European Journal of Sport Science

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/tejs20

Impacts of mental fatigue and sport specific film sessions on basketball shooting tasks

Bryce D. Daub, Blake D. McLean, Aaron D. Heishman, Keldon M. Peak & Aaron J. Coutts

To cite this article: Bryce D. Daub, Blake D. McLean, Aaron D. Heishman, Keldon M. Peak & Aaron J. Coutts (2022): Impacts of mental fatigue and sport specific film sessions on basketball shooting tasks, European Journal of Sport Science, DOI: 10.1080/17461391.2022.2161421

To link to this article: https://doi.org/10.1080/17461391.2022.2161421

Published online: 30 Dec 2022.

EUROPEAN JOURNAL OF SPORT SCIENCE
https://doi.org/10.1080/17461391.2022.2161421

Routledge
Taylor & Francis Group

ORIGINAL INVESTIGATION

Impacts of mental fatigue and sport specific film sessions on basketball shooting tasks

Bryce D. Daub [a,b], Blake D. McLean[a,c], Aaron D. Heishman [b,d], Keldon M. Peak[b] and Aaron J. Coutts [a]

[a]University of Technology Sydney, School of Sport, Exercise and Rehabilitation, Sydney, Australia; [b]Department of Athletics, Basketball Strength and Performance, University of Oklahoma, Norman, OK, USA; [c]Oklahoma City Thunder Professional Basketball Club, Human and Player Performance, Oklahoma City, OK, USA; [d]Vegas Golden Knights Professional Hockey Club, Las Vegas, USA

ABSTRACT

Purpose: The aim of this investigation was to examine the impact of mental fatigue on basketball specific shooting performance, utilising the newly developed basketball Standardized Shooting Task (SST).

Methods: Fifteen male elite NCAA Division 1 collegiate basketball players (Age 20.2 ± 1.2 y, height 199.3 ± 7.1 cm, body mass 93.1 ± 8.6 kg) volunteered to participate in a randomised, counterbalanced crossover design undergoing three conditions (Control, Stroop, and Film). The task, performed on three consecutive days, was comprised of 60 free throw attempts followed by a 4-minute spot-to-spot shooting.

Results: Visual Analog Scales revealed significantly higher levels of mental fatigue following the Stroop (54.2 ± 24.5) condition compared to the Control (24.5 ± 16.2) and higher levels of mental effort in the Stroop (61.0 ± 31.3) and Film (49.9 ± 27.7) compared to the Control (14.0 ± 18.5). No significant differences were observed for Motivation among groups ($p > 0.05$). There was a significant decrease ($p = 0.006$) in number of shots made in 4-minutes ($MAKE_{4MIN}$; control = 49.5 ± 10.2, Stroop = 44.0 ± 10.6, and Film = 45.1 ± 11.7) and shots missed in 4-minutes ($MISS_{4MIN}$; control = 27.3 ± 7.0, Stroop = 30.9 ± 7.1, and Film = 30.9 ± 7.6). No significant differences were detected for any other performance variables.

Conclusion: These data demonstrate that mental fatigue negatively impacts basketball shooting performance in elite collegiate basketball players. We suggest that practitioners and coaches encourage athletes to abstain from cognitively demanding tasks prior to basketball competition.

HIGHLIGHTS

- Basketball shooting performance was significantly reduced following acutely increased levels of mental fatigue.
- This study provides novel preliminary evidence that a sport-specific Film session of 30-minutes in duration (or longer) requires a large amount of mental effort and may also have a detrimental effect on subsequent basketball shooting performance
- The outcomes of this study suggest that practitioners and coaches should encourage elite collegiate basketball players to abstain from potential cognitively demanding tasks prior to practice and games when shooting performance is required.

KEYWORDS
Athlete monitoring; sport performance; fatigue; team sports

Introduction

Mental fatigue is a psychobiological state induced by sustained periods of demanding cognitive activity and characterised by feelings of tiredness and lack of energy (Boksem & Tops, 2008; Marcora et al., 2009; Smith et al., 2016). The deleterious effects of mental fatigue on cognitive function (Boksem et al., 2006; Lorist et al., 2005) motor performance (Duncan et al., 2015; Lal & Craig, 2001), and exercise performance (Van Cutsem et al., 2017; Smith et al., 2015) have been well documented (Van Cutsem et al., 2017; Habay et al., 2021), which has led to increased research examining the impact of mental fatigue on team sport performance. Earlier studies have revealed the association of mental fatigue with reductions in technical performance in both soccer and volleyball (Smith et al., 2016; Fortes et al., 2021; Sun et al., 2021). Specifically, soccer players demonstrated reduced shooting speed and accuracy (Smith et al., 2016), while volleyball athletes exhibited impaired attacking skills and passing abilities with mental fatigue (Fortes et al., 2021). Although yet to be determined, it is likely that mental fatigue may also impair performance in other sports which require similar cognitive processing, such as basketball

CONTACT Bryce D. Daub bdaub@ou.edu University of Technology Sydney, School of Sport, Exercise and Rehabilitation, Sydney, Australia

shooting, therefore warranting investigation (Laurent et al., 2006; Afonso et al., 2012).

