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The Relationship Between Mental Fatigue and Shooting Performance Over the Course of a National Collegiate Athletic Association Division I Basketball Season

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Abstract

Daub, BD, McLean, BD, Heishman, AD, Peak, KM, and Coutts, AJ. The relationship between mental fatigue and shooting performance over the course of a National Collegiate Athletic Association Division I basketball season. *J Strength Cond Res* XX(X): 000–000, 2023—The aim of this investigation was to examine the presence of mental fatigue and concurrent changes in shooting performance across various experimental weeks throughout a National Collegiate Athletic Association (NCAA) basketball season. Fifteen elite male NCAA Division I collegiate basketball players (age 20.2 ± 1.2 years, height 199.3 ± 7.1 cm, and body mass 93.1 ± 8.6 kg) volunteered for this study. Mental fatigue and basketball shooting performance was evaluated at 4 timepoints with varying seasonal demands: high game volume (GAME), high academic load (ACADEMIC), no games and no academic load (PRACTICE), and standard number of games and academic requirements (TYPICAL). Subjective mental fatigue increased significantly ($p \leq 0.05$) from Pre to Post *brief psychomotor vigilance test (PVT-B)* measurements at the end of the ACADEMIC week ($p = 0.002$, $d = 1.51$) and from beginning to end of the ACADEMIC week ($p < 0.001$, $d = 2.21$). Ratings of mental effort were significantly increased during the ACADEMIC week ($p < 0.001$, $d = 1.67$). Recovery stress questionnaire (REST-Q) showed significant differences between week GAME and ACADEMIC with an increase in Social Stress ($p = 0.001$, $d = 0.84$), Fatigue ($p = 0.021$, $d = 1.12$), Disturbed Breaks ($p = 0.024$, $d = 0.57$), and Emotional Exhaustion ($p = 0.035$, $d = 0.75$). Lower shooting performance was observed during the ACADEMIC week from Pre to Post ($p = 0.009$, $d = 0.35$) and higher scores Pre to Post in the TYPICAL week ($p = 0.008$, $d = 0.25$). Basketball shooting performance was significantly reduced after increased levels of mental fatigue stemming from added academic stress. In addition, an increase in sport-specific training or games had no effect on subsequent basketball shooting performance. Special consideration should be given by coaches around examination periods because the existence of academic stressors can influence basketball shooting performance.

Key Words: athlete monitoring, sport performance, fatigue, team sports, training load, academic stress

Introduction

In the United States, Division I (DI) is the highest level of intercollegiate athletics sanctioned by the National Collegiate Athletic Association (NCAA). The student-athletes selected to compete in DI are an exclusive group, with only 2.5% of high school athletes receiving the opportunity to compete at that level (19). These highly sought after competitive student-athletes possess exceptional sport-specific skills, but also the academic aptitude needed for eligibility (27). To participate in NCAA competitions, athletes must be full-time students and are required to meet academic standards, which include a minimum grade point average and ongoing enrollment requirements, while also exhibiting adequate progress toward degree completion (27). According to NCAA rules, if an athlete fails to meet these standards, they will not be eligible to participate in the sport and are subject to losing athletic scholarships (36). Owing to the dual demands placed on these individuals, they are often referred to as "student-athletes."

Student-athletes encounter an array of stressors as they attempt to succeed in their respective sports and academics (10,28). Division I student-athletes have been reported to spend considerable time in both academic and athletic domains, investing as much as 38.5 and 34 hours per week, respectively (26). Owing to these extensive time demands, previous research has shown that student-athletes report higher levels of academic stress compared with their non–student-athlete counterparts (18,28). Academic stress has also been linked to athletic outcomes, whereby increased academic load was associated with increased injury rates in collegiate football (23). The academic demands, combined with an extensive training schedule and performance expectations, likely place high mental and physical load on student-athletes, which may affect their performance in both domains.

The NCAA collegiate basketball season spans 5 months and includes approximately 30 regular season games. As basketball requires frequent bouts of high-intensity movement in complex scenarios (32), most research examining athlete stressors has

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centered around the rigorous physical demands of the sport. However, recent investigations have begun to examine the cognitive components of the sport, including the effects of mental fatigue on basketball-specific performance (6). Mental fatigue is a psychobiological state induced by prolonged periods of cognitively demanding activity and characterized by feelings of tiredness and lack of energy (3,24,31). It has also been well documented that mental fatigue can have deleterious effects on cognitive function (4,22), motor performance (11,21), and physical performance (30,33). Indeed, previous work in basketball has shown that mental fatigue impairs both technical and cognitive performance (i.e., decision making) (6,8). Despite the negative effects of mental fatigue on multiple facets of performance, and the significant mental load and stress imposed on student-athletes from multiple domains, the possible manifestation of mental fatigue during the intercollegiate basketball season has not been investigated. Moreover, mental fatigue has also been shown to increase after other tasks that are likely part of student-athletes weekly routines, such as screen time on social media (14), prolonged tactical sport videos (13), and video games (12).

