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The effects of VAR interventions on self-rated mental fatigue and self-rated performance of football referees

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ABSTRACT

Football referees are required to make numerous decisions per match under physiological and emotional strain. Within this context, VAR (video assistant referee) interventions represent a key match event in which referees' critical decisions are challenged and thus their perceived ability to control the match might also be obscured. In this study, we investigated the effects of a VAR intervention on referees' self-rated mental fatigue (MF) and performance. Nine elite referees completed over 2–6 real matches each (total of 44 matches) a single item of MF before the match, at half-time, and immediately after the match. Situational and performance indices were also collected. The referees' level of MF significantly increased from pre-match to half-time to post-match, yet the referees were not completely mentally fatigued at the end of the matches. Post-match MF was higher (a medium effect) for matches with a VAR intervention ($n = 9$) compared with matches without an intervention ($n = 35$). Post-match MF correlated negatively with self-rated performance, $r(44) = .35$, $p = .019$. These findings are discussed in relation to current theory and research in the area of self-control and MF in sports. We also provide recommendations for referee training and match preparation.

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Football; officiating; mental fatigue; self-control; video assistant referee

Football (soccer) referees at the elite level are required to meet high professional standards by the governing bodies, the sporting community (e.g. coaches, players, fans), and the media (Dawson, 2012; Page & Page, 2010; Schnyder & Hossner, 2016; Slack et al., 2013). These demands mostly pertain to fitness levels, decision-making (DM), and game management (Samuel, 2020; Schmidt et al., 2019; Union of European Football Associations – UEFA, 2020). In a rapidly changing and dynamic environment, football referees have to make quick and accurate decisions while experiencing physical stress and psychological fatigue (Bloß et al., 2020; Pizzera et al., 2022; Schmidt et al., 2019). During a competitive match, an elite referee may cover 9–13 km (4–18% of the total distance is covered at a high intensity) and reach approximately 85–90% of the maximal heart rate (Castagna et al., 2007). Schmidt et al. (2019) suggested that either the physiological stress from exercise (i.e. running, sprinting) or the psychological stressors (e.g. pressure from

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the crowd, self-induced pressure not to make errors) may impair attentional control leading to increased distractibility and difficulties in sustaining attention.

Samuel et al. (2021) suggested that elite referees make numerous decisions per match in a sequential manner, including active decisions not to whistle. To achieve this, they must first decide where to run on the field of play to achieve adequate locations (Johansen & Erikstad, 2021) and then be anticipative of the potential match events and infringements (van Biemen et al., 2022). They must maintain their optimal attentional focus to identify the match infringements (Brams et al., 2019; van Biemen, Oudejans, et al., 2023) which can be measured by applying eye tracking technology (i.e. quiet eye; Vickers, 2007). In doing so, they need to overcome various environmental distractors, such as crowd noise (e.g. Picazo-Tadeo et al., 2017) and visual illusions, such as the flag-flash effect (e.g. Luis Del Campo et al., 2018). When an infringement occurs, referees need to decide whether it constitutes a violation of the "Laws of the Game" or not (IFAB – International Football Association Board, 2023) and whether they should issue a card, and which card (i.e. yellow, red). Finally, they need to execute their actions while maintaining optional modifications, e.g. changing one's call when the VAR intervenes (see Samuel et al., 2021). Referees must also control and manage the game appropriately, considering the contextual information of the match in their tactical approach (Raab et al., 2021; Russell, Jenkins, et al., 2019). As part of their game management, referees also communicate with the players and coaches (Schnyder & Hossner, 2016; Slack et al., 2013), typically under time pressure in dynamic circumstances that demand spontaneous responses to players (Cunningham et al., 2018).

Within this context, the video assistant referee (VAR) system was introduced in 2018 and influenced the game, in terms of referee decision accuracy, decision prevalence, and playing time (e.g. Errekagorri et al., 2020; Lago-Peñas et al., 2021; Spitz et al., 2021). It remains unclear, however, whether VAR interventions influence the referee's level of mental fatigue (MF) and subsequent performance. In this study, therefore, elite referees self-reported their level of MF prior to real matches, at half-time, and immediately after the match using a single item. Situational and performance indices were also evaluated.

2. VAR influence on the game

According to the IFAB's VAR protocol (IFAB – International Football Association Board, 2022), the VAR is a match official with independent access to match footage, who may assist the referee only in the event of a "clear and obvious error" or "serious missed incident" in relation to (a) goal/no goal, (b) penalty/no penalty, (c) direct red card, or (d) mistaken identity. The on-field referee is not permitted to use the VAR while making on-field decisions. Also, whereas the VAR can *recommend* initiating a review, only the on-field referee can initiate an on-field review (OFR), and in any case, the final decision is always taken by the on-field referee.