Basketball requires the integration of sport-specific skill and frequent bouts of high-intensity movements in complex technical-tactical scenarios (Scanlan et al., 2011; Stojanović et al., 2018). Among the various specific skills (i.e. shooting, dribbling, and passing), shooting performance has been identified as a key indicator of success for both the team and individual athlete (Ibáñez et al., 2003; Karipidis et al., 2001). The most common type of shot taken in elite level basketball games are "jump shots" (i.e. a basketball shot attempted by jumping into the air and releasing the ball at the peak of the jump) (Erčulj, 2015). Indeed, it has been shown that superior in-game shooting accuracy (from both two- and three-point shots) increases win probability (Erčulj, 2015; Pojskić, 2014; Pyne et al., 2008). Accordingly, understanding the factors that affect basketball shooting performance, would assist in developing interventions to increase likelihood of success and require further investigation.

To date, few studies have examined the effects of mental fatigue on basketball shooting performance in elite players and methodological shortcomings limit the generalizability of these previous findings (Filipas et al., 2021; Bahrami et al., 2020). However, the limited evidence available shows that mental fatigue in basketball players may increase turnovers (Moreira & Aoki, 2018) and compromise free-throw shooting performance (Filipas et al., 2021). More specifically, Moreira and Aoki (2018), observed increased turnovers during small-sided youth basketball games after participants underwent a mentally fatiguing Stroop protocol. Similarly, Filipas et al. (2021), reported a decrease in free throw shooting percentage, in amateur basketball players, following exposure to both a mentally fatigued and a sleep restricted condition. The observed unfavourable changes in performance may be attributed to underlying impairments such as the ability to react quickly and accurately (Boksem et al., 2006), as well as the capacity to identify and respond to cues (Boksem et al., 2006; Lorist et al., 2000) when mentally fatigued. Nonetheless, these observations were documented in amateur lower level populations which may respond differently to mental fatigue compared to higher level athletes with a greater training history or even superior level of fitness (Martin et al., 2016). Furthermore, a recent systematic review exploring research related mental fatigue and basketball performance illuminated the paucity of evidence in the literature, with only 7 studies identified relating mental fatigue to basketball performance, and of those studies only 1 study incorporated the most frequently attempted shot in basketball, the jump shot (Cao et al., 2022). Ultimately, the lack of studies focusing on elite basketball athletes and the limitations surrounding the ecological validity of performance tests used previous studies (i.e. lack of detail in shot order, location, timing and number of shot attempts) warrants further investigation (Bahrami et al., 2020).

A recent systematic review demonstrated the negative impact of mental fatigue on sport specific skill (Sun et al., 2021). However, most of the experimental studies included in this review used structured interventions to induce mental fatigue (i.e.-Stroop task) (Smith et al., 2016; Rozand et al., 2014), which are rarely encountered by athletes in their normal training and competition setting. Additionally, sustained performance on mentally demanding tasks has been shown to be impacted by motivation, leading to a declined willingness to perform (Herlambang et al., 2019). While athletes are thought to be highly motivated individuals, there are circumstances or situations encountered by collegiate basketball players that may manifest mental fatigue and evoke similar adverse effects on sport-specific skill performance. For example, screen time/social media has been shown to produce a state of mental fatigue in amateur volleyball athletes (Fortes et al., 2021), while similar observations were made with amateur basketball players following a prolonged bout of watching tactical videos (Filipas et al., 2021). Lengthy film sessions for tactical and technical teaching purposes are common part of basketball, thus warranting the exploration of ecologically valid tasks that potentially induce mental fatigue.

Therefore, the purpose of this investigation was to compare the impact of mental fatigue induced through a Stroop task and basketball-specific film session on basketball shooting performance. Based on the limited prior research on mental fatigue and sport performance, it was hypothesised that prolonged periods of cognitively demanding tasks would be detrimental to acute basketball shooting performance.

Methods

Subjects

Fifteen male elite (McKay et al., 2022) collegiate basketball players currently competing in NCAA Division 1 (Age 20.2 ± 1.2 y, height 199.3 ± 7.1 cm, body mass 93.1 ± 8.6 kg) volunteered to participate in this study. Participants 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 prior to providing written informed consent. This research was approved by the

Human Research Ethics Committee of the University of Technology Sydney (UTS).

Design

To examine the impact of mental fatigue on basketball specific shooting performance, the basketball Standardized Shooting Task (SST) (Daub et al., 2022) was utilised to assess changes following a mental fatiguing Stroop protocol (Stroop), a basketball specific film session (Film) and a control session (Control). The study began with a familiarisation session, where athletes were provided with standardised instructions for the SST, condition groups, visual analog scale (VAS) and test preparation of future testing days. After familiarisation, participants completed the three experimental sessions. Procedures of each session were the same, with the only difference being the intervention prior to SST completion: Stroop intervention, sport-specific film and control documentary (Figure 1).

Methodology

Participants visited the testing facility on four separate occasions, with the first visit functioning as a familiarisation session. The remaining three visits included the control and two experimental sessions (Film and Stroop) and were performed in a randomised, counterbalanced order by online software (Microsoft Excel, Redmond, Washington, USA). Testing sessions were completed at the same time of day and separated by a minimum of 48 h (Heishman et al., 2017). The researchers assessing the outcomes measures were not blinded to the treatment but refrained from providing any information to the participants. In line with the SST shoot protocol classification methods (Daub et al., 2022), before familiarisation and testing, players were categorised as "3-point" shooters and "non 3-point" shooters by the basketball coaching staff.

