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THE ACUTE EFFECT OF MENTAL FATIGUE ON STRENGTH ENDURANCE IN YOUNG KICKBOXERS

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ABSTRACT

This study was conducted to examine the acute effects of Mental Fatigue (MF) on strength endurance in well-trained young kickboxers. A total of 17 female/male athletes (age: 15.76±1.44 years; height: 167.06±8.63 cm; body weight: 62.03±10.63 kg) participated. The Repeated Measurement Design was used. Accordingly, the participants had 3 sessions; pre-preparation, control, and mental fatigue. In the pre-preparation session, demographic information and one repetition maximum (1RM) for bench press (BP) and squat (SQ) exercises were taken. The athletes' strength endurance was performed until 60% of 1RM exhaustion; the number of repetitions (NOR) and movement time (MT) were recorded. In the MF session, the participants were subjected to a 30-minute Stroop task before the strength test. In order to determine the differences in NOR and MT between the sessions and the differences in measurements according to gender, the Paired sample t-test was used. The presence of MF significantly reduced SQ-NOR by 34.5%, SQ-MT by 36.88%, BP-NOR by 22.71%, and BP-MT by 28.27% ($p<0.05$). Based on gender, MF had a significant negative effect on SQ-NOR, SQ-MT, and BP-MT in women and men and on BP-NOR only in women athletes ($p<0.05$). As a result of the research, 30-min MF application negatively affects the lower and upper extremity strength endurance performance in young kickboxers. In this respect, young kickboxers should avoid activities that will cause mental fatigue such as using digital screens or *solving questions or puzzles for social media purposes for 30 min or more before training and competition, which will prevent possible muscular performance loss.*

Keywords: *endurance, kickboxing, mental fatigue, strength, young athlete*

AKUTNI UČINEK DUŠEVNE UTRUJENOSTI NA VZDRŽLJIVOST MOČI PRI MLADIH KIKBOKSERJIH

IZVLEČEK

Študija je bila izvedena zaradi proučitve akutnih učinkov mentalne utrujenosti (MF) na vzdržljivost moči pri dobro treniranih mladih kikbokserjih. Sodelovalo je 17 športnic in športnikov (starost: 15,76 ± 1,44 leta; višina: 167,06 ± 8,63 cm; telesna teža: 62,03 ± 10,63 kg). Uporabljena je bila metoda ponovljenih meritev. V skladu s tem so udeleženci opravili tri treninge: predpripravo, kontrolo in psihično utrujenost. V predpripravi so bili zbrani demografski podatki in največja mogoča hitrost ene ponovitve (1RM) pri vajah z dvigom na klop (BP) in sklece (SQ). Športniki so vzdržljivost moči izvajali do 60-odstotne izčrpanosti 1RM, beležili so število ponovitev (NOR) in čas gibanja (MT). V seji MF so udeleženci pred testom moči opravili 30-minutno Stroopovo nalogo. Za ugotavljanje razlik v NOR in MT med sejami in razlik v meritvah glede na spol je bil uporabljen t-test za parne vzorce. Uporaba MF je pomembno zmanjšala SQ-NOR za 34,5 %, SQ-MT za 36,88 %, BP-NOR za 22,71 % in BP-MT za 28,27 % (p<0,05). Glede na spol je MF pomembno negativno vplivala na SQ-NOR, SQ-MT in BP-MT pri ženskah in moških in na BP-NOR samo pri športnicah (p<0,05). Rezultat raziskave je, da 30-minutna uporaba MF negativno vpliva na vzdržljivostno zmogljivost moči spodnjih in zgornjih okončin pri mladih kikbokserjih. V zvezi s tem se morajo mladi kikbokserji 30 minut ali več pred treningom in tekmovanjem izogibati dejavnostim, ki povzročajo duševno utrujenost, kot so uporaba digitalnih zaslonov ali reševanje vprašanj ali ugank v okviru družbenih omrežij, kar prepreči morebitno izgubo mišične zmogljivosti.

Ključne besede: *vzdržljivost, kikboksing, psihična utrujenost, moč, mladi športnik*