Supporting VAR's introduction into football, Spitz et al. (2021) evaluated 2195 competitive football matches across 13 countries that used the VAR system and reported that VAR improved the referee's DM accuracy rates from 92.1% to 98.3%. Further research on VAR showed that its introduction into the German Bundesliga and Italian Serie A had resulted in more time being added in the first half of matches, as well as a reduced number of offside calls, fouls, and yellow cards (Lago-Peñas et al., 2019).

Another examination of the influence of VAR on the German Bundesliga showed that VAR facilitated fairer outcomes, reducing the home-field advantage effects (Dufner et al., 2023). Data from the Spanish La Liga showed that there was a significant decrease in the number of offsides after the VAR was inserted and a slight increase in the number of minutes added to the playing time (Lago-Peñas et al., 2021). A study on the effects of VAR at FIFA women's World Cups found that after VAR was introduced, playing time increased significantly with moderate to large effect sizes, while the number of most referees' decisions, as well as the number of goals, did not change significantly (Zhang et al., 2022). In the Chinese Super League, the VAR introduction resulted in a significant reduction in the number of offsides and fouls, a significant increase in the playing time, and a slight decrease in the home team advantage (Han et al., 2020).

While the above research examined the general influence of the introduction of the VAR system on the game of football, Errekagorri et al. (2020) specifically evaluated the influence of VAR interventions. Purposely, they examined whether VAR interventions affected the playing time and the technical-tactical and physical performances of the teams in the Spanish La Liga during the 2018–19 season (a total of 375 matches). They found a slight increase in the total playing time in matches with two or three VAR interventions compared to matches with a single or no intervention (i.e. 99.1 min vs. 96.0 min vs. 95.1 min, respectively). Additionally, there was an increase in the number of goals (1.2 vs. 1.5 vs. 1.7) comparing matches with no intervention to matches with a single or multiple interventions. Finally, there was a slight decrease in the total distance covered by the players in matches with interventions. Errekagorri et al. (2020) concluded that the study's findings suggest that the VAR hardly changes the game in elite soccer.

3. VAR influence on the referee

While the VAR protocol dictates interventions only in "clear and obvious errors" (IFAB – International Football Association Board, 2022), it should be noted that in many cases, VAR interventions are initiated concerning match events that are debatable. For example, it was reported that in the first part of the 2022–2023 English Premier League season, the VAR was incorrect in six out of 48 interventions, which reflects an error rate of 12.5% (Johnson, 2022). It is not surprising, therefore, that there is criticism of this system by fans (Hamsund & Scelles, 2021; Scanlon et al., 2022) and team managers (Chen & Davidson, 2022). Moreover, while the IFAB VAR protocol states that the on-field referee must initiate the OFR, in many cases, when a VAR intervention occurs, the on-field referee would ultimately modify his or her original decision. Thus, pressure might be related to the on-field referee's use of the VAR system; there might be discrepancies in the way the VAR and the on-field referee are judging the match events, so the on-field referee may feel uncertain of how to act when there is a VAR intervention (Samuel, Galily, et al., 2020).

VAR interventions, especially when an OFR is initiated, create a complex challenge for the on-field referees. On the one hand, they are provided with a chance to rectify a major decision error and not affect the outcome of the match in a debilitative manner. In this context, Lima et al. (2023) examined the mental health of Turkish professional league referees. They suggested that VAR can positively influence referees' mental health as it protects against critical errors. Thus, having the VAR as a backup DM system might

decrease the referees' stress levels. A study on the introduction of the VAR system into the Israeli league supported this notion and showed that overall, it was appreciated positively by the referees, and also resulted in decreased stress levels (Samuel, Galily, et al., 2020). Likewise, Dadi and Yildiz (2022) interviewed 20 Turkish referees of various levels about the VAR system and its education. Content analysis revealed that the positive aspects of the VAR system are that it contributes to making fair decisions in competitions, and to increasing confidence in the referee and his or her decisions. Moreover, the referees identified the positive mental effects of the VAR system; it provides referees the opportunity to correct wrong decisions so they can make their decisions confidently. It, therefore, reduces the referees' stress and anxiety due to reducing thoughts related to making errors. On the other hand, a VAR intervention typically means that the referee made a critical error, in most cases resulting in a low performance mark (i.e. for an explanation of the refereeing performance mark see Samuel, Galily, et al., 2020). Such critical errors can negatively influence referees' subsequent match assignments and career development (Samuel, 2015; Samuel et al., 2017). As elite referees are typically high achievers (Samuel et al., 2017) who perform under high public scrutiny (Slack et al., 2013), adhering to the VAR, at the expense of maintaining "face" (Cunningham et al., 2018), becomes a professional challenge.

