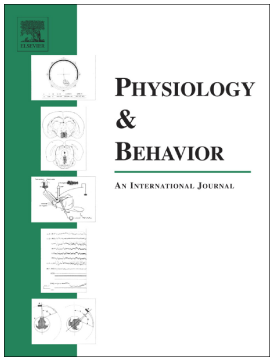

Testosterone and cortisol responses in male soccer players: The effect of home and away venues

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Testosterone and cortisol responses in male soccer players: the effect of home and away venues

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Testosterone and cortisol responses in male soccer players: the effect of home and away venues

Abstract

The present studies examined the influence of playing venue on psychobiological responses in male soccer players. Many studies have demonstrated the existence of a home advantage, wherein teams perform better at home than away. A recent focus has attempted to explain this advantage from a psychobiological perspective, with studies showing hormonal differences with regard to venue, game outcome, dominance and perceived stress. Two studies investigated testosterone and cortisol responses in relation to home and away venues. In an initial study of 18 male elite Premier League academy soccer players (age, 17.47, SD, 64), salivary cortisol levels were monitored in two competitive matches, both at home and away. Higher post-game cortisol levels were observed at home (p=.002), with the team winning all its games. In a second study involving a 12 semi-professional group of players (age, 23.17, SD, 3.8), the same post-game cortisol findings at home were replicated (p=.001), with this team losing all its games. No effects were observed for testosterone in either study. The results extend earlier research findings on the complex relationship which surrounds the psychobiological impact on the home advantage. The findings suggest that higher levels of stress are experienced by home players in their home matches.

Keywords: testosterone, cortisol, playing venue, soccer

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1. Introduction

The phenomenon of the 'home advantage' is well-established within many sports in that teams typically perform better when playing at their home venue than at an away venue. Teams score more goals and win more games at home [1-6]; in fact, it has been estimated that in soccer the home advantage may be worth approximately 0.5 goals per game to the home team [7]. Various explanations have been proposed to account for the home advantage; these include the support from the home crowd, familiarity with the home stadium and its playing surface, travel and fatigue of the away team, and referee bias in favour of the home team [8]. A less studied factor that might relate to this issue concerns hormonal effects, which could have a direct bearing on performance-related behavioural states. A variety of studies have demonstrated strong links between home performance and the sex steroid testosterone (T), a hormone which has been associated with activation and assertiveness, faster reaction time, cardiovascular efficiency and dominance [4], all of which would be implicated in better performance. In addition, the glucocorticoid cortisol (C) has been specifically related to responses to the appraisal of threatening and challenging situations [9].

One model which has attempted to explain the hormonal effects associated with competitive encounters is Mazur's [10, 11] biosocial model of status. The model hypothesizes that increasing levels of T are apparent in individuals who have experienced a victory, which will subsequently prepare them for future dominance encounters, whilst those individuals who experience defeat will show a decrease in T and avoid future encounters [10]. The direction of causality in the relationship between T and performance has been debated, and it appears that a circular relationship is likely. Levels of T are not only assumed to be causally related to competitive drive and improved performance, but performance outcomes can also subsequently influence T levels [see reviews by [10, 12-14]. Thus, some studies have reported that T rises in anticipation of a competitive encounter and may influence individual and team performances during the encounter [15-17]. These findings are consistent with those of Neave and Wolfson [18], who found pre-game increases in T in home games, where players may have experienced a protective response in relation to a perceived invasion of their territory.

Other studies have shown that T remains elevated in winners compared to losers in both competitors [19] and fans [20], and T can even rise in competitors watching a video of a previous victory [21]. However, not all studies report such clear-cut findings, and it has been suggested that certain psychological factors could mediate the relationship between T and competitive behaviours and outcomes [22-24].

It is also well established that the hypothalamic-pituitary-adrenal (HPA) axis reacts to both physical and psychological stressors by increasing C [13, 25]. C has been recognised as a key indicator of adrenocortical function and also as a sign of disturbances within the HPA axis [26]. Moreover, C is known to rise in response to stress, and in competitive encounters exercise can be viewed as an additional physiological stressor [27], with rising C increasing

cardiovascular activation, glucose levels and anti-inflammatory responses [28]. Indeed, Mazur's [11] biosocial model originally centred upon explaining competitive encounters and T effects, but reference was also later made with regard to the possible inclusion of C, suggesting increased C with defeat and subsequent decreases with victory [13].

In animals, social stressors are potent triggers of HPA activation, with high C levels being associated with defeat in dominance encounters and in lower social rank individuals view [29]. In humans, C levels have also been shown to rise in advance of a competitive encounter [30-34]. It has been proposed that the nature of the competition is of importance; for example, a particularly strong rise in C has been observed when the competition is between groups who have a history of social rivalry [35]. Winners of a wrestling match have been observed to show a rise in C shortly after the competition [32] though this effect was not seen for judo competitors [36]or basketball players [16]. Thus, changes in C following competition may be unrelated to game outcome [30, 31, 37] though there is evidence that increased levels may instead reflect such factors as increased effort levels during the competitive encounter [38].

