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Brain Endurance Training improves shot speed and accuracy in grassroots padel players

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Ethics:

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Abstract

Objective: Evidence that mental fatigue impairs sport performance has created a demand for countermeasures. We examined the effects of Brain Endurance Training (BET), a form of fatigue-inoculation, on shot performance in grassroots padel players.

Design: A pre-, mid- and post-test design, with participants randomized to BET (n = 30) or control (n = 31) training groups.

Method: During testing, participants completed a Padel Stroke Performance Test, before and after a demanding 30-min cognitive task (Stroop). The Stroop task was performed on a computer while sitting. Training comprised 3 sessions per week for 6 weeks. In each training session, participants completed 10-min warm-up, 15-min technical drills, 15-min tactical drills, and 20-min simulated games. These physical activities were intermixed with short 4-min periods of seated Stroop (BET group) or rest (control group) totaling 20-min. Performance was measured by shot speed and accuracy of four core padel strokes. Multiple indices of mental fatigue were measured before and after the Stroop task using a visual analog-scale rating, a psychomotor vigilance task, and a go/no go task.

Results: During testing, the 30-min Stroop task elicited a state of mental fatigue, confirmed by higher subjective ratings, slower responses during the psychomotor vigilance task, and slower saccade latencies during the go/no go task. Compared to pre-testing, in mid- and post-testing, the BET group hit progressively faster and more accurate padel shots after the Stroop task compared to controls.

Conclusion: BET enhanced skill-based psychomotor performance when fatigued compared to standard padel training. BET is a countermeasure that promotes mental fatigue durability.

Keywords: cognitive load; fatigue inoculation; psychomotor performance; racket sport

Practical Applications

- BET could be included in padel training programs to help improve shot performance under the demands of competition that can elicit a state of mental fatigue.
- BET could help optimize players' tournament performance given evidence that multi-stage padel tournaments are sources of mental fatigue.
- The standard design of padel training sessions, with recovery periods between exercises, allows coaches to easily incorporate short bouts of cognitive loading intermixed with warm-up, technical, tactical, and game-based physical activities.

1. Introduction

Padel is a doubles racket sport, similar to tennis, played on a 40 × 20 m court enclosed by glass and walls [1]. As an elite sport, padel has progressed rapidly, with professional players now supported by coaches and other specialist personnel funded by increased tournament prize money [2]. Moreover, padel is an increasingly popular sport. The International Padel Federation reported that the number of grassroots players has grown from ten thousand in 2010 to two million in 2019, and the professional circuit, that previously took place almost exclusively in Spain, is now global [3]. Finally, padel has attracted the attention of researchers wishing to understand the factors, such as fatigue, that can influence the performance of grassroots and professional players [4].

Fatigue is an important determinant of sporting performance [5], with padel matches and tournaments causing mental fatigue [6]. Mental fatigue, defined as a psychobiological state caused by cognitive demands, with subjective, behavioral, and physiological symptoms [7,8], impairs sport performance [9]. Padel imposes high cognitive demands, including decision-making (e.g., move based on ball direction and speed), attention (e.g., spot opponents' tendencies), memory (e.g., remember coach's instructions), and response inhibition (e.g., ignore distractions). Importantly, playing matches elicits mental fatigue in padel players [6], which, in turn, impairs their psychomotor performance [10].

Countermeasures are available to combat mental fatigue [11], including avoidance (e.g., no smartphones), stimulation (e.g., taking caffeine), and training (e.g., fatigue inoculation). Marcora and colleagues [12] [13] have proposed that Brain Endurance Training (BET) – the addition of mentally fatiguing cognitive tasks to standard physical training – will improve subsequent physical performance. The combination of cognitive and physical training is expected to augment the overall cognitive load when exercising during training and increase the rating of perceived exertion. In other words, exercise feels harder to perform. Moreover, repeated exposure to such experiences during training recalibrates the relationship between the actual workload and the perceived workload. Accordingly, following BET the performer can produce more work for the same effort or the same work for less effort. Moreover, the deleterious effects of mental fatigue on performance are reduced by BET because the performer can be expected to develop mental fatigue durability thereby mitigating its effects on subsequent physical performance. The effectiveness of BET for endurance performance has been established in cycling [12], running [13] and handgrip [14,15] tasks. To date, one study has demonstrated that BET improved decision-making speed and accuracy during soccer-specific agility tasks [13]. Accordingly, its impact on skill-based psychomotor performance has yet to be established. Here we opted to evaluate BET as a countermeasure, rather than one of the other options, because it can be readily incorporated into multi-week training programs and it is effective in the medium-term over the course of 1-3 months.

To address this gap in the literature, our innovative study evaluated the effects of BET in grassroots padel players. Our study purposes were threefold. Our first study purpose was to determine the effects of BET on padel shot speed. We hypothesized that players would hit faster shots following BET than standard training (control) when mentally fatigued. Our second study purpose was to determine the effects of BET on padel shot accuracy. We hypothesized that players would hit more accurate shots following BET than control when mentally fatigued. Our third study purpose was to evaluate the impact of BET on mental fatigue. We hypothesized that players would experience less mental fatigue following BET than control.