Therefore, the aim of this investigation was to examine the presence of mental fatigue and its relationship to sport-specific performance (i.e., shooting) throughout an NCAA Division I basketball season. It was hypothesized that high levels of academic load would cause increased mental fatigue, associated with concurrent decrements in basketball shooting performance.

Methods

Experimental Approach to the Problem

To better understand the effects of undulating game and academic load, 4 weeks throughout the year were selected to examine, based on the number of basketball games played and projected academic demands, as presented in Table 1. The number of games was predetermined by the NCAA schedule, and projected academic load was categorized as low (i.e., semester break), standard (i.e., a normal academic week [semester week 7/16]), or high (i.e., examination periods). Games played and academic load varied between the 4 experimental weeks and were categorized as follows:

- GAME: high game volume.
- ACADEMIC: high academic load.
- PRACTICE: no academic load (i.e., no classes), no games, multiple practices.
- TYPICAL: standard number of games and academic requirements during conference play

To examine the impact of mental fatigue on basketball-specific shooting performance in collegiate basketball, the basketball Standardized Shooting Task (SST) (8) was used to assess shooting performance during 4 weeks throughout the season.

Subjects

Fifteen elite (25) male basketball players currently competing in NCAA Division I (age 20.2 ± 1.2 years, height 199.3 ± 7.1 cm, body mass 93.1 ± 8.6 kg) volunteered to participate in this study. Subjects were active squad members of the University of Oklahoma's Men's basketball team and were provided with verbal and written instructions outlining the procedures, risks, and benefits of the study before providing written informed consent. This research was approved by the Human Research Ethics Committee Institutional Review Board of the University of Technology Sydney.

Procedures

The study began with a familiarization session, where athletes were provided with standardized instructions for the SST, visual analog scale (VAS), brief Psychomotor Vigilance Test (PVT-B), and Recovery Stress Questionnaire (REST-Q). After familiarization, athletes participated in 4 separate experimental weeks, during which testing sessions took place at the start (Monday) and end (Sunday) of each week, and procedures were the same for every testing session (Figure 1). Testing at the start and end of each week took place before practice. In addition to these standardized tests, the athletes' academic study time, exposure to coaching film sessions, and training load were recorded during each experimental week. Specifically, each athlete was asked to self-report the time (minutes) spent on academic studies outside the classroom. Furthermore, researchers recorded the duration (minutes) of film sessions, as well as session rating of perceived exertion (sRPE) during basketball for each day throughout all 4 experimental weeks.

Testing sessions were completed at the same time of day and separated by a minimum of 1 week (16). The researchers assessing the outcome measures were not blinded to the conditions for that week but refrained from providing any information to the subjects.

Finally, the subjects were provided written instructions to follow before each upcoming testing session. The testing preparation instructions directed subjects to maintain regular sleeping patterns, food consumption, fluid intake, and prescription medication use, while avoiding caffeine, nicotine, alcohol, and physically demanding tasks immediately before each testing sessions.

Standardized Shooting Task Protocol. The SST has been previously validated within a similar cohort (8) and shown to possess sufficient reliability and sensitivity to detect meaningful changes in shooting performance after both physically and cognitively demanding stimuli. This sport-specific test requires players to first attempt 60 free throws, followed by a 4-minute shooting task comprised "jump shots" from 7 locations on the court, either

Table 1

Structure of experimental weeks, determined by the basketball games and projected academic load.*

Descriptor (of 19-wk season)	Number of games/practices	Projected academic load	Rationale for experimental week selection
High games (GAME; week 3)	3/3	Standard	Highest number of games in 1 week
High academic load (ACADEMIC; week 7)	0/6	High	University examinations week, therefore projected to be a high academic load
No academic load, no games, multiple practices (PRACTICE; week 9)	0/6	None	No basketball games and between university semesters, therefore no academic load
Standard academic load and standard games (TYPICAL; week 16)	2/4	Standard	Standard academic and game load. Increased importance of games due to conference play

*GAME = high game volume; ACADEMIC = high academic load; PRACTICE = no academic load and no games; TYPICAL = standard number of games and academic requirements.

