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Effects of different post-match recovery interventions on subsequent athlete hormonal state and game performance

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ABSTRACT

We tested the effects of different post-match recovery interventions on the subsequent hormonal responses to a physical stress-test and game performance in professional rugby union players. On four occasions, participants (n = 12) completed a video session (1 h each) with accompanying coach feedback the day after a rugby union match. The interventions showed either video footage of player mistakes with negative coach feedback (NCF1) or player successes with positive feedback (PCF1). Both approaches were repeated (NCF2 and PCF2). In the following week, participants were assessed for their free testosterone (T) and cortisol (C) responses to a physical stress-test, pre-game T and game-ranked performance. The PFC1 and PCF2 approaches were both associated with significantly ($p<0.01$) greater free T (36% to 42%) responses to the stress-test when compared to NCF1 and NCF2 (16% to −3%), respectively. The PCF interventions were also associated with higher (28% to 51%) pre-game T concentrations and superior game-ranked performances than the NCF approaches ($p<0.01$). In conclusion, the post-game presentation of specific video footage combined with different coach feedbacks appeared to influence the free hormonal state of rugby players and game performance several days later. Therefore, within the sporting context, future behaviour and performance might be modified through the use of simple psychological strategies. These data are applicable to generalised human stress responses and their modifiability by prior exposure to a stressor.

1. Introduction

For elite athletes, the recovery process plays an important role in maximising performance, ensuring consistent performance, and preventing overtraining and fatigue. Recovery from competition generally often involves light physical activity combined with one or more passive interventions (e.g. compression garments, cold water therapy, massage) [1,2]. Maximising athlete recovery is particularly important in combative sports (e.g. rugby union, rugby league), which have been shown to induce muscle damage, depress neuromuscular performance and/or alter hormonal function for several days [3,4]. However, little specific data on utilising psychological recovery approaches is present in the literature.

Traditionally, the training role of testosterone (T) has been presented as being anabolic and anti-catabolic to protein synthesis and degradation, respectively [5]. However, aspects of this role have been recently challenged [6–8]. Literature now indicates that T has more complex training roles, outside of direct hypertrophy, in regulating adaptive physiology and physical performance itself [9,10]. These include rapid bioavailability and effects on the central nervous system, such that human behaviour and thereafter motivation and aggression towards physical performance might be modified through acute perturbations in T [9,11]. From this perspective, T could provide an important mediator of athlete recovery.

Testosterone is also very important as a stress biomarker and the T responses to a challenge can provide information on dominance, as seen in animals in a social hierarchy [12]. Conceivably this could be likened to the sporting environment. For example, winning in competition is often accompanied by elevated T concentrations relative to losing [13–15] and we recently demonstrated (accepted manuscript) an association between the T responses to a mid-week exercise stressor and subsequent winning (being elevated) and losing (no change) in elite rugby league players. Thus, the monitoring of T responsiveness to a physical 'stress-test' could provide additional information on competitive readiness and future resilience and, potentially, a marker of recovery intervention success.

The presentation of video footage offers one practical method for acutely modifying T concentrations [16–18]. This approach could allow an examination of the linkage between changes in free T and behaviour (e.g. aggression, motivation, willingness to perform) [11,19,20],

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and their subsequent impact on athlete performance. Indeed, we recently found that the watching of short video clips with different contents (e.g. aggressive, motivational, erotic) can increase T levels in elite male athletes and is subsequently associated with improved voluntary squat performance [21]. It would be informative to address the efficacy of using video footage as a psychological recovery tool in sport, particularly around a competitive stressor, and the possibility of longer time effects (i.e. days).

A pre-match talk by a coach is commonly employed to motivate an athlete or team to compete [22,23], but less is known about the influence of post-match feedback when athletes are perhaps more receptive to coach feedback, with performances fresh in their mind. Both T administration and positive priming can enhance one's motivation for action [24]. As a recovery strategy, combining direct positive priming (i.e. coach feedback) with the watching of a motivational video clip might elicit a transient T response, which in turn influences behaviour and performance. No research has examined the efficacy of combining coach feedback and video clips in the post-game environment as a recovery intervention.

We examined the effects of four recovery interventions, each administered the day after a professional rugby union match, on several measures during the following week; the hormonal responses to a physical test (stressor), pre-game T concentrations and game-ranked performance. The interventions involved the watching of video footage around a game showing player mistakes with negative coach feedback (NCF1 and NCF2) and the watching of video footage of correct player performance with positive coach feedback (PCF1 and PCF2). We hypothesised that the PCF interventions would produce greater T responses, higher pre-game T and better performance outcomes than the NCF approaches.