During the familiarisation session, participants were provided standardised instructions for the use of the visual analogue scales (VAS) to assess mental fatigue, mental effort and motivation. Participants were also provided with instructions for the mentally fatiguing task (Stroop Task) and practiced until comfortable. Each of the participants then participated in a practice trial of the SST protocol. Finally, the participants were provided written instructions to follow prior to the upcoming tests. Test preparation instructions directed participants to maintain regular sleeping patterns, food and fluid and prescription medications, and avoid caffeine, nicotine, alcohol, and physically demanding tasks immediately prior to subsequent testing sessions.

Treatment

To induce mental fatigue prior to the SST, participants performed a computerised version of the Stroop colour-word task for 30 min (Soma Technologies, Lucerne, Switzerland). This task has previously been shown to increase mental fatigue and mental effort without effecting motivation (Smith et al., 2016; Smith et al., 2016; Badin et al., 2016). In this task, participants were presented with six words (red, blue, pink, white, green, yellow) in random order on the screen. Participants were then required to ignore the meaning of the word and only respond to the colour. To increase difficulty, when the colour of the word was red, the correct response was to respond to the word rather than the printed colour (Smith et al., 2016; Rozand et al., 2014). To increase motivation a member of the research team challenged the participants to complete more words than the highest score among other participants.

In addition to the Stroop treatment, participants also engaged in basketball-specific film review. This condition included 30 min of basketball specific plays in which the same terminology for the tactical execution

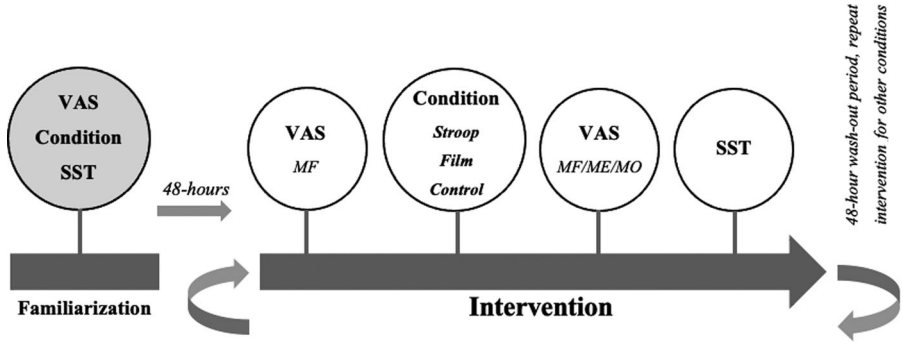

Figure 1. Schematic timeline of study design. SST, Standardised Shooting Task; VAS, Visual Analogue Scale; MF, Mental Fatigue; ME, Mental Effort; MO, Motivation

of plays both offensively and defensively was instructed to the participants. The film session was conducted by the same basketball staff member to provide continuity for each participant. While previous work has suggested performing a longer duration of a Stroop task (Habay et al., 2021; Van Cutsem et al., 2019), the authors chose to parallel the film session with the duration typically experienced by the student-athletes to maximise ecological validity of the results, while also remaining courteous with participants time commitment to the study.

The control treatment required the participants to watch a 30 min emotionally neutral documentary (The History of the Car), similar to those used in previous investigations (Van Cutsem et al., 2017). Participants completed all treatment and control sessions in the same room while under supervision from the same member of the research team.

Subjective ratings

Participants subjective rating of mental fatigue, mental effort, and motivation were assessed using the same 100-mm VAS as in previous literature (Smith et al., 2016; Badin et al., 2016). The scales consisted of one 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 participant were recorded in millimetres, with values ranging from 0 to 100, by measuring the distance from the left end of the scale to the self-selected vertical mark. Participants rated "current feelings" of mental fatigue both pre-treatment and post-treatment to compare differences in perceived mental fatigue induced by the stimuli. Mental effort and motivation were rated post-treatment 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".

SST protocol

The novel SST possesses sufficient reliability and sensitivity to detect meaningful changes in performance, as well as adequate construct validity (Daub et al., 2022). 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 behind the 3-point line or at a 15 ft mark, as determined by expert coaches. All athletes start from location "1" and were required to successfully make two consecutive shots, before moving to the next spot. Once the athlete reached the opposite baseline and makes two 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 (Daub et al., 2022). The objective when completing the SST is 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, while spots completed refers to the number of locations obtained from making two consecutive attempts throughout the 4-minutes. Typical outcome measures of the SST include: (1) sum of the makes during 4-minute shooting ($MAKE_{4MIN}$); (2) sum of the misses during 4-minute shooting ($MISS_{4MIN}$); (3) sum of the total shots 4-minute shooting ($SST_{TOTALSHOTS}$); (4) sum of the spots completed during 4-minute shooting (SST_{SPOTS}).

Statistical analysis

All data are presented as means and standard deviations (SD) unless otherwise stated. Data normality and sphericity was verified using the Kolmogorov–Smirnov test and Mauchly's test, respectively. When the assumption of data sphericity was violated, the Greenhouse-Geiser correction was used. A one-way (Film vs. Stroop vs. Control) repeated measures analysis of variance (RM-ANOVA) was used to evaluate differences in each subjective assessment, including mental fatigue, mental effort and motivation. When a significant difference was detected, a post hoc analysis with Bonferroni correction of 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 (Cohen, 1992). Statistical analyses were performed using Statistical Package for Social Sciences (SPSS) software (v 25.0; IBM Corp., Armonk, NY, USA). Statistical significance was set at $p \leq 0.05$.