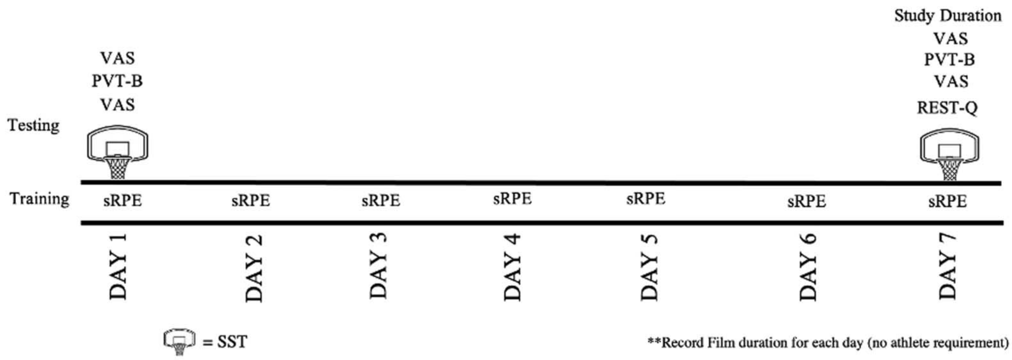

Figure 1. Schematic timeline during each experimental week. SST = Standardized Shooting Task; PVT-B = brief Psychomotor Vigilance Test; sRPE = session rating of perceived exertion; VAS = visual analog scale; REST -Q = Recovery Stress Questionnaire; Study Duration = minutes of individual study.

behind the 3-point line or at a 15 ft mark. In line with previous methods (8), to determine an individual's shooting location, players were categorized as either a "3-point shooter" or a "non–3-point shooter" by expert coaching staff, depending on the player's role within the team. During the jump shot protocol, all athletes start from location "1" and were required to successfully make 2 consecutive shots, before moving to the next spot. Once the athlete reached the opposite baseline and makes 2 consecutive shots (location 7), they repeated the shooting sequence in reverse order. The full layout of the SST and detailed procedures can be found in the reliability study (8). The verbal instruction given to the players when completing the SST was to "make as many shots as possible during a four-minute shooting segment." All made or missed attempts are counted as 1 in the sum of each respective outcome measure, whereas spots completed refers to the number of locations obtained from making 2 consecutive attempts throughout the 4 minutes. We report the following outcome measures from the SST: (a) sum of the makes during 4-minute shooting ($MAKE_{4MIN}$), (b) sum of the misses during 4-minute shooting ($MISS_{4MIN}$), (c) sum of the total shots during 4-minute shooting ($SST_{TOTALSHOTS}$), and (d) sum of the spots completed during 4-minute shooting (SST_{SPOTS}).

Brief Psychomotor Vigilance Test. The 3-minute PVT-B (Soma Technologies, Lucerne, Switzerland) was performed using a handheld device (iPad, Apple, Cupertino, CA). The visual response time (RT) stimulus and performance feedback were presented on the device's LED display. The interstimulus intervals varied randomly from 1 to 4 seconds (including a 1-second RT feedback interval). For this version of the PVT-B, subjects were instructed to press the response button (i.e., tap the screen) as soon as each stimulus (blue illuminated circle) appeared on the LED display, to keep RT as low as possible, but not to press the button too soon (which yielded a false start warning on the display). Based on previous systematic analysis of different PVT-B outcome measures in the literature (2), we chose to include the following variables in our analyses: (a) mean RT and (b) the performance score (accuracy), calculated as 100% minus the number of lapses and false starts relative to the number of valid stimuli and false starts.

Visual Analog Scales. Subjects' subjective rating of mental fatigue, mental effort, and motivation were assessed using the same 100-mm VAS as in previous literature (1,31). The scales consisted of 1 horizontal line measuring 100 mm with no markings. Each scale was anchored with the words "none at all" at the left end and "maximal" at the right end. Ratings from each subject were recorded in millimeters, with values ranging from 0 to 100, by measuring the distance from the left end of the scale to the self-selected vertical mark. Subjects rated "current feelings" of mental fatigue both pretreatment and posttreatment to compare differences in perceived mental fatigue induced by the stimuli. Mental effort and motivation were rated posttreatment only, with mental effort referring to the "level of effort required from the previous task" and motivation referring to the "completion of the upcoming basketball task."

Recovery Stress Questionnaire. The recovery stress state of each athlete was assessed at the end of each experimental week using the REST-Q (20). The REST-Q begins with the stem of "In the past 3 days/nights," and athletes indicated item responses on a 7-point Likert scale ranging from never (0) to always (6). The REST-Q consists of general stress scales (General Stress, Emotional Stress, Social Stress, Conflicts/Pressure, Fatigue, Lack of Energy, and Physical Complaints), general recovery scales (Success, Social Recovery, Physical Recovery, General Well-being, and Sleep Quality), sport-specific stress scales (Disturbed Breaks, Emotional Exhaustion, and Injury), and sport-specific recovery scales (Being in Shape, Personal Accomplishment, Self-Efficacy, and Self-Regulation).