2. Methods

Sixty-one amateur padel players from Portugal and Spain (mean [SD], age 28.71 [7.68] y, height 178.44 [9.61] cm, and weight 75.31 [7.45] kg) who trained three times per week for the past two years and regularly played tournaments were recruited and gave informed consent. The protocol was approved by the Ethics Committee at the University of Extremadura in accordance with the Declaration of Helsinki. Participants were naïve to our study purposes and hypotheses. We told them that we wanted to examine the effects of a training program on padel shot performance. However, if they enquired, we told them that we would describe the study purposes during the debrief at the end of the study. Power calculations indicated that with a sample of 61 the study was powered at 80% to detect significant ($p < .05$) between-within interaction effects corresponding to a small effect size ($\eta_p^2 = .03$, f = .18) by analysis of variance. None dropped out.

Perceptual, behavioral, and physiological indices of mental fatigue were obtained before and after the 20-min Stroop task during testing as well as before and after each training session (see **Figure 1**). Using a Visual Analog Scale - Mental Fatigue (VAS-MF), participants were asked "*How mentally fatigued do you feel*?" and responded by placing a mark on a 10-cm line, anchored by "not at all" and "maximum level of mental fatigue possible" [16]. They completed a 3-min Brief Psychomotor Vigilance Task (PVT-B) to assess mental alertness and readiness to perform [17]. Specifically, they were presented a visual stimulus, with a 1-4 s interstimulus interval, in the centre of a smartphone, and were required to respond by pressing the touchscreen as fast as possible; reaction time was recorded. They completed a 160-s go/no-go task to assess ocular indices of mental fatigue. Specifically, on each of 16 trials, they fixated on a white central cross displayed on a screen, placed 60 cm away, and after a variable 2–5 s interval, were randomly presented with a black or white circle for 3 s at one of the four corners of the screen. If the circle was black they needed to make a saccadic eye movement and re-fix their gaze on the circle (i.e., the go condition), whereas if the circle was white they needed to maintain their gaze fixed on the central cross (i.e., the no-go condition). A mobile eye-tracker (SensoMotoric Instruments, SMI) was used to record pupil diameter and saccadic eye movement latency (i.e., time between appearance of the black circle and eye movement onset) during the task [18,19].

The Padel Stroke Performance Test [20] was used to assess padel shot speed and accuracy (for details see **Supplementary Materials**). Participants performed each of four padel strokes in a blocked 4-shot set in the following fixed order: drive attack, drive volley, bandeja, and drive after glass. They rested 20 s between sets. The ball was propelled by a machine to standardize the test.

Shot accuracy was assessed by an evaluator standing close to the court using a points-based scoring system, with the most accurate shots awarded 9-points (i.e., ball bounced within 3 m of the corner of the court) and least accurate shots awarded 0 points (i.e., ball bounced more than 5 m from the corner of the court). The evaluator was blinded to the participant's group allocation. Shot speed was measured using a ball-tracking radar (Stalker Professional Sports Rada, Richardson, TX, USA).

Participants completed three 1-hour testing sessions: 0 (pre-test), 3 (mid-test), and 6 (post-test) weeks (see **Figure 1**). The pre-test was scheduled before the first training session of week 1, the mid-test was scheduled after the third training session of week 3, and the post-test was scheduled after the third training session of week 6. Sessions took place at the same time of day. Players were encouraged to sleep at least 7 h the previous night, refrain from caffeine and alcohol for 12 h before each session, refrain from vigorous physical activity for 24 h before each session, and avoid creatine. In each testing session, players completed a padel stroke performance test and measures of mental fatigue (see above) before and after a 30-min Stroop task (UMH-MEMTRAIN, Elche, Spain). The incongruent Stroop test is a response inhibition task that elicits mental fatigue [21]. In this incongruent Stroop test, a word representing one of four colors (blue, green, red, yellow) was displayed on a 69 × 55 cm monitor in a different color on a black background, and participants were instructed to press a button to indicate the meaning of the words as quickly and accurately as possible. All words were displayed in a different color to their meaning (i.e., 100% incongruent trials). The interstimulus interval was 1900 ms. A researcher sat behind the participant to ensure compliance.

The study employed a pre-, mid- and post-test design (see **Figure 1**), with participants randomly allocated to BET (*n* = 30) or control (*n* = 31) training groups. Both groups completed the same coach-based training sessions with four players from the same group, comprising the following activities: 10-min warm-up, 15-min technical sets (e.g., volleys or drives) where the ball was thrown by the coach, 15-min tactical exercises using constraints to focus on a specific tip, and 20-min simulated games. These activities were separated (preceded / followed) by a 4-min Stroop task (BET) or 4-min rest (control), that were completed while sitting silently. The BET group performed the Stroop on a smartphone. The control group rested without a smartphone. With this intermixed training schedule, the cognitive loading lasted 20 min (i.e., 5 x 4-min cognitive tasks) per session, for a total of 18 sessions (i.e., 3 sessions per week for 6 weeks). We chose to use short bouts of the mentally-fatiguing cognitive tasks because this arrangement fit around the players' standard training sessions and imposed little additional time on them. In other words, this intermixed BET protocol was convenient and efficient. Indices of mental fatigue were obtained before and after each training session.

