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Motivation counteracts fatigue-induced performance decrements in soccer passing performance

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ABSTRACT

Recent theories suggest that negative effects of fatigue on performance are determined by perception of effort and motivation rather than being directly caused by reaching physiological limits. In the current experiment, the influence of motivation on fatigue-induced decrements in soccer performance was experimentally investigated. Sixty amateur soccer players performed a validated soccer-passing test before and after a fatigue protocol. Results showed that players' motivation and performance decreased after the fatigue protocol for players in the control group. In contrast, players in the motivation group (i.e., with motivation experimentally induced after the fatigue protocol) were able to uphold their motivation and increase their performance. These results indicate that motivation plays a crucial role in performance under fatigue, as fatigue-induced decrements in soccer passing performance can be counteracted by high levels of motivation. Future research may explore the limits of this counteracting effect and extend findings to other relevant performance aspects.

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KEYWORDS
Fatigue; effort; perceived exertion; task disengagement; football

Introduction

Fatigue is a psycho-physiological state that results from prolonged physical or mental activity, and is often associated with decrements in performance (Hockey, 2013). A long-standing perspective in exercise physiology is that performance decrements under high fatigue are the result of decreased muscle functioning, with physiological processes related to muscle functioning reaching their biological limits (e.g., Allen, Lamb, & Westerblad, 2008; McKenna & Hargreaves, 2008; Sejersted & Sjogaard, 2000). However, instead of reduced muscle functioning, recently a more psychological perspective suggests that performance decrements under high fatigue may rather be attributed to a form of task disengagement or "giving up" and argue for a central role for perception of effort and motivation (Marcora & Staiano, 2010). Taking this perspective as a starting point, the current study aimed to experimentally test the influence of motivation on fatigue-induced performance decrements on a validated soccer task.

Fatigue often negatively affects sports performance and has been reported to result in, amongst others, reduced muscle force, endurance performance, sprint performance, and motor skill execution (Knicker, Renshaw, Oldham, & Cairns, 2011). In soccer, both running performance and soccer skill execution may be negatively affected by fatigue. For example, sprint performance was negatively affected by match fatigue (Rampinini et al., 2011), and performance on a soccer passing task (i.e., Loughborough Soccer Passing Test; LSPT) deteriorated directly after playing a fatiguing soccer match (Rampinini et al., 2008).

In explaining how fatigue negatively affects sports performance, the psychobiological model of endurance performance argues that perception of effort plays a crucial role (Marcora & Staiano, 2010). With increasing levels of fatigue, activities are perceived as more effortful. For example, running at a given speed feels increasingly effortful as the task continues (Horstman, Morgan, Cymerman, & Stokes, 1979; Noble & Noble, 2000). When athletes reach the maximal amount of effort they are willing or perceive themselves as able to invest, task behaviour (e.g., running speed) will be adjusted to keep their effort within acceptable limits, often leading to a decrease in performance (e.g., running slower). In line with this account, previous research confirmed that perception of effort during self-paced exercise was negatively related to exercise intensity, with higher levels of perceived effort being associated with decreased running or cycling pace (de Koning et al., 2011). Similarly, perception of effort was shown to strongly predict athletes' exercise tolerance in a time-to-exhaustion test, with higher levels of perceived effort being associated with earlier task disengagement (Marcora & Staiano, 2010). Interestingly, in their experiment, Marcora and Staiano (2010) showed that on a brief maximal-power test that was performed immediately upon task disengagement, athletes were still able to produce a much higher power output than what was needed to continue the time-to-exhaustion test. This indicates that reduced physiological capacity does not directly determine task disengagement. This finding is also supported by other studies concluding that – in addition to preceding activity of directly involved muscles – preceding activity of non-involved muscles as well as preceding mental activity may increase perception of effort and negatively affect subsequent endurance performance (Pageaux & Lepers, 2016).

