

Effects of mental fatigue on psychophysiological, cognitive responses, and technical skills in small-sided soccer games in amateur players

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A Study Design
B Data Collection
C Statistical Analysis
D Data Interpretation
E Manuscript Preparation
F Literature Search
G Funds Collection

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abstract

- Background:** The purpose of this study was to assess the effects of mental fatigue (MF) on the psychophysiological and cognitive responses and technical skills in small-sided games (SSGs) in amateur soccer players.
- Material and methods:** 18 soccer players played 2vs2, 3vs3, and 4vs4 SSGs under 2 different playing conditions: MF+SSGs and SSGs. The Feeling Scale (FS), Felt Arousal Scale (FAS), Visual Analogue Scale-Anxiety (VAS-A) and Motivation (MTV) were determined after each SSGs bout. A Trail-Making Test (TMT) was also determined in the beginning and at the end of each SSGs. Technical performance was continuously recorded with a camera during all SSGs.
- Results:** The results demonstrated that MF induced higher negative psychophysiological and cognitive responses ($p \leq 0.05$, $d =$ ranging from 0.73 to 2.78) in 2vs2 and 3vs3 SSGs compared to 4vs4 SSGs except for VAS-A and MTV responses. Furthermore, the MF intervention also induced an adverse effect on technical skills ($p \leq 0.05$, $d =$ ranging from 0.65 to 2.50) in 2vs2 and 3vs3 SSGs compared to 4vs4 SSGs except for interception, tackle and two touches skills.
- Conclusions:** These findings showed that MF impacted the psychophysiological and cognitive responses, and technical skills during SSGs. Coaches should take MF into account before planning SSGs.
- Key words:** soccer, mental fatigue, technical performances, psychological responses.

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INTRODUCTION

The soccer game concept, which includes aerobic capacity, feelings and perceptual-cognitive skills, is related to physical, technical-tactical, psychological and cognitive demands [1-3]. Therefore, many types of soccer training sessions are mainly used to develop different strategies in the face of increasing and changing in-game contexts. Small-sided games (SSGs), one of the commonly used time-efficient training methods, are an effective role in order to improve soccer-specific aerobic capacity, technical skills, and psychological conditions transferred from training activities to a match [4, 5].

Recent studies have focused on psychological and mental factors in SSGs including mood, enjoyment, and decision making in soccer players [6-8]. In the light of these studies, the players are not only exposed to the external loading, but also feeling higher internal loading during the SSGs. Several alternative training methods have been used to enhance the performance and technical capabilities of young soccer players [5, 9]. In contrast to traditional training drills, the SSGs simulate soccer game conditions with an enjoyable, effective and time-efficient training approach [3, 4, 10]. Generally, the characteristics of SSGs training have been adapted to the integration of physical development, team cohesion, technical and tactical variability to soccer matches [11, 12].

Most of the previous studies have shown that performance in SSGs is measured by different methods such as internal and external loading [3, 5, 13, 14]. However, a popular topic on soccer in recent studies has focused on some interventions such as mental fatigue [15-17] that can affect players' performance in SSGs. Mental fatigue (MF) refers to a psychobiological state representing a feeling of tiredness and lack of energy, decreased motivation and alertness by leading to long periods of cognitive activity [18-20]. Researchers state that MF has been linked to increasing time on a task which changes cognitive and behavioural performance [21, 22].

Soccer-specific psychophysiological [17] and cognitive performance [16], and technical skills [23] are negatively affected by MF. Considering that SSGs are an important part of game-based training in soccer, MF interventions might play a key role in decreasing soccer game demands. Therefore, we hypothesise that MF would negatively affect the psychophysiological, cognitive and technical performance responses, such as feelings, response attention, and technical skills especially interception, successful and unsuccessful tackle during SSGs.

MATERIAL AND METHODS

PARTICIPANTS

18 male soccer players (age: 19.1 ± 1.2 years, body height 176.8 ± 6.2 cm) participated in this study. All the players were members of an amateur soccer team, competing in the regional league. They were familiar with a training workload of >4 training units per week, each lasting 90-minutes and a league match for more than 5 years. Before signing the informed consent form, detailed information was declared to the players. The study protocol was approved by Tokat Gaziosmanpasa University the Research Ethics Committee (2021/E-33490967-044-22125) and was conducted with the institutional ethical requirements for human experimentation in accordance with the Declaration of Helsinki.