For most current referees, the introduction of the VAR reflects a career change event (Samuel, Galily, et al., 2020). After they developed their skills over years without VAR, they were expected to adapt to having a "big brother" who watches their decisions and might intervene and correct them. They were required to adjust to a new situation in which every decision was not finite and could be corrected. They also must have adjusted to the OFR, which required them to acknowledge a potential critical error and then quickly shift from an on-field DM to a video-based DM. One of the main barriers experienced by the Israeli referees in Samuel, Galily, et al'.s study, was related to gaps in professional interpretations of the match key incidents between them and the VARs. These gaps resulted in several of them wishing to officiate the matches without getting corrected by the VAR. In some cases, they did not accept the VARs' interventions and maintained their original decision. In a similar vein, the Turkish referees in Dadi and Yildiz's (2022) study identified that having to correct the decisions of the on-field referees with the use of the VAR system causes stress as well as contradictions in the decision-making process.

3.1. VAR interventions, self-control, and mental fatigue

In order to deal with the adversity that comes with VAR interventions effectively and to stay focused during the totality of the match it is essential for the referees to control their impulses or more precisely, to invest self-control. In a study that examined self-control processes in football refereeing, Samuel et al. (2018) found that Israeli referees exhibited high levels of trait and state self-control compared to the normal population. Significant reductions in state self-control compared to pre-match levels were evident in almost half of the matches officiated and were negatively related to self-rated match performance. These results highlighted the important role of self-control in football refereeing (e.g. managing endurance and fatigue, being able to maintain focus and make numerous decisions, managing players calmly).

In this context, self-control describes the process of volitionally overriding prepotent response tendencies while displaying a required behaviour in order to achieve higher-level goals (De Ridder et al., 2012). Research indicated inter-individual differences in one's general self-control abilities (i.e. trait self-control; e.g. De Ridder et al., 2012) and also intra-individual differences in the ability to exert self-control (i.e. state self-control; e.g. Englert, 2019). Previous research has reliably shown that constantly controlling the self is an effortful process that eventually leads to increased sensations of MF (e.g. Van Cutsem et al., 2017). Smith et al. (2019) define MF as "a psychobiological state experienced during and after prolonged periods of demanding cognitive activity, and associated with feelings of tiredness and lack of energy" (p. 760). MF can be behaviourally manifested in increased response time and reduced response accuracy during cognitive tasks as well as in physiological changes such as elevated adenosine and decreased dopamine (Sun et al., 2021). It has been proposed that the high cognitive load needed to deal with self-control situations, such as VAR interventions, leads to MF, subsequently resulting in a decline in the DM process and several behavioural outcomes (Inzlicht et al., 2014). While Samuel et al. (2018), did not explicitly measure MF, the notable pre-to-post-match reductions in self-reported state self-control might be indicative of MF, however, this is only speculative.

It has been suggested that the refereeing task involves a sequential DM process under high physical strain (Samuel et al., 2021). As part of the sequential DM process, referees need to encode environmental cues by applying perception and attention strategies (i.e. visual scan, attentional focus, anticipation of events). In addition, they must process complex information through ongoing interactions between working memory and long-term working memory (Ericsson & Kintsch, 1995) to induce action-related DM. These demands might be associated with the application of self-control, and the increase of MF. Thus, we assume that football refereeing is a self-control demanding, and thus effortful, task that may increase the level of perceived MF. The higher the amount of self-control demanding situations (e.g. several VAR checks in a match) and the higher the significance of the given situation (e.g. the need to overturn a penalty call or a red card) referees might experience higher levels of perceived MF and a potential decline in refereeing performance. However, we must also acknowledge that VAR is a DM support system that can also be associated with increased confidence and reduced stress. It can decrease mental load and pressure and therefore positively impact MF and performance. Still, we suggest that since elite referees are high achievers, who attempt to produce errorless performance (Samuel et al., 2017), a VAR intervention would negatively affect their perceived level of MF and perceived performance (Samuel et al., 2018). Within this context, research indicates that following an important decision error, referees with an obsessive passion for refereeing engage in maladaptive functioning, including subsequent poor DM (Philippe et al., 2009).

The VAR system provides referees with a useful tool to produce more accurate decisions. Still, a VAR intervention is a substantial match event that can have a mental influence on referees. Referees are typically required to maintain self-control for adequate performance (Samuel et al., 2018) and a VAR intervention can potentially increase such a demand. In the case of a VAR intervention, referees might need to apply self-control to efficiently maintain the DM process, as well as control the players' reactions and the referee's own psychological and behavioural responses following an intervention.