Results

No significant differences were seen in mental fatigue prior to intervention ($p = 0.827$); Stroop vs Film ($p = 1.000$, $d = 0.23$) and Control ($p = 1.000$, $d = 0.09$) or Film vs Control ($p = 1.000$, $d = 0.16$), (Control: 21.5 ± 9.9; Stroop: 22.5 ± 11.9; Film: 19.6 ± 13.6). However, significant differences in subjective mental fatigue post intervention, were observed across conditions ($p < 0.001$). Post-hoc pairwise comparisons revealed significant increases in subjective mental fatigue following the Stroop condition compared to both Film ($p = 0.015$, $d = 0.63$) and Control ($p < 0.001$, $d = 1.43$). However, no significant differences in subjective

Table 1. Differences in Shooting Performance across conditions (Mean ± SD).

Variable	Control	Stroop	Film
Free Throw Makes	48.9 ± 7.3	47.8 ± 7.4	49.1 ± 6.9
$MAKE_{4MIN}$	49.5 ± 10.2	44.0 ± 10.6#	45.1 ± 11.7
$MISS_{4MIN}$	27.3 ± 7.0	30.9 ± 7.1*	30.9 ± 7.6
$SST_{TOTALSHOTS}$	76.5 ± 6.1	75.3 ± 5.4	76.1 ± 5.9
SST_{SPOTS}	18.3 ± 7.1	17.2 ± 6.5	17.2 ± 6.4

Free Throw Makes (sum of 60 attempts); $MAKE_{4MIN}$ (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 4 min shooting); SST_{SPOTS} (sum of the spots completed during 4 min shooting); # = significant different from Control, $p < 0.01$; * = significantly different from Control, $p < 0.05$.

mental fatigue were detected between the Film and Control conditions ($p = 0.094$, $d = 0.71$), (Control: 24.5 ± 16.1; Stroop: 54.2 ± 24.5; Film: 38.9 ± 23.8). Ratings of mental effort were significantly greater during the Stroop compared to both Film ($p = 0.046$, $d = 0.38$) and the Control ($p < 0.001$, $d = 1.83$). Additionally, Film exhibited significantly greater mental effort than the Control ($p = 0.001$, $d = 1.52$), (Control: 14.0 ± 18.5; Stroop: 61.0 ± 31.3; Film: 49.8 ± 27.7). No significant differences across conditions were observed in Motivation ($p = 0.249$) for the upcoming basketball shooting task; Stroop compared to Film ($p = 1.000$, $d = 0.65$) and the Control ($p = 1.000$, $d = 0.86$) as well as Film to Control conditions ($p = 0.516$, $d = 1.46$), (Control: 82.2 ± 23.2; Stroop: 86.7 ± 17.4; Film: 89.1 ± 12.2).

The results of the basketball performance task are shown in Table 1. There were no significant differences for Free Throw Makes across any of the conditions ($p = 0.523$). However, a significant main effect was observed for both $MAKE_{4MIN}$ ($p = 0.006$) and $MISS_{4MIN}$ ($p = 0.021$). Further analysis of $MAKE_{4MIN}$ revealed significantly lower scores in shooting performance during the Stroop compared to the Control ($p = 0.003$, $d = 0.53$). Additionally, a significant difference in $MISS_{4MIN}$ ($p = 0.034$, $d = 0.51$) between the Stroop and Control was observed (Figure 2). There were no significant differences in $MAKE_{4MIN}$ or $MISS_{4MIN}$ during the Film compared to the Control ($p = 0.098$, $d = 0.40$; $p = 0.111$, $d = 0.49$), as well as no significant difference for the Stroop compared to the Film ($p > .999$, $d < 0.01$). Additionally, no significant