A series of mixed factorial ANOVAs, with group (BET, Control) as the between-participant factor and with time (0, 3, 6 weeks) and test (before Stroop, after Stroop) as the within-participant factors, were performed on the measures of padel performance and mental fatigue during testing.

A series of mixed factorial ANOVAs, with group (BET, Control) as the between-participant factor and training (before, after) as the within-participant factor, were performed on the measures of mental fatigue during the 6-week training period. We report the multivariate solution to minimize the risk of violating sphericity and compound symmetry assumptions in ANOVA designs. The data met the ANOVA assumptions. Partial eta-squared (η_p^2) was reported as a measure of effect size, with values of .02, .13 and .26 indicating small, medium and large effect sizes, respectively [22]. Significance was set at $p < .05$. Analyses were conducted using the Statistical Package for the Social Sciences (SPSS) software (IBM, United States).

3. Results

A series of 2 group (BET, Control) by 3 time (0, 3, 6 weeks) by 2 test (before Stroop, after Stroop) ANOVAs on padel shot speed yielded large main effects for time and test for all four shot types (see **Figure 2** and **Table 1**), with players hitting progressively faster shots as a function of weeks of training completed as well as consistently slower shots when tested after compared to before the 30-min Stroop task. Importantly, large group by time by test interaction effects were found for each shot. In all cases, shot speed was consistently slower after compared to before Stroop in the Control group whereas shot speed was slowed less and less by the Stroop task as training progressed for the BET group. In brief, the impact of the Stroop task was equally large at week 0 and week 6 for Control but was largest at week 0 and smallest at week 6 for BET, with no before-after differences for volley and drive shots following BET.

The 2 group by 3 time by 2 test ANOVAs on padel shot accuracy yielded large main effects for time and test for all four shot types (see **Figure 3** and **Table 1**), with players hitting more accurate shots as a function of weeks of training completed as well as consistently less accurate shots when tested after compared to before the 30-min Stroop task. Moreover, medium-to-large group by time by test interaction effects were found for volley, drive, and bandeja shots whereas a large group by time interaction effect was found for after glass shots. In contrast to the drop in accuracy after Stroop compared to before Stroop that was evident at week 0 and week 6 in the Control group, the initial drop in performance accuracy at week 0 was no longer manifested at week 6 in the BET group.

The mental fatigue indices during testing are displayed in **Figure 4** and the accompanying 2 group by 3 time by 2 test ANOVAs are summarized in **Table 1**. ANOVA on VAS-MF mental fatigue ratings produced large effects for time, test, and time by test coupled with a small-to-medium effect for group by Stroop. The Stroop task produced a state of mental fatigue, with VAS-MF ratings increasing from less than 2 to more than 8 out of 10, with this increase being smaller for the BET group than the Control group. ANOVA on reaction times during the 3-min psychomotor vigilance task generated large effects for time, test, and group by test coupled with medium effects for group by time and group by time by test. Reaction times were slowed after completing the Stroop task in both groups, with the extent of the slowing becoming relatively smaller in the BET group compared to the Control group as training progressed, such that the BET group were less slowed after 3 weeks and least slowed after 6 weeks of training. ANOVA on pupil diameter produced large effects for time and test as well as medium effects for group by time and time by test). Pupil diameter was increased following the Stroop test and was progressively smaller over the course of training, with the BET group's pupil diameter decreasing in size over the course of training more quickly than that of the Control group. ANOVA on saccade latency yielded large effects for time, test, and group by time by test coupled with medium effects for group and group by time by test. Latencies were slower after completing the Stroop task in both groups, with the extent of the slowing becoming relatively smaller in the BET group compared to the Control group as training progressed, such that the pupil latencies of the BET group were less slowed after 3 weeks and least slowed after 6 weeks of training compared to Control.

The mental fatigue indices, averaged across the training sessions completed during the 6-week training period, are presented in **Table 2**. The 2 group (BET, Control) by 2 training (before, after) ANOVAs yielded group, training, and group by training effects for every index. Effect sizes were large, with one exception (the group main effect for pupil diameter was small). Training increased VAS-MF ratings, slowed PVT-B reaction times, increased pupil diameters, and slowed saccade latencies in both groups. Importantly, before training the two groups exhibited similar levels of mental fatigue, however, after training the BET group gave higher VAS-MF ratings, responded slower during the PVT-B, displayed more dilated pupil diameters, and moved their eyes slower than the Control group. Taken together, these data confirm that the cognitive load during training was more fatiguing for BET than Control.