2. Materials and methods

2.1. Participants

Twelve professional rugby players (six forwards and six backs) were recruited for this study with a mean age, body mass and height of 20.0 ± 0.7 years, 95.7 ± 9.5 kg and 1.85 ± 0.06 m, respectively. Participants were playing at an academy or senior level and all were considered healthy and injury-free at the time of this study. Pre-screening indicated that participants were free from any medical conditions, and not taking any substances, likely to influence the measured outcomes from this study. Each player had a full explanation of the protocols and signed informed consent before the study commenced. The experimental procedures were performed with university ethics approval and in compliance with national legislation and The Code of Ethical Principles for Medical Research involving Human Subjects of the World Medical Association (Declaration of Helsinki).

2.2. Study design

This experiment was conducted over a 4-week period during the competitive season. Two interventions were individually tested after two rugby union games (NCF1 and PCF1) and then retested after a further two games (NCF2 and PCF2). In the week following each intervention, participants were subsequently assessed for their free T and C responses to a physical stress-test, pre-game T concentrations and match-day performance. To improve compliance and the internal validity of the study findings, the procedures were implemented within, or as part of, the normal training and competition schedules of the team recruited.

2.3. Post-game recovery interventions

The four recovery interventions were implemented after four competitive games, at least six to seven days apart. Participants reported to the training facility 24 h after each game (1400–1500 h), where they were assigned to a different intervention. In the first two games, two interventions (1 h in duration) were presented to six players (group one and two) in a randomised fashion using a cross-over design. These were:

1. NCF1: Group one players sitting in front of individual computer screens (Dell Inspiron with 1024 × 768 pixel screen resolution) watching a one hour video in which the players' skill and performance mistakes were shown with the coach present during the viewing and providing scripted commentary. The video footage was selected by the coaching staff, based on the specific requirements of this study, and formatted by the team analyst to allow each video clip to be played on a laptop computer. Whilst the players watched these clips, the coach criticised the action of each player in a very simple manner. Coach script consisted of choosing one of several key phrases — for example “you did that poorly”, “why couldn't you do that right”.
2. PCF1: Group two players watching a one hour of video (as above), but the focus was on correct skill execution and performance by the player and only praise was given with positive coach feedback. Coach script consisted of choosing one of several key phrases — for example “you performed that well”, “well done that's how you do it”. The two groups crossed over on the subsequent week to complete the other intervention.

Both interventions were repeated (PCF2 and NCF2) after the third and fourth games, respectively, but the two groups were combined during each intervention. Randomisation was not possible within the training schedules of the team. For consistency, the same coaches presented to each group on the four testing occasions. Each player maintained their normal weekly training, which generally involved strength and conditioning, specific skill training sessions and recovery work. As this was an in-season professional rugby environment, there were practicalities of normal training that had to be adhered to. However, the volume and intensity of training were kept relatively consistent across the monitored weeks to ensure that participants were exposed to the same overall stressors. Participants were assessed after a consistent consumption of breakfast and fluid (between 0800 and 0830 h), and at least 7 h of sleep from the previous night and alcohol consumption was avoided. Breakfast generally comprised cereals, yoghurt, toast, eggs, fruit juice and/or water. No food was taken 1.5 h before the first saliva sample to reduce the effect of food intake on salivary hormone concentrations [25].

2.4. Stress-test assessments

Three days following each intervention a short physical stress-test (20 min in duration) was performed to assess hormonal reactivity to a consistent exercise stimulus. Testing was conducted at the same time of day (1100 h) with testing scheduled as part of a normal training workout. The test involved a series of resistance exercises (i.e. three sets of power cleans, three sets of back squats and three sets of bench press) that were each performed for five repetitions using a relative load of 40%, 60% and 70% of individual one repetition maximum. Rest periods of 1 and 3 min were used between sets and exercises, respectively. These protocols were deemed sufficient to elicit a stress response. The loading protocols were kept consistent for the duration of this study. Participants were well accustomed to resistance exercise as part of their normal training and testing procedures. A saliva sample was collected 5 min before the stress test and 5 min after the completion of this test. These samples were assayed for T and C concentrations.