Statistical Analyses

All data are presented as mean and *SD* unless otherwise stated. Data normality and sphericity were verified using the Kolmogorov-Smirnov test and Mauchly's test, respectively. When the assumption of data sphericity was violated, the Greenhouse-Geisser correction was used. A one-way repeated-measures analysis of variance was used to evaluate differences in each subjective assessment (including mental fatigue, mental effort, and motivation), sRPE, and Psychomotor Vigilance Test. A multivariate analysis of variance was used to evaluate reported values for the REST-Q. In addition, a two-way repeated-measures analysis of variance was used to evaluate differences in shooting performance. When a significant difference was detected, a post hoc analysis with Bonferroni correction was used to isolate pairwise differences. Effect sizes (*d*) were calculated to assess the magnitude of difference between each pairwise comparison and were interpreted based on the following classifications: trivial = 0–0.19, small = 0.20–0.49, medium = 0.50–0.79, and large = >0.80 (7). A linear regression model was used to analyze trends for objective mental fatigue variables over the course of the season. Statistical analyses were performed using Statistical Package for Social Sciences (SPSS) software (v 25.0; IBM Corp., Armonk, NY). Statistical significance was set at $p \leq 0.05$.

Results

Significant differences in VAS scores for the perceptions were observed across experimental weeks ($p = 0.039$). Post hoc pairwise comparisons revealed significant increases in perceived mental fatigue from Pre to Post PVT-B measurements at the end of the ACADEMIC week ($p = 0.002$, $d = 1.51$) and from Pre to Post of the ACADEMIC week ($p < 0.001$, $d = 2.21$; Figure 2). No significant differences were detected in perceived mental fatigue for any of the other experimental weeks. Perceptions of mental effort were significantly greater from Pre to Post of the ACADEMIC week ($p < 0.001$, $d = 1.67$). No significant differences across experimental weeks were observed in motivation for the upcoming basketball shooting task ($p = 0.247$).

There was significant main effect across experimental weeks for both reaction time and accuracy in the PVT-B task ($p = 0.007$). There were no significant differences in reaction time from Pre to Post for any of the experimental weeks, but reaction time was significantly higher in the TYPICAL week compared with the GAME week ($p = 0.012$, $d = 0.85$; Figure 3). Accuracy during the PVT-B showed no significant differences between experimental weeks. However, Pre to Post values for accuracy decreased during the PRACTICE week only ($p = 0.024$, $d = 0.81$). The linear regression model for reaction time produced values of $R = 0.27$, $p = 0.003$, whereas the linear regression model for accuracy demonstrated values of $R = -0.041$, $p = 0.66$ (Figure 3).

Recovery Stress Questionnaire results showed significant differences between experimental weeks ($p = 0.004$). The ACADEMIC week displayed higher levels of Social Stress ($p = 0.001$, $d = 0.84$), Fatigue ($p = 0.021$, $d = 1.12$), Disturbed Breaks ($p = 0.024$, $d = 0.57$), and Emotional Exhaustion ($p = 0.035$, $d = 0.75$) compared with the GAME week. In addition, the TYPICAL week showed a significant increase in Social Stress ($p = 0.020$, $d = 0.72$) compared with the GAME week. No significant differences were observed for any other subcategory between experimental weeks (Table 2).

In addition, there was a significant difference between all experimental weeks for sRPE (GAME/ACADEMIC: $p < 0.001$, $d = 2.87$; GAME/PRACTICE: $p < 0.001$, $d = 8.36$; GAME/TYPICAL: $p < 0.001$, $d = 1.51$; ACADEMIC/PRACTICE: $p < 0.001$, $d = 8.17$; ACADEMIC/TYPICAL: $p = 0.014$, $d = 1.28$; PRACTICE/TYPICAL $p < 0.001$, $d = 7.63$; Table 3). For minutes spent on academic studies outside the classroom, significant differences were observed between GAME/ACADEMIC ($p = 0.009$, $d = 0.87$) and ACADEMIC/TYPICAL ($p = 0.009$, $d = 0.86$). In addition, minutes of film in each experimental weeks were as follows: GAME: 275 minutes, ACADEMIC: 165 minutes, PRACTICE: 295 minutes, and TYPICAL: 330 minutes (Table 3).

The results of the SST are shown in Table 4. Analysis of $MAKE_{4MIN}$ revealed a significant reduction in shooting performance scores from the beginning of the ACADEMIC week to the end of the week ($p = 0.009$, $d = 0.35$) and higher scores at the beginning of the TYPICAL week when compared with the end of the week ($p = 0.008$, $d = 0.25$; Figure 4). A significant decrease in SST_{SPOTS} was observed from Pre to Post in the ACADEMIC week ($p = 0.002$, $d = 0.43$) and an increase in SST_{SPOTS} was evident in the TYPICAL week ($p = 0.007$, $d = 0.25$). In addition, a