Research has shown that MF can negatively impact physical, technical, tactical, and psychological aspects of sporting performance including reaction time and DM (Habay et al., 2021; Pageaux & Lepers, 2018; Russell, Renshaw, et al., 2019; Sun et al., 2021). For example, within the context of a football DM task, Smith et al. (2016) found that players' response accuracy was lower and response time was slower under a MF condition (i.e. following a 30-min Stroop task) compared with a control condition. No significant effects were found in relation to the players' visual search patterns. Similar findings were reported by Gantois et al. (2020). Specifically, professional players exhibited impaired passing decision-making performance and an increased response time following a 30-min Stroop task compared with a 15-min Stroop task and a control condition.

To the best of our knowledge, there are currently no published studies that examined MF in football referees. Still, Ahmed et al. (2020) examined MF in futsal referees. The referees completed a 10-minute Psychomotor Vigilance Task (PVT) 60 min before the match kick-off time (pre-test) and immediately after futsal matches (post-test). The PVT can be viewed as a task designed to induce MF, as self-control needs to be invested to master the task (Smith et al., 2019). In this case, higher levels of self-reported MF in the post-test could be attributed to the increased self-control demands referees had to deal with during the futsal match. While unexpectedly PVT performance significantly improved from pre-match to post-match, there was an increase in self-reported fatigue ($p < 0.001$), reflecting an increase in MF after matches. Within this context, Pageaux and Lepers (2018) suggested that when exploring the negative impact of MF on physical performance one should use cognitive tasks involving sustained attention, working memory, and response inhibition for a minimum duration of 30 min (e.g. the Stroop test). This is particularly relevant to football refereeing which is a 90-min task involving various cognitive demands, including visual attention, working memory, and self-regulation (Samuel et al., 2021).

4. Research purpose and objectives

In this study, our purpose was to examine the development of MF throughout a match and the effects of VAR interventions on MF and performance. We were also interested in the relationship between MF and performance. It should be noted that referees typically self-assess their performance following a match. They analyse their DM processes, game management, and refereeing style (Samuel, 2015). Interestingly, as most studies in this area used a lab-based single cognitive task to induce MF, they could not measure the development of MF levels throughout a real-life sports task (Pageaux & Lepers, 2018; Sun et al., 2021). In this aspect, our study presents an innovative design to explore the interplay between a sports task and MF. It can be suggested that the refereeing task which involves physical, cognitive, emotional, and interactional demands, affects MF which in turn affects refereeing performance (Samuel et al., 2018).

The subjective perception of one's temporary level of MF can be reliably measured, using a one-item mental fatigue scale (Russell et al., 2022). Currently, there are no studies, to the best of our knowledge, which examined football referees' development of MF levels during actual matches and the potential influence of VAR interventions on referees' levels of MF. Most studies in this area used lab-based cognitive tasks to deliberately induce MF and did not rely on real-life sport-context conditions. We believe

that examining the potential influence of the refereeing task on referees' MF, and specifically when a VAR intervention occurs, has meaningful practical implications for referee training and match preparation. Therefore, we aimed to examine the development of MF levels during official matches (i.e. Israeli Premier League matches) as well as the influence of VAR interventions on the referees' self-rated MF levels and subsequent performance. We hypothesised that: (a) referees experience an increase in their level of MF as the match develops (i.e. from pre-match to halftime to post-match), (b) matches with a VAR intervention are associated with higher post-match MF levels, (c) MF is negatively associated with self-rated performance, (d) matches with a VAR intervention are associated with lower self-rated performance.

5. Method

5.1. Participants

Nine Israeli Premier League football referees volunteered for this study (*M* age = 32.89 yrs, *SD* = 6.01). Participants were recruited from the Referee Association in the Israel Football Association and were representative of this elite group (i.e. there were overall 17 referees in the Premier League). They had, on average, 17 years (*SD* = 6.32 yrs) of refereeing experience. All referees had tailored VAR training and adequate experience (i.e. at least two seasons) officiating with the VAR system since it was introduced in the Israeli Premier League in the playoff of the 2018–2019 season (see Samuel, Galily, et al., 2020). The study received institutional ethical approval by the ethics committee of the Baruch Ivcher School of Psychology at Reichman University (approval P_2021188), and all participants provided informed consent prior to data collection.