Table 1. The dimensions of SSGs

SSGs Formats	Bouts	Work : Rest		Pitch Dimensions	
		Bouts (min)	Resting (min)	Pitch Size (m)	Area Per Player (m ²)
2v2+MG		2		15x27	
3v3+MG	4	3	2	20x30	100
4v4+MG		4		25x32	

INSTRUMENTS

Feeling Scale. The Feeling Scale (FS) is a psychophysiological bipolar scale of 11 items and ranging from + 5 to - 5. The verbal anchor asked is “How do you feel right now?” [24].

Felt Arousal Scale. The Felt Arousal Scale (FAS) is a psychophysiological measure which assesses pleasure and displeasure. Players were asked to report on “How aroused do you actually feel?”. The FAS is a single item bi-polar scale ranging from low arousal (1) to high arousal (6) [25].

Visual Analogue Scale-Anxiety. The Visual Analogue Scale-Anxiety (VAS-A) is a self-report measure which assesses anxiety. The VAS-A used consisted of a 100mm horizontal line labelled with ‘not at all anxious’ at one end (score of 0) and ‘extremely anxious’ at the other (score of 100) [26].

Motivation. The Motivation (MTV) measure time trial was measured using a single item (“I am motivated to do the time trial”) scored on a 5-point Likert scale (0=not at all, 1=a little bit, 2=somewhat, 3=very much, 4=extremely) [27].

Trail-Making Test. The Trail-Making Test (TMT) is a neuropsychological test measure of attention, speed, and cognitive flexibility. The TMT includes two different paper/pencil parts a TMT-A and TMT-B. Participants performed each part as fast as possible. The TMT is widely used as a reliable and valid measure of scanning, visuomotor tracking, split attention and cognitive flexibility [28].

TECHNICAL ACTIONS

All SSGs were recorded using a high-definition camera (SONY HDR-CX130, Sony Corp., Tokyo, Japan), and the analysis of the technical actions of each SSGs was performed using eAnalyse soccer match-analysis software (Espor Digital, Ankara, Turkey). The technical variables determined from video recordings were interception, successful and unsuccessful tackle, 1 Touch (Succ-Unsucc), 2 Touches (Succ-Unsucc), and a lost ball.

EXPERIMENTAL PROTOCOL

A randomized counterbalanced cross-over design was used to compare MF on the psychophysiological, cognitive responses and technical skills in SSGs in amateur players. All players were randomly separated into two groups as MF with SSGs (MF+SSGs) and SSGs without MF (SSGs). The MF intervention protocol was completed for 17 days every 48 hours to prevent any risk of physical, psychological and mental state. A session familiarizing with the tests was carried out a week before training days. All SSGs sessions used a mini-goal, and were completed at the same time of day and on the same pitch.

INTERVENTIONS

Mental Fatigue Intervention. The paper version of the 30-min Stroop task was performed to induce MF. Previous studies [8,16] demonstrated that the Stroop task is used to induce MF

in soccer. Before the MF intervention, all players were provided with clarification by the practitioner. The Stroop task, consisting of four words (red, blue, green and yellow), was shown in a random order, following by a 1.5 s resting interval. Players were also instructed to quickly and accurately finish the task in competition with the other teammates. This prolonged cognitive task requires intensive attention and automatic response inhibition [29].

SSGs Intervention. A standard 15-minutes warm-up protocol consists of jogging, dynamic stretching, and soccer-specific actions that were performed by players. The SSGs protocol is formed by two conditions (MF+SSGs and SSGs) and three different games (2v2, 3v3 and 4v4), as detailed in Table 1. All SSGs sessions were performed with 48 hours of scheduled rest. Before the use, VAS-A, FS, FAS, MTV and TMT were explained to the players, and then VAS-A, FS, MTV and TMT were used before the sessions. During the bouts of SSGs, VAS-A, FS, FAS, MTV and technical actions were used. All assessments were made post sessions in all SSGs (Figure 1).