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In sport science, most research on perception of effort has focused on endurance performance. However, there are good indications that increases in perception of effort also play a role in determining the effects of fatigue in other (more complex) motor tasks, such as soccer skill execution (e.g., shooting, passing, dribbling). Exerting force to shoot or pass a ball, dribbling at high speed, and exerting accurate control over one's movements, can all be regarded as "effortful actions". As such, on these actions, any increase in perceived effort beyond the amount that a player is able to or willing to invest, may lead to a change in behaviour (i.e., to reduce the amount of effort invested) and, hence, a reduction in performance. For example, players may decide to shoot or pass with less force, dribble at a lower speed, or pay less attention in accurately coordinating their movement. Empirical evidence to support this view comes from Smith, Marcora, and Coutts (2015), who showed that mental fatigue affected soccer players' perception of effort and decreased their intermittent running performance. Similarly, mental fatigue was also shown to decrease performance on more technical soccer tasks such as the LSPT and the Loughborough Soccer Shooting Test (LSST) (Smith et al., 2016).

According to the psychobiological model of endurance performance (Marcora, 2008; Marcora, Bosio, & de Morree, 2008; Marcora & Staiano, 2010; Marcora, Staiano, & Manning, 2009), the maximal amount of effort that individuals are willing to invest is determined by motivation. When motivation is higher, individuals are expected to tolerate higher levels of perceived effort and, consequently, to be better able to uphold their performance despite being fatigued. Following this line of thought, it can be argued that increasing an athletes' motivation may (partly) counteract performance decrements under fatigue. Indeed, previous research has already shown that high motivation increases endurance performance (e.g., Wilmore, 1968; for a review see McCormick, Meijen, & Marcora, 2015). Just as high motivation may explain why individuals' are able to sustain a certain workload for a longer amount of time, it may also explain why soccer players are able to keep up a certain speed of acting, or keep investing in accurate movement control when shooting or passing a ball, when they are fatigued. In line with this view, a recent study confirmed that in elite soccer players, high task motivation was related to smaller self-perceived performance decrements under fatigue across a range of different soccer skills (Barte, Nieuwenhuys, Geurts, & Kompier, 2017). To date, however, no study has directly investigated the effect of motivation on fatigue-induced performance decrements in soccer by experimentally manipulating players' motivation.

Against this background, the current study investigated the effect of motivation on soccer passing performance under fatigue. Using an experimental design, soccer players performed the Loughborough Soccer Passing Test (Ali et al., 2007) before and after a fatigue protocol. One group of players (i.e., motivation group) was externally motivated for their performance under fatigue, while another group of players (i.e., control group) was not. Motivation was hypothesized to increase effort tolerance and, as such, counteract fatigue-induced performance decrements. That is, fatigue was predicted to negatively influence performance in the control group, while performance decrements were expected to be smaller for players in the motivation group.

Methods

Sample

Sixty male amateur (i.e., competitive but not professional) soccer players participated in our experiment. Players were 24.3 ± 4.7 years, had 16.8 ± 6.3 years of experience in playing soccer, and trained at least twice a week. Before the experiment, block randomization using a computerized random number generator (not blinded) was used to randomly assign participants to either the motivation group (n= 30) or control group (n= 30). Participants' age and experience did not differ significantly between both groups. All participants signed an informed consent and received €15 for their participation. Ethical approval was granted by the Ethics Committee Faculty of Social Sciences of the Radboud University (EC2014-2411-264a).

Experimental design and setup

A 2 × 2 design was used, with fatigue as a within-subject factor (i.e., pretest/posttest) and motivation as a between-subject factor (i.e., motivation group/control group). On pretest and posttest, all players performed an extended version (i.e., five blocks) of the Loughborough Soccer Passing Test (LSPT). In between pretest and posttest, all players were subjected to a fatigue protocol. After the fatigue protocol but before commencing the posttest, motivation was experimentally increased for players in the motivation group, but not for players in the control group.

Fatigue protocol

After the pretest, all players performed a validated fatigue protocol (Little & Williams, 2007) to induce fatigue. This protocol consisted of 40 repetitions of a 15 meter sprint with 10.4 s rest between each sprint. As reported by Little and Williams (2007), the protocol results in high levels of blood lactate and high ratings of perceived exertion. In the current study, players' sprints were timed manually and players were verbally encouraged to ensure that they gave maximal effort and would become fatigued.