More recently, there has been a resurgence of studies dedicated to examining the home advantage from a psychophysiological perspective. Arruda et al. [39] examined the influence of venue on T and C responses in basketball players and reported that playing at home resulted in elevated pre game T levels, with T and C levels similarly elevated across time. The authors reported that no differences were observed regarding state anxiety or perception of effort. In rugby, higher pre game T and C levels were also observed, demonstrating an anticipatory rise prior to competition, although they did not show an effect of venue. However, the authors did find differences in starting status differences, with non-starters having lower home game T levels and higher away C levels than their starting counterparts

[40]. In a recent Futsal study, Arruda et al. [41] reported that resting T and C levels were not influenced by venue, but interestingly, significantly higher T and C levels were observed from pre- to post- game with a higher rise in post-game C concentrations after a home game. The authors attributed such differences in study findings to territoriality, perceived threats to status and social dominance.

The conflicting reports regarding the relationship between game location and outcome in relation to T and C require further scrutiny, especially since laboratory studies may not successfully simulate the same challenges as those in real life settings. Thus, in two studies involving different soccer teams playing real competitive matches, the effects of game venue (home and away) and time of testing (before and after competition) on T and C levels were examined. It was hypothesized, in keeping with most of the previous studies, that there would be a marked T and C response to playing a competitive game, with T and C levels higher prior to a home game [39]. It was also hypothesized, in accordance with Mazur's [11] biosocial model of status, that T and C levels would be dependent upon game outcome, with T higher with a victory and C higher in a defeat.

2. Study 1

2.1. *Participants*

Participants comprised the Academy squad of a UK Premiership soccer team, for whom success or failure can have major consequences. At this level, only the best young players are selected to receive a contract with the team, with those not selected perhaps missing their chance of a career in the game. Eighteen players were originally recruited, but due to injury this number was subsequently reduced to fifteen, all of whom were present in all conditions

and included in the analysis. Mean age of participants was 17.47, SD = .640 with an average of 10.73, SD = .96 years playing competitive soccer. On average the players trained for 10 hours per week which culminated with one league game on a weekend. Players participated in 3-4 games between study testing sessions. Training content typically involved endurance, strength training, technical preparation and yoga based sessions.

2.2. *Procedure*

The study received institutional ethical approval from a UK University Ethics Committee, and all players provided written informed consent to take part in the study. Players were asked to produce saliva samples one hour before two home games and two away games against the same teams and within 30 minutes post-game; these games were chosen after discussions with coaches to ensure that the levels of rivalry and the positions of the rival teams within the previous season were equivalent. The previous season's league positions of the reference team, Team 1 and Team 2 were 1st, 4th, and 6th respectively. The comparative league positions of teams at the time of testing were: team of reference 1st; Team 1 3rd and Team 2 5th out of 10 competing teams within the league. In keeping with previous research, players were instructed not to consume food 90 minutes prior to sampling to control for any consequential effects [42] but were instructed to maintain hydration with water at breaks. Samples were collected from October to May, and all competitive games commenced between 11 and 11:30am. The testing schedule is shown in Table 1. Players were given labelled Salicaps and asked to produce around 2ml of saliva which was collected using passive drool. Samples were then stored at -20° within 8 hours of collection and were analysed within the recommended 28-day period [43]. Saliva was analysed in duplicate (aside from two due to laboratory error) for T and C using specialist diagnostic assay kits. Samples were then thawed and centrifuged within the university specialist laboratory. T and C samples

were then analysed using luminescence immunoassay according to specific recommendations; this method is based on the competition principle (IBL Hamburg, Germany). The inter-assay and intra-assay coefficients of variation for T and C were <10%.

Insert Table 1 Here

2.2.1 *Statistical analyses*

Prior to analyses, normality of data was ensured using the Shapiro-Wilks test which was supplemented with Levene's test to check for homoscedasticity. As all participants in each study were tested in each condition, repeated measures analyses of variance were carried out in both studies. In Study 1, the repeated measures factors were Venue (home/away) and Time (before/ after the match), and the dependent variables were C and T. In Study 2, the repeated measures factors were Venue (home/away/ training) and Time (before/after), and the dependent variables were C, T and mood. All data are reported as mean, standard deviation (SD) and effect sizes (ηp^2).

2.3. *Results*

A repeated measures 2x2 analysis of variance for venue (home/away) and time (before/after match) revealed main effects for C on both factors (See Figure 1). Home C level (M=13.32 nmol/L) was significantly higher $F(1, 14) = 6.78$, $p=.002$ $\eta p^2 = .33$ than away (M = 9.99 nmol/L). Before the match (M= 9.06 nmol/L), C was significantly lower $F(1, 14) = 14.067$, $p =.02$ $\eta p^2 = .50$ than after (M=14.16 nmol/L).