5.2. Measures

5.2.1. Pre-match assessment

In line with Russell et al. (2022), the referees were instructed to indicate their level of MF just prior to going on the pitch. The definition and sport-specific manifestations of MF were explained to the referees, including feelings of disengagement, decreased motivation and enthusiasm, increased displays of emotion and withdrawal, changes in concentration, and decreased discipline and attention to detail, as previously indicated by elite athletic populations. MF was assessed using a single 5-point Likert-type scale (1 – *completely mentally exhausted*; 2 – *slightly more mentally fatigued than usual*; 3 – *normal*; 4 – *mentally fresh*; 5 – *very mentally fresh*). Thus, lower values reflect higher levels of MF (Russell et al., 2022). While it is common practice to measure MF via self-report (Russell et al., 2022), it should be noted, that self-reporting is not without its challenges and potential biases (e.g. answering favourably to present oneself as mentally tough) and that measuring MF through self-report reflects a "feeling" of the particular referee at a specific time point.

5.2.2. In-match assessment

The referees were asked to indicate their level of MF level once more during the half-time break, using the same single item (Russell et al., 2022).

5.2.3. Post-match assessment

The referees were asked to complete the post-match assessment immediately following the match and further indicate their level of MF. They were also asked to self-rate their performance using a one-item 7-point Likert-type scale. It should be stressed, that elite referees are accustomed to self-assessment, as for each official match they receive verbal feedback, a written assessment, and a performance mark delivered by a referee match observer (Carvalho et al., 2023). Also, the use of a single item to evaluate referees' self-rated performance was previously validated (Samuel et al., 2018). Nevertheless, we acknowledge the potential bias and self-report issues associated with self-rated performance scores (e.g. not being fully aware of one's on-field behaviour, a self-serving bias of rating one's performance as higher than it really was, Hyun et al., 2022). In addition, the referees were asked to indicate whether a VAR intervention occurred in the match. If so, they indicated "to what degree the VAR intervention influenced your performance in the rest of the match" and "to what degree the VAR intervention influenced your mental state in the match", using a 7-point Likert-type scale.

5.3. Procedure

Potential participants were recruited by the first author who serves as the sport psychology consultant of the Israel Referee Association. The research topic and purpose of the study were explained, the voluntary nature of participation was emphasised, and then the participants were asked to read and sign the consent form. The researcher introduced the measurements and explained instructions for completion. Each participant received a packet with six match-related assessment measures (all by pencil and paper). The referees were instructed to indicate their level of MF state just prior to going on the pitch, and then once more during the halftime break. Following the match, they were asked to indicate once more their level of MF as close as possible to the end of the match and to complete the post-match assessment. The participants were assured of confidentiality and anonymity throughout the research process.

The study was conducted during the 2021–2022 season. In total, the referees completed the measures over 44 official Israeli Premier League matches. There were nine matches with a single VAR intervention out of the total 44 matches. Interventions occurred in relation to various decisions, including penalties, red cards, and goal approval. Three referees did not experience any VAR interventions, three experienced an intervention in one match, and three in two matches. Five of the interventions occurred in the first half of the match and four in the second half. Due to ethical considerations, we could not further specify the contextual information of the matches and VAR interventions.

5.4. Data analyses

Due to the relatively small sample size, we were somewhat limited in our data analyses approach. Specifically, though we acknowledged that the data had a hierarchical structure (i.e. matches were nested within referees) we could not apply hierarchical linear modelling as performed by Samuel et al. (2018) due to the sample size of referees and matches. Likewise, we did not have a sufficient sample size for performing a repeated-measures

multiple analysis of variance. We, therefore, initially evaluated descriptive statistics concerning MF, the referees' evaluations of the VAR interventions' effects, and their self-rated performance. Next, in the main analyses, we initially performed a repeated measures analysis of variance to examine differences in MF levels between pre-match, halftime, and post-match measurement points. We then used a paired sample t-test to examine differences in MF between matches with and without VAR interventions. Additionally, we calculated Pearson correlations among the three MF subscales and the match performance subjective evaluation. Finally, we used an independent sample t-test to examine differences in subjective performance evaluations in matches with and without a VAR intervention.

6. Results

6.1. Descriptive statistics

Descriptive statistics of the match-related factors are presented in Table 1. As can be seen in Table 1, MF increased from pre-match to the halftime to the post-match. Still, the post-match MF levels were moderate ($M = 2.43$, $SD = 0.82$) and reflected a middle point between being *slightly more mentally fatigued than usual* and *normal*. Also, the referees felt that the VAR intervention did not have much influence on their further performance in the match nor their mental state. Self-rated performance was perceived favourably ($M = 5.56$, $SD = 0.66$) across all matches.