Motivation manipulation

After the fatigue protocol, players in the motivation group were motivated for their posttest by using a combination of (the prospect of) financial reward, competition, and verbal encouragement (McCormick et al., 2015). That is, in the one-minute break between the fatigue protocol and the posttest, players in the motivation group were promised an additional 15 euros if they would rank among the 30% best performers on the posttest. During the posttest (i.e., before each new LSPT-block), players were verbally encouraged and reminded of the financial reward. For players in the control group, motivation was not experimentally induced.

Loughborough soccer passing test

On the pretest and posttest, soccer-passing performance was tested with an extended version of the LSPT, which has previously been shown to be a reliable and valid test of soccer skill performance (Ali et al., 2007; Le Moal et al., 2014). Figure 1 shows an overview of the layout of the LSPT, which – in the current experiment – was conducted in an indoor sports hall. On an area of 12.0 × 9.5 m, four standard gymnasium benches were positioned around a central box (2.5 x 1.0 m) and surrounding passing area (4.0 x 2.5 m). In the middle of each bench, coloured targets (0.6 x 0.3 m) and an aluminium plate (0.1 x 0.15 m; indicating the middle of each target) were attached to indicate where participants had to pass the ball.

During both pretest and posttest, players performed five blocks of the LSPT, with 30 s rest in between each block. During each block, players were instructed to perform 16 passes as quickly and accurately as possible. They started with the ball in the central box and were instructed to dribble into the passing area to pass the ball against the first target (i.e., the blue target). The returning ball had to be taken back into the central box before moving to the next target. For subsequent passes, players turned into one direction (i.e., clockwise or counterclockwise) (Lyons, Al-Nakeeb, & Nevill, 2006; Rampinini et al., 2011, 2008). Right-footed players performed the passes in a clockwise order, while left-footed players went counterclockwise[1]. Time and errors during the LSPT were recorded to calculate players' performance on the LSPT.

Following LSPT guidelines (Ali et al., 2007), time penalties were awarded according to the following performance errors:

- 5 s for missing the bench completely or passing to the wrong bench;
- 3 s for missing the colored target area;
- 2 s for passing the ball from outside the passing area;
- 2 s for touching any cone;
- 3 s for handling the ball;
- 1 s for every second slower than 43 s to complete the test (i.e., time errors);
- 1 s bonus (i.e., deducted from the errors) for hitting the aluminum plate.

Before starting the pretest, players performed a 10-minute warm up, had one-minute of free practice and then performed