4. Discussion

The present study evaluated the effectiveness of a 6-week intermixed BET intervention on the psychomotor performance of amateur padel players. The main study findings indicated that BET consistently improved shot speed and accuracy subsequent to a 30-min mentally-fatiguing Stroop task. This demanding cognitive task elicited a state of mental fatigue in all players, confirmed by their increased VAS-MF ratings, slower PVT-B reaction times, and slower saccadic eye movement latencies. Importantly, BET reduced the impact of the Stroop task on players' perceptual, behavioral, and physiological indices of mental fatigue. Accordingly, BET represents a form of fatigue-inoculation that improves psychomotor performance in sport, at least in part, via adaptions to mental fatigue demands. Our main findings are discussed in detail below.

The padel stroke outcomes during mentally fatiguing conditions showed that the BET players were more resilient to mental fatigue and better able to maintain their shot speed and accuracy than control players. Indeed, both groups performed worse, shown by the decreased speed and accuracy of all four padel shots, when in a state of mental fatigue. This evidence confirms that mental fatigue induced by the demanding cognitive task impaired padel shot performance, in line with extant research in padel [10], and other sports, such as table-tennis [23, 24]. The reason why mental fatigue impairs sport performance has yet to be established [25]. It should be noted that perceived effort [26, 27] and frontal cortical activity have been touted as possible mechanisms [7] underlying fatigue-impaired endurance exercise performance. Similarly, the reasons why BET improves subsequent performance and makes athletes more resilient to mental fatigue and its deleterious effects on performance are also the subject of lively debate. The best physiological evidence to date points to a BET-induced maintenance of pre-frontal oxygenation during exercise task performance, suggestive of reduced mental effort during demanding physical activity [14,15]. The current study is unable to confirm this neurophysiological efficiency adaptation. Our finding that BET attenuated the slowing of the onset of eye movement to track an object in the visual field that happened after performing a mentally demanding cognitive task, suggests that the improvements in shot speed and accuracy may be attributable, at least in part, to BET players being better able to track the incoming ball that they subsequently hit back over the net as fast and as close to the corner of the court as possible. Future studies would do well to explore changes in cortical efficiency and processing in relation to BET using mobile electroencephalographic recordings.

Our results showed that BET helped players develop tolerance to a mentally-fatiguing cognitive task. Specifically, BET mitigated the extent of the increases in the mental fatigue indices from before to after the Stroop task. This is a novel observation. Previous BET studies, which focused on endurance exercise performance, were not designed to prove such an effect. The one exception is the study showing that BET improved soccer-specific agility metrics [13]. Among researchers and practitioners, there is considerable interest in identifying countermeasures to deal with the negative effects of mental fatigue experienced by athletes. Our evidence indicates that BET is an effective and trainable countermeasure to preserve performance under the demands of sporting competition when athletes are in a state of increased mental fatigue.

Our findings confirm that the mental demands of padel training sessions were increased by BET compared to standard training activities. In line with evidence that padel is a mentally fatiguing sport [6], we observed that players in the control group also experienced increased mental fatigue following training. Crucially, we also observed that the addition of a series of 4-min Stroop tasks, intermixed with standard padel training activities, further increased the mental demands associated with padel training in the BET group. The incongruent Stroop task, which involves a complex series of cognitive processes, including attention, memory and response inhibition, is the most popular choice for researchers interested in investigating the effects of mental fatigue on subsequent sport performance [21]. Nonetheless, it is likely that players adapted and learned how to perform the Stroop task, and, therefore, future BET studies should include a diverse battery of cognitive tasks, including ones that emphasise memory updating and set switching, two of the three core executive functions (the third being response inhibition), to help impose a high cognitive load on athletes due because of high task novelty and difficulty.

The current innovative study demonstrates the positive effects of BET on the performance of mentally fatigued racquet sport players. However, some potential study limitations should be noted.

First, the study focused on amateur players. Our findings therefore may not fully generalize from grassroots to professional players, who may be less vulnerable to the deleterious effects of mental fatigue [28]. It should be noted that this possibility is questioned by a recent meta-analysis [29]. Regardless, future studies should evaluate the effects of BET on better players, ideally elite performers. Second, we employed a passive control group who performed standard padel training. A more active control would be helpful to rule out the possibility that the performance benefits with BET might have been due, at least in small part, to doing some form of extra training (e.g., cognitive) in addition to standard training. Third, we employed the same cognitive task for testing and training. It is therefore possible that the observed fatigue-inoculation effect was specific to the Stroop task. Accordingly, future studies would do well to examine whether the performance benefits of BET generalise to other experimental manipulations of mental fatigue. These manipulations could be classic tasks that demand other cognitive functions, such as memory updating and task switching, as well as more naturalistic tasks, such as using social media on a smartphone. Finally, we did not collect data on process variables to investigate why BET works. We only assessed subjective, behavioral, and physiological indices of mental fatigue. Accordingly, future mechanistic studies should include other measures, such as cortical oscillations and connectivity, to help identify the brain mechanism(s) underpinning the improved shot performance that we observed in grassroots padel players.