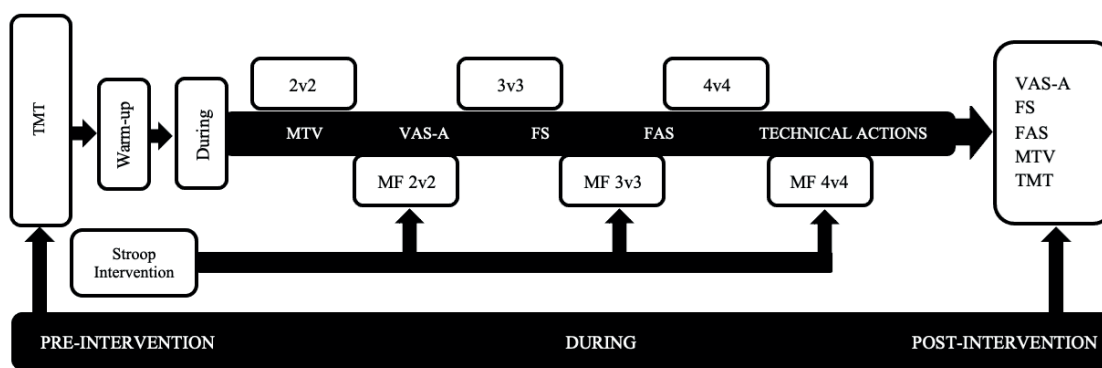


Fig. 1. Study design

STATISTICAL ANALYSES

All the data was collected pre, during and post all SSGs and to analyse each dependent variable using a paired-sample t-test to compare MF+SSGs and SSGs sessions and present means with standard deviation (SD), mean differences, means with a 95% confidence interval (95% CI). To estimate differences between pre and post MF effects, Cohens d and rating (effect size) were calculated for each dependent variable. The thresholds for effect size statistics were as follows: 0.2 - trivial; 0.6 - small; 1.2 - moderate; 2.0 - large; and <2.0 - very large [30]. Statistical analyses were performed with SPSS software version 24.0 (SPSS, Version 24.0 for Windows; SPSS Inc., Chicago, IL, United States). The level of statistical significance was set at $p \leq 0.05$.

RESULTS

Table 1 presents comparisons of psychophysiological differences between MF+SSGs and SSGs 2v2, 3v3, and 4v4 formats. The results demonstrated that MF induced higher negative psychophysiological and cognitive responses ($p \leq 0.05$, d =ranging from 0.73 to 2.78) in 2vs2 and 3vs3 SSGs compared to 4vs4 SSGs except for VAS-A and MTV responses.

Table 2. Psychophysiological and cognitive responses of amateur soccer players to SSGs+MF and SSGs conditions

		Variables	MF+SSGs Mean ± SD	SSGs Mean ± SD	Mean Difference	%95 CI	Cohens d and Rating
Psychophysiological and cognitive responses	2-a-side	VAS-A	2.56 ± 2.75*	1.00 ± 0.59	1.56	-2.91 – -0.20	0.78; Moderate
		FS	0.61 ± 1.33*	3.11 ± 3.22	-2.5	0.88 – 4.12	-1.01; Moderate
		FAS	2.28 ± 0.67*	3.72 ± 1.27	-1.44	-2.15 – -0.74	-1.42; Large
		MTV	1.50 ± 0.51*	3.28 ± 0.75	-1.78	-2.28 – -1.28	-2.78; Very Large
		TMT-1	17.24 ± 2.62*	13.20 ± 4.53	4.04	1.57 – 6.51	1.10; Moderate
		TMT-2	24.46 ± 5.10*	20.23 ± 4.46	4.23	0.72 – 7.73	0.88; Moderate
	3-a-side	VAS-A	2.61 ± 3.16*	0.89 ± 1.08	1.72	-3.12 – -0.33	0.73; Moderate
		FS	1.22 ± 0.88*	3.67 ± 3.16	-2.45	0.91 – 3.98	-1.06; Moderate
		FAS	2.17 ± 1.04*	3.78 ± 1.17	-1.61	-2.32 – -0.90	-1.45; Large
		MTV	2.00 ± 0.77*	3.22 ± 0.88	-1.22	-1.78 – -0.67	-1.48; Large
		TMT-1	17.23 ± 1.31*	11.96 ± 4.22	5.27	0.22 – 3.50	1.69; Large
		TMT-2	19.66 ± 2.93*	15.52 ± 6.10	4.14	1.30 – 7.00	0.87; Moderate
	4-a-side	VAS-A	2.22 ± 2.94	0.61 ± 0.50	1.61	-2.99 – -0.23	-
		FS	1.94 ± 0.54*	3.94 ± 3.46	-2.0	0.26 – 3.74	-0.81; Moderate
		FAS	2.17 ± 0.99*	3.57 ± 1.04	-1.39	-2.14 – -0.64	-1.37; Large
		MTV	2.33 ± 0.69	3.17 ± 0.71*	-0.84	-1.35 – -0.31	-1.19; Moderate
		TMT-1	17.09 ± 1.72*	12.51 ± 4.81	4.58	1.41 – 4.74	1.27; Large
		TMT-2	21.04 ± 3.49*	14.39 ± 3.34	6.65	4.11 – 9.18	1.95; Large

