). Generally increasing mental performance demands are linked to internal and external load in soccer players (23). As it is well known, mental skills play an important role in soccer, particularly in technical and tactical contexts, and recent studies have shown that mental fatigue affects players' psychophysiological responses such as heart rate, RPE, and motivation, as well as decision-making skills such as attention, accuracy, and response time (24-29).

2.Objectives

In the light of studies in the literature, this systematic review aims to investigate the psychophysiological and cognitive effects of mental fatigue on soccer performance.

3. Methods

This study is a systematic review of papers in various scientific and peer-reviewed journals to examine the Psychophysiological impact of mental fatigue on soccer performance during training or competition. The researcher reviewed the literature by using the keywords of "mental fatigue and soccer" and "cognitive fatigue and soccer" in the content of confined space, Psychophysiological and cognitive performance in soccer within the databases of Pubmed, Scopus, Web of Science (WOS) and Sport Discuss from the 1st of January 2010 to the 31st of January 2022 and screened the reference lists of the papers found.

Once the databases were searched and relevant papers were identified, data were not compiled but extracted in a standardized way. A systematic review of the literature was conducted by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines by confining the review with peer-reviewed journals in English Languages (30) (Figure 1). Once we got the paper results for each database and additional source, we conducted the preliminary examination of the headlines and abstracts to sort out the relevant papers. The PICO (Population, Intervention, Comparison, Outcome) approach was used as the starting point for our inclusion criteria (31) (Figure 2).

4. Results

In this part of the study, results regarding mental fatigue and psychophysiological responses in soccer have been presented (Table 1)

4.1. Mental Fatigue Intervention

Various treatments, such as the 30-minute Stroop word/colour test (26, 27, 32, 33, 35) and the D2 attention test (34), have been reported in trials to cause mental fatigue in soccer players.

4.2. Psychophysiological Responses

It was seen that the mental fatigue task caused a decrease in Yo-Yo IR1 distances (32, 35) and had a negative impact on physical performance markers such as high musculoskeletal load during the performance (34). No change was observed in responses to variables such as heart rate (HR) (35), heart rate variability (HRV), weather temperature, relative humidity, urine density and recovery (33). Psychophysiological responses have shown that there was an increase in rating of perceived exertion (RPE) (32, 33, 35), and visual analogue scale (VAS) (26, 27, 35). Some studies suggested that there was no change in RPE, recovery level and motivation (32, 35) whereas Smith et al. (26) suggested increased motivation.

4.3. Cognitive Performance

Regarding cognitive performance results, which is observed that changes in the cognitive workload index of NASA-TLX (32, 34). It was reported that the mental fatigue task was inhibited the response (33) and there was an increase in responses related to cognitive processes such as overall response accuracy, response time, and visual search (fixations/s and fixation duration) (26).

5. Discussion

This current systematic review reveals the impacts of mental fatigue intervention on psychophysiological responses and cognitive performance in soccer. The review has shown that various mental fatigue intervention affected psychophysiological and cognitive responses and reducing soccer performance. Regarding performance task in this study observed that including YO-YO IR1 (32, 35), 90-minute training match (33), SpeedCourt pace and agility intervention (34), the Loughborough soccer passing test (27), Loughborough soccer passing and shooting test (26, 35). In the present studies, soccer performance was negatively indicated to effected by many soccer performance-related applications.

5.1. Mental Fatigue Intervention

As regards, the mental fatigue intervention designed in the literature, six studies (26, 27, 32, 33, 35) have experienced the Stroop colour/word test for 30 minutes. On the other hand, Auer et al. (34) used the D2 attention