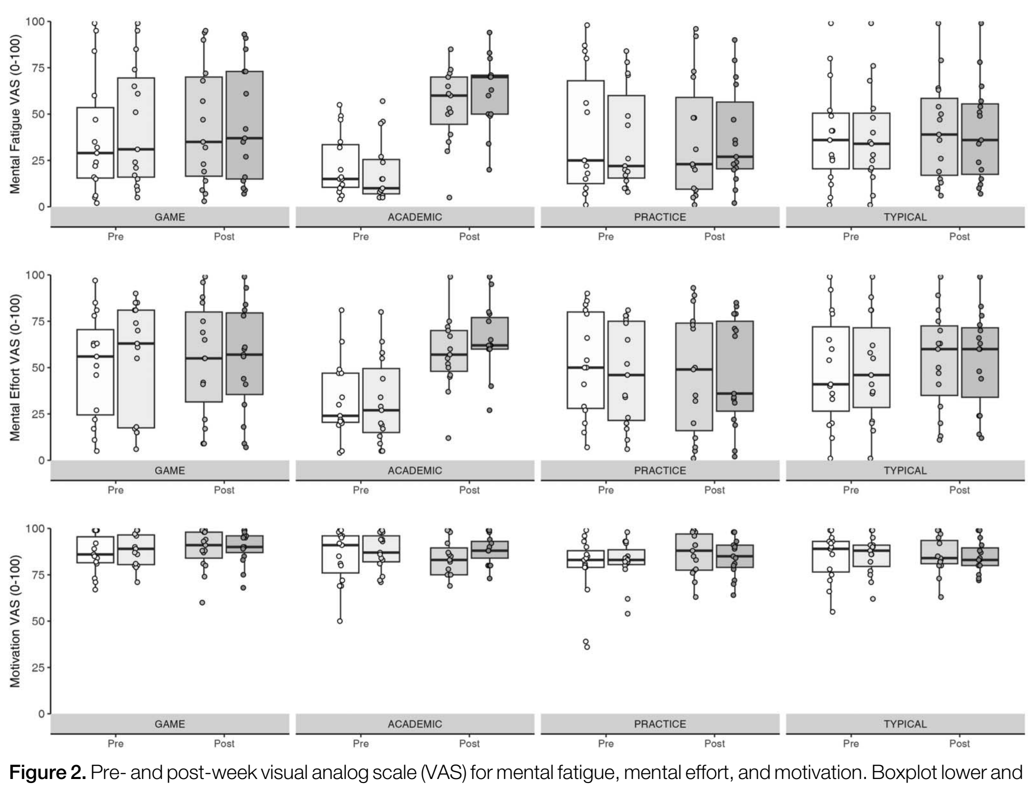

Figure 2. Pre- and post-week visual analog scale (VAS) for mental fatigue, mental effort, and motivation. Boxplot lower and upper hinges correspond to the first and third quartiles and whiskers extend to the value closest to the hinge between; largest/smallest value, or no further than 1.5 × the interquartile range.

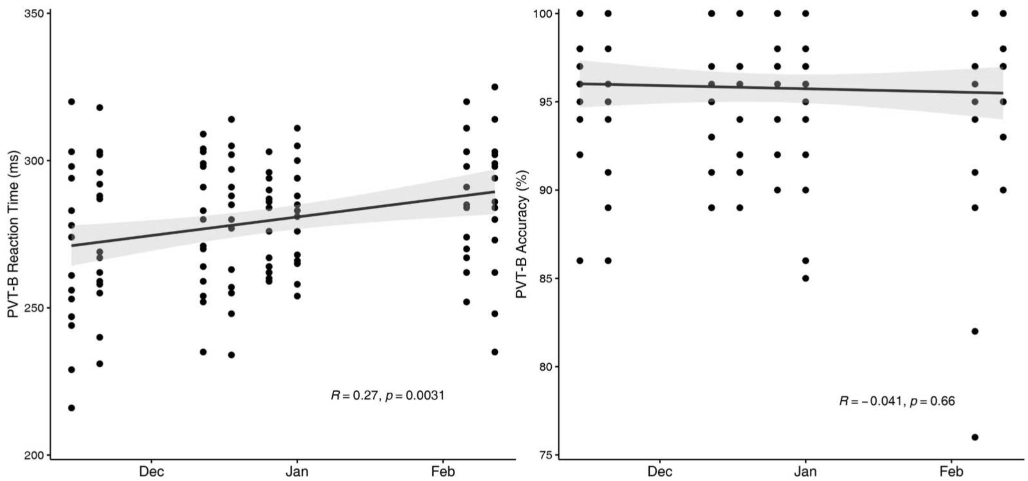

Figure 3. SOMA reaction time (ms) and accuracy (%) during the season.

significant increase in $MISS_{4MIN}$ ($p = 0.004$, $d = 0.55$) was observed from Pre to Post during the ACADEMIC week. During the GAME or PRACTICE weeks, there were no significant differences from Pre to Post in $MAKE_{4MIN}$ (GAME $p = 0.52$, $d = 0.09$; PRACTICE $p = 0.62$, $d = 0.03$) or $MISS_{4MIN}$ (GAME $p = 0.78$, $d = 0.06$; PRACTICE $p = 0.92$, $d = 0.01$). No significant difference was observed in $MAKE_{4MIN}$ when comparing Pre values across each of the experimental weeks ($p = 0.33$). Finally, no significant differences were observed during any of the experimental weeks for $SST_{TOTALSHOTS}$ ($p = 0.123$).