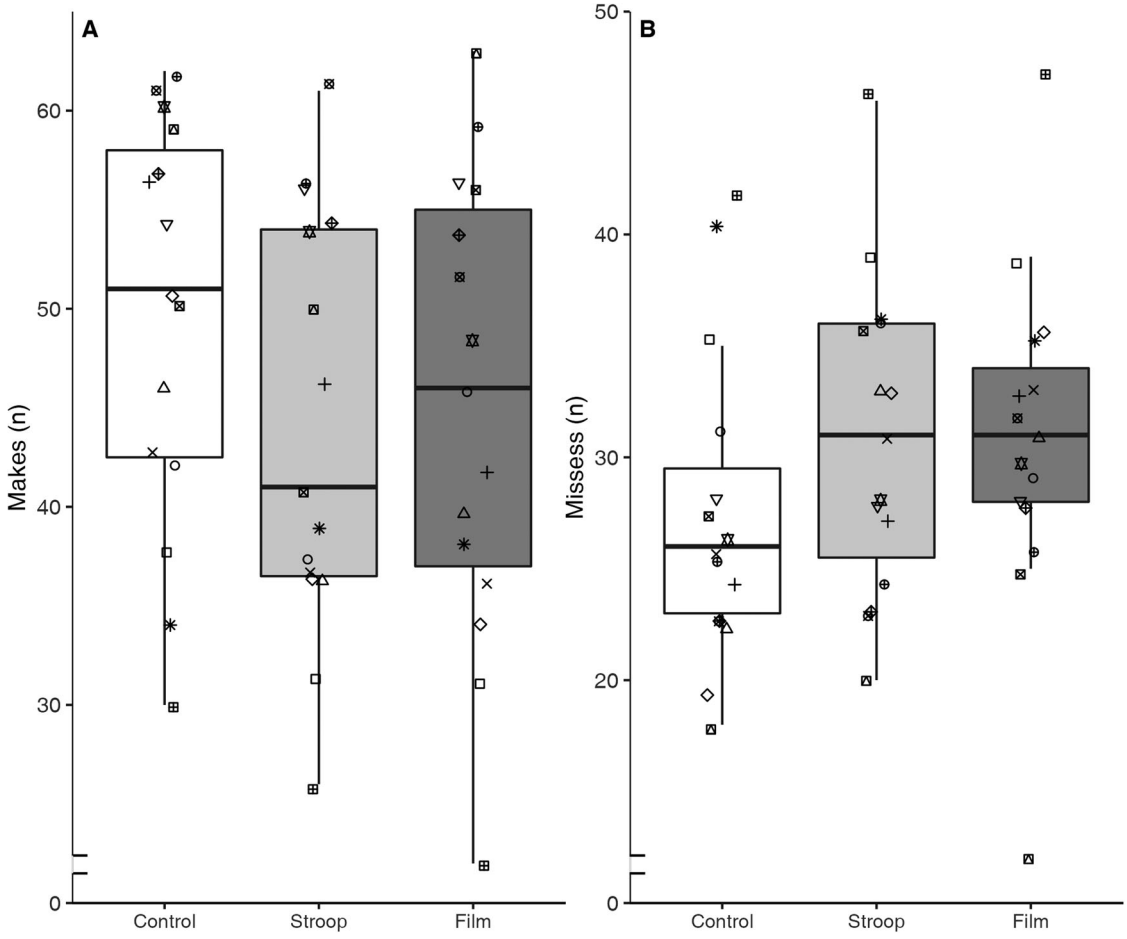

Figure 2. Differences in the number of (A) made and (B) missed shots during the SST between Control, Stroop and Film conditions. Boxplot lower and upper hinges correspond to the first and third quartiles and whiskers extend to the value closest to the hinge between; largest/smallest value, or no further than 1.5 * the interquartile range.

differences were observed for the performance outcomes across conditions for $SST_{TOTALSHOTS}$ ($p = 0.220$) or SST_{SPOTS} ($p = 0.635$). Lastly, no significant differences were observed between subject groupings across time regardless of condition ($p = .202$) and no significant difference occurred between condition order ($p = .110$).

Discussion

The primary purpose of this study was to examine the effects of mental fatigue, induced by the Stroop task and Film sessions, on basketball shooting performance using the novel SST. The primary finding was that the Stroop task resulted in a significant increase in subjective mental fatigue, with a subsequent reduction in shots made and increase in missed shots. There was also a non-significant moderate decrease in shots made, as well as a moderate increase in shots missed following the Film, which exceeded the minimal detectable change previously established with the SST protocol (Daub et al., 2022). Participants reported an increase in metal effort during these Film sessions, and there was a large, non-significant effect of Film on ratings of mental fatigue. These results show that elite collegiate basketball players exhibit impaired shooting performance following mentally fatiguing tasks and offers preliminary evidence that a fatiguing Film session exerts a negative effect on shooting performance.

Previous investigations that have used a prolonged Stroop task to induce mental fatigue showed a greater demand of mental effort when compared to control conditions, which indicated the successful provocation of a state of mental fatigue (Smith et al., 2016; Rozand et al., 2014). Our results align with previous investigations where mental fatigue was increased following the Stroop, compared to the control condition and whilst not statistically significant, the Film session resulted in a moderate-to-large increase in perceived mental fatigue compared to the control condition (Rozand et al., 2014). This is in contrast to previous investigations, which showed increased levels of mental fatigue follow sport specific video (Filipas et al., 2021). Differences in findings may be related to the previous work by Filipas et al. requiring participants to engage in the film session, which was followed by a 12-question quiz to assess engagement (Filipas et al., 2021). In contrast, the present study required athletes to interact with a coach to mimic the typical experience in the collegiate setting, where an exit quiz is not realistic or included. In addition, the Film session and Stroop task also both induced greater subjective mental effort compared to the control condition, with a both conditions exhibiting a large effect (film: $d = 1.52$; Stroop: $d = 1.83$). We speculate that greater effects may be observed with film sessions requiring greater vigilance or with increased sample size. As observed in previous literature, varying task duration and different levels of cognitive demand have been shown to induce mental fatigue (Smith et al., 2016; Rozand et al., 2014; Pageaux et al., 2013). The video duration in this investigation might be considered short compared typical film sessions experienced in a typical training setting, which could subsequently reduce the likelihood of inducing severe mental fatigue. It is possible that an extended duration of the film session, which is often the case in collegiate basketball, may produce a magnitude of mental fatigue more like that of the Stroop. The decision was made to standardise the duration of film to coincide with previous Stroop protocols of 30 min (Smith et al., 2016; Smith et al., 2016). Although further studies are needed to better understand this relationship, practitioners and coaches should carefully plan film sessions, specifically exercising caution when engaging in long, demanding film in close temporal proximity to sessions when high shooting performance is desired (e.g. skill development training, competition). To progress understanding in this concept, future research should explore the dose–response of relationship between film sessions and mental fatigue, as well as investigate the potential for exploring film periodisation strategies that might mitigate mental fatigue, when needed, while maintaining adequate film review and instruction.