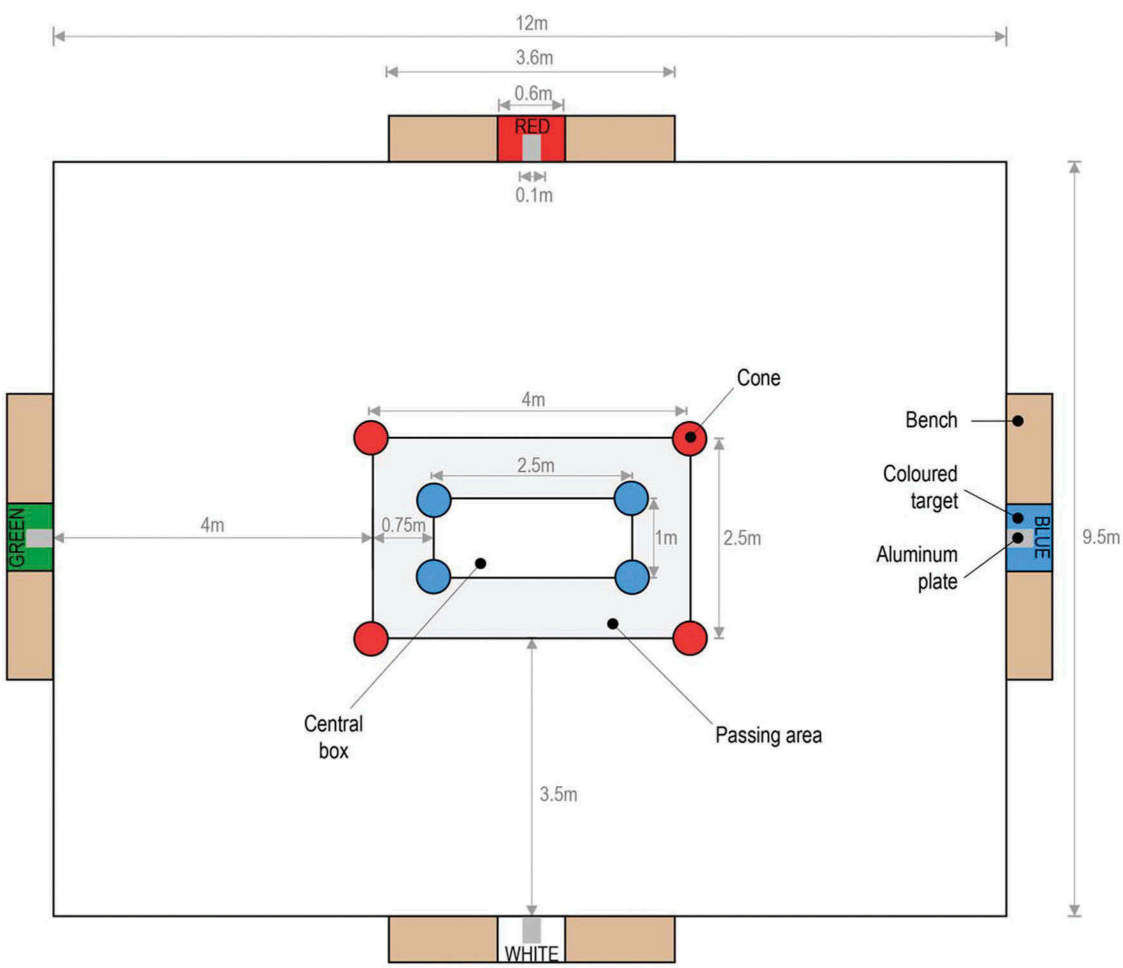

Figure 1. An overview of the LSPT set-up (with permission of the main author and publisher adopted from Ali et al. (2007). Reliability and validity of two tests of soccer skill. *Journal of Sports Sciences, 25*(13), 1461–1470, Taylor & Francis Ltd).

[1]Left-footed and right-footed players did not significantly differ in LSPT performance (*p*'s > .05).

five practice blocks (i.e., 5 × 16 passes) in order to familiarize with the LSPT and to prevent possible learning effects.

Measurements

Manipulation checks

To provide insight in the intensity of the fatigue protocol, session rate of perceived exertion (sRPE; Foster et al., 2001) was assessed directly after the protocol and heart rate was measured continuously during the protocol (Polar RS800CX, Polar Electro Oy, Kempele, Finland). To check whether the fatigue protocol and the manipulation of motivation reliably induced fatigue and task motivation, immediately before commencing the pretest and posttest, players reported their fatigue and their motivation in response to two single-item questions (i.e., "How fatigued do you feel at this moment?" and "How motivated are you to perform well on the next test?"). Answers were provided on a 10-point scale (1–10; not at all – very much). Several studies indicate that when study requirements allow little time to assess subjective feelings or experiences, single item questions are a quick and valid alternative to more elaborate questionnaires (Bowling, 2005; van Hooff, Geurts, Kompier, & Taris, 2007).

LSPT performance

Performance on the LSPT was scored manually using a stopwatch (performance time) and score sheet (performance errors) and was checked post-hoc based on video recordings. Performance time (in seconds) and time penalties for performance errors (in seconds) were summed, resulting in one LSPT total score (in seconds) for both the pretest and posttest. Lower scores indicate better performance. To provide more insight into speed and accuracy, in addition to the LSPT total score, LSPT performance time (including time errors) and LSPT performance errors (excluding time errors) were also calculated separately.

Perceived effort and physical effort

To indicate their perceived level of effort during the pretest and posttest, players were asked to provide a sRPE immediately following their pretest and posttest (Foster et al., 2001). In addition, to provide an objective indication of physical effort during both tests, heart rate was recorded continuously using a Polar RS800CX heart rate monitor (Polar Electro Oy, Kempele, Finland).