Discussion

The primary finding of this study was that elite college basketball players exhibit impaired shooting performance and increased mental fatigue at the end of a week with high academic demands. Conversely, decrements in shooting performance were not observed after weeks with increased games (GAME and TYPICAL) or increased training load (PRACTICE). In addition, although subjective ratings of mental fatigue and effort were increased at the end of the ACADEMIC week, these elevated ratings of fatigue and effort were not present at any other time measured throughout the season. Furthermore, results of the objective measure of cognitive performance displayed slower reaction times over the course of the season. These results show that elite collegiate basketball players exhibit impaired shooting performance and increased levels of mental fatigue at specific timepoints and offer preliminary evidence that cognitive performance declines throughout the season.

One unique aspect of this study was that both subjective (VAS) and objective (PVT-B) measures of mental fatigue were examined. Although subjective ratings of mental fatigue and effort increased from in the beginning to the end of the ACADEMIC week, this is the only experimental week where this type of change was observed. By design, the ACADEMIC week displayed the highest level of academic demands when compared with all other experimental weeks. The source of higher academic load during this week was likely outside the classroom because official class time did not change, but student-athletes were preparing for final academic examinations. Although previous investigations have shown increased stress for student-athletes from academics when compared with non–student-athletes (10), to the best of our

Table 2

Recovery Stress Questionnaire (REST-Q) scores measured at the end of each experimental week (mean ± *SD*).*

	GAME	ACADEMIC	PRACTICE	TYPICAL
Stress				
General Stress	2.3 ± 2.2	3.2 ± 2.5	3.1 ± 2.4	3.5 ± 2.9
Social Stress	2.8 ± 2.3†,‡	5.1 ± 3.2†	4.9 ± 3.5	4.6 ± 2.7‡
Fatigue	4.3 ± 2.9†	8.1 ± 3.8†	6.9 ± 3.9	5.9 ± 3.6
Disturbed Breaks	2.6 ± 2.6†	4.3 ± 3.3†	2.8 ± 3.1	3.1 ± 2.7
Emotional Exhaustion	1.7 ± 2.3†	3.5 ± 2.5†	3.0 ± 1.9	3.5 ± 2.3
Injury	7.5 ± 4.7	9.7 ± 4.0	7.7 ± 3.8	7.9 ± 3.4
Recovery				
Recovery	11.3 ± 2.6	9.6 ± 3.6	10.5 ± 2.9	11.6 ± 3.6
Well-being	13.1 ± 3.1	12.8 ± 3.5	12.7 ± 3.2	13.0 ± 3.2
Sleep Quality	9.7 ± 3.7	9.8 ± 3.4	11.7 ± 3.2	11.7 ± 3.4
In Shape	11.1 ± 2.5	11.2 ± 2.9	10.5 ± 3.3	12.6 ± 3.4
Personal Accomplishment	10.8 ± 3.5	10.1 ± 3.1	8.9 ± 4.0	9.5 ± 2.8
Self-Efficacy	11.3 ± 3.8	11.7 ± 3.4	11.1 ± 3.1	12.1 ± 3.4

*GAME = high game volume; ACADEMIC = high academic load; PRACTICE = no academic load and no games; TYPICAL = standard number of games and academic requirements.
†Significant differences from week GAME to ACADEMIC, $p \leq 0.05$.
‡Significant differences from week GAME to TYPICAL, $p \leq 0.05$.

Table 3

Session rating of perceived exertion (sRPE), academic load duration, and team film duration during each of experimental weeks (mean ± *SD*).*

	GAME	ACADEMIC	PRACTICE	TYPICAL
sRPE combined (AU)	2,456 ± 469§,‖,¶	3,341 ± 219‡,‖,¶	5,820 ± 369‡,§,¶	3,031 ± 386‡,§,‖
sRPE training (AU)	2,014 ± 328	3,341 ± 219	5,820 ± 369	2,737 ± 234
Duration	*341#*	*491#*	*819#*	*434#*
Intensity	*5.9 ± 2.4*	*6.8 ± 1.3*	*7.1 ± 2.0*	*6.3 ± 1.5*
sRPE games (AU)	442 ± 282	0	0	294 ± 172
Duration	*110 ± 36*	*0*	*0*	*75 ± 26*
Intensity	*4.0 ± 1.1*	*0*	*0*	*3.9 ± 1.6*
Academic load ($min \cdot wk^{-1}$)	194 ± 215†	499 ± 449†	0	198 ± 209†
Team film ($min \cdot wk^{-1}$)	275#	165#	295#	330#