5. Conclusion

The present study provides the first evidence that BET improves skill-based psychomotor performance in sport, with grassroots padel players learning to hit progressively faster and more accurate shots when confronted with mentally-fatiguing cognitive demands. This evidence adds to the previous literature showing that BET improves endurance performance in a variety of exercise tasks, including cycling, handgrip and running. Our findings illustrate how BET can be readily adapted to accommodate the training regimes of athletes, in this case, with intermixed BET (i.e., brief cognitive loading taking place during scheduled rest periods between physical training activities). Research studies are required to replicate and extend these findings (e.g., in other sports and/or performance levels) and to try and isolate the psychobiological mechanism(s) underlying BET-related improvements in sport performance.

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Figure 1

Study protocol.

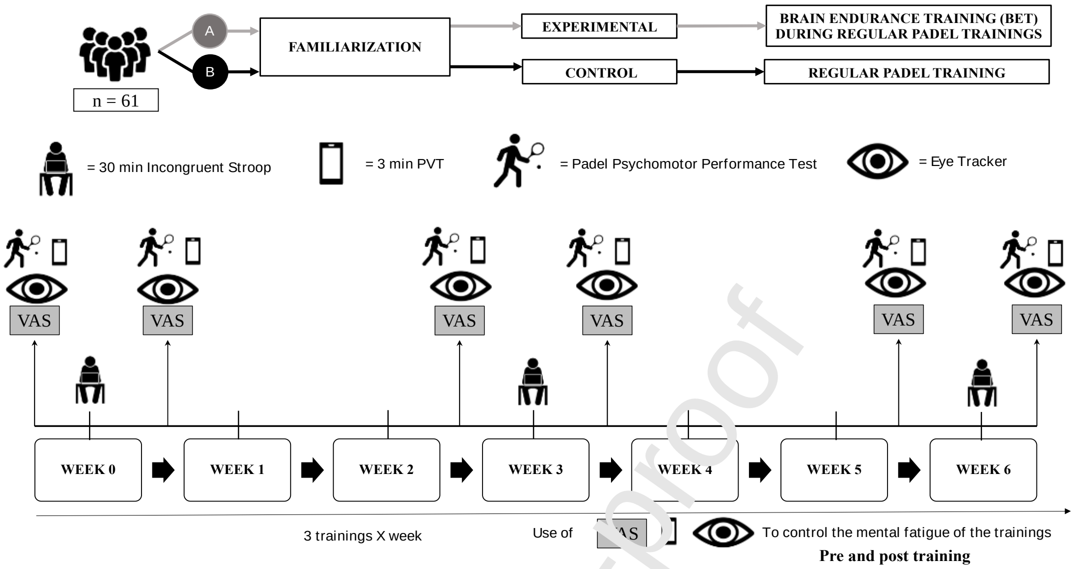

Figure 2.

Mean (SE) shot speed as a function of group (BET, Control), time (0, 3, 6 weeks) and test (before Stroop, after Stroop).