We also showed that the cognitive stimulus resulting from the Stroop task and the Film session did not significantly impact motivation to perform in the forthcoming skills assessment. Conflicting observations have been reported regarding the association of motivation and mental fatigue (Boksem & Tops, 2008; Marcora et al., 2009; Smith et al., 2016). For example, some previous works have shown a suppression of motivation following mentally fatiguing tasks, suggesting motivation as a central component and indicator of mental fatigue (Boksem & Tops, 2008; van der Linden et al., 2003). However, other investigations focusing on the impact of mental fatigue on physical exertion have shown similar motivation levels between intervention and control conditions, which suggests that alterations in motivation may have been more closely related to the forthcoming task (Marcora et al., 2009; Smith et al., 2016). In the present study, the similarity in motivation to complete the upcoming task across conditions may relate to the high intrinsic drive and competitive nature of the collegiate student-athlete participants, who typically exhibit a strong "willingness to succeed", especially in a sport specific shooting task (Brehm & Self, 1989). Ultimately, the similar levels of motivation

we observed across conditions supports the postulation that changes in performance are credited to other factors related to mental fatigue rather than motivational disparities alone.

Although the importance of shooting performance to success in basketball is well established (Ibáñez et al., 2003; Karipidis et al., 2001), it is difficult to assess due to a lack of suitably valid tests that are feasible to apply within a performance environment. The current investigation was conducted with elite collegiate basketballers utilising the SST, which has good construct validity, sufficient reliability and is sensitive enough to detect meaningful changes in shooting performance (Daub et al., 2022). Moreover, the development of the task in consultation with expert coaches ensures high levels of ecological validity, allowing for easy implantation into the applied setting, but also an amplified translation to applied performance.

While we have shown that mentally fatiguing tasks negatively impact jump shooting performance, the same interventions had little influence on free-throw shooting performance. These findings contrast Filipas et al. (Filipas et al., 2021), who reported decreases in free-throw makes in amateur basketball players following 30-minutes of watching tactical videos (Filipas et al., 2021). The differences in findings between studies may be related to the athletes' experience level, as previous research has shown that elite basketball players display greater free-throw accuracy, which may lead to increased resiliency from outside perturbations, such as mental fatigue, resulting in less impact on performance (Martin et al., 2016; Mandić et al., 2019). Similarly, previous studies in soccer have proposed that professional soccer players may be more resilient to the negative effects of mental fatigue since they display higher cognitive/executive function than less experienced athletes (Smith et al., 2018; Vestberg et al., 2012). Additionally, previous work by Martin et al, showed that professional cyclists displayed superior inhibitory control and increased resiliency to the negative effects of mental fatigue compared to their recreationally training counterparts (Martin et al., 2016). Furthermore, it is important to consider that jump shooting may require more cognitively demanding efforts than free-throws, which was reflected through performance decrements when athletes are mentally fatigued.

The current results reveal the negative impacts of mental fatigue on basketball shooting performance. Despite the noteworthy findings, the current study does contain limitations. The first limitation is the current study focused on evaluating acute cognitive stimulus on subsequent basketball shooting performance. 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, more research is needed in this area to assess changes in mental fatigue longitudinally, in order to understand implications over the course of the basketball season. Second, the current investigation did not include any physiological measures of the brain. In a previous investigation neuroendocrine readings were recorded to help provide context into potential mechanisms of mental fatigue, however, in an attempt to limit invasiveness and be cognizant of participants time commitment, no such measures were recorded.

Practical applications

The outcomes of this study suggest that elite collegiate basketball players should be encouraged to abstain from extremely cognitively demanding tasks prior to practice and games when shooting performance is required. Additionally, the present investigation combined with other works, suggests that practitioners and coaches should use caution when prescribing sport specific film sessions to basketball players directly preceding shooting tasks, in order to avoid the potential negative effects on performance. Furthermore, sport professionals should explore the effects of a variety of influencers on their own team, as mental fatigue could manifest from an array of circumstances within the collegiate setting.

Conclusions

Basketball shooting performance was significantly reduced following acutely increased levels of mental fatigue. In addition, this study provides novel preliminary evidence that a sport-specific Film session of 30-minutes in duration (or longer) requires a large amount of mental effort and may also have a detrimental effect on subsequent basketball shooting performance. These have significant implications for applied basketball performance, which requires players to accurately perform shooting tasks during competition, as increases in mental fatigue suppress performance. As such, practitioners should use caution when incorporating high-effort Film sessions prior to competition as they may induce mental fatigue, thus impairing acute basketball shooting performance.

Acknowledgements

The authors thank all the research volunteers for their support of this project. The authors would also like to express their gratitude to the Basketball Programs at the University of

Oklahoma for their continued support of research focused on athlete performance and welfare.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Funding

The author(s) reported there is no funding associated with the work featured in this article.

