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The effect of smartphones and playing video games on decision-making in soccer players: A crossover and randomised study

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ABSTRACT
The objective of this study was to analyse the effect of the use of social networks in smartphones or playing video games on the passing decision-making performance in professional soccer athletes. Participants were 25 male professional soccer athletes (mean ± SD: age 23.4 ± 2.8 years). The participants performed three randomised conditions divided into three groups: control (CON), smartphone (SMA), and video game (VID). Before and after each experimental condition, the Stroop Task assessed the level of induced mental fatigue. Then, the athletes performed a simulated soccer match. A CANON® camera recorded the matches for further analysis on passing decision-making performance. A group effect was identified ($p < .01$) with impairment on passing decision-making performance for the SMA ($p = .01$, ES = 0.5) and VID ($p = .01$, ES = 0.5) conditions. We concluded that the use of social networks on smartphones and/or playing video games right before official soccer matches might impair the passing decision-making performance in professional soccer athletes.

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KEYWORDS
Sports psychology; team sports; mental fatigue; athletes

Introduction

Soccer is a team sport that aims to score in the opponent's goal. It presents intermittent high-energy demand due to the actions that vary in intensity and duration throughout the game (Coutinho et al., 2017, 2018). Considering the technical-tactical actions, inconstant patterns during the games are observed and motor activities are abruptly interrupted and restarted several times, randomly (Smith et al., 2016b, 2018). In this sense, soccer is a dynamic sport of high unpredictability and requires the right decision-making for success (Romeas, Guldner, & Faubert, 2016).

Thereby, Ecological dynamics of decision-making performance highlights the key role of the environment in shaping player's behaviours, that is, soccer athletes must be able to identify and use, in their favour, the relevant information from the field (Travassos et al., 2012a). It has been observed that players couple their actions in both space and time, looking for the best way to comprehend the environment and task restrictions during performance (Travassos, Duarte, Vilar, Davids, & Arajo, 2012b). Thus, mental fatigue may affect the ecological dynamics of decision-making performance, which might impair the interpretation of environmental information, impairing their decisions and behaviours.

Decision-making is the brain's ability to extract contextual information from the visual scene, which is essential for high-level performance in unpredictable sports (Gil-Arias et al., 2016; Romeas et al., 2016). To achieve success in decision-making performance, soccer athletes have to enhance perception-action couplings to improve their attention to perceptual variables and clarify which actions are possible to perform during each game situation (Travassos et al., 2012a). In addition, decision-making involves cognitive brain mechanisms, such as perception, attention, anticipation, and working memory (Araújo et al., 2015; Vestberg, Gustafson, Maurex, Ingvar, & Petrovic, 2012) that are impaired by mental fatigue.

Mental fatigue is a psychobiological state characterised by feelings of tiredness and lack of energy after long periods of cognitive activity (Smith et al., 2018) and according to scientific findings, it also impairs cognitive function (Coutinho et al., 2017; Smith et al., 2016a) and motor performance (Cutsem et al., 2017). These impairments have been attributed to a minor focus capacity, slower and less accurate reactions, and poor visual perception (Smith et al., 2018). Therefore, since those executive functions are important to sport-specific performance, researchers have recently begun to investigate the effects of mental fatigue on soccer performance (Coutinho et al., 2017, 2018; Smith et al., 2016a, 2016b).

The Stroop Task, from 30-min onwards, might cause mental fatigue (Smith et al., 2016a), but other common activities may induce mental fatigue as well, for example, driving a car for long periods, mainly in high traffic conditions (Ting, Hwang, Doong, & Jeng, 2008; Zhao, Zhao, Liu, & Zheng, 2012). Previous studies about soccer have shown that mental fatigue may reduce decision-making performance (Smith et al., 2018, 2016a). It is important to note that Smith et al. (2016a); Smith et al. (2018) conducted their study in the laboratory (participants underwent a 30-min Stroop colour-word task), thus, it presents low ecological power for sports

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conditions. Given the complexity and unique nature of soccer, different results may emerge from mental fatigue in different approaches. For example, activities that require attention may impact mental fatigue, such as the use of social networks on smartphones (Fortes et al., 2019), and playing video games. Once those activities are performed before official soccer matches, it may impair decision-making performance. Thus, it is necessary to conduct experimental studies to confirm this hypothesis.