6.2. Main analyses

Considering the development of the levels of MF throughout the matches, a repeated-measures analysis of variance was significant, *Wilk's Lambda* = 0.29, $F(2, 1) = 58.85$, $p < .001$, $\eta_p^2 = 0.58$. Post-hoc pairwise comparisons revealed a significant increase in MF levels from pre-match ($M = 4.09$, $SD = 0.86$) to halftime ($M = 3.36$, $SD = 0.84$, $p < .01$), as well as from halftime to post-match ($M = 2.43$, $SD = 0.81$, $p < .01$). These results are presented in Figure 1. Therefore, we found support for the first hypothesis that MF increases throughout the match.

To examine the second hypothesis, we compared the levels of MF at the three measurement points, between matches with ($n = 9$) and without ($n = 35$) VAR interventions, using independent *t*-tests. The mean difference in the level of MF pre-match ($M = 4.11$, $SD = 0.93$ vs. $M = 4.09$, $SD = 0.85$, $p = 0.938$, *Hedge's* $g = 0.023$) and at halftime ($M = 3.22$, $SD = 0.97$ vs. $M = 3.40$, $SD = 0.81$, $p = 0.576$, *Hedge's* $g = 0.214$) were

Table 1. Match-related factors.

	Range	M (SD)	Skewness
Self-Rated Mental Fatigue Pre-match*	2–5	4.09 (0.86)	−0.88
Self-Rated Mental Fatigue Halftime**	1–5	3.36 (0.84)	−0.54
Self-Rated Mental Fatigue Post-Match***	1–4	2.43 (0.82)	0.63
VAR Intervention influence on Performance***	1–4	1.75 (1.16)	1.36
VAR Intervention influence on Mental State***	2–4	2.77 (0.83)	0.50
Self-Rated Match Performance***	4–7	5.57 (0.66)	0.24

* Evaluated pre match ** Evaluated during match *** Evaluated post-match.

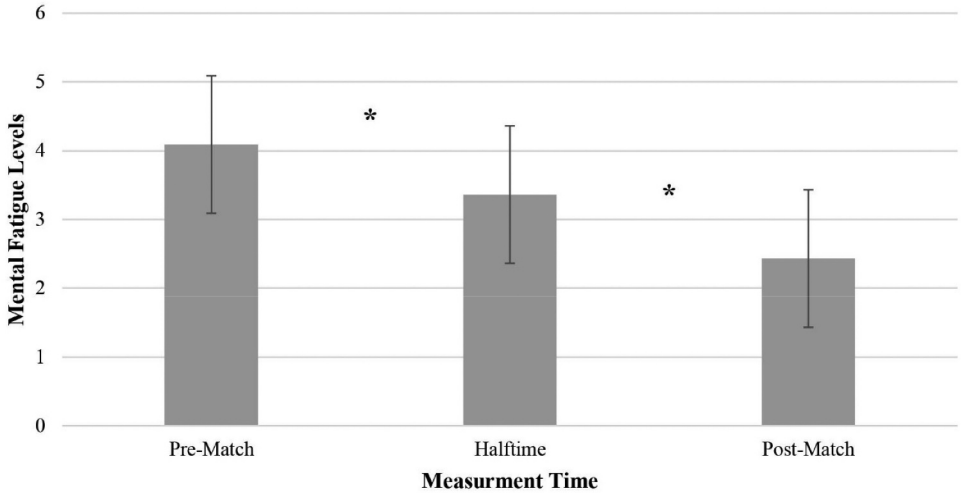

Figure 1. Change in mental-fatigue levels from pre-match to halftime to post-match.
Note: * p < .01.

not statistically significant. The difference in post-match MF between matches with ($M = 2.11$, $SD = 0.33$) and without VAR interventions ($M = 2.51$, $SD = 0.89$) was statistically significant, $t(35.76) = -2.16$, $p = 0.037$, *Hedge's* $g = 0.492$. Thus, in line with our second hypothesis, the results indicate that MF was higher at the end of the match in games that involved a VAR intervention compared to games without a VAR intervention.

Considering the third hypothesis, post-match MF correlated significantly with subjective performance, $r(44) = .35$, $p = .019$, indicating that as the referees felt less mentally fatigued their performance was better (i.e. this can be interpreted as a negative correlation between MF and performance). Thus, providing support for the third hypothesis. Finally, we found support for the fourth hypothesis. Specifically, the referees evaluated their performance in matches with VAR interventions ($M = 5.22$, $SD = 0.44$) lower than in matches without interventions ($M = 5.66$, $SD = 0.68$), $t(19.21) = -2.33$, $p = 0.031$, *Hedge's* $g = 0.69$.