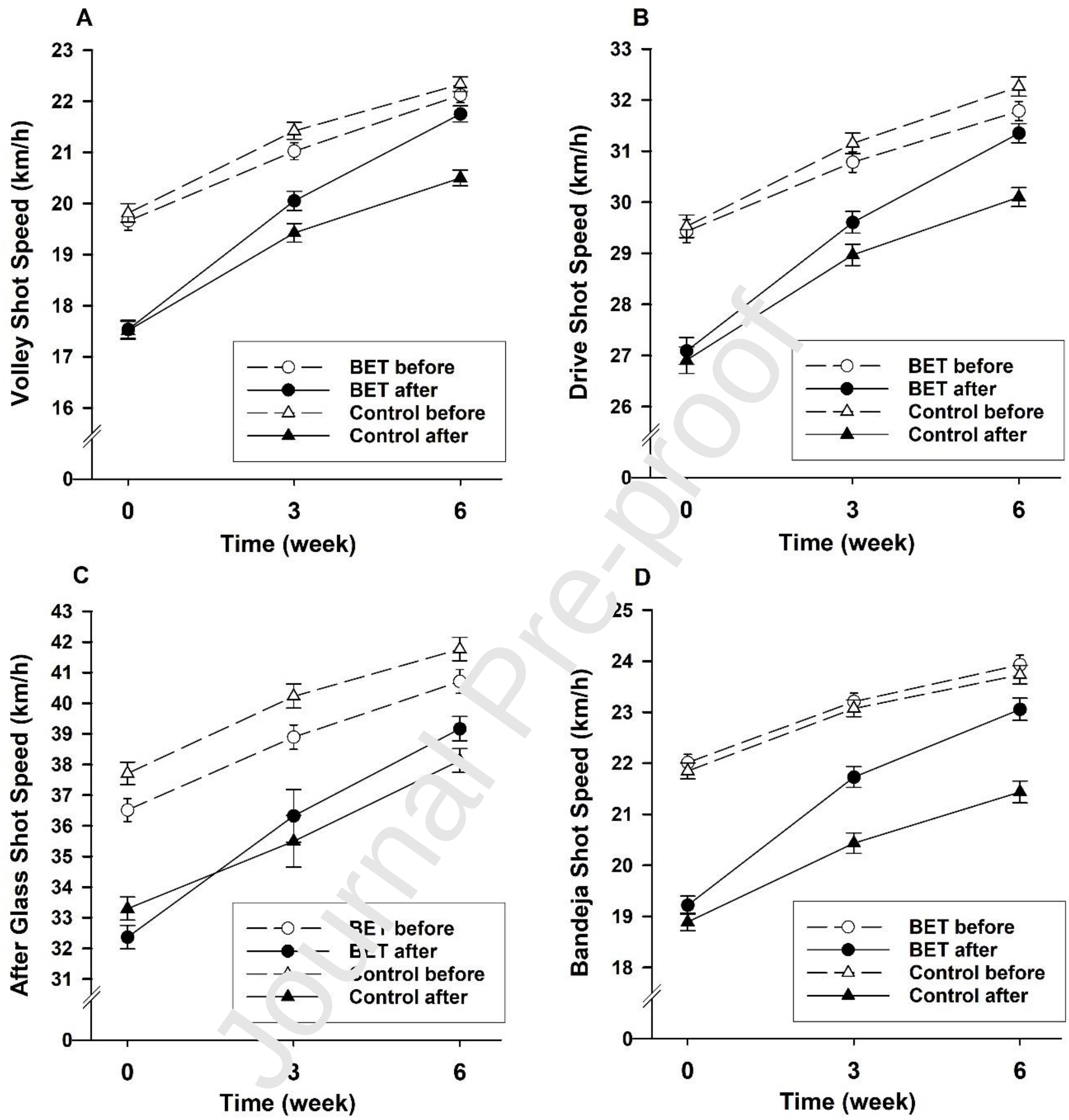

Figure 3.

Mean (SE) shot accuracy as a function of group (BET, Control), time (0, 3, 6 weeks) and test (before Stroop, after Stroop).