INTRODUCTION

Mental Fatigue (MF), a psychobiological condition, occurs due to prolonged intense cognitive activities with behavioral and physiological symptoms (Job & Dalziel, 2000); it causes a lack of energy (Boksem & Tops, 2008) and decreased motivation (Boksem, Meijman, & Lorist, 2006). MF can also alter brain activity (Wascher et al., 2014; Cook, O'Connor, Lange, & Steffener, 2007; Hopstaken, van der Linden, Bakker, & Kompier, 2015). Therefore, MF negatively affects cognitive functioning and performance (Marcora, Staiano & Manning, 2009; Möckel, Beste, & Wascher, 2015; Wascher et al., 2014). Although the factors affecting performance in sports vary for each branch, they can be generally divided into three categories: physical, cognitive, and psychological. Although performance can be maintained simultaneously with these factors during exercise, athletes struggle separately with each factor that will negatively affect their performance (Aras, Yiğit, Kayam, Arslan, & Akça, 2020). With the long duration of this struggle, it can be said that sporting activities cause both physical and MF in the body. Sievertsen, Gino, and Piovesan (2016) found that training activities reduce cognitive test performance by 0.9% for each hour of the day; additionally, they reported that a 20-30-min break increased it by 1.7%. According to the literature, it can be said that the length of educational activities at school, the frequency of breaks, and the length of breaks are all related to MF. Sports competitions, intense physical training, and the stress of the intense exam period can cause various psychological stresses such as the need to focus for a long time, the need to maintain the level of perception, and difficulty making decisions under the pressure of the opponent, as well as physical strain in athletes (Kızıltoprak, 2019). Combat sports such as kickboxing especially require superior attention and concentration, so the cognitive robustness and readiness of athletes can directly affect performance management. In addition, if the athlete is at an elite-level status, it is thought that mental fatigue may cause a decrease in the maximum performance (Knicker, Renshaw, Oldham, & Cairns, 2011).

Fatigue is not only caused by the neuromuscular system (Van Cutsem, De Pauw, Marcora, Meeusen & Roelands, 2017a), but also by mental causes (Sharon & Denise, 2003). Therefore, the concept of fatigue can be defined as physical fatigue when it affects the strength capacity of the muscle after a physical task and MF when it increases the level of burnout after performing a cognitive task for a certain period of time. Although physical fatigue and MF may seem different, they are mechanisms that affect each other and any disruption in the mechanism may affect the effort spent on contraction and the perceived level of difficulty (Chaudhuri & Behan, 2004). In this respect, in order to ensure continuity in strength, athletes should be able to cope with both MF and physical fatigue.

It is noteworthy that there are few MF studies in the literature covering the effect on sportive performance, and when the studies are examined, it can be seen that prolonged cognitive efforts have a negative effect on attention, movement tracking, and cognitive control (Boksem & Tops, 2008). In addition, scientific research reported that the level of MF is directly proportional to the duration of the cognitive task performed and it can be said that athletes who are exposed to cognitive tasks for a long time have more MF. The relationship between MF and athletic performance was first mentioned by Angelo Mosso in 1891, who reported that MF decreases muscle strength (Giulio et al., 2006). During some mental tests (Stroop, etc.), the anterior supplementary motor area and anterior cingulate cortex (ASC) were found to be activated in the brain (Mostofsky & Simmonds, 2008); activation of these areas was associated with the degree of rating of perceived exertion (RPE) (De Morree, Klein, & Marcora, 2012). Therefore, MF is considered one of the important determinants of performance in sports and exercise.

Several tests in literature, such as time-clamped self-paced running and cycling protocols and the yo-yo intermittent recovery test, have shown that MF reduces endurance performance. These tests can be characterized by an increase in the time to completion, a decrease in self-selected power output/speed, or a decrease in the time to exhaustion (Van Cutsem, Marcora, De Pauw, Bailey, Meeusen & Roelands, 2017b). In studies on the effect of MF on athletic performance, it has been reported that MF negatively affects endurance performance; high-level athletes are more resistant to MF (Martin et al., 2016). Although different results are obtained in the literature depending on the level of the athlete, all the results show that MF causes more performance decline in recreational athletes. Although these results show that competitive athletes are less affected by MF, considering that success at this level is achieved based on very small differences, it is a significant possibility that the stress of athletes who train at a high level may cause MF, which could negatively affect performance (Russell, Jenkins, Smith, Halson, & Kelly, 2019).

Kickboxing (KBX) is a sport discipline that includes both punching and kicking movements and their combinations (Cynarski & Zieminski, 2010). KBX athletes need the highest level of strength ability among the motoric characteristics. Strength is an important motoric feature in sportive performance in all branches (Atıs, Yerlikaya, Can, & Atlı, 2023) and the long duration of competitions in KBX also requires endurance ability. In order for the athlete to be superior to his/her opponent, superior strength and endurance are required; at the same time, it can be said that he/she should have superior mental performance in order to react to the punches and kicks from the opponent at the right moment. Practices related to this are an important element in the physical and mental development of the athlete and can be effective in building strength and defense stability. In addition, athletes must have a high level of endurance, both physically and mentally.

Recently, MF has become a popular topic and this study was planned because of the lack of studies on this concept and the results on the effect of this concept on performance in strength and combat sports. It is also a matter of interest how much the performances of elite level KBX athletes are affected by the MF that may occur due to the stress experienced in daily life, social life, educational life, and as a result of continuous training. Therefore, the aim of the study was to investigate the effect of MF on lower and upper extremity strength endurance in elite-level young kickboxing athletes.