These effects were due to the high level of C in the home/after condition (M=18.80 nmol/L), reflected in the significant interaction $F(1, 14) = 12.71$, $p=.003$ $\eta p^2 = .50$ (see Figure 1). Post hoc matched paired t-tests showed that C in the home/after condition differed

significantly from all the other three conditions (home/before, away/after, away/before), with no differences between these latter conditions.

T was not significantly different at home (M=140.31 pg/mL) than away (M=125.13 pg/mL), F (1, 14) = 1.10, p=.31), nor were any other effects significant.

Insert Figure 1 and Figure 2 Here

2.4. *Discussion*

Significantly higher levels of C were found after the games ended. This provides support to the findings of Arruda et al. [41] who also found higher C levels post-game at home in Futsal players. Post-game increases in C have also been found in soccer by Edwards, Wetzel and Wyner [37], as well as in a variety of other sports such as judo [17], basketball [16] and American football [44, 45]. An exception is a study by Mazur [46] using a video game competition; it may be noteworthy that participants engaged in the latter task expended far less energy than competitors in the sports where increases in C emerged.

Importantly, the present study's main finding is the interaction between venue and time. The post-game increase in C was largely due to the extremely high increases in players competing at home; in away games the level of C was no different before and after the matches. Elevations in stress are associated with increased C triggered by the HPA axis which can elicit an anti-inflammatory response and impact upon metabolic states during activity [47]. Psychologically, it is also likely that playing at home is associated with greater expectations and perceived social stress to perform well. Thus, it could be postulated that home players may work harder due to their desire to avoid disappointing the expectant home crowd or to

maintain their social status. It is also possible that they feel dominant and territorial in their home stadium.

Although not examining home and away venues, Elias [32] also reported that C levels in competitive wrestlers rose from pre-competition to post-competition and continued to remain elevated during the final sampling 35 minutes post-game. Interestingly, the wrestlers who won showed greater increases in C than did losers. This is particularly relevant to the present results, as the team under investigation won all four of the selected games, and it is possible that this was implicated with the increased C after their home games.

Contrary to the trend of previous research into the psychobiological responses associated with playing at home [15, 18], there were no significant differences observed for T in relation to venue or time. Nor did the positive outcome affect post-game T. The findings in the literature regarding winning and losing are mixed, with some studies showing increases in T among winners [16, 19], and others [30, 35] finding no outcome effects.

The T and C results obtained in the present study are not supportive of Mazur's [11] biosocial model of status, where T levels should rise and C levels should decrease in winners. It is thus difficult to explain these findings in light of the literature, and there appear to be no studies at all which have studied patterns of C and T for games which have all ended in a victory. One shortcoming of the present study is that direct self-reports reflecting the emotions of the players were not obtained; however, previous studies such as Neave and Wolfson [18] have found ceiling effects, with players reporting high levels of positive affect. A final limitation is the unavailability of hormone measures in training to compare as a baseline with competition results. Therefore, a further study was conducted to compare pre and post T and C measures at home, away and training and where players provided self-reports of their psychological state.

3. Study 2

3.1. *Participants*

Twenty male soccer players were originally recruited from a local semi-professional team playing in the Blue Square North Division, in the sixth tier of the English Soccer League. Due to loans, transfers and injuries, only 12 players were included in the final analysis as they were present in all conditions. Prior to the commencement of the study, institutional ethical approval was granted, players completed an informed consent form and supplied biographical information relating to age and position played. Mean age of participants was 23.17, SD = 3.83 years, older than and less likely to train as frequently as the Academy scholars in Study 1. Players typically trained for up to six hours throughout the week and played one competitive game on a weekend. Training content prior to match testing was kept consistent to avoid potential training load differences and consisted of technical, endurance and interval based training.

3.2. *Procedure*

The study gained institutional ethical approval from the University Ethics Committee. The same procedure was followed as in Study 1 with regard to collection and analysis. Games in this league can take place at 3pm or 7:45pm, and the sample of 4 games included both time slots. The game and training session saliva samples were collected from October to April. The fixture against the first opponent occurred on Tuesday evenings for both home and away games, and kick off was at 7:45pm. The fixture for the second opponent occurred in December, with both home and away games taking place in this month, and the kick off for this fixture was at 3pm for both games. Game samples against both opponents were collected

approximately 60 minutes prior to kick-off and 30 minutes post-game. The testing schedule is shown in Table 2.

In addition to the salivary measures, players were asked to complete the STAI-6 questionnaire pre-game. This comprises a six item short form of Spielberger's [48] State Anxiety Questionnaire, with Cronbach's α of .82 being reported for internal reliability [49]. The STAI-6 asks participants to rate themselves on how they feel right at that moment on a 4 point Likert scale (1 = not at all, 2 = somewhat, 3= moderately, 4 = very much) for a series