*GAME = high game volume; ACADEMIC = high academic load; PRACTICE = no academic load and no games; TYPICAL = standard number of games and academic requirements; sRPE combined = session rating of perceived exertion for all activity, games + training (arbitrary units); sRPE training = session rating of perceived exertion for practice only (arbitrary units); sRPE games = session rating of perceived exertion for games only (arbitrary units); Academic load = minutes of study on average per day outside of classroom; Film = total minutes of sport-specific film for the week.
†Significant difference between weeks, (ACADEMIC/GAME; ACADEMIC/TYPICAL) $p \leq 0.05$.
‡Significantly different to GAME, $p \leq 0.001$.
§Significantly different to ACADEMIC, $p \leq 0.001$.
‖Significantly different to PRACTICE, $p \leq 0.001$.
¶Significantly different to TYPICAL, $p \leq 0.001$.
#Duration the same for all subjects for that week.

knowledge, this is the first investigation to demonstrate an increase in mental fatigue after periods of high academic load in collegiate basketball student-athletes. In addition to these changes from the start to the end of the academic week, subjects also reported acute changes in mental fatigue at the end of the ACADEMIC week after the cognitively challenging PVT-B. Throughout the study, VAS scores mostly remained stable when measured Pre to Post PVT-B. However, at the end of the ACADEMIC week, ratings of both mental fatigue and metal effort increased after the 3-minute PVT-B, suggesting that the increases in academic stress throughout the week lead to reduced resiliency for that short task.

Notably, the PVT-B task results did not show any changes in cognitive performance after any of the experimental weeks. However, there was a temporal trend showing an increase in reaction time over the course of the season (Figure 4). Despite these novel findings, some studies have demonstrated that PVT-B performance returns to baseline levels after 1 night of recovery (35). However, to the best of our knowledge, no studies have investigated cognitive RTs in basketball athletes over the course of a season. Therefore, it is speculated that the longer RTs observed toward the end of the season may be due to accumulated fatigue throughout the year, warranting further investigation.

Accuracy during the PVT-B showed no differences between weeks, but there were Pre-Post week decreases in accuracy during the PRACTICE week. Notably, sRPE training loads were also highest during the PRACTICE week as increased training was completed in the absences of requirements of academic commitments or games. The decrease in PVT-B accuracy could be attributed to increased physical demands because previous studies in team sports have found that prolonged exercise causes a decline in the decision making and attention (29). However, this intensification in physical load had no impact on levels of mental fatigue or basketball shooting performance.

Altered motivation is a central component of mental fatigue (34). Others have reported that motivation can be suppressed after a mentally fatiguing task, suggesting that decreased levels of motivation may be an indicator of mental fatigue (3,34). Furthermore, increases in motivation have been shown to reverse declines in cognitive performance (17). Previous investigations have used varying protocols to manipulate motivation including monetary incentives (4) and reduced duration of task requirements (17). In this study, we observed very high levels of motivation (Figure 3) similar to our previous work in comparable basketball populations before shooting tasks (9) and no difference in the student-athletes motivation across the season. This likely reflects of the collegiate student-athlete high intrinsic drive and competitive nature, especially in a sport-specific shooting task (5).

Player stress levels were increased during the ACADEMIC week, with elevated Social Stress, Fatigue, Disturbed Breaks,

Table 4

Differences in shooting performance across experimental weeks (mean ± *SD*).*

	GAME		ACADEMIC		PRACTICE		TYPICAL	
Variable	Pre	Post	Pre	Post	Pre	Post	Pre	Post
$MAKE_{4MIN}$	47.3 ± 10.5	46.4 ± 9.9	48.3 ± 11.0	44.3 ± 11.6†	48.6 ± 12.1	48.2 ± 11.2	45.3 ± 10.1	48.2 ± 12.1†
$MISS_{4MIN}$	29.1 ± 7.5	28.7 ± 6.7	26.3 ± 7.4	30.7 ± 8.5†	26.6 ± 8.9	26.5 ± 7.7	27.9 ± 6.3	26.7 ± 7.3
$SST_{TOTALSHOTS}$	76.4 ± 6.6	75.1 ± 6.5	74.5 ± 6.2	74.9 ± 6.3	75.2 ± 6.2	74.7 ± 6.5	72.9 ± 7.1	74.87 ± 7.9
SST_{SPOTS}	17.1 ± 6.3	18.0 ± 5.6	19.6 ± 6.5	16.8 ± 6.8†	19.7 ± 6.9	19.1 ± 6.6	17.6 ± 5.9	19.2 ± 6.5†

*GAME = high game volume; ACADEMIC = high academic load; PRACTICE = no academic load and no games; TYPICAL = standard number of games and academic requirements; $MAKE_{4MIN}$ = sum of the makes during 4-min shooting; $MISS_{4MIN}$ = sum of the misses during 4-min shooting; $SST_{TOTALSHOTS}$ = sum of the total shots during 4-min shooting; SST_{SPOTS} = sum of the spots completed during 4-min shooting; SST = Standardized Shooting Task.
†Significant difference from Pre-week, $p \leq 0.05$.