METHOD

Study Design and Participants

Licensed athletes who have been training regularly for 5 days a week for at least two years, aged 14-18, 9 females and 8 males totaling 17 kickboxing athletes (age: 15.76 ± 1.44 years; height: 167.06 ± 8.63 cm; body weight: 62.03 ± 10.63 kg) were included in this study. Participants who were on regular medication, had a health problem in the last 6 months, or were injured were excluded from the study. Their parents read and signed the informed consent form on behalf of all the participants. The tests performed in the sessions were conducted in accordance with the principles of the Declaration of Helsinki and permission was obtained from the Çanakkale University School of Graduate Studies Scientific Research and Publication Ethics Committee (09.05.2024 date and 07/37 number). The participants were instructed to avoid caffeine, alcohol consumption, and high-intensity exercise in the 24 hours before the tests. The use of sports supplements was restricted during the tests. Descriptive statistics of the participants' body weight, height, and body mass index (BMI) data are presented in Table 1.

Table 1. Descriptive statistics of the physical properties data of the participants

Variables	N	Mean	Sd	Min	Max
Age (year)	17	15.76	1.44	14.00	18.00
Height (cm)	17	167.06	8.63	155.00	185.00
Body weight (kg)	17	62.02	10.63	44.00	89.00
BMI (kg/m2)	17	22.10	2.32	17.85	26.49

Sd: Standard deviation, Min: Minimum; Max: Maximum

Procedures

In the study, which used a control group experimental research design, the participants were tested in the same order during the experimental tests (Control and Mental Fatigue sessions). In the study, the protocols were performed in the same way in all sessions and the tests were carried out between 16.00 and 19.00 in the evening, during the athletes' usual training hours. A total of three sessions were carried out: Preparation (PRE), Control (CON), and Mental Fatigue (MF). Three-day wash-out periods was given between the sessions. In all sessions, general warm-up, testing, and cool-down were performed respectively. A bench press (BP) test was used to assess the upper body strength and a squat (SQ) test was used to assess the lower body strength. During the sessions, 10 min rest was given between the upper and lower body strength tests. In the PRE session, demographic information was obtained, body weight and height measurements were taken, the Stroop test was performed and the 1RM values of the participants were determined. In the CON session, the total number of repetitions (NOR) and the movement time (MT) in seconds were recorded until the participants were exhausted at 60% of the 1RM value. In the MF session, the NOR and MT of the participants at 60% of the 1RM BP-SQ value were recorded after a 30-min Stroop test. The athletes were required to follow the same dietary regime for 24 hours before each test day and to avoid caffeine, alcohol consumption and vigorous exercise.

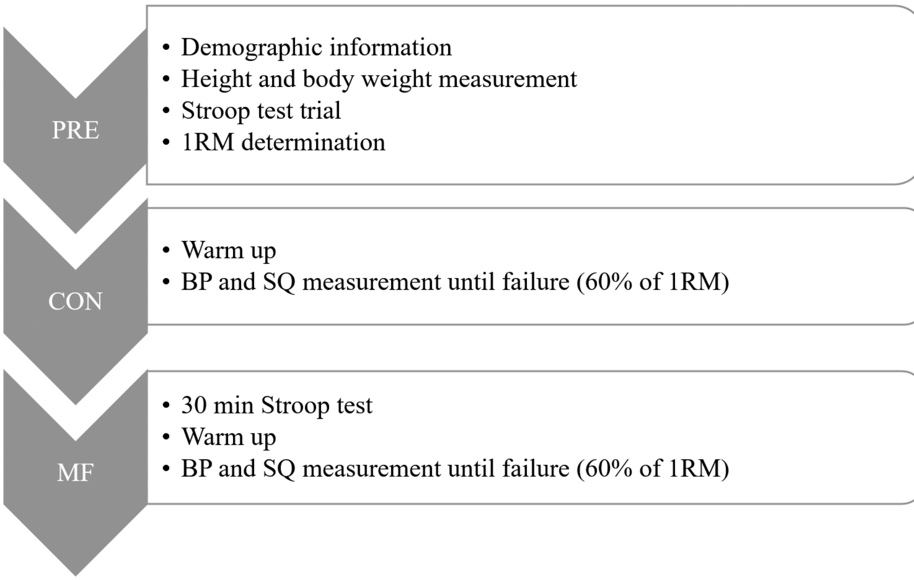

Figure 1. Application Flow Chart

One-repetition Maximum (1RM) Test

After requesting the demographic information of the participants and recording their body height and weight, the 1RM test was performed to determine the maximal weight they could lift in one repetition in order to determine the weights to be used in the strength assessments. In the tests performed separately for BP and SQ movements, the specified protocol was followed:

The 1RM test is recognized as the gold standard for assessing muscle strength under non-laboratory conditions (Levinger et al., 2009). The initial warm-up for the strength endurance test was performed as 8-10 repetitions at 50% of the 1RM determined in the preparation phase, followed by 3-5 repetitions at 75% of the 1RM. Participants then completed one repetition at 95% of the 1RM with a constant movement tempo of 3s eccentric / 3s concentric. After each trial, the weight was increased by 2.5-10 kg until the 1RM was reached, depending on whether the participants successfully lifted the weight. 5-min rest intervals were adopted between the 1RM strength trials to recover well.