From a practical standpoint, the effect of mental fatigue on decision-making performance during matches would indicate if the team's technical committee should limit the use of smartphones and video games before official matches. Thus, the objective of this study was to analyse the effect of social networks on smartphones and playing video games on the passing decision-making performance in professional soccer athletes. It was developed a hypothesis: the mental fatigue induced by smartphones and video games impairs passing decision-making performance.

Materials and methods

Participants

The sample size was analysed in the G*Power 3.1 software. A power of .80, α = .05 and effect size of .50 were adopted. The sample size of 21 subjects was revealed as necessary to conduct the experiment.

Participants were 25 professional soccer athletes (mean ± SD; age 23.4 ± 2.8 years; height 1.7 ± 0.08 m; body mass 76.1 ± 5.6 kg; body fat 14.4 ± 4.1%), selected in a non-probabilistically way. The athletes had a similar level of expertise in soccer (8.7 ± 3.3 experience years as a soccer player). The participants belonged to two professional teams linked to the Brazilian Soccer Confederation. Only line-players were part of the investigation.

Habitually, on a weekly basis, the players were involved in one training session per day (~180 minutes per session), five days per week. In addition, during the week, one official match was performed. Training sessions usually consisted of soccer drills, tactics, sprints, intermittent running exercises, and specific conditioning work as well as weight training and plyometrics.

To be included in the study, athletes should: (a) be a soccer player for at least three years; (b) train soccer systematically for at least 10 hours per week; (c) be enrolled in the State Soccer Championship.

The procedures of this study were approved by the Institutional Review Board at the Federal University of Pernambuco in compliance with the Brazilian National Research Ethics System Guidelines. Written informed consent was obtained from each participant before participation.

Experimental design

This was a controlled and randomised investigation with an experimental within-subject design that consisted of six visits (two for each experimental condition) with an interval of 72 to 96 h. Male soccer athletes participated in three randomised conditions throughout the six visits: control (CON), smartphone (SMA) and video game (VID).

It was adopted simple randomisation. The survey coordinator used a manually generated number to determine the allocation of athletes in each condition. The participants were randomised as a group. Thus, during the experimental conditions, the players were under the same treatment condition. The final order of the experimental conditions was SMA, CON, and VID.

Before and after each experimental condition, the Stroop Task was conducted to assess the level of induced mental fatigue. Then, the athletes performed a simulated soccer match (two halves of 45 min, totalling 90 min), adopting the official rules. The matches were filmed by a CANON® camera (SX60 model, Yokohama, Japan), and for further analysis of passing decision-making performance, the Game Performance of Assessment Instrument (GPAI) (Memmert & Harvey, 2008) was used. It is noteworthy that the number of decision-making opportunities across conditions (SMA, VID, and CON) was not controlled. However, no significant differences for number of passes ($F_{(3, 22)} = 1.97$, $p = .31$) between experimental conditions were found.

The head coach divided the players into two balanced teams according to his perception of the athletes' skill levels in ball passing, ball control, shooting, and game knowledge. The division of the teams was the same in all the experimental conditions. To keep the players motivated in all the experimental conditions, they were told the simulated games would be used to select players to the main team for the competitive season.

Before the simulated match, a 5-minute warm-up using balls was performed. It is worth mentioning that in all experimental conditions the time between the two halves was 15 min. Urine osmolarity and perceived recovery were measured before the simulated match. Blood lactate was measured shortly after the simulated match and the RPE-session following 30 min of the match. Although the study lacks a familiarisation session, it is important to highlight all the participants were familiar with the procedures of the study that was performed during the pre-season. All experimental procedures are illustrated in Figure 1.

Interventions

CON, SMA, and VID

It was recommended that up to 2 h before each experimental session the athletes ingested fluid ad libidum. The CON condition watched advertisement videos with a 30-min duration. The SMA condition consisted of the use of social networking applications (Facebook and Instagram) with a 30-min duration. The VID condition was composed of playing video games (FIFA 2018, EA Sports, EUA) with 30-min duration. Noteworthy, during the simulated matches, the athletes were not allowed to ingest any type of liquid.