7. Discussion

The results generally supported our hypotheses. Concerning our first hypothesis, we found an increase in MF over time as the match developed. The referees moved from feeling "mentally fresh" prior to the match to feeling "slightly more mentally fatigued than usual" at the end of the match. This finding echoes the findings of a previous study (Samuel et al., 2018) conducted with a somewhat similar design, in which Israeli referees reported moderate levels of MF following matches, as well as an increase in MF (i.e. manifested in state self-control) from pre-match to post-match levels, although these levels were relatively high at both times. Therefore, it can be argued that while referees at

the elite level tend to experience some increase in MF during matches, this is a moderate increase.

Regarding our second hypothesis, we found that the referees' level of MF was higher post-match when a VAR intervention occurred, and this effect was medium. This finding supports the notion that a VAR intervention is a match event that requires the referee to exert self-control, resulting in higher levels of MF. In line with two meta-analyses, dealing with adversity and negative emotions increases one's level of MF, which in turn impairs the ability to selectively control attention and decreases DM accuracy (Brown et al., 2019; Giboin & Wolff, 2019).

Finally, concerning the relationships with performance, we expected that in line with Samuel et al. (2018) findings, higher levels of MF would be associated with lower performance subjective evaluations. Indeed, we found support for this assumption, as post-match MF levels correlated negatively with self-rated performance. However, we must note that this was a small correlation, which indicates that additional factors explain the variance in the referees' performance evaluations. There is ample evidence for the debilitative influence of MF on sports performance, especially in relation to psychomotor skills, such as response time and DM accuracy (Habay et al., 2021; Sun et al., 2021), which are essential in football refereeing performance (Samuel et al., 2021).

Also, the referees evaluated their performance in matches with VAR interventions less favourably in terms of performance, as one would expect. It is unclear, however, whether this effect reflects merely the fact that a VAR intervention occurred and thus their match mark would be reduced (i.e. potentially influencing their career development), or that this effect reflects the referee's self-assessment that the overall match performance was lower. It is worth noting that the referees' self-rated performance evaluations were relatively positive in both cases. In this context, Schmidt et al. (2019) suggested that either the physiological stress from exercise (i.e. running) or the psychological stressors (e.g. pressure from the crowd, self-induced pressure to be successful and not make errors) may impair attentional control leading to increased distractibility and difficulties in sustaining attention. Therefore, it is possible that a VAR intervention increases the mental load of referees and impairs their psychomotor efficiency (Hatfield et al., 2020), making their ability to focus on the match, anticipate new events, and react quickly, less efficient. However, these postulations necessitate additional research.

We should acknowledge that the referees in our study were not conscious of such debilitating effects and reported that the VAR intervention did not have much influence on their mental state or further performance in the match. This is an interesting finding, especially given the finding that MF did change over the course of the match and did affect their refereeing performance (see also Samuel et al., 2018), that can be explained in two ways. First, it might reflect some potential bias in their responses – their willingness to "maintain face" and not be perceived as "mentally weak". Alternatively, the referees might already be accustomed to the VAR and thus they did not feel interventions as highly threatening. Also, it is possible that the referees were able to differentiate between their overall match performance (i.e. as reflected in running, DM, and game management) and the fact that a VAR intervention occurred. This could be attributed to the organisational culture in the Israel Referee Association which *does not* perceive VAR interventions as a problem affecting the referees' overall match performance. Therefore, while referees might receive

a lower performance mark due to a VAR intervention (i.e. when they could have made a correct on-field decision), they would not necessarily be scrutinised by the Referee Association if they accept the VAR intervention and rectify their decisions. This certainly creates some internal tension for referees, between their achievement motivation of officiating matches free of errors and their organisational commitment to accept the VAR system as a supporting aid. Further research is needed to examine this psychological process.

During a VAR intervention, the on-field referee becomes a central player in the social environment of the match. There is much evidence to support the notion that optimal refereeing performance is associated with task-focused attention and minimal focus on one's "self". When referees become aware of their own perceptions of themselves or the perceptions of others (private or public self-focus, Jones et al., 2019), they might exit the state of flow and potentially experience higher anxiety (Gray, 2020; Jones et al., 2019), typically associated with the fear of making an additional major DM error (Schnyder & Hossner, 2016; Slack et al., 2013). This may cause referees to disrupt the automatic components of the action by consciously attending to and/or controlling their movements (i.e. "step-by-step" explicit control, Gray, 2020). Previous research has reliably shown, that mentally fatigued individuals are less capable of regulating their anxiety, leading to impaired attention regulation and subsequent performance declines (e.g. Englert & Bertrams, 2015). Still, additional research is needed to explore these notions.