MF+SSGs = Small-Sided Games with Mental Fatigue; SSGs=Small-Sided Games without Mental Fatigue VAS-A = Visual Analogue Scale-Anxiety; FS = Feeling Scale; FAS: Felt Arousal Scale; MTV: Motivation; TMT: Trail Making Test *Significant difference p<0.05.

Interception, successful tackle, unsuccessful tackle, 1 touch (successful-unsuccessful), 2 touches (successful-unsuccessful), and lost ball are shown in table 3.

Table 3. Technical responses of amateur soccer players

		Variables	MF+SSGs Mean ± SD	SSGs Mean ± SD	Mean Difference	%95 CI	Cohens d and Rating
Technical responses	2-a-side	Interception	2.78 ± 1.17	3.61 ± 1.04*	0.83	0.21 – 1.45	0.75; Moderate
		SuccTackle	0.56 ± 0.62	1.17 ± 0.92*	0.61	0.95 – 1.13	0.78; Moderate
		UnSuccTackle	1.17 ± 0.92*	0.39 ± 0.50	-0.78	-1.31 – 0.25	-1.05; Moderate
		1 Touches (Succ-Unsucc)	1.22 ± 0.81	3.06 ± 1.43*	1.83	0.99 – 2.67	1.58; Large
		2 Touches (Succ-Unsucc)	0.78 ± 0.55	1.72 ± 0.83*	0.94	0.42 – 1.47	1.34; Large
		Lost Ball	4.61 ± 0.92*	4.00 ± 0.97	-0.61	-1.21 – -0.02	0.65; Moderate
	3-a-side	Interception	3.17 ± 1.34	3.78 ± 0.94	0.61	-0.15 – 1.38	-
		SuccTackle	0.67 ± 0.77	2.39 ± 0.98*	1.72	1.09 – 2.36	1.95; Large
		UnSuccTackle	2.50 ± 0.79*	0.67 ± 0.77	-1.83	-2.38 – -1.29	-2.50; Very Large
		1 Touches (Succ-Unsucc)	3.17 ± 1.04	4.56 ± 0.92*	1.39	0.79 – 1.98	1.42; Large
		2 Touches (Succ-Unsucc)	2.17 ± 0.79	4.11 ± 0.83*	1.94	1.39 – 2.50	2.39; Very Large
		Lost Ball	5.89 ± 1.32*	3.78 ± 1.22	-2.11	-3.09 – -1.13	1.66; Large
	4-a-side	Interception	4.72 ± 0.96	5.17 ± 0.92	0.44	-0.22 – 1.11	-
		SuccTackle	1.11 ± 0.76	1.22 ± 0.65	0.11	-0.43 – 0.65	-
		UnSuccTackle	1.28 ± 0.83	1.06 ± 0.64	-0.22	-0.75 – 0.31	-
		1 Touches (Succ-Unsucc)	4.67 ± 1.19	6.78 ± 1.00*	2.11	1.21 – 1.01	1.92; Large
		2 Touches (Succ-Unsucc)	4.67 ± 0.91	4.78 ± 0.88	0.11	-0.55 – 0.77	-
		Lost Ball	5.61 ± 1.20*	4.67 ± 0.91	-0.94	-1.79 – -0.10	-0.88; Moderate

MF+SSGs=Small-Sided Games with Mental Fatigue; SSGs=Small-Sided Games without Mental Fatigue SuccTackle: Successful Tackle; UnSuccTackle: Unsuccessful Tackle; Succshot: Successful Shot; 1 Touches [Succ-Unsucc]: 1 Touches Successful SSGs; *Significant difference p<0.05

DISCUSSION

The purpose of the current study was to compare the effect of MF intervention in different SSGs. We hypothesized that MF negatively affected soccer players' psychophysiological responses, cognitive performance and technical actions. Study findings showed that MF+SSGs sessions induced higher psychophysiological (VAS-A, FS, FAS, MTV), cognitive demands (TMT), and decreased technical skills compared to SSGs.