Variables measurements

Primary outcome

Decision-making index (DMI). The decision-making was evaluated during the matches. The participants played two halves of 45 min, adopting the official soccer rules. The entire matches

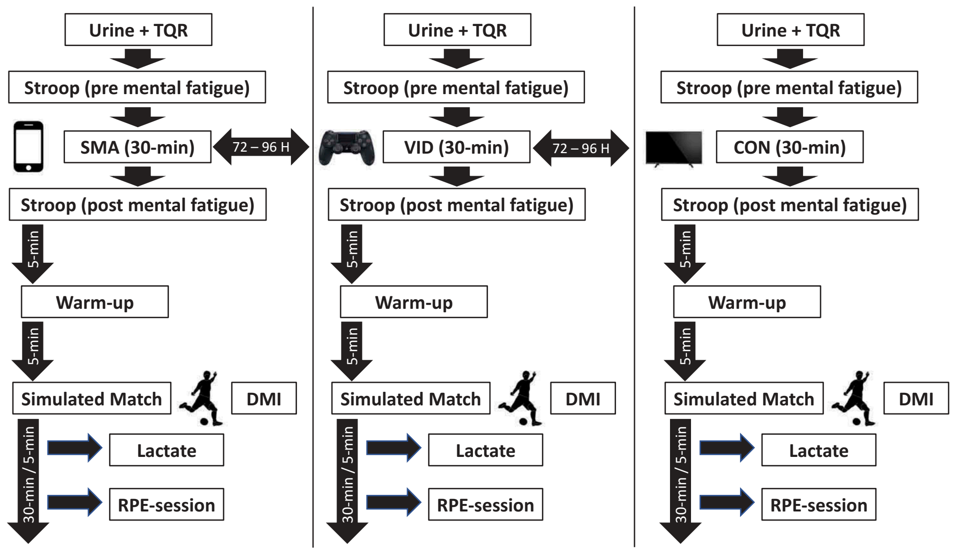

Figure 1. Experimental design.

Note. SMA = smartphone; VID = video game; CON = control; TQR = Total Quality Recovery; DMI = decision-making index.

were filmed with a CANON® camera (SX60 model, Yokohama, Japan). The analyses and categorisation of actions were based on the GPAI (Memmert & Harvey, 2008). The soccer decision-making components proposed by Romeas et al. (2016) were adopted. Thus, it was considered as appropriate decision-making when the pass went to one of the members of the team who was unmarked and: (a) directly or indirectly created a goal chance or; (b) it was in a better position than the opponent.

The DMI of the pass was calculated according to the formula below (1), considering the modifications suggested by Memmert and Harvey (2008). Two experienced researchers analysed and categorised the athletes' actions as appropriate and inappropriate. The researchers were blinded to the experimental treatments [SMA vs. VID vs. CON] to decrease bias. Acceptable coefficient of agreement (*kappa* = .92, p = .01) was identified for the categorisations of the two specialists. The intraclass correlation coefficient (ICC) and coefficient of variation (CV) were used to determine the reliability of DMI in each experimental condition: CON (ICC = 0.98, CV = 1.2%), SMA (ICC = 0.97, CV = 1.4%), and VID (ICC = 0.99, CV = 0.9%).

$$DMI = \frac{Aa}{Aa + Ia} x100 \qquad (1)$$

Aa = appropriate actions

Ia = inappropriate actions

Secondary outcomes

Stroop task. Stroop Task (Graf, Uttl, & Tuokko, 1995) was adopted to assess inhibitory control and selective attention, both considered a component of cognitive function. Thereby, two assessments (pre and post-use of smartphone or video game) in each experimental condition were performed. The tests were carried out on a full-HD screen (1800 x 1260 pixels) laptop (MacBook Pro, A1502 model, EUA).

Accordingly, the participants answered the word colour or according to its name, since the colour of the words might be different from what is typed (e.g., the word "blue" might show up in "red" colour, the word "green" in "blue", and so on). Stimuli of 62 words with 200 ms of the interval were provided between the response and a new stimulus. Moreover, the stimulus remained on the screen until any response was given. Stimuli vary between congruent (word and colour have the same meaning), incongruent (word and colour have a different meaning) and control (coloured rectangle with one of the colours of the test: red, green, blue, and black).