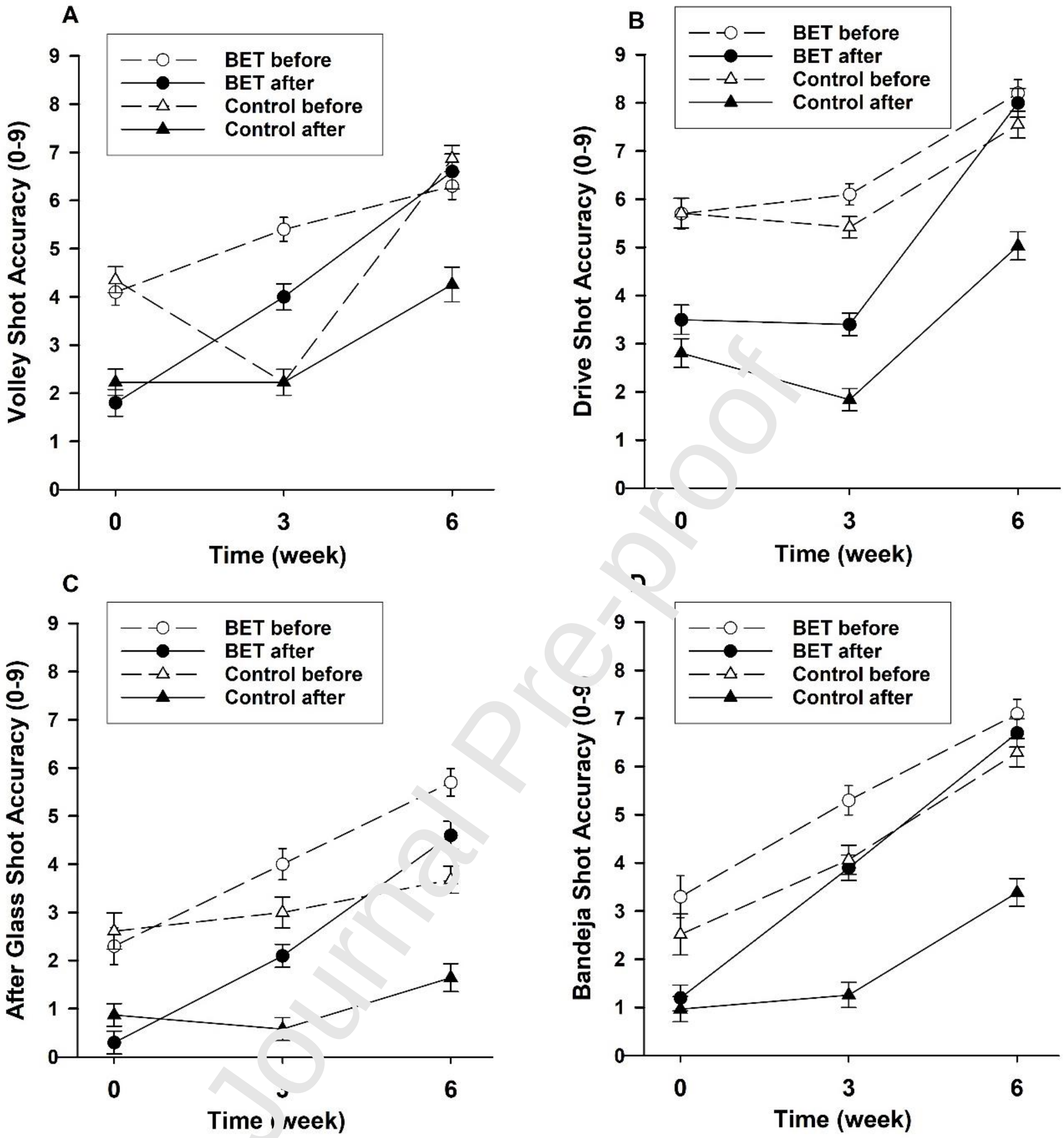

Figure 4.

Mean (SE) VAS mental fatigue rating, PVT-B reaction time, pupil diameter, and saccade latency as a function of group (BET, Control), time (0, 3, 6 weeks) and test (before Stroop, after Stroop).

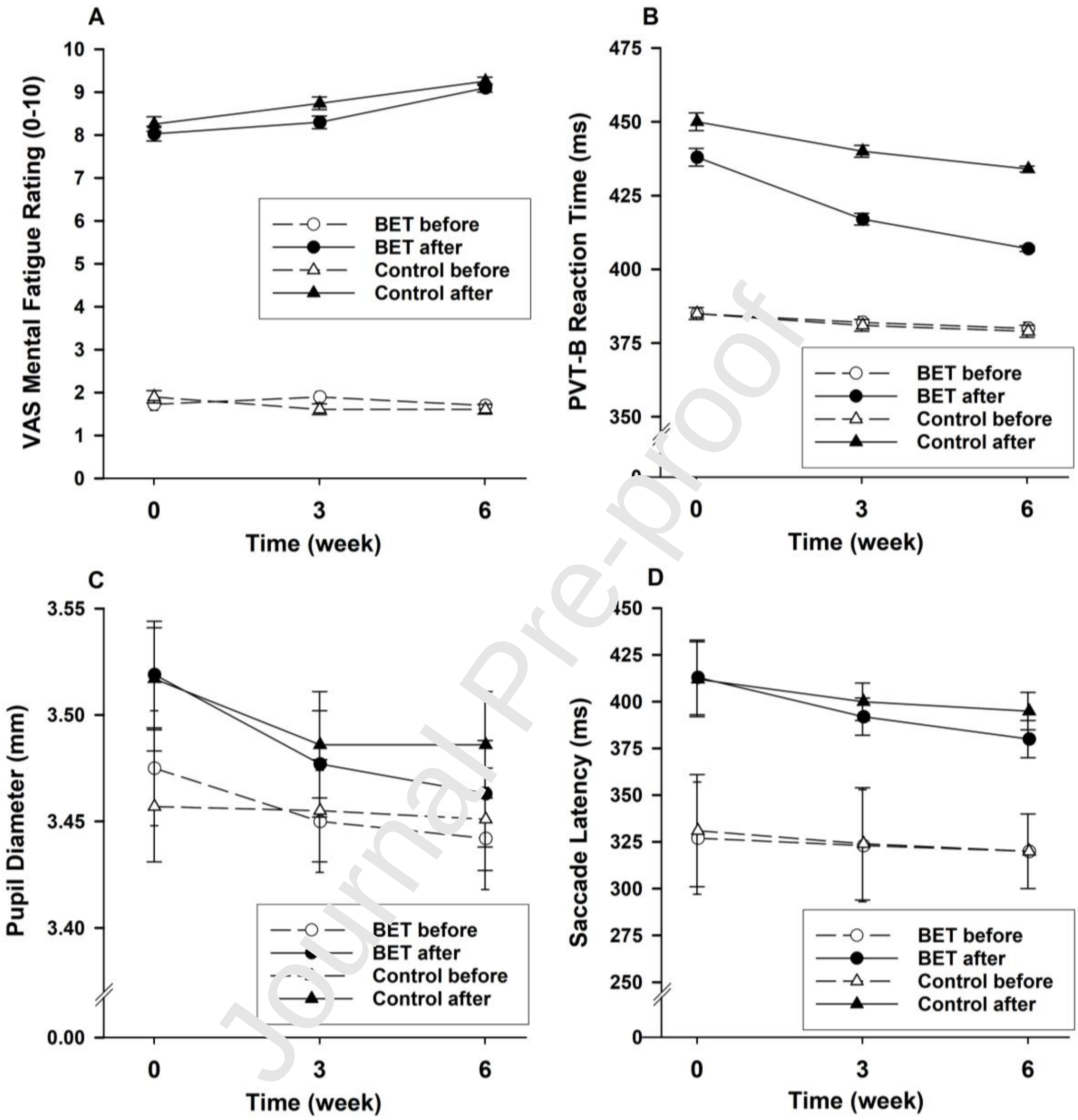

Table 1. *Summary of the 2 group (BET, Control) by 3 time (0, 3, 6 weeks) by 2 test (before Stroop, after Stroop) ANOVAs on padel performance and mental fatigue indices during testing.*