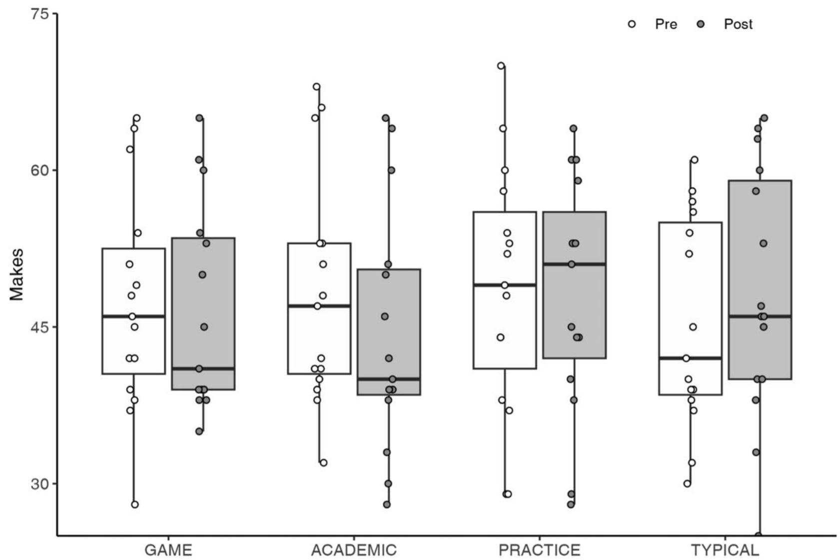

Figure 4. Pre-week and post-week Standardized Shooting Task outcome for number of made shots (SST $MAKE_{4MIN}$). Boxplot lower and upper hinges correspond to the first and third quartiles and whiskers extend to the value closest to the hinge between; largest/smallest value, or no further than 1.5 × the interquartile range.

and Emotional Exhaustion. Indeed, similar increases in stress during examination periods in student-athletes are well documented (10,15) and in some cases have also been shown to increase prevalence of injury (23). During the ACADEMIC week, this increase in stress coupled with no change in recovery, indicating a poorer recovery-stress balance, whereas a simultaneous increase in subjective ratings of mental fatigue was evident. Interestingly, during the TYPICAL week, athletes also reported an increase in Social Stress which took place during the most critical portion of the regular season, conference play. Although no change in mental fatigue was observed, the elevated social stress may be due to increased pressure to perform at a critical point in the season.

When interpreting the novel findings reported in this work, several limitations should also be considered. First, the basketball and academic workloads for each week were not controlled experimentally and are therefore not perfectly matched. Although our approach of selecting "experimental weeks" throughout the season enhances ecological validity, the differences in physical demands could affect the outcome of the shooting performance. Furthermore, because experimental weeks were selected based on the predicted academic requirements and frequency of games, an order effect across the season could be present. Although this limitation could not be avoided, the authors attempted to limit the impact by taking Pre-Post measures each week. Finally, despite the increases in subjects' mental fatigue and effort along with changes in objective cognitive performance, the specific underpinning mechanism of these responses in the current investigation is unknown. This could be important for collegiate athletes as mental fatigue may accumulate from various stimuli, including academic requirements, social commitments, media obligations, and team duties. Therefore, future research should explore specific underlying mechanisms and contributors of mental fatigue in elite college basketball players throughout the season. Moreover, future research should consider the impact of the cumulative effects of mental fatigue on performance.

Practical Applications

The current results show increased mental fatigue during periods of high academic load, which was accompanied by negative impacts on basketball shooting performance in student-athletes. Our findings suggest that high academic loads during the season lead to an increase in subjective ratings of mental fatigue and effort, which seem to be detrimental to shooting performance in the SST. In addition, this study provides evidence that an increase in sport-specific training or games may have little to no effect on subsequent standardized basketball shooting test performance. These have significant implications for applied basketball performance in the collegiate setting, which requires student-athletes to perform both in the classroom and on the court. As such, practitioners, basketball coaches, and student-athletes should use caution when academic demands are high before competition because these periods may be associated with increases in mental fatigue and impaired basketball shooting performance. Specifically, special consideration should be given around examination periods, when increased time commitments are required for academics. In addition, monitoring mental fatigue or examining skill performance may help understand the impacts of training and studying on the student basketball athletes. Furthermore, coaches may periodize sport-specific skill development during highly demanding academic periods and limit student-athlete exposure to potential mental fatiguing tasks, such as sport-specific film sessions (9).

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