The duration of the Stroop Task varied between 150 and 165 seconds in the experimental conditions. The keys D (red), F (green), J (blue), and K (black) were used to answer the questions. When the answer was correct, the stimulus disappeared and a new one was set. In case of incorrect answers, an X showed up on the screen and a new stimulus appeared subsequently. At the end of the test, accuracy and mean response time of the answers were collected. The evaluator was blind for all the assessments and had previous training for the test. The ICC and CV were used to determine the reliability of the Stroop Task (Δ% pre vs-post mental fatigue) in each experimental condition: (a) accuracy: CON (ICC = 0.98, CV = 1.2%), SMA (ICC = 0.97, CV = 1.4%), and VID (ICC = 0.99, CV = 0.9%); (b) response time: CON (ICC = 0.95, CV = 2.6%), SMA (ICC = 0.94, CV = 2.8%), and VID (ICC = 0.97, CV = 2.0%).

Hydration state. The athletes collected urine in transparent containers to determine the urinary colour index immediately before each condition. The urine colour index was determined by Armstrong's scale (2007). This scale adopts eight different urine colours, ranging from light yellow (colour 1) to brownish green (colour 8). The hydration state was evaluated before every experimental condition because recent findings showed hypohydration might impair decision-making performance in soccer players (Fortes, Nascimento-Júnior, Mortatti, Lima-Júnior, & Ferreira, 2018b). The ICC and CV were used to determine the reliability of hydration state in each experimental condition: CON (ICC = 0.99, CV = 0.4%), SMA (ICC = 0.96, CV = 0.7%), and VID (ICC = 0.97, CV = 0.6%).

Total quality recovery (TQR). The Total Quality Recovery (TQR) scale proposed by Kenttä and Hassmén (1998) and validated to the Brazilian culture by Osiecki, Osiecki, Burigo, Coelho, and Malfatti (2015) was used before each experimental condition to assess the level of perceived recovery. TQR is a scale that ranges from six (nothing recovered) to 20 (fully recovered). That is, the higher the value, the higher the level of perceived recovery. The ICC and CV determined the reliability of the level of perceived recovery in each experimental condition: CON (ICC = 0.94, CV = 0.7%), SMA (ICC = 0.98, CV = 0.4%), and VID (ICC = 0.97, CV = 0.5%).

Internal load. The lactate blood concentration was analysed shortly after the overtime. The lactacidemic analysis was performed in samples of 25 µl of blood collected from the athlete's earlobe, without hyperaemia, in the heparinised capillary. These samples were immediately transferred to 1.5 ml Eppendorf tubes containing 50 µl of 1% NaF solution and stored on ice for further electro-enzymatic reading (YSL 2700 STAT, Yellow Springs Co., USA).

The internal load was quantified by the session-rating of perceived exertion (RPE-session) (Foster et al., 2001). After 30 min of the GPAI analysis in each of the experimental conditions (CON, SMA, and VID), the athletes answered the following question: "How was your training?". The athlete was asked to demonstrate the intensity perception of the session from the 10-point Borg scale (0 = rest to 10 = maximum effort), according to the method developed by Foster et al. (2001). The product of the values demonstrated by the RPE scale and the total time in minutes of the session was calculated, thus, expressing the internal load of the training session in arbitrary units (A.U.). Noteworthy, the athletes were familiar with the RPE-session method for a period of 30 days before the beginning of the investigation. The ICC and CV were used to determine the reliability of internal game load in each experimental condition: CON (ICC = 0.95, CV = 2.7%), SMA (ICC = 0.99, CV = 1.6%) and VID (ICC = 0.96, CV = 1.9%).

Weather condition. Data on the weather conditions were obtained by a heat stress monitor (Instrutemp®, São Paulo, Brazil) and recorded at the beginning and end of each simulated match to obtain the environment temperature and the relative humidity of the air. The ICC and CV were used to determine the reproducibility of the temperature and relative humidity of the air in each experimental condition: (a) temperature: CON (ICC = 0.99, CV = 3.6%), SMA (ICC = 0.99, CV = 3.1%) and VID (ICC = 0.96, CV = 4.7%); (b) relative humidity of the air: CON (ICC = 0.95, CV = 5.7%), SMA (ICC = 0.97, CV = 4.9%) and VID (ICC = 0.98, CV = 4.0%).