The psychophysiological findings in the present study were assessed with VAS-A, FS, FAS, MTV and these scales are frequently used to measure psychophysiological responses in soccer [8, 31]. Previous studies [16, 32] demonstrated that psychophysiological responses in soccer were negatively affected by a MF intervention. Regarding our study psychophysiological results, MF had a detrimental effect on VAS-A, FS, FAS, MTV. Mood [31, 33] and feelings responses [34] changed with MF, higher exhaustion was induced and performance was worse during sport and exercise.

In the current study, MTV reduced in MF+SSGs 2v2 and MF+SSGs 3v3 sessions. In contrast to our results, numerous MF and SSG studies [8, 16, 32] showed no alteration in MTV during MF conditions. Physical responses with perceived mental effort indicated feelings/emotions as a decreasing motivation, recovery demand [35, 36] and lead to physical weakness due to lack of energy and unwillingness [18]. Van der Linden et al. [37] demonstrated that MF induces a deteriorating alteration in psychophysiological condition with maintaining performance. Many researchers [38, 39] have stated that an activated mental inhibitor system with increasing mental effort, might cause MF to be a barrier to driving and decreasing willingness. Therefore, individual mood has negatively changed, this and might lead to a lack of energy and unwillingness during physical performance.

Our study provided considerable results concerning the detrimental effects of MF on soccer cognitive performance. TMT was decreased in all MF+SSGs compared to SSGs sessions. There are limited SSGs studies in the literature that supported our study findings [40, 41]. MF also induced deterioration in cognitive performance during SSGs. In the soccer context recent evidence has shown that [16, 17, 42] MF has a negative impact on decision-making performances, including mental-temporal demands, accuracy and response time. The mental performance process with an increase or sustain depends on mental facilitation. Therefore, if the inhibitory system is activated during the cognitive task, it causes a considerable decrease in cognitive performance. However, during a cognitive task, when the inhibitory system is activated, it causes the cognitive performance to decrease [43]. Despite MF having a negative reflection on players' performance, it might be possible to manipulate an increase in the MF effect with environmental conditions, including team cohesion, encouragement, changing the game strategy. Thus, the distraction of players, the unfavourable influence of MF could disappear in the decision-making process.

Essentially, the decision-making process is formed by a combination of perception, attention and working memory [44]. Considering technical actions, MF has reduced technical abilities consisting of interception, successful or unsuccessful tackle, 1 touch (success-unsuccess), 2 touches (success-unsuccess) and lost ball. Our study showed that successful performance-related technical indicators, such as interception, successful tackle, 1 touch and 2 touches, were decreased in MF+SSGs sessions contrary to increasing unsuccessful tackle and lost ball. Regarding technical performance, previous studies have shown similar results [23, 40, 45, 46]. All these results clarify that MF impaired technical skills. In the light of these results, the researchers and coaches might focus on the decision-making process in the relationship between perceived exertion and cognitive system activation.

This study focused on psychophysiological responses, cognitive performance and technical skills of soccer SSGs. We had some restrictions, namely an acute kinematic profile (total

distance, accelerations and decelerations) and metabolic responses (lactate, cortisol, heart rate) in SSGs. Another limitation of this study was that the sample group were members of an amateur club.

CONCLUSIONS

The present study indicates the effect of MF on psychophysiological responses, cognitive performance and technical skills. Results demonstrated that before SSGs sessions, MF interventions negatively affected soccer performance including VAS-A, FS, FAS, MTV and TMT. MF interventions could increase perceived effort and lead to deteriorating psychophysiological responses and cognitive function, hence decreasing soccer performance. In the light of these results, it is important for coaches to control the negative effects of MF on players' effort and the potential links with motivation while performing tasks.

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