2.5. Game-day assessments

The rugby union matches were scheduled six to seven days after each recovery intervention. The matches were all played at different venues on a home (n = 3, 2 wins and 1 loss) and away (n = 1, draw) basis, and the games were conducted at a similar time of day (1430–1500 h start time), which helped to control for diurnal variation in hormones and performance. On game day, participants arrived at the venue (<2 h before kick-off) to complete their pre-game mental and physical preparation. A saliva sample was taken from players approximately 40 min before kick-off and subsequently tested for T concentrations. The games themselves lasted 80 min (two periods of 40 min) and participants had at least 75% (60 min) of playing time in each. Player performance was assessed by two coaches using a simple ranking scale across all of the games played (where 1 = best performance to 4 = worst performance), based on several coach-identified skills (e.g. for a forward lineout wins and ruck clears). These ratings were averaged for analysis. These statistics are collected routinely by this team to evaluate and manage players.

2.6. Free hormone assessment

Saliva was collected on each occasion described above by passive drool into sterile containers, approximately 2 ml over a timed collection period of 2 min. The samples were stored at −30 °C until assay. After thawing and centrifugation (2000 rpm × 10 min), the saliva samples were analysed in duplicate for T and C concentrations using commercial kits (Salimetrics LLC, USA) and the manufacturers' guidelines. The minimum detection limit for the T assay was 6.1 pg/ml with inter-assay coefficients of variation (CV) of <10%. The C assay had a detection limit of 0.12 ng/ml with inter-assay CV of <7%.

2.7. Statistical analyses

The sample size was determined by athlete availability within a professional sports team, but similar to that used in previous studies on elite athletes [4,11,15,21]. Based on the number of participants (n = 12), alpha level (0.05) and effect size (0.80) for the pooled stress-test data (PCF versus NCF), the study power was 0.705. The relative (%) changes in free T and C concentrations with the stress-test (from pre to post) were assessed using paired t-tests, in line with previous research [21,26,27]. The relative hormonal changes were compared across each treatment using a one-way analysis of variance (ANOVA) with repeated measures. A one-way ANOVA with repeated measures was also used to compare pre-game T concentrations. Where appropriate, post hoc testing was performed using paired t-tests and the Bonferroni correction procedure. The game rankings were compared across treatments using the Friedman test for non-parametric data and post hoc testing was performed using the Wilcoxon Signed-Rank test with the Bonferroni procedure. A corrected alpha value of $p < 0.008$ was derived (i.e. 0.05/6) for the Bonferroni methods. The significance level for all other tests was set at $p < 0.05$.

3. Results

The T responses (% change) to the stress-test were significantly elevated irrespective of the treatment (Table 1). When the T responses were compared across treatments, a significant effect was identified ($F_{3,33} = 29.5$, $p < 0.001$). Both PCF approaches produced significantly greater T responses (36% to 42%) than the NCF interventions, with NCF1 (16%) also being significantly higher than NCF2 (−3%). The individual range for the T responses was; PCF1 (24% to 61%), PCF2 (19% to 103%), NCF1 (10% to 31%) and NCF2 (−18% to 3%).

Significant elevations in the stress-test responses of free C were noted after the PCF1, PCF2 and NCF1 interventions (Table 2). When comparisons were made across all treatments, a significant effect was identified ($F_{3,33} = 6.27$, $p = 0.001$) with the C responses to NCF1 (26%) being significantly greater than that observed for the PCF2 (13%) and NCF2 (7%) approaches. The individual range for the C responses were as follows; PCF1 (5% to 29%), PCF2 (5% to 28%), NCF1 (10% to 47%) and NCF2 (−4% to 31%).

Analysis of the recovery interventions revealed a significant treatment effect on pre-game free T concentrations ($F_{3,33} = 22.4$, $p < 0.001$) and game-ranked performance, $x^2(3) = 30$, $p < 0.001$. The PCF approaches both promoted significantly higher T levels on game day than NCF1 and NCF2 (Fig. 1). In terms of game rankings (Fig. 2), the PCF1 and PCF2 treatments also produced significantly better performance outcomes than NCF1 and NCF2.

Table 1
Stress-test changes in salivary testosterone concentrations following the different recovery interventions (Mean ± SD).