Strength Endurance Test

In the CON and MF sessions, a strength endurance test was performed to assess the strength endurance of the participants. The athletes first performed a general warm-up at a heart rate of 130 for 5 min, followed by a special warm-up with 15 repetitions at 20%, 10 repetitions at 40%, 5 repetitions at 60%, and 3 repetitions at 80% of the 1RM at a movement tempo of 3s eccentric / 3s concentric. The concentric phase was performed at the highest possible speed in each repetition (Wilk, Golas, Krzysztofik, Nawrocka, & Zajac, 2019). All the repetitions were performed without jumping, concentric, and without pausing. During all the sessions, the following parameters were recorded:

1. Number of repetitions of Squat (SQ-NOR)
2. Movement time of Squat (SQ-MT)
3. Number of repetitions of Bench Press (BP-NOR)
4. Movement time of Bench Press (BP-MT)

Mental Fatigue Test (Stroop Test)

The Stroop test is a type of neuro-psychological test that evaluates the function of the prefrontal region of the brain (Stroop, 1935). The Stroop test consists of three different parts: control, congruent, and incongruent trials. The Stroop task was assessed using the Inquisit Lab 6 program. Participants sitting in front of the computer were asked to press the "D", "F", "J", or "K" buttons, which were color-matched and written as a note on the screen, in order to give the fastest possible response. The word that appears on the computer screen is in color and states the name of four basic colors; blue, red, yellow, and green; this has to be answered correctly and as soon as possible with the help of the pre-determined keys. The Stroop test included incongruent trials, in which a colored word image was presented in a different color than that of the word (e.g., the word "red" was shown in black), congruent trials, in which words were presented printed in the same ink color as that of the word (e.g., the word "red" was shown in red), and control trials consisting of colored shapes. In this task, stimuli did not disappear from the screen until a response was made and a 500 ms interval was given between one stimulus and the next. When the participants answered correctly, the stimuli disappeared and a new stimulus appeared; however, when participants answered incorrectly, an "X" mark appeared on the screen and was immediately followed by a new stimulus (Faria, Frois, Fortes, Bertola, & Albuquerque, 2024). If the word does not match the color, the time to answer is much longer than in the normal situation. The total time, reaction time, and error rates were recorded after 30 minutes of testing. For an acceptable response, responses given within 200 and 2000 ms after stimulus presentation were considered correct. Responses that were not within the time interval and responses given by pressing the wrong color button were considered incorrect.

Data Analysis

The data were analyzed in SPSS 25 and a Paired Sample t-test with Bonferroni corrected was used to compare the number of repetitions and movement time values between the trials. The normality of the data was tested using the Skewness-Kurtosis test and the data was found to be in a normal distribution (±1.5). The significance level was accepted as $p<0.05$.

RESULTS

Since the Skewness-Kurtosis values of the BP and SQ test results and the MF test total time and reaction times were between -1.5/+1.5, it was determined that the data was normally distributed (Tabachnick & Fidell, 2013). Descriptive statistics of the demographic information of the participants are presented in Table 2.

Table 2. Descriptive statistics of the demographic information of the participants

<table>
<tr><th>Variables</th><th>Categories</th><th>N</th><th>f (%)</th><th>Variables</th><th>Categories</th><th>N</th><th>f (%)</th></tr>
<tr><td rowspan="2">Gender</td><td>Female</td><td>9</td><td>52.9</td><td rowspan="2">Coach Type</td><td>Enthusiastic/
Job-maker</td><td>14</td><td>82.4</td></tr>
<tr><td>Male</td><td>8</td><td>47.1</td><td>Tame/
Good-natured</td><td>3</td><td>17.6</td></tr>
<tr><td rowspan="3">Sports age</td><td>0-1 year</td><td>4</td><td>23.5</td><td rowspan="3">Branches</td><td>K1</td><td>8</td><td>47.1</td></tr>
<tr><td>2-4 year</td><td>8</td><td>47.1</td><td>Low Kick</td><td>5</td><td>29.4</td></tr>
<tr><td>≥5 year</td><td>5</td><td>29.4</td><td>Full Contact</td><td>4</td><td>23.5</td></tr>
</table>