Statistical analysis

The Shapiro Wilk test was conducted to evaluate data distribution. The Levene test assessed homoscedasticity. Repeated measures ANOVA was used to compare the number of passes, weather conditions (temperature and relative humidity in air), urine osmolarity, perceived recovery level, internal game load (lactate and internal load), and DMI (the number of decision-making opportunities as a covariate) between the treatments (CON, SMA, and VID). The Bonferroni post hoc test, when necessary, was used to identify statistical differences. Wilcoxon test was used to compare the number of passes, weather conditions (temperature and relative humidity in air), urine osmolarity, perceived recovery level, internal game load (lactate and internal load), and DMI (the number of decision-making opportunities as a covariate) between the two visits of the same experimental condition. Additionally, the Wilcoxon test was used to compare the Stroop Task performance before and after each condition for mental fatigue (CON, SMA, and VID). The effect size was used to assess the differences from a practical point of view. The following criteria was used according to the Rhea (2004) guidelines for highly trained participants: $h^2 < .25$ = trivial, $.25 \le h^2 < .50$ = low, $.50 \le h^2 < 1.0$ = moderate and $h^2 \ge 1.0$ = large effect size. The data were analysed by the SPSS 21.0 software (IBM Corp., Armonk, NY, EUA), adopting a significance level of 5%.

Results

The descriptive demographics data (age, body mass, height, and %BF) are depicted in Table 1. The number of passes ($F_{(3, 22)} = 1.97$, $p = .31$), perceived recovery level ($F_{(3, 22)} = 2.34$, $p = .26$), hydration state ($F_{(3, 22)} = 2.09$, $p = .33$), lactate ($F_{(1, 3)} = 2.68$, $p = .23$), internal load ($F_{(1, 3)} = 1.28$, $p = .47$), temperature ($F_{(1, 3)} = 1.50$, $p = .41$), and relative humidity in air ($F_{(1, 3)} = 1.21$, $p = .44$) were similar between the CON, SMA, and VID conditions. The results showed significant difference for accuracy (Figure 2, $F_{(3, 22)} = 47.3$, $p = .01$) and response time (Figure 3, $F_{(3, 22)} = 32.5$, $p = .02$) following induced mental fatigue (Stroop Task) in the SMA and VID experimental treatments compared with the CON (Table 1).

Table 2 presents the results of the comparisons of DMI between conditions. It was identified a group effect ($p < .01$), with impairment in SMA ($p = .01$, ES = 0.5) and VID ($p = .01$, ES = 0.5) conditions.

Discussion

The objective of this study was to analyse the effect of social networks in smartphones and playing video games on the passing decision-making performance in professional male soccer athletes. The DMI decreased in the SMA and VID conditions

Table 1. Demographic characteristics of participants, number of passes, induced mental fatigue (accuracy and response time), perceived recovery level, hydration state and weather conditions.

	Mean ± SD		
	SMA	VID	CON
Number of passes	36.3 ± 9.7	40.4 ± 9.3	38.2 ± 8.2
Induced Mental Fatigue			
Accuracy (Δ%)	−7.3 ± 2.7*	−8.6 ± 3.2*	1.2 ± 0.4
Response time (s)	0.9 ± 0.4*	1.0 ± 0.3*	0.3 ± 0.2
Perceived Recovery Level	16.9 ± 3.0	17.3 ± 2.7	17.6 ± 2.5
Hydration state (osmolarity)	1.9 ± 0.8	1.6 ± 0.9	1.7 ± 1.2
Lactate (mmol/l)	6.9 ± 1.7	7.1 ± 1.8	6.4 ± 1.4
Internal load (a.u.)	748.2 ± 150.1	763.9 ± 168.0	703.1 ± 135.7
Weather conditions			
Temperature (°C)	28.5 ± 2.2	28.3 ± 1.9	27.1 ± 1.6
Relative humidity (%)	75.8 ± 3.6	77.0 ± 2.8	78.4 ± 2.5

Values are presented as mean ± standard deviation; SD = standard deviation; CON = control condition; SMA = smartphone condition; VID = video game condition; *p < .05 different to CON.

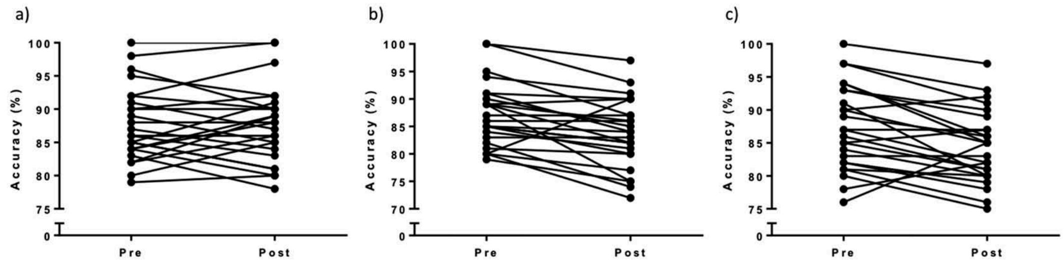

Figure 2. Individual analyses for accuracy.