	Group	Time	Test	Group x Time	Group x Test	Time x Test	Group x Time x Test
Measures	*F*(1, 59) η_p^2	*F*(2, 58) η_p^2	*F*(1, 59) η_p^2	*F*(2, 58) η_p^2	*F*(1, 59) η_p^2	*F*(2, 58) η_p^2	*F*(2, 58) η_p^2
Volley Speed	0.78 .01	698.77*** .96	1649.15*** .97	6.34** .18	127.49*** .68	66.43*** .70	22.58*** .44
Drive Speed	3.17 .01	386.59*** .93	1459.50*** .96	1.39 .05	111.21*** .65	67.26*** .70	27.79*** .49
After Glass Speed	0.60 .01	343.11*** .92	372.78*** .86	3.99* .12	17.24*** .23	85.37*** .75	26.86*** .48
Bandeja Speed	8.05** .12	274.88*** .91	2005.20*** .97	4.78** .14	8[illegible].70*** .60	63.44*** .69	15.78*** .35
Volley Accuracy	4.18* .07	68.50*** .70	258.57*** .81	6.11** .17	40.[illegible]3*** .41	13.14*** .31	19.75*** .41
Drive Accuracy	30.01*** .39	101.45*** .78	198.11*** .77	6.67** .1[illegible]	15.16*** .20	24.73*** .46	4.59** .14
After Glass Accuracy	28.35*** .33	50.51*** .64	122.13*** .67	20.16[illegible] .41	1.39 .02	1.48 .05	1.22 .04
Bandeja Accuracy	27.98*** .32	144.70*** .83	207.92*** .78	[illegible].96** .19	18.82*** .24	1.72 .06	9.79*** .25
VAS Mental Fatigue	1.43 .02	10.20*** .26	8485.85** .99	0.29 .01	5.29* .08	36.69*** .56	1.64 .05
PVT-B Reaction Time	44.92*** .43	124.14*** .81	81[illegible]** .93	5.37** .16	36.81*** .38	35.40*** .55	5.44** .16
Pupil Diameter	0.02 .00	21.46*** .43	[illegible].99*** .40	4.71** .14	1.01 .02	4.51* .14	2.17 .07
Pupil Latency	8.56** .13	300.84*** .91	[illegible]733.98*** .97	9.21*** .24	5.55* .09	63.83*** .69	23.51*** .45

Note: * $p < .05$, ** $p < .01$, *** $p < .001$.

Table 2. *Descriptive statistics (M, SD) and summary of the 2 group (BET, Control) by 2 training (before, after) ANOVAs on mental fatigue indices before and after training during the 6-week training period.*

	Before Training		After Training		Group	Training	Group x Training
Measures	BET	Control	BET	Control	*F*(1, 59) η_p^2	*F*(1, 59) η_p^2	*F*(1, 59) η_p^2
VAS Mental Fatigue (0-10)	1.43 (0.41)	1.23 (0.28)	8.38 (0.50) [c, b]	5.13 (0.66) [b]	380.40*** .87	3941.11*** .99	310.59*** .84
PVT-B Reaction Time (ms)	340 (13)	342 (11)	412 (4) [c, b]	380 (5) [b]	74.51*** .56	1112.71*** .95	99.67*** .63
Pupil Diameter (mm)	3.29 (0.13)	3.23 (0.13)	3.33 (0.13) [c, b]	3.25 (0.13) [b]	4.40* .07	268.44*** .82	36.12*** .38

Saccade Latency (ms)	329 (12)	329 (10)	393 (11) [c, b]	362 (7) [b]	79.94*** .58	1013.92*** .95	105.33*** .64

Note: * $p < .05$, *** $p < .001$. Superscript [c] indicates significant difference from control group. Superscript [b] indicates significant difference from before training.

Declaration of Interest

We have no conflicts of interest.

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Confirmation of Ethical Compliance

This study was approved by our local Research Ethics Committee (protocol number: 93/2020; University of Extremadura, Spain). The study protocol conformed with the Declaration of Helsinki.

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The contribution of each author is a follows:

	J D-G	T G-C	D M-R	MA L-G	J A P	CR
Conceptualization	X	X	X			
Methodology	X	X		X	X	
Software	X	X				X
Validation	X	X				
Formal Analysis	X	X				X
Investigation	X	X		X	X	
Resources	X	X			X	
Data Curation	X	X		X		
Writing – Original Draft	X	X	X		X	X
Writing – Review & Editing	X	X	X	X	X	X
Visualization	X	X				X
Supervision	X	X			X	
Project Administration	X	X				X
Funding Acquisition	X	X			X	

A all authors have revised and agreed upon the contribution table here presented.