ORCID

Bryce D. Daub http://orcid.org/0000-0002-5445-3406
Aaron D. Heishman http://orcid.org/0000-0002-6432-7630
Aaron J. Coutts http://orcid.org/0000-0002-1782-7691

References

Afonso J, Garganta J, Mesquita I. A tomada de decisão no desporto: o papel da atenção, da antecipação e da memória. *Rev Bras Cineantropometria e Desempenho Hum*. 2012;14(5):592-601. doi:10.5007/1980-0037.2012v14n5p592

Badin OO, Smith MR, Conte D, Coutts AJ. Mental Fatigue: Impairment of Technical Performance in Small-Sided Soccer Games. *International Journal of Sports Physiology and Performance*. 2016;11(8):1100-1105. doi:10.1123/ijspp.2015-0710

Bahrami A, Moradi J, Etaati Z. The Effect of Mental Fatigue on Three-Point Shot Performance in Skilled Basketball Players. *Int J Mot Control Learn*. 2020;2(4):4-10. doi:10.29252/ijmcl.2.4.4

Boksem MAS, Meijman TF, Lorist MM. Mental fatigue, motivation and action monitoring. *Biological Psychology*. 2006;72(2):123-132. doi:10.1016/j.biopsycho.2005.08.007

Boksem MAS, Tops M. Mental fatigue: costs and benefits. Brain Res Rev. 2008;59(1):125-139. doi:10.1016/j.brainresrev.2008.07.001

Brehm JW, Self EA. The intensity of motivation. *Annual Review of Psychology*. 1989;40(1973):109-131. doi:10.1146/annurev.ps.40.020189.000545

Cao S, Geok SK, Roslan S, Sun H, Lam SK, Qian S. Mental Fatigue and Basketball Performance: A Systematic Review. *Frontiers in Psychology*. 2022;12(January):1-10. doi:10.3389/fpsyg.2021.819081

Cohen J. A power primer. Psychol Bull. 1992;112(1):155-159. doi:10.1037/0033-2909.112.1.155

Daub BD, McLean BD, Heishman AD, Coutts AJ. The reliability and usefulness of a novel basketball Standardized Shooting Task. *Int J Sport Sci Coach*. 2022;Accepted(4/27/22).

Duncan MJ, Fowler N, George O, Joyce S, Hankey J. Mental fatigue negatively influences manual dexterity and anticipation timing but not repeated high-intensity exercise performance in trained adults. *Res Sport Med*. 2015;23(1):1-13. doi:10.1080/15438627.2014.975811

Erčulj F, Štrumbelj E. Basketball shot types and shot success in different levels of competitive basketball. *PLoS One*. 2015;10(6):1-14. doi:10.1371/journal.pone.0128885

Filipas L, Ferioli D, Banfi G, La Torre A, Vitale JA. Single and Combined Effect of Acute Sleep Restriction and Mental Fatigue on Basketball Free-Throw Performance. *International Journal of Sports Physiology and Performance*. 2021;16(3):415-420. doi:10.1123/ijspp.2020-0142

Fortes LS, Fonseca FS, Nakamura FY, et al. Effects of Mental Fatigue Induced by Social Media Use on Volleyball Decision-Making, Endurance, and Countermovement Jump Performance. *Perceptual and Motor Skills*. 2021:1-22. doi:10.1177/00315125211040596

Habay J, Proost M, De Wachter J, et al. Mental fatigue-associated decrease in table tennis performance: is there an electrophysiological signature? *International Journal of Environmental Research & Public Health*. 2021a;18(24). doi:10.3390/ijerph182412906

Habay J, Van Cutsem J, Verschueren J, et al. Mental Fatigue and Sport-Specific Psychomotor Performance: A Systematic Review. *Sport Med*. 2021b;51(7):1527-1548. doi:10.1007/s40279-021-01429-6

Heishman AD, Curtis MA, Saliba EN, Hornett RJ, Malin SK, Weltman AL. Comparing Performance During Morning vs. Afternoon Training Sessions in Intercollegiate Basketball Players. *Journal of Strength and Conditioning Research*. 2017;31(6):1557-1562. doi:10.1519/JSC.0000000000001882

Herlambang MB, Taatgen NA, Cnossen F. The Role of Motivation as a Factor in Mental Fatigue. *Human Factors*. 2019;61(7):1171-1185. doi:10.1177/0018720819828569

Ibáñez SJ, Sampaio J, Sáenz-López P, Giménez J, Janeira MA. Game statistics discriminating the final outcome of junior world basketball championship matches (Portugal 1999). *J Hum Mov Stud*. 2003;45(1):1-19.

Karipidis, A., Fotinakis, P., Taxildaris, K., & Fatouros J (2001). Factors characterising a successful performance in basketball. Journal of Human Movement Studies, 2001;41:385-397.

Lal SKL, Craig A. A critical review of the psychophysiology of driver fatigue. *Biological Psychology*. 2001;55(3):173-194. doi:10.1016/S0301-0511(00)00085-5

Laurent E, Ward P, Williams AM, Ripoll H. Expertise in basketball modifies perceptual discrimination abilities, underlying cognitive processes, and visual behaviours. *Visual Cognition*. 2006;13(2):247-271. doi:10.1080/13506280544000020

Lorist MM, Boksem MAS, Ridderinkhof KR. Impaired cognitive control and reduced cingulate activity during mental fatigue. *Cogn Brain Res*. 2005;24(2):199-205. doi:10.1016/j.cogbrainres.2005.01.018

Lorist MM, Klein M, Nieuwenhuis S, De Jong R, Mulder G, Meijman TF. Mental fatigue and task control: Planning and preparation. *Psychophysiology*. 2000;37(5):614-625. doi:10.1017/S004857720099005X