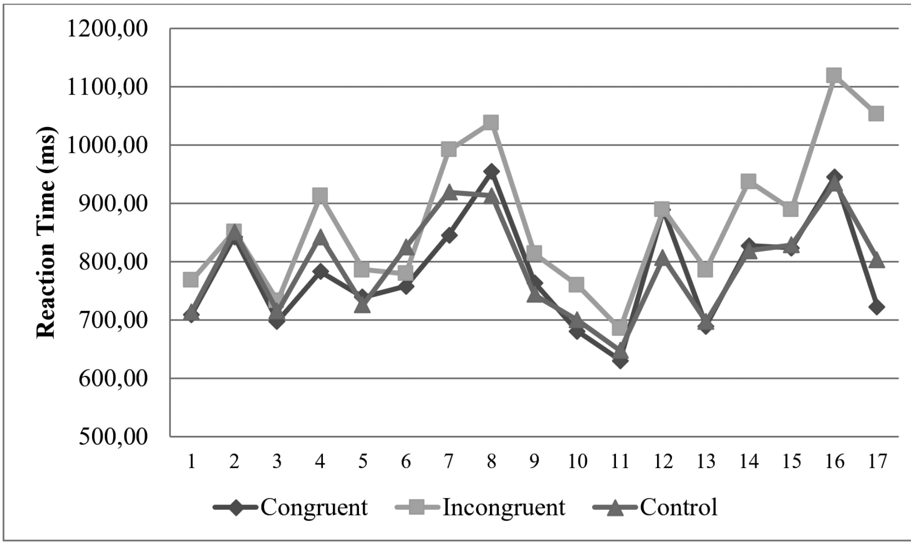

Figure 2. Reaction time of participants during the Stroop test

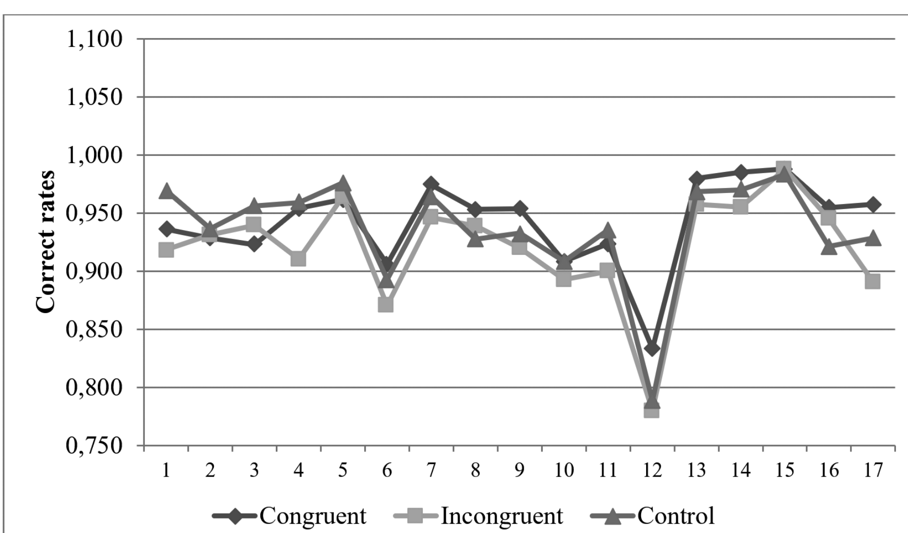

Figure 3. Correct rates of participants during the Stroop test

The data indicates that 52.9% of the participants were female. 76.5% of them had a sports age of 2 years or more. 47.1% of them fought in the K1 branch, 29.4% in the low kick branch, and 23.5% in the full contact branch.

The reaction times and correct rates demonstrated by the participants in the MF session are presented below.

The statistical data on the participants' strength endurance number of repetitions (NOR) and movement time (MT) measured for SQ and BP in the CON and MF sessions are presented in the figure and table below.

According to the data, it was determined that the presence of MF had a significant effect on SQ-NOR with a 34.5% decrease, on SQ-MT with 36.88%, on BP-NOR with 22.71% and on BP-MT with 28.27% in young kickboxers ($p<0.05$).

The statistical data on the mean number of repetitions of strength endurance (NOR) and movement time (MT) measured for SQ and BP in the CON and MF sessions of the participants, according to gender are presented in the figure and table below.

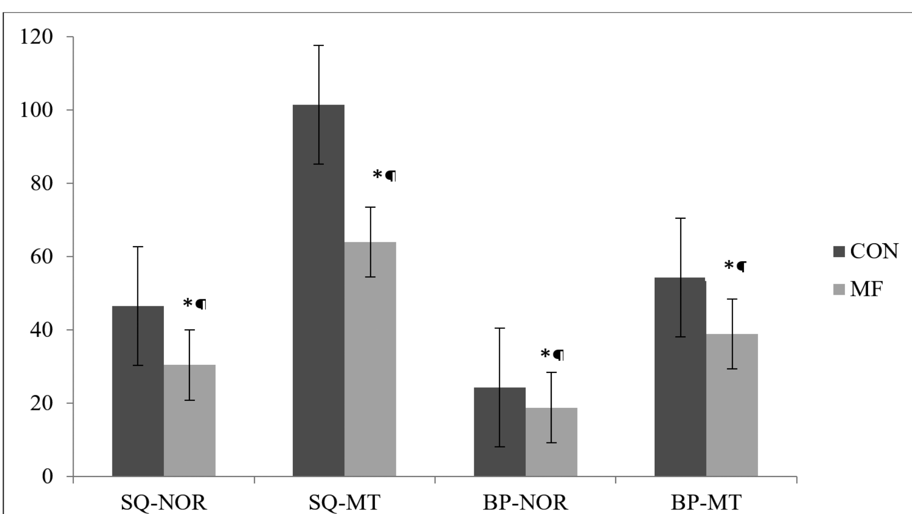

Figure 4. Difference between mean Squat (SQ) and Bench Press (BP) Number of Repetitions (NOR) and Movement Time (MT) in CON and MF Session