Note. a) control; b) smartphone; c) video game.

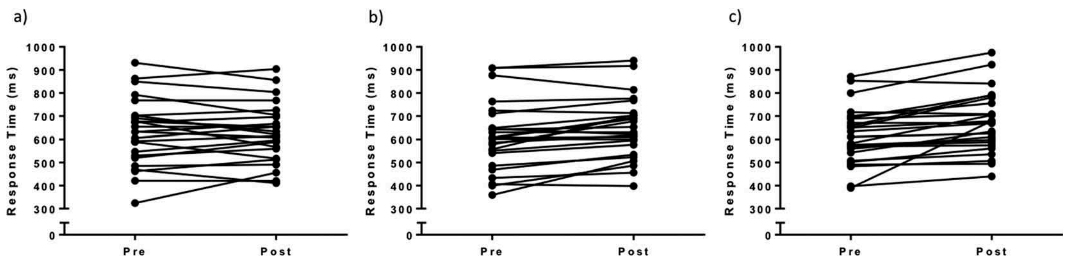

Figure 3. Individual analyses for response time.

Note. a) control; b) smartphone; c) video game.

Table 2. Mean and standard deviation of DMI according to condition (SMA, VID, and CON).

Variables	SMA (n = 25)	VID (n = 25)	CON (n = 25)	Effect	F	*p*
DMI (%)						
Game	57.2 ± 9.1*	60.7 ± 9.6*	67.2 ± 8.5	Group	23.6	.01
ES (between conditions)		0.5				

Values are presented as mean ± standard deviation; DMI = decision-making index; CON = control condition; SMA = smartphone condition; VID = video game condition; *p < .05 different to CON; ES = effect size.

when compared with the CON, corroborating with the hypothesis of our investigation.

The findings showed the use of social networks and playing video games before a soccer match compromises the passing decision-making performance. Thereby, considering it is a common practice among athletes, coaches should be aware of the impairments and avoid their excessive use (i.e. 30min) before matches (Dietrich, Shipherd, Gershgoren, Medeiros-Filho, & Basevitch, 2012). Noteworthy, the results were similar in the number of passes, hydration state, internal game-load, perceived recovery, and weather conditions between the experimental treatments. Thus, the impaired performance might be related to the augmented mental fatigue since the athletes performed the sessions under the same conditions.

Studies have shown that residual mental fatigue might negatively impact the accuracy and response time in cognitive tests (Coutinho et al., 2017; Smith et al., 2018). More specifically, once the speed of information processing has been reduced in soccer athletes, decision-making performance might also be attenuated (Smith et al., 2016a). Mentally fatigued athletes may not adequately interpret (sports perception) or anticipate (frontal cortex) opponent's actions, which affects the decision-making accuracy (Smith et al., 2018). Thus, it seems that mental fatigue negatively affects the way players choose their tactical actions during matches (Coutinho et al., 2018). Therefore, mental fatigue implies a reduction of the perception capacity, which might deteriorate decision-making performance.

When mentally fatigued, athletes usually demonstrate longer fixation time (visual and motor behaviour) on opponents and shorter fixation time on their teammates (Smith et al., 2016a). Thus, although mentally fatigued athletes may observe the decisions (tactical movements) of their opponents, little focus is given to the displacements of their teammates, impairing the passing decision-making performance, as pointed out in the findings of this investigation.

In fact, the possible mechanisms that explain decision-making impairment in mentally fatigued athletes might be explained by a reduction in the activity of the brain areas responsible for cognitive flexibility (Smith et al., 2018). The frontal cortex is in charge of the cognitive functions (Zheng, Xia, Zhou, Tao, & Chen, 2016), specifically cognitive flexibility and attention that are directly associated with decision-making performance (Fortes et al., 2018a). Thereby, electrical impulses in highly activated areas of the brain for a prolonged time might compromise information processing in the brain.