		PCF1	NCF1	PCF2	NCF2
Pre testosterone (pg/ml)	M	131.6	121.4	138.5	120.1
	SD	32.8	23.4	32.6	17.3
Post testosterone (pg/ml)	M	178.8	140.8	193.3	117.0
	SD	42.9	29.8	39.1	20.0
% change (pre to post)	M	36.4*,α	15.7*,ε	42.2*,α	−2.9
	SD	9.9	6.3	22.0	6.0

PCF = positive coach feedback, NCF = negative coach feedback.
* Significantly different from baseline $p < 0.001$.
α Significantly different from NCF1 and NCF2 $p < 0.01$.
ε Significantly different from NCF2 $p < 0.01$.

4. Discussion

The use of relatively simple "psychological" recovery interventions one day after a competitive rugby union match, with specific relevance to that match, had a significant effect on several measures over the following week. These included the free hormonal responses to a physical stress-test, the hormonal state of participants prior to the next competitive match, as well as a simple ranking of subsequent game performance.

Exposure to different post-match psychological environments appeared to influence the free hormonal responses to a physical stressor performed some days later. The PCF interventions were both associated with greater free T (36–42%) stress-test responses than the NCF approaches (16% to −3%). These data suggest that the physiological responses of elite sportspeople engaged in combat sports, similar to other animal species [28,29], exhibit a degree of plasticity that can be influenced by prior exposure to stressful events or perceptions of those events. Our results also support the reciprocal model [19], which states that free hormones not only influence behaviour, but are in turn affected by behaviour. Within the group results, we also noted large individual variation in the T and C responses, even within a relatively homogenous population. Large subject variation has been previously demonstrated following different physiological [30] and psychological stressors [16,31]. These variances may be explained by individual differences that exist on a number of levels (e.g. hormonal, life experiences, psychosocial, personality) [31,32].

Table 2
Stress-test changes in salivary cortisol concentrations following the different recovery interventions (Mean ± SD).

		PCF1	NCF1	PCF2	NCF2
Pre cortisol (ng/ml)	M	2.18	2.58	2.50	2.65
	SD	0.47	0.48	0.40	0.36
Post cortisol (ng/ml)	M	2.50	3.25	2.79	2.82
	SD	0.53	0.64	0.34	0.31
% change (pre to post)	M	14.6*	26.1*,α	12.6*	7.2
	SD	7.1	11.4	7.2	11.6

PCF = positive coach feedback, NCF = negative coach feedback.
* Significantly different from baseline $p < 0.001$.
α Significantly different from PCF2 $p < 0.05$ and NCF2 $p < 0.01$.

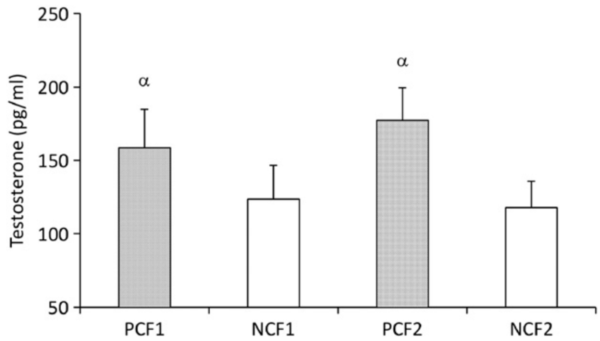

Fig. 1. Pre-match salivary testosterone concentrations following the different recovery interventions (Mean ± SD). PCF = positive coach feedback, NCF = negative coach feedback. $^{\alpha}$Significantly different from NCF1 and NCF2 $p < 0.01$.

We do recognise that the study outcomes could be psychologically driven resulting in the hormones simply reflecting these changes as biomarkers. This in itself would be useful as it suggests that hormones can track the success or failure of a psychological intervention, similar to that reported previously in the evaluation of different stress management techniques in women with early-stage breast cancer [33] and in human immunodeficiency virus-seropositive men [34]. Alternatively, the hormones themselves could be adding to the behavioural outcomes. We cannot of course determine a causal link from this work, but it remains speculatively interesting and an area for further investigation.

Temporary increases in free T concentrations in the initial phase of stress can result from several potential pathways including; increases in the bioavailable T pool due to binding protein changes [35], or from increased sensitivity of the testes to luteinizing hormone, especially when luteinizing hormone is relatively stable [12]. In humans, winning in competition is often associated with elevated T relative to losing [13–15], and we recently found (accepted manuscript) that the T responses to a mid-week workout was associated with winning (being elevated) and losing (no change) in rugby league games three to four days later. Although speculative, a greater free T response to a physical challenge might reflect a hormonal state conducive to future dominance and related behaviours [36,37], which would seem to be beneficial for aggressive and combative sports such as rugby.