Table 3. Paired sample t-test results for the mean strength endurance measured for SQ and BP in CON and MF sessions

Variable	Session	N	Mean	Sd	%	t	p
SQ-NOR (rep)	CON	17	46.53	18.38	34.5	3.661	0.002*
	MF	17	30.47	10.53			
SQ-MT (s)	CON	17	101.41	29.26	36.88	4.649	0.000*
	MF	17	64.00	22.09			
BP-NOR (rep)	CON	17	24.35	8.61	22.71	3.773	0.002*
	MF	17	18.82	7.13			
BP-MT (s)	CON	17	54.29	17.40	28.27	5.264	0.000*
	MF	17	38.94	15.08			

*p<0.05; Sd: Standard deviation; SQ: Squat; BP: Bench Press; SQ-NOR: Number of repetitions of Squat; SQ-MT: Movement time of Squat; BP-NOR: Number of repetitions of Bench press; BP-MT: MoWvement time of Bench press, rep: repetition.

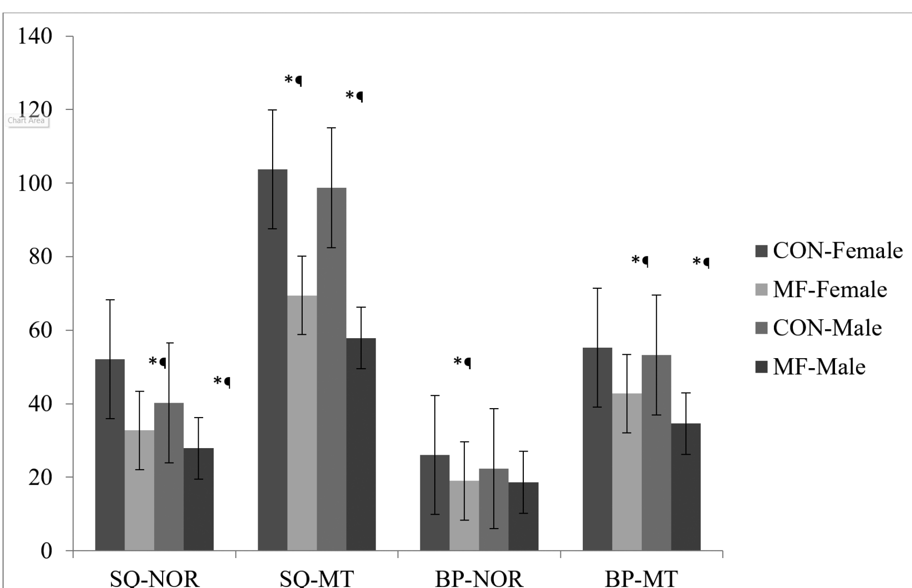

Figure 5. The difference between the mean number of repetitions (NOR) and movement time (MT) of Squat (SQ) and Bench Press (BP) in CON and MF sessions according to gender

Table 4. Paired sample t-test results of the strength endurance averages measured for SQ and BP in the CON and MF sessions, according to gender

Variable	Gender	Session	N	Mean	Sd	%	t	p
SQ-NOR	Female	CON	9	52.11	21.86	37.09	2.624	**0.030***
		MF	9	32.78	11.50			
	Male	CON	8	40.25	11.88	30.73	2.767	**0.028***
		MF	8	27.88	9.39			
SQ-MT	Female	CON	9	103.78	36.82	33.08	2.720	**0.026***
		MF	9	69.44	21.51			
	Male	CON	8	98.75	19.84	41.38	3.961	**0.005***
		MF	8	57.88	22.49			
BP-NOR	Female	CON	9	26.11	7.56	27.23	3.076	**0.015***
		MF	9	19.00	5.98			
	Male	CON	8	22.38	9.80	16.75	2.280	0.057
		MF	8	18.63	8.68			
BP-MT	Female	CON	9	55.22	14.89	22.53	3.714	**0.006***
		MF	9	42.78	13.20			
	Male	CON	8	53.25	20.89	34.96	3.802	**0.007***
		MF	8	34.63	16.76			

*$p<0.05$; Sd: Standard deviation; SQ: Squat; BP: Bench Press; SQ-NOR: Number of repetitions of Squat; SQ-MT: Movement time of Squat; BP-NOR: Number of repetitions of Bench press; BP-MT: Movement time of Bench press, CON: Control; MF: Mental Fatigue.

According to the data, when the NOR and MT of the SQ and BP were analyzed on the basis of gender, it was found that MF had a significant effect on SQ-NOR, SQ-MT, and BP-MT in both women and men ($p<0.05$), while there was a significant decrease in BP-NOR in female athletes ($p<0.05$) but no significant effect on BP-NOR in male athletes ($p>0.05$). The decreasing effect of MF caused a significantly greater decrease in female athletes than male athletes in NOR, while it was found that male athletes had a significantly greater decrease in MT than female athletes ($p<0.05$).