The use of smartphones and video games in the present study demonstrated impairment in the Stroop Task performance. In addition, studies indicated that protocols of mental fatigue cause impairment on Stroop Task performance (Coutinho et al., 2017; Smith et al., 2016a). Thus, it is reasonable to assume the use of smartphones and video games for at least 30 min caused mental fatigue in soccer players.

Interestingly, the Stroop Task is commonly used to induce mental fatigue (Smith et al., 2016a, 2016b), however, in the present study, the Stroop Task assessed mental fatigue caused by the exposure of smartphone applications and video games. The most affected brain region appears to be the anterior cingulate cortex (ACC) (Smith et al., 2018). The mental fatigue increases adenosine and reduces dopamine in ACC (Smith et al., 2018), which impairs attention and inhibition control performance. Thus, the Stroop Task might be considered suitable to measure mental fatigue. It is important to highlight the duration of Stroop Task in the present study was short (< 3-min), differently from other investigations that used Stroop Task to induce mental fatigue with 30-minute duration (Smith et al., 2016a, 2016b). Therefore, the decision-making performance during the game was unlikely affected by the accumulated mental fatigue from the exposure to smartphone and video game plus the Stroop Task. Additionally, the design of the present study is closer to reality.

The present study presents some limitations. It was not possible to use the electroencephalogram to analyse the amplitude of brain waves (alpha and theta) at rest and after the induction of mental fatigue. The motivation before the accomplishment of every experimental condition was not measured. Moreover, we did not utilise the Eye-Track System to assess passing decision-making performance. Therefore, the findings should be treated with caution.

Conclusions

We concluded that social networks on smartphones and/or playing video games for at least 30 min before official soccer matches impair the passing decision-making performance in professional soccer athletes. Thereby, coaches should evaluate the use of social networks on smartphones and/or playing video games before official matches in soccer athletes. Furthermore, in future studies, different levels of athlete's mental fatigue should be manipulated in different sports to evaluate its effect on decision-making.

Disclosure statement

No potential conflict of interest was reported by the authors.

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References

Araújo, D., Davids, K., Diniz, A., Rocha, L., Santos, J. C., Dias, C., & Fernandes, O. (2015). Ecological dynamics of continuous and categorical decision-making: The regatta start in sailing. *European Journal of Sport Science*, *15*(3), 195–202.

Armstrong, L. E. (2007). Assessing hydration status: The elusive gold standard. *Journal of the American College of Nutrition*, *26*, 575S–584S.

Coutinho, D., Gonçalves, B., Travassos, B., Wong, D. P., Coutts, A. J., & Sampaio, J. E. (2017). Mental fatigue and spatial references impair soccer players' physical and tactical performances. *Frontiers in Psychology*, *8*(1), 1–12.

Coutinho, D., Gonçalves, B., Wong, D. P., Travassos, B., Coutts, A. J., & Sampaio, J. (2018). Exploring the effects of mental and muscular fatigue in soccer players' performance. *Human Movement Science*, *58*(1), 287–296.

Cutsem, J. V., Marcora, S., De Pauw, K., Bailey, S., Meeusen, R., & Roelands, B. (2017). The effects of mental fatigue on physical performance: A systematic review. *Sports Medicine*, *47*, 1569–1588.

Dietrich, F., Shipherd, A. M., Gershgoren, L., Medeiros-Filho, E., & Basevitch, I. (2012). Sport psychology group consultation using social networking web sites. *Psychological Services*, *9*(3), 323–324.

Fortes, L. S., Freitas-Júnior, C. G., Paes, P. P., Vieira, L. F., Nascimento-Júnior, J. R. A., Lima-Júnior, D. R. A. A., & Ferreira, M. E. C. (2018a). Effect of an eight-week imagery training programme on passing decision-making of young volleyball players. *International Journal of Sport and Exercise Psychology, a Head of Print*, 1–9. doi:10.1080/1612197X.2018.1462229

FIFA 18 (2018, January 10). EA Sports [https://www.ea.com]. Retrieved from https://www.ea.com/pt-br/ea-access/landing-page/fifa-18.

Fortes, L. S., Lima-Júnior, D., Nascimento-Júnior, J. R. A., Costa, E. C., Matta, M. O., & Ferreira, M. E. C. (2019). Effect of exposure time to smartphone apps on passing decision-making in male soccer athletes. *Psychology of Sport and Exercise*, *44*, 35–41.