7.1. Study limitations and practical implications

There were several limitations in this study. First, there were only nine participants, and their data was hierarchical in nature. We could not perform hierarchical linear modelling analyses due to the small sample size. Although we attempted to account for this issue (i.e., we checked for inter-individual differences) we must acknowledge this as a study limitation. We must emphasise that the sample was representative of the population of elite referees in Israel and that collecting real field data is challenging. Also, not all participants completed the inventory over six matches, as they simply did not receive sufficient match assignments. Likewise, not all referees experienced a VAR intervention, thus emphasising the nested structure of the data. We, therefore, encourage researchers to replicate our design in other leagues to see if this effect is global, as refereeing is a task that occurs within a context. Whereas the measurement of MF effects in real matches was a major strength of this study, we believe that experimental designs are needed to better control for additional factors that can moderate the MF – performance relationship and determine causality. Indeed, we must acknowledge that we could not control for factors such as weather and match difficulty. Finally, we must note the challenges of self-reports of mental fatigue and performance, and thus recommend that future studies incorporate objective measures (e.g. heart rate variability; Melo et al., 2017).

The findings of this study present some practical implications for referees. Specifically, referees should be provided with information on the potential effects of VAR interventions on MF so that they can manage their cognitive load and maintain optimal performance (Samuel, 2015), for example through communication (Cunningham et al., 2018) and effective teamwork (Aragão e Pina et al., 2021). Furthermore, training protocols for referees should mimic game situations and conditions (perhaps through the use

of virtual reality, see van Biemen, Müller, et al., 2023), including VAR interventions, so that they can prepare and improve their self-control throughout a match, regardless of whether there was a VAR intervention or not (Kittel et al., 2021).

In this context, two mental skills are highly important for referees. First, they must develop self-regulation techniques, such as self-talk, to be able to maintain their self-control when a VAR intervention occurs in the match (Samuel, Matzkin, et al., 2020). Both instructional and motivational self-talk (Hatzigeorgiadis et al., 2011) might prove effective in mitigating the potential negative effects of a VAR intervention on referees' MF and performance. It has been shown, for example, that instructional self-talk (i.e. attention-alerting and attention-directing cues) facilitated the performance accuracy of visual selective attention on the Vienna Test System test battery in individuals with lower levels of perceived available self-control strength (Gregersen et al., 2017). Still, motivational self-talk could be useful following a VAR intervention to maintain referees' motivation to produce subsequent positive performance.

Second, elite referees are typically mentally skilled (even before the VAR era) in maintaining their effective attentional focus (e.g. van Biemen et al., 2022) and quiet eye (Vickers, 2007) to identify the match infringements as well as their mental composure in dealing with errors. Still, following a VAR intervention, they should be aware not to dwell on their error (i.e. an internal focus, Gray, 2020) and lose sight of the match events. Therefore, they should work on developing skills that allow them to recognise when their attention is too internal and shift their attention externally. Mental preparation (e.g. Samuel, 2015) is also important to achieve this, as the referees must not focus on how an error influences their own performance but be committed to continue officiating the match even after an error. Organisational support and guidance are pivotal to referees' ability to accept VAR interventions in a positive manner (i.e. their error did not affect the match's outcome).

Finally, an important recommendation is to involve the assistant referees more, especially after a VAR intervention involving the head referee's on-field decision. Relying on the assistants, even for a short period, can assist referees in increasing their self-control, reducing the cognitive load, and maintaining high levels of performance throughout the remainder of the match (Samuel et al., 2018). Still, it must be acknowledged that in case of a VAR intervention concerning the assistant referees' decisions (e.g. offsides turnover when a goal is scored or a penalty is called), they may also experience increased levels of MF. In such cases, the head referee should support the assistant who made the error, during the post-intervention phase.

8. Conclusions

This was a novel attempt to explore an area typically hidden from the eyes of the public, namely the elite referee's MF levels while officiating. We believe that this study opens a glimpse into the mind of referees while performing in real matches and thus provides innovative methodology and findings. In general, the findings indicated that the MF levels of elite referees increase as the match progresses, and this is associated with the quality of their performance. In addition, referees were mentally influenced by VAR interventions, as can be indicated by their elevated MF levels. While VAR interventions have become a common practice in football matches worldwide (FIFA –

Fédération internationale de Football Association, 2022), they still attract much scrutiny (e.g. Chen & Davidson, 2022; Scanlon et al., 2022). For the referees, a VAR intervention reflects a challenge to their DM and thus their authority, and a potential reduction of their performance mark (Samuel, Galily, et al., 2020). Therefore, it is a critical match event that referees must manage well – internally and externally.

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Data availability statement

Due to the high profile of the study participants (i.e. elite referees) and the need to maintain their anonymity, supporting data is not available.

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