DISCUSSION

This study examined the acute effects of MF on the strength endurance performance of well-trained male and female kickboxing athletes. According to the results, the presence of MF significantly decreases SQ-NOR (34.5%), SQ-MT (36.88%), BP-NOR (22.71%), and BP-MT (28.27%) in young kickboxers. Task duration has an important effect on the reduction of sports performance due to mental fatigue. It is known that tasks lasting less than 30 min have no effect on exercise performance, though they do reduce cognitive capacity (Hagger, Wood, Stiff, & Chatzisarantis, 2010; Graham, Sonne, & Bray, 2014). In this respect, 30 min of the Stroop test applied for mental fatigue in the study decreased performance. In athletes exposed to prolonged mental fatigue, the ratio of perceived exertion increased (Marcora, Staiano, & Manning, 2009; Pageaux, 2014; Van Cutsem et al., 2017a). However, from a neurophysiological point of view, mental fatigue negatively affects physical effort and decreases motivation (Rudebeck, Walton, Smyth, Bannerman, & Rushworth, 2006; Walton, Kennerley, Bannerman, Phillips, & Rushworth, 2006). Therefore, it could be that the prolonged Stroop test applied to the athletes also affected brain regions related to the cognitive aspects of central motor command and deactivated the facilitative system that encourages athletes to act.

According to a study conducted by Cao et al. (2022) on basketball players, similar to the results of the current research, it shows that MF impairs technical performance such as free throw, three-point shooting, and turnovers, as well as mental performance such as making the first move, intuitiveness, and decision-making. It is known that MF practices have negative effects not only in basketball but in other branches as well. Recent studies aiming to understand the MF phenomenon have shown that it is detrimental to endurance skills such as cycling, running, yo-yo, motor skills such as accuracy, speed and finishing time, and decision-making skills such as making mistakes and slower reaction time (Van Cutsem et al., 2017b; Pageaux & Lepers, 2018; Habay et al., 2021). In another study, MF impairs sport-specific psychomotor performance in football, badminton, basketball, table tennis, cricket, and other sports (Habay et al., 2021).

In another study conducted by Coutinho et al. (2017) on football players, they reported that MF impairs physical and tactical performance, negatively affects the athletes' ability to use environmental information and the players' positioning. Smith et al. (2016) found a decrease in distance traveled on the yo-yo test and technical performance following mental fatigue from a 30-minute incongruent Stroop test in football players. In a study by Pageaux and Lepers

(2016) on active adolescent endurance athletes investigating the effects of MF on cognitive and aerobic performance, it was found that a 30-minute Stroop test negatively affected the maximum oxygen intake and running speed; the rating of the perceived exertion level is also high. As a result, they reported that mental fatigue impairs aerobic and cognitive performance in active male endurance athletes. In the literature, as a result of the negative consequences of MF applications on the endurance performance of athletes in all branches, a negative effect on kickboxing athletes is expected.

While there are studies that show a decrease in sports performance after MF application, there are also studies that show no effect, though they are very few in number. However, Vrijkotte et al. (2018) showed that mental fatigue has a negative impact on cycling performance. In the study conducted by Silva-Cavalcante et al. (2018) with 8 recreational male road cyclists, after 90 minutes of AX-CPT testing, they found no effect on the visual analogue scale, RPE, 5-second maximal voluntary contraction with 30-second rests in the quadriceps muscle, electrical muscle stimulation and 4 km time trial cycling performance. Proost et al. (2023) reported that MF did not affect RPE or movement-related cortical potential (MRCP) during leg extension. The researchers reported that this situation could be related to the lack of performance output; also, the increase in alpha power in the experimental group may be linked to a focused internal attention mechanism to reduce the feeling of fatigue. Similarly, Filipas, Mottola, Tagliabue, and La Torre (2018) reported that 60 minutes of Stroop or solving math problems had no effect on heart rate (HR), rating of perceived exertion (RPE), and 1500-meter rowing performance in young rowers. In line with these results, although the presence of MF does not affect sports performance, when the studies are taken as a whole, it can be inferred that mental fatigue negatively affects sports performance in general and it can be said that the possibility of negative results is higher. If a more detailed inference needs to be made, it is thought that the results may differ in terms of test type, application time, the athletic level of the athletes, and the measured characteristics (endurance, speed, etc.).

In the current study, when the effect of MF on sports performance was examined on a gender basis, it was observed that it had a negative effect on both genders. Contrary to this result, Pereira et al. (2015) found in their study that elderly women fatigued the upper extremity more with incremental mental activity applied during continuous postural contractions; they emphasized that women are more sensitive than men. In line with the different results in the literature, it is thought that the effects of mental practices on a gender basis cannot be predicted. However, considering that women are more psychologically sensitive, it is estimated that the performance of female athletes may deteriorate more than male athletes during long-term mental practices for long-distance athletes. However, this needs to be proven by scientific studies.