Analyses

To examine possible group differences in intensity of the fatigue protocol, independent t-tests were used to analyze the sRPE and average heart rate of the fatigue protocol. To check whether the fatigue protocol and the motivation manipulation indeed resulted in higher levels of fatigue and motivation, respectively, 2 × 2 (fatigue x group) mixed ANOVAs were used to analyze subjective ratings of fatigue and motivation. In these analyses, fatigue (pretest/posttest) was a within-subject factor and group (motivation/control) was a between-subject factor. Similarly, to provide insight in the effects of fatigue and motivation on soccer performance (LSPT total scores, LSPT performance time, LSPT performance errors) and perceived and physical effort during the test (sRPE; average heart rate), separate 2 × 2 (fatigue x group) mixed ANOVAs were performed. In these analyses, the fatigue x group interaction represents the effect of our motivation manipulation under fatigue. In case of significant interaction effects, paired t-tests and independent t-tests were conducted to further specify these effects.

Before conducting the statistical analyses, assumptions of normality, homoscedasticy, and linearity were tested. The assumptions were generally met, and only small violations of normality were found for sRPE on posttest, heart rate on posttest, and sRPE of the fatigue protocol. When assumptions were not met, data were additionally analysed using transformations and using non-parametric tests in order to verify robustness of the original outcomes. Performing these additional tests produced – in all cases – similar outcomes to the original analyses. Consequently, we considered our results to be robust and – for ease of interpretation – only the original analyses (performed as described above) are reported. Full test reports of the additional analyses are available from the first author upon request. For all analyses, effect sizes (η_p^2 for ANOVAs and Cohen's *d* for t-tests) were calculated. All analyses were performed in SPSS 23.0 and $p< .05$ was considered statistically significant.

Results

Manipulation checks

Fatigue

Players on average rated their exertion during the fatigue protocol between "really hard" and "maximal", showing no differences between groups (control group: 8.43 ± 1.76, motivation group: 8.53 ± 1.07; $t(58) = 0.27$, $p= .791$, $d= 0.07$). Similarly, average heart rate during the fatigue protocol was 173.45 and did not differ between groups (control group: 172.07 ± 7.84, motivation group: 175.09 ± 13.00; $t(42) = 0.95$, $p= .347$, $d= 0.29$). In line with these findings, the ANOVA on feelings of fatigue indicated that players reported significantly higher levels of fatigue before commencing the posttest as compared to the pretest ($F(1,58) = 495.74$, $p< .001$, $\eta_p^2 = .895$) (see Table 1). No difference between groups ($F(1,58) = 0.03$, $p= .869$, $\eta_p^2 = .000$) and no significant interaction effect ($F(1,58) = 2.10$, $p= .152$, $\eta_p^2 = .035$) was observed. Taken together, these findings indicate that the fatigue protocol was highly demanding and – for both groups – resulted in higher fatigue levels on the posttest compared to the pretest.

Motivation

The ANOVA on players' motivation ratings showed a significant main effect of fatigue ($F(1,58) = 4.87$, $p= .031$, $\eta_p^2 = .077$), a significant main effect of group ($F(1,58) = 11.55$, $p= .001$, $\eta_p^2 = .166$), and a significant interaction effect ($F(1,58) = 12.03$, $p< .001$, $\eta_p^2 = .172$) (see Table 1). Pairwise comparisons on the interaction effect showed that motivation decreased from pretest to posttest for players in the control group ($t(29) = 3.97$, $p< .001$, $d= -0.72$), but not for players the motivation group ($t(29) = 0.90$, $p= .375$, $d= 0.16$). In line with

Table 1. Descriptive results (means and standard deviations) for all dependent variables.

	Motivation Group		Control Group		Fatigue x Group Interaction	
	pretest	posttest	pretest	posttest	*p*-value	η_p^2
Manipulation checks						
Fatigue (1–10)	4.00 (1.58)	8.07 (1.14)	3.67 (1.65)	8.30 (1.12)	.152[c]	.035
Motivation (1–10)	8.43 (1.07)	8.63 (1.27)[b]	8.07 (1.20)[a]	7.17 (1.29)[a, b]	< .001	.172
LSPT Performance						
LSPT total score (seconds)	307.01 (64.22)[a]	292.99 (64.17)[a]	287.06 (64.58)[a]	302.21 (65.44)[a]	< .001	.192
Performance time (seconds)	273.21 (60.51)[b]	273.79 (57.47)[b]	260.36 (51.49)[a, b]	275.84 (60.33)[a, b]	.006	.123
Performance errors (seconds)	33.80 (36.51)[a]	19.20 (36.94)[a]	26.70 (33.43)	26.37 (26.35)	.026	.083
Perceived and physical effort						
sRPE (0–10)	4.40 (1.48)	5.80 (1.63)	4.23 (1.61)	5.23 (1.79)	.280[c]	.020
Average heart rate (bpm)	158.93 (20.46)	167.00 (17.09)	149.04 (15.29)	153.49 (13.75)	.195[c]	.040