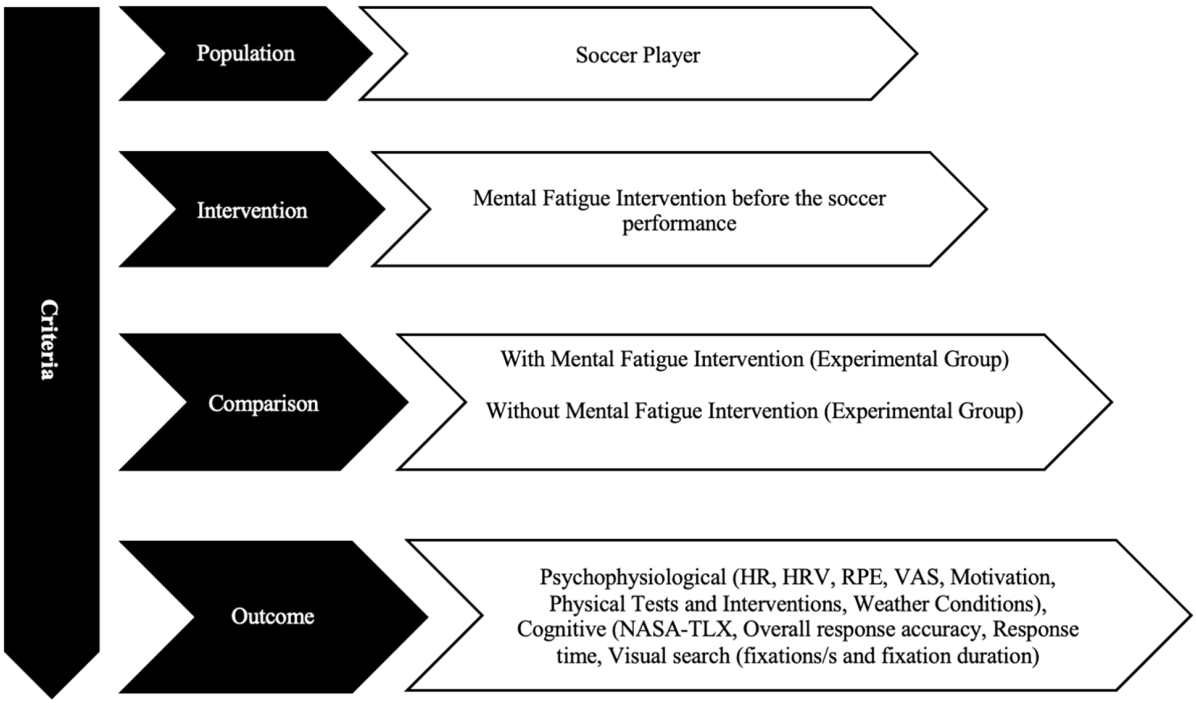

Figure 1. PRISMA flow diagram showing identification, screening, eligibility and included of studies in systematic review

test for inducing mental fatigue. Stroop Colour and Word Test is a neuropsychological test widely used for both experimental and clinical purposes (36). During the Stroop test, cognitive activities incorporating response-inhibitors are known to activate the pre-supplementary motor area and the anterior cingulate cortex (ACC) (37). Previous studies (38, 39) indicated that the cortical area activity is associated with effort perception. The Stroop test or AX-CPT inhibits attention and cognitive performance during the motor imagery task used to induce mental fatigue, which was described (40-42). However, Coutinho et al. (25) performed a motor coordination task to induce mental fatigue. As result, these findings revealed that different mental fatigue treatments were used in soccer performance. However, further study may indicate that soccer-specific mental fatigue tasks validate environmental conditions rather than clinical tasks.

5.2. Psychophysiological Responses

According to the review's psychophysiological findings, mental fatigue intervention reduced YO-YO IR1 running distances while increasing HR and musculoskeletal load (32, 34, 35), RPE (26, 27, 32, 33, 35). However, it was no differences between HRV and HR (33, 35). While studies any significantly changing in motivation (32, 35), Smith et al. (26) highlighted to increase motivation. Researchers (14, 43-46) suggested that HR was not affected by mental fatigue. In contrast to there was a significant decrease (24, 47, 48) and increases (49, 50). In general, physiological changes associated with mental fatigue were related to increased mental energy or increased cognitive function demands during the activity (51, 52).

Concerning RPE provided to scale perceived exertion during performance task (32, 33, 35). The internal load could measure with several methods such as HR, VO2, blood lactate but RPE is a good indicator that is also low cost, simple and useful in measuring in soccer training (53). Marcora (54) identified that perceived exertion related to endurance performance and higher levels of RPE couldn't maintain the exercise. Similar results have confirmed that (25, 43, 48, 55, 56) mental fatigue led to a greater increase perceived exertion. One of the main reasons increasing RPE, while MF caused to reducing performance profile during the task (57) simultaneously changing perceived exertion to both against exercise time and exhaustion time (14, 49, 58). VAS is also non-expensive equipment and practical tool which is assessed motivation (26, 27, 35). Filipas et al, (32). Conversely, previous motivation theories (59) defined that was demanded