The duration of the activity that causes mental fatigue has a significant impact on the deterioration of sports performance. When the studies conducted in this context are examined, Smith, Marcora, and Coutts (2015) examined the effect of the AX-CPT test applied for 90 min on intermittent running performance and reported that the athletes' perceived difficulty level was high, running speed and oxygen consumption significantly decreased, and this negative effect of cognitive fatigue was mediated by the perception of high effort. In the study conducted by Terentjeviene et al. (2018) on 30 healthy adult male athletes, it was reported that after 120 minutes of Go / No Go, there was a decrease in motivation and hand grip strength, and an increase in reaction time, perceived workload and frontal cortex activity. Le Mansec, Pageaux, Nordez, Dorel, and Jubeau (2018) reported that 90 minutes of AX-CPT application resulted in a decrease in ball speed and total score, an increase in the number of errors, an increase in RPE, and a decrease in the rate of hitting the target in 22 experienced male table tennis athletes. Contrary to these results, Rozand, Pageaux, Marcora, Papaxanthis, and Lepers (2014), supporting the thesis on the effect of practice time on performance, reported that the 27-minute Stroop test did not affect isokinetic strength, RPE, HR, and voluntary maximum contraction in adult men. In line with the results obtained, it can be said that mental fatigue does not occur following periods under 30 minutes, regardless of the test type, measured feature, and sport branch.

From another perspective, just as cognitive practices have a negative effect on sports performance, it has been revealed in studies in the literature that sports loads also have a negative effect on mental performance. Mancı et al. (2023) revealed that elite basketball players showed better cognitive performance than amateur players after 4 sets of 30s sprint intervals. As a result of the negative effects of applications in both directions, it can be concluded that cognitive and physical performance cannot be considered separately from each other. In this sense, both the mental and the physical aspects must be well supported in all planning and programs for sports performance. It is known that there is a negative relationship between the long-term use of technological devices and executive functions (Warsaw et al., 2021). Social media use requires constant attention as it involves listening, writing, and reading; therefore, spending long periods of time on smartphones can also cause mental fatigue (Russell et al., 2019; Fortes et al., 2020). When the studies on the subject are examined, using social media before a sports performance for at least 30 minutes impairs the decision-making skills in professional football players (Fortes et al., 2020). It has also been reported that smartphone use before training sessions in football negatively affects both technical and endurance performance (Greco, Tambolini, Ambruosi, & Fischetti, 2017). In line with these results, athletes need to be able to manage their self-control mechanisms regarding the use of technological devices just before training or competition in order to prevent mental fatigue. If coaches and parents pay attention to this issue, it will allow the factors that negatively affect the athletes' sports performance to be reduced and the performance to be kept at an optimum level. In terms of the negative effects of long-term cognitive activities, 20 mg dopamine (DA) and 8 mg noradrenaline (NA) supplementation applied before the MF delays the onset of the MF and improves cognitive performance (Arenales Arauz et al., 2024). In this context, both athletes and individuals with cognitive tasks can minimize the negative effects of cognitive fatigue by taking DA and NA supplements. The use of NA and DA may help increase endurance performance in order to make long-term performance outputs more efficient.

CONCLUSION

Based on the results of this study, it has been revealed that mental fatigue negatively affects the strength endurance of kickboxers, one of the strength sports. Many coaches and sports trainers attach importance to the training process for performance development; however, when acute studies are examined, factors that negatively affect performance should also be taken into consideration. Mental fatigue emerges as an acute factor that negatively affects performance, and when looking at studies in the literature, it is known that mental fatigue negatively affects performance in many branches. In this respect, before training or competition, regardless of whether you are a woman or a man, it is necessary to avoid activities that may cause mental fatigue. It is essential for coaches and sports trainers to pay attention to this situation when creating and implementing programs.

PRACTICAL IMPLICATIONS

While there have been efforts to increase exercise and sports performance for a long time, studies continue to identify factors that negatively affect performance and precautions that can be taken. Mental fatigue and what to do about it is one of them. This study was conducted on kickboxing athletes and their muscular endurance performance was examined.

– This study was conducted on young individuals. Wascher and Getzmann (2014) found that performance declined in the older participants but not in the young after an 80-min task, so the results of this study may vary for older individuals. Therefore, future studies should be conducted separately with adults.

– Gender is also an important factor in MF. Therefore, gender comparisons can be made in studies examining the effects of MF applications on sports performance.

– Applications that may cause MF before exercise may negatively affect performance; Therefore, coaches and athletes should avoid such practices just before training and competition. Appropriate methods and techniques can be developed for athletes who cannot achieve self-control in this regard.

– The effect of MF on sports performance may vary depending on the sports level of the athletes; it is thought that high-level athletes have better cognitive control and their responses to cognitive tasks may be better. Therefore, research should be conducted separately on amateur and professional athletes.

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