Mandić R, Jakovljević S. S, Erèulj F, Štrumbelj E. Trends in NBA and Euroleague basketball: Analysis and comparison of statistical data from 2000 to 2017. *PLoS One*. 2019;14(10):1-17. doi:10.1371/journal.pone.0223524

Marcora SM, Staiano W, Manning V. Mental fatigue impairs physical performance in humans. *Journal of Applied Physiology*. 2009;106(3):857-864. doi:10.1152/japplphysiol.91324.2008

Martin K, Staiano W, Menaspà P, et al. Superior inhibitory control and resistance to mental fatigue in professional road cyclists. *PLoS One*. 2016;11(7):1-15. doi:10.1371/journal.pone.0159907

McKay AKA, Stellingwerff T, Smith ES, et al. Defining Training and Performance Caliber: A Participant Classification Framework. *International Journal of Sports Physiology and Performance*. 2022;17(2):317-331. doi:10.1123/ijspp.2021-0451

Moreira A, Aoki MS, Franchini E, da Silva Machado DG, Paludo AC, Okano AH. Mental fatigue impairs technical performance and alters neuroendocrine and autonomic responses in elite young basketball players. *Physiology & Behavior*. 2018;196(August):112-118. doi:10.1016/j.physbeh.2018.08.015

Pageaux B, Marcora SM, Lepers R. Prolonged mental exertion does not alter neuromuscular function of the knee extensors. *Medicine & Science in Sports & Exercise*. 2013;45(12):2254-2264. doi:10.1249/MSS.0b013e31829b504a

Pojskić H, Šeparović V, Muratović M, Uièanin E. The relationship between physical fitness and shooting accuracy of professional basketball players. *Motriz Rev Educ Fis*. 2014;20(4):408-417. doi:10.1590/S1980-65742014000400007

Pyne DB, Saunders PU, Montgomery PG, Hewitt AJ, Sheehan K. Relationships Between Repeated Sprint Testing, Speed, and Endurance. *Journal of Strength and Conditioning Research*. 2008;22(5):1633-1637. doi:10.1519/JSC.0b013e318181fe7a

Rozand V, Pageaux B, Marcora SM, Papaxanthis C, Lepers R. Does mental exertion alter maximal muscle activation? *Frontiers in Human Neuroscience*. 2014;8(SEP):1-10. doi:10.3389/fnhum.2014.00755

Scanlan A, Dascombe B, Reaburn P. A comparison of the activity demands of elite and sub-elite Australian men's basketball competition. *Journal of Sports Sciences*. 2011;29(11):1153-1160. doi:10.1080/02640414.2011.582509

Smith MR, Coutts AJ, Merlini M, Deprez D, Lenoir M, Marcora SM. Mental Fatigue Impairs Soccer-Specific Physical and Technical Performance. *Medicine & Science in Sports & Exercise*. 2016a;48(2):267-276. doi:10.1249/MSS.0000000000000762

Smith MR, Marcora SM, Coutts AJ. Mental Fatigue Impairs Intermittent Running Performance. *Medicine & Science in Sports & Exercise*. 2015;47(8):1682-1690. doi:10.1249/MSS.0000000000000592

Smith MR, Thompson C, Marcora SM, Skorski S, Meyer T, Coutts AJ. Mental Fatigue and Soccer: Current Knowledge and Future Directions. Sport Med. 2018;48(7):1525-1532. doi:10.1007/s40279-018-0908-2

Smith MR, Zeuwts L, Lenoir M, Hens N, De Jong LMS, Coutts AJ. Mental fatigue impairs soccer-specific decision-making skill. *Journal of Sports Sciences*. 2016b;34(14):1297-1304. doi:10.1080/02640414.2016.1156241

Stojanović E, Stojiljković N, Scanlan AT, Dalbo VJ, Berkelmans DM, Milanović Z. The Activity Demands and Physiological Responses Encountered During Basketball Match-Play: A Systematic Review. *Sport Med*. 2018;48(1):111-135. doi:10.1007/s40279-017-0794-z

Sun H, Soh KG, Roslan S, Wazir MRWN, Soh KL. Does mental fatigue affect skilled performance in athletes? A systematic review. *PLoS One*. 2021;16(October):1-18. doi:10.1371/journal.pone.0258307

Van Cutsem J, De Pauw K, Vandervaeren C, Marcora S, Meeusen R, Roelands B. Mental fatigue impairs visuomotor response time in badminton players and controls. *Psychology of Sport and Exercise*. 2019;45:101579. doi:10.1016/j.psychsport.2019.101579

Van Cutsem J, Marcora S, De Pauw K, Bailey S, Meeusen R, Roelands B. The Effects of Mental Fatigue on Physical Performance: A Systematic Review. *Sport Med*. 2017;47(8):1569-1588. doi:10.1007/s40279-016-0672-0

van der Linden D, Frese M, Meijman TF. Mental fatigue and the control of cognitive processes: Effects on perseveration and planning. *Acta Psychol (Amst)*. 2003;113(1):45-65. doi:10.1016/S0001-6918(02)00150-6

Vestberg T, Gustafson R, Maurex L, Ingvar M, Petrovic P. Executive functions predict the success of top-soccer players. *PLoS One*. 2012;7(4):1-5. doi:10.1371/journal.pone.0034731