Fortes, L. S., Nascimento-Júnior, J. R. A., Mortatti, A. L., Lima-Júnior, D. R. A. A., & Ferreira, M. E. C. (2018b). Research quarterly for exercise and sport. A head of print. doi:10.1080/02701367.2018.1488026

Foster, C., Florhaug, J. A., Franklin, J., Gottschall, L., Hrovatin, L. A., Parker, S., … Dodge, C. (2001). A new approach to monitoring exercise training. *Journal of Strength and Conditioning Research*, *15*, 109–115.

Gil-Arias, A., Moreno, M. P., García-Mas, A., Moreno, A., García-González, L., & Villar, F. (2016). Reasoning and action: Implementation of a decision-making program in sport. *The Spanish Journal of Psychology*, *19*(1), 575.

Graf, P., Uttl, B., & Tuokko, H. (1995). Color- and picture-word Stroop tests: Performance changes in old age. *Journal of Clinical Experimental Neuropsychology*, *17*, 390–415.

Kenttä, G., & Hassmén, P. (1998). Overtraining and recovery A conceptual model. *Sports Medicine*, *26*(1), 1–16.

Memmert, D., & Harvey, S. (2008). The Game Performance Assessment Instrument (GPAI): Some concerns and solutions for further development. *Journal of Teaching in Physical Education*, *27*, 220–240.

Osiecki, R., Osiecki, T., Burigo, T., Coelho, R. L., & Malfatti, C. R. M. (2015). The Total Quality Recovery Scale (TQR) as a proxy for determining athletes? Recovery state after a professional soccer match. *Journal of Exercise Physiology Online*, *18*(3), 27–32.

Rhea, M. R. (2004). Determining the magnitude of treatment effects in strength training research through the use of the effect size. *Journal of Strength and Conditioning Research*, *18*, 918–920.

Romeas, T., Guldner, A., & Faubert, J. (2016). 3D-multiple object tracking training task improves passing decision-making accuracy in soccer players. *Psychology of Sport and Exercise*, *22*, 1–9.

Smith, M. R., Coutts, A. J., Merlini, M., Deprez, D., Lenoir, M., & Marcora, S. M. (2016b). Mental fatigue impairs soccer-specific physical and technical performance. *Medicine & Science in Sports and Exercise*, *12*, 267–276.

Smith, M. R., Thompson, C., Marcora, S. M., Skorski, S., Meyer, T., & Coutts, A. J. (2018). Mental fatigue and soccer: Current knowledge and future directions. *Sports Medicine* a head of print. doi:10.1007/s40279-018-0908-2

Smith, M. R., Zeuwts, L., Lenoir, M., Hens, N., De Jong, L. M. S., & Coutts, A. J. (2016a). Mental fatigue impairs soccer-specific decision-making skill. *Journal of Sports Sciences*, *26*, 1–8.

Ting, P., Hwang, J., Doong, J., & Jeng, M. C. (2008). Driver fatigue and high- way driving: A simulator study. *Physiology and Behavior*, *94*, 448–453.

Travassos, B., Araújo, D., Davids, K., Vilar, L., Esteves, P., & Vanda, C. (2012a). Informational constraints shape emergent functional behaviours during performance of interceptive actions in team sports. *Psychology of Sport and Exercise*, *13*, 216–223.

Travassos, B., Duarte, R., Vilar, L., Davids, K., & Arajo, D. (2012b). Practice task design in team sports: Representativeness enhanced by increasing opportunities for action. *Journal of Sports Sciences*, *30* (13), 1447–1454.

Vestberg, T., Gustafson, R., Maurex, L., Ingvar, M., & Petrovic, P. (2012). Executive functions predict the success of top-soccer players. *PloS One*, *7*(4), e34731.

Zhao, C., Zhao, M., Liu, J., & Zheng, C. (2012). Electroencephalogram and electrocardiograph assessment of mental fatigue in a driving simulator. *Accident Analysis & Prevention*, *45*, 83–90.

Zheng, G., Xia, R., Zhou, W., Tao, J., & Chen, L. (2016). Aerobic exercise ameliorates cognitive function in older adults with mild cognitive impairment: A systematic review and meta-analysis of randomised controlled trials. *British Journal of Sports Medicine*, *50*, 1443–1450.