[a]Significant difference between pretest and posttest for the motivation or control group.
[b]Significant difference between the groups on pretest or posttest.
[c]Fatigue x Group interaction did not reach significance and no follow-up tests were performed.

these effects, motivation on the posttest was higher for the motivation group compared to the control group ($t(58) = 4.44$, $p < .001$, $d = 1.15$), while on the pretest no difference between the groups was found ($t(58) = 1.25$, $p = .217$, $d = 0.32$). Taken together, these findings indicate that our manipulation of motivation effectively increased motivation in the motivation group.

LSPT performance

Table 1 shows the LSPT scores for both groups. The ANOVA on players' LSPT total scores showed no significant main effect of fatigue ($F(1,58) = 0.02$, $p = .886$, $\eta_p^2 = .000$), no significant main effect of group ($F(1,58) = 0.11$, $p = .739$, $\eta_p^2 = .002$), but did show a significant interaction effect ($F(1,58) = 13.82$, $p < .001$, $\eta_p^2 = .192$) (see Table 1). Pairwise comparisons on the interaction effect showed that performance decreased (i.e., LSPT score increased) from pretest to posttest for players in the control group ($t(29) = 2.40$, $p = .023$, $d = 0.24$), while performance increased (i.e., LSPT score decreased) for players in the motivation group ($t(29) = 3.01$, $p = .005$, $d = -0.22$). No differences in performance were found between the groups on pretest ($t(58) = 1.23$, $p = .224$, $d = 0.32$) and posttest ($t(58) = 0.55$, $p = .584$, $d = -0.14$). Taken together, these findings indicate that motivation effectively counteracted performance decrements under fatigue.

Further specifying this effect, the ANOVA on LSPT performance time showed a significant main effect of fatigue ($F(1,58) = 9.43$, $p = .003$, $\eta_p^2 = .140$), no significant main effect of group ($F(1,58) = 0.14$, $p = .713$, $\eta_p^2 = .002$), and a significant interaction effect ($F(1,58) = 8.12$, $p = .006$, $\eta_p^2 = .123$) (see Table 1). Pairwise comparisons on the interaction effect showed that performance time increased from pretest to posttest for players in the control group ($t(29) = 3.90$, $p < .001$, $d = 0.28$), but not for players in the motivation group ($t(29) = 0.17$, $p = .865$, $d = 0.01$). No differences in performance time were found between the groups on the pretest ($t(58) = .89$, $p = .379$, $d = 0.23$) and posttest ($t(58) = 0.14$ $p = .893$, $d = -0.03$). The ANOVA on LSPT performance errors showed a significant main effect of fatigue ($F(1,58) = 5.73$, $p = .020$, $\eta_p^2 = .090$), no significant main effect of group ($F(1,58) = 0.00$, $p = .997$, $\eta_p^2 = .000$), and a significant interaction effect ($F(1,58) = 5.23$, $p = .026$, $\eta_p^2 = .083$) (see Table 1). Pairwise comparisons on the interaction effect showed that performance errors decreased from pretest to posttest for players in the motivation group ($t(29) = 3.37$, $p = .002$, $d = -0.40$), but not for players in the control group ($t(29) = 0.07$, $p = .941$, $d = -0.01$). No differences in performance errors were found between the groups on the pretest ($t(58) = 0.79$, $p = .435$, $d = 0.20$) and posttest ($t(58) = .87$, $p = .391$, $d = -0.22$). Taken together, these findings indicate that despite high fatigue, players in the motivation group maintained their performance speed and improved their accuracy, while players in the control group maintained their accuracy but decreased their performance speed.