The PCF approaches were also associated with higher pre-game T concentrations (28% to 51%) and obtained better performance outcomes than the NCF interventions. Again, associations between T levels and the expression of dominant behaviours would seem to be one factor important for successful performance in rugby union. The current findings also suggest that the behavioural T effects might persist for several days, although the actual changes occurring might be transient in nature. As supporting evidence, research on stock brokers indicates that morning measures of T are related to subsequent behaviour and performance (financial) several hours, at least, later [38,39]. Also, lab-based studies have demonstrated that acute changes in T can influence one's decision to compete again in future contests [27,36,37,40–42]. If changes in T concentrations can influence the cognitive ability of an athlete to deal with defeat or victory, then the structure of this cognition might endure in one's memory long after T levels have returned to baseline [43].

The presentation of videos with different contents has been shown to induce acute hormonal changes [16,18,21,26] and subsequent voluntary performance [21]. Athlete data does highlight the situational importance of the video clip, in that the footage shown does not produce a change without relevant context to the study population [21,26]. For example, we found the largest free T response to a video clip that was highly aggressive and this might be explained by the video content (big rugby hits), relative to the study population (rugby players) tested [21]. However, in reasonably elite gym goers (unpublished data) the same video stimulus had no effect on free T. Our previous work also suggests that the T association to performance might be more apparent in elite than in sub-elite athletes [9] and in particular with their leading physical attributes (e.g. association with speed performance in very fast athletes or strength performance in very strong athletes) [11].

Given the current design we can only speculate as to the individual or combined effect of each stimulus (video clip or coach feedback) on the study outcomes. Furthermore, we did not measure the acute hormonal milieu associated with the post-game application of each recovery strategy. Therefore, determining the relative contribution of watching video footage and accompanying coach feedback on the acute and delayed hormonal responses, as seen in this study, are areas for further investigation in psychobiology. Another study limitation is the lack of randomisation of the recovery interventions following the last two games. However, certain practicalities and constraints have to be adhered to when undertaking research on elite athletes and within a professional sporting environment.

Two important features have emerged from this work; first, the perspective that T is not simply a classic anabolic or hypertrophy factor; a concept that has been recently challenged [6–8]; second, any such effects are highly situational dependent and maybe expressed differently in elite as opposed to non-elite athletes. We have also identified the post-game environment as an opportunity in which the free hormonal state and athlete performance can be modulated, for up to one week, by the use of relatively simple psychological strategies. Our results open up interesting avenues to assess the physiological impact of motivational techniques in sports, either as a recovery or performance enhancement tool. In a broader stress physiology scenario, our data also suggest that in humans relatively small, and transient, modifications in perception of a performance can have quite marked effects on subsequent stress responses and physical performance a number of days later.

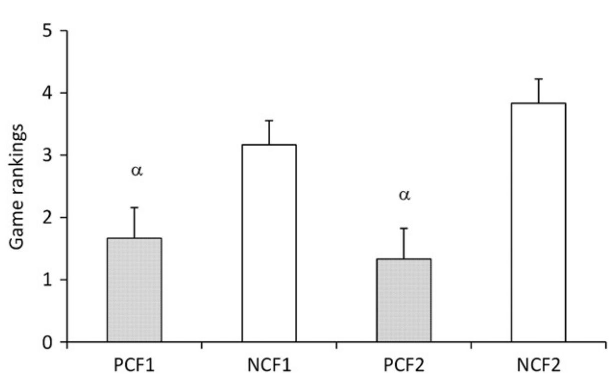

Fig. 2. Game-ranked performance following the different recovery interventions (Mean ± SD). PCF = positive coach feedback, NCF = negative coach feedback. $^{\alpha}$Significantly different from NCF1 and NCF2 $p = 0.002$.

5. Conclusions

The post-game presentation of a specific video footage combined with different coach feedbacks appeared to influence the free hormonal state of elite rugby players and game performance several days later. Specifically, PCF1 and PCF2 were associated with greater T stress-test responses, higher pre-game T and superior game-ranked performances than NCF1 and NCF2. Thus, future behaviour and performance might be modified through the use of simple psychological strategies within the sporting context. These data are applicable to generalised human stress responses and their modifiability by prior exposure to a stressor.

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