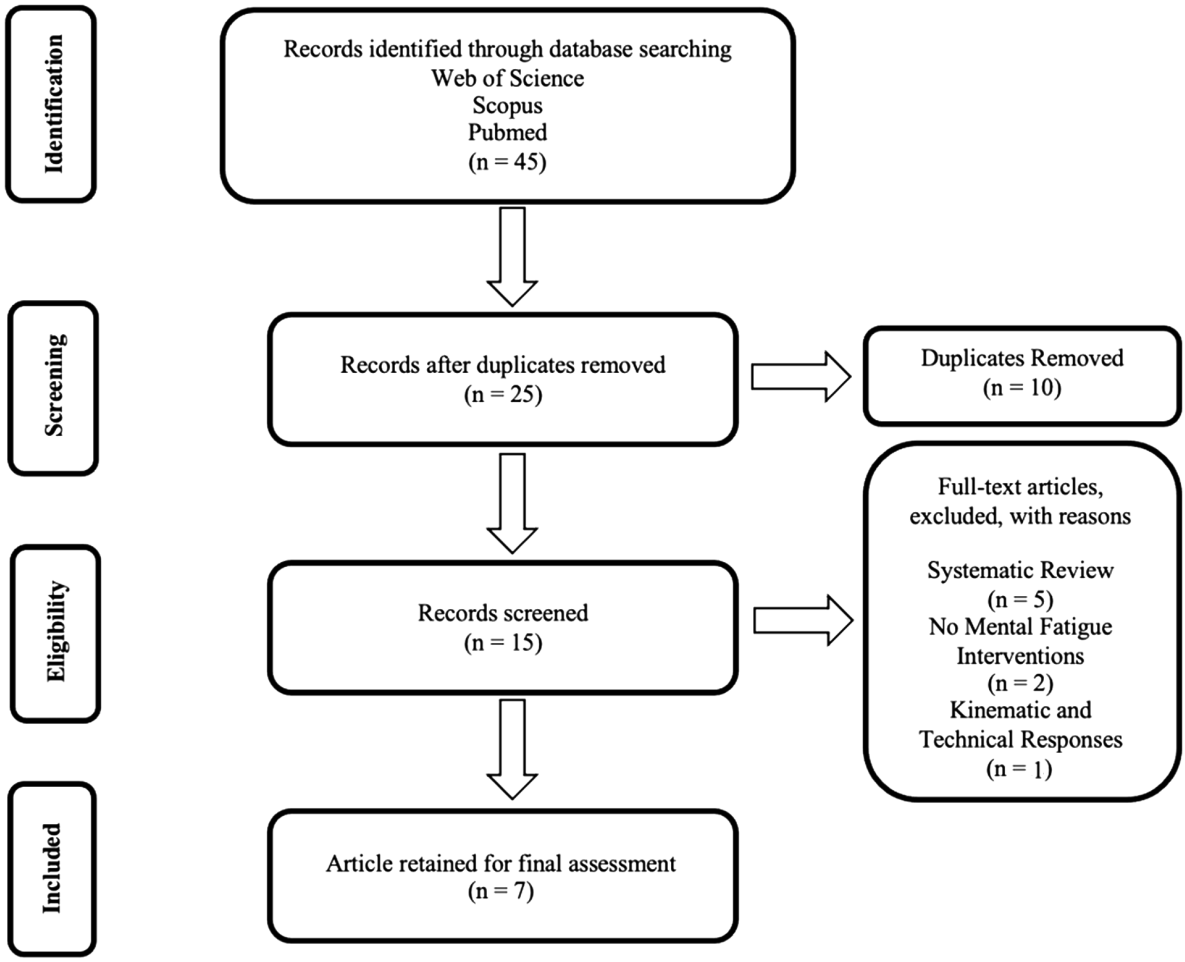

Figure 2. Criteria of PICO

voluntarily higher effort to performance to achieve during the specific task as a part of motivational factors. Similarly, perceived exertion was increased through MF, activating the inhibitory system, causing decreased motivation and willingness (60).

5.3. Cognitive Performance

Cognitive responses were obtained using VAS and NASA-TLX which are very popular and objective methods to identify MF (32, 61). The present study has shown that mental exertion significantly has increased under the MF effect (26, 27, 32, 35). According to studies, impaired cognitive skills increased perception of effort (62), alter brain activity (63), decrease attention (17), response accuracy (12) and decision-making (64). The mental performance process an increase or sustain depends on mental facilitation however, during the cognitive task, when the inhibitory system is activated, causing cognitive performance to decreases (8). Thus, mental inhibitor system activated with increasing mental effort in MF conditions may cause the barrier to driving and decreasing willingness (60, 65). Induced mental fatigue during the match, soccer players cope with the complexity of the game and to achieve optimal performance not only focus on an environmental stimulant such as ball, opponent and empty space but also well-develop cognitive skills and decision-making (64, 66). Researchers stated that the cognitive performance impaired by mental fatigue reduced physical performance (43), including low goal-directed attention, response time and inhibitory control (11, 17, 26, 67). Thus, given the cognitive and psychological demands of soccer, it is considered that the cognitive participation of players in the game to find out

practical solutions could cause mental fatigue (68).

5.4. Conclusions

In a conclusion, this systematic review explains that increasing and combining psychophysiological and cognitive demands characteristic of soccer games led to search specific areas such as mental fatigue. However, mental fatigue negatively induces psychophysiological (HR, RPE and Motivation), physically (musculoskeletal load) and cognitive (inhibitory control, response time, response accuracy) on soccer performance. Coaches and players might be designed to consist of simulating mindfulness-based intervention or mental exercise to pieces of soccer-specific training to manipulate the MF effect on performance.

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Footnotes

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Table 1. Mental Fatigue Intervention Response to Psychophysiological Responses and Cognitive Performance in Soccer

Study	Experimental Group	Control Group	Performance Intervention	MF Intervention	Physiological Responses	Psychological Responses	Cognitive	Performance
(32)	U14, U16, U18 (n = 36)		YO-YO IR1	Stroop, Word/Colour Test 30'	HR ↑	Motivation ↔	VAS ↑	↓
							NASA-TLX	
					RPE-20 ↔		Mental Demand ↑	
							Physical Demand ↔	
					YO-YO IR1(m) ↓		Temporal Demand ↑	
							Effort ↑	
							Frustration ↑	
(33)	Professional (n = 20) 22.6 ± 3.3		GK+10vs10+GK; 2x45'-15'R	Stroop, Word/Colour Test 30'	RPE-10 ↔	-	Inhibitory ↑	↓
					HRV			
					RMSSD ↔			
					SDNN ↔			
				Stroop, Word/Colour Test 30'	pNN50 ↔			
					Weather Conditions			
					Temperature (°C) ↔		Response time (%) ↔	
				Watching TV 30'	RH (%) ↔			
					HS (osmolarity) ↔			
					Recovery ↔			
(34)	Elite U 17 (n = 12) 15.9 ± 0.3		SpeedCourt	D2 Attention Test	Musculoskeletal Load ↑		NASA-TLX	↓
							Mental Demand ↑	
							Physical Demand ↔	
							Temporal Demand ↑	
							Performance ↔	
							Effort ↔	
							Frustration ↔	
(27)	Well-trained (n = 14) 19.6 ± 3.5		Loughborough Soccer Passing Test	Stroop, Word/Colour Test 30'	-		VAS ↑	↓
(35) (**Study 1**)	Recreational (n = 12) 24.0 ± 0.4		YO-YO IR1	Stroop, Word/Colour Test 30'	HR ↔	Motivation ↔	VAS ↑	↓
					RPE- 20 ↑			
					YO-YO IR1 (m) ↓			
(35) (**Study 2**)	Well-trained (n = 14) 19.6 ± 3.5		Loughborough Soccer Passing and Shooting Test	Stroop, Word/Colour Test 30'		VAS ↑		↓
						Motivation ↔		
(26)	ND (n = 14) 19.3 ± 1.5		Soccer-Specific Decision-Making Task	Stroop, Word/Colour Test 30'		Motivation ↑	Overall response accuracy ↓	↓
							Response time ↑	
							Visual search (fixations/s and fixation duration) ↔	
							VAS ↑	

Abbreviations: HR, heart rate; RPE, rating of perceived exertion; VAS, visual analogue scale; HRV, heart rate variability; RMSSD, root mean square of successive differences; SDNN, the standard deviation of NN intervals; pNN50, the proportion of NN50 divided by total number of NNs; RH, relative humidity; HY, hydration state; ↑, increase; ↓, decrease; ↔, no change.