Perceived effort and physical effort

The ANOVA on perception of effort (i.e., sRPE) showed a significant main effect of fatigue ($F(1,58) = 42.79$, $p < .001$, $\eta_p^2 = .424$), no significant main effect of group ($F(1,58) = 0.94$, $p = .338$, $\eta_p^2 = .016$), and no significant interaction effect ($F(1,58) = 1.19$, $p = .280$, $\eta_p^2 = .020$) (see Table 1). The ANOVA on heart rates showed a significant main effect of fatigue ($F(1,42) = 20.71$, $p < .001$, $\eta_p^2 = .330$), a significant main effect of group ($F(1,42) = 5.84$, $p = .020$, $\eta_p^2 = .122$), and no significant interaction effect ($F(1,42) = 1.74$, $p = .195$, $\eta_p^2 = .040$) (see Table 1)[2]. On the posttest, perceived effort (sRPE) and physical effort (heart rate) were higher than on the pretest.

Discussion

The current study investigated the effects of motivation on fatigue-induced performance decrements in soccer. As hypothesized, findings indicated that players in the motivation group were able to counteract performance decrements under fatigue. These findings support the idea that motivation – and not only physiological factors – plays a crucial role in determining performance decrements under fatigue.

In line with previous experiments (Impellizzeri et al., 2008; Lyons et al., 2006; Rampinini et al., 2008), the control group showed decrements in soccer passing performance after fatiguing high-intensity exercise. More specifically, under fatigue, players in the control group reported to be less motivated

[2]Due to technical malfunctioning, heart rate data was only available for 20 participants in the motivation group and 24 participants in the control group. Players with and without missing data on heart rate did not differ in age, experience, or any of the outcome measures (p's > .05).

and – whilst maintaining their accuracy (i.e., no increase in performance errors) – significantly reduced their performance speed. Similar to what is seen in endurance exercise, we argue that high levels of fatigue caused players in the control group to be less willing to invest the required amount of effort to keep up their speed of acting (de Koning et al., 2011; Marcora & Staiano, 2010), leading them to perform at a slower pace and, potentially, allowing them concentrate their effort on maintaining accuracy. Comparable strategy changes following fatigue were also shown in previous studies (Aune, Ingvaldsen, & Ettema, 2008; Boksem, Meijman, & Lorist, 2006; Nibbeling, Oudejans, Canal-Bruland, van der Wurff, & Daanen, 2013), and may occur to keep performance at an acceptable level while minimizing effort investment.

While fatigue had a negative effect on performance for players in the control group, following our manipulation of motivation, players in the motivation group were able to increase their performance despite being fatigued. This finding convincingly shows that motivation can counteract fatigue-induced decrements in soccer passing performance. Unlike players in the control group, players in the motivation group were able to maintain high levels of motivation and – despite feeling equally fatigued as players in the control group – maintained their speed of acting. In line with previous research (Marcora & Staiano, 2010), this finding suggests that it was not a reduction in physical capacity that caused players in the control group to slow down when they were fatigued but rather perceived effort, which may have exceeded the amount of effort that they were willing to invest. Players in the motivation group were more motivated and, hence, likely to tolerate higher levels of effort. As a consequence, players in this group did not slow down when fatigue increased their perception of effort and they maintained their speed of acting. In addition, high motivation may have caused them to invest additional resources in accurately coordinating their movement, resulting in a reduction in performance errors and better overall performance with fatigue. Overall, and in line with the psychobiological model of endurance performance (Marcora, 2008; Marcora et al., 2008; Marcora & Staiano, 2010; Marcora et al., 2009), the results of the current study clearly demonstrate that fatigue-induced decrements in soccer passing performance can be overridden, with motivation as the underlying mechanism.

From a psychological perspective, it is interesting to note that although motivation did influence players' performance, it had no significant impact on their perception of effort (i.e., sRPE). That is, perceived effort increased following fatigue but this increase did not differ between the motivation and control group. A possible explanation for this may be that the adjustments in task behavior that occurred from pretest to posttest (slowing down in the control group vs. maintaining speed of acting in the motivation group) may have been too small to be reflected in significant differences in sRPE ratings. Another potential explanation for this finding is that high levels of motivation may have lowered players' perception of effort (Kurzban, Duckworth, Kable, & Myers, 2013), causing players in the motivation group to show a comparable increase in sRPE as the control group despite doing more work. If so, this would corroborate previous work showing that psychological factors such as music, social influence, motivational self-talk, self-efficacy, placebo, and reward (Blanchfield, Hardy, De Morree, Staiano, & Marcora, 2014; Hardy, Hall, & Prestholdt, 1986; Hopstaken, van der Linden, Bakker, Kompier, & Leung, 2016; Karageorghis & Priest, 2012; Piedimonte, Benedetti, & Carlino, 2015; Robertson & Noble, 1997) can effectively reduce feelings of effort and fatigue.

From a physiological perspective, the current study showed that players' actual biological limits were not yet reached when performance decreased. That is, while the players performed a highly-demanding repeated sprint protocol that is associated with severe physiological changes (e.g., increase in muscle lactate, decrease in adenosine triphosphate [ATP], decrease in phosphocreatine [PCr]) (Little & Williams, 2007; Spencer, Bishop, Dawson, & Goodman, 2005), the impact of our motivation manipulation on performance shows that players were still able to willfully regulate their behavioral responses to these changes (e.g., upholding versus lowering speed of acting). Although in the current study this was not immediately reflected in players' heart rate, by choosing not to give in to increased feelings of fatigue, individuals arguably demand more of their bodies; metabolic processes continue and will develop towards their biological limits. Generally, when continued, this may result in biological failure or – in the long run – in overuse and overtraining (Schiphof-Godart & Hettinga, 2017). In this respect, future research is needed to investigate the limits of this counteracting effect of motivation and investigate possible negative consequences for recovery and future performance.

In addressing limitations of the current study, it is important to acknowledge that whereas the LSPT tests the execution of an important soccer skill (Ali et al., 2007; Le Moal et al., 2014), actual soccer performance involves whole a range of skills (e.g., shooting, dribbling) and, apart from skill execution, also involves other performance aspects, such as tactical decision making. In this respect, more research is needed to extend the current findings to other skills and performance aspects. Similarly, while distinguishing between speed and accuracy on the LSPT does provide some information about which motor processes may be affected by fatigue (and motivation), more research is required to pinpoint underlying mechanisms. In doing so, future studies are advised to not only focus on physiological processes that determine power output or rate of force development, but also consider cognitive functions that are related to decision making and accurate movement coordination (Brisswalter, Collardeau, & Arcelin, 2002; Chang, Labban, Gapin, & Etnier, 2012; Lambourne & Tomporowski, 2010; McMorris & Hale, 2012). Furthermore, athletes' performance under fatigue may be influenced by the level of expertise. In the current study amateur soccer players were selected. However, it may be that players with higher levels of expertise (i.e., professional soccer players) have developed more effective strategies (e.g., use more efficient techniques or better prioritize their actions) to uphold performance under fatigue (Aune et al., 2008). Another point to consider is that, in the current study, a combination of different motivational strategies was used to maximize players' motivation levels (i.e., prospect of financial reward, competition, and verbal encouragement; McCormick et al., 2015). Therefore, our conclusions are limited to the intensity of motivation and future work is needed to examine independent effects of these strategies and to differentiate between the impact of different types of motivation (e.g., intrinsic and extrinsic motivation, Ryan & Deci, 2000). Thereby, it is important to note that motivational strategies that manipulate players' extrinsic motivation (e.g., financial reward) may undermine intrinsic motivation (Deci, Koestner, & Ryan, 1999) and that repeated use of these strategies might result in increasingly smaller effects over time. Finally, although participants in the current study were already highly motivated, the effects of motivational strategies may be smaller when motivation levels are even higher, such as during competitive matches.

In conclusion, the results of the current study show that motivation plays a crucial role in performance under fatigue, as fatigue-induced decrements in soccer passing performance were counteracted by high motivation. Our findings support the view that performance decrements under fatigue can be seen as a form of task disengagement rather than limited physiological capacity and – from a practical perspective – clear the path for motivational strategies that help players uphold crucial aspects of their performance when it counts the most. Future research should explore the differences between different types of motivation (e.g., applying self-determination theory), the limits of this counteracting effect of motivation, and the possible negative consequences for recovery and future performance.

Disclosure of interest

The authors report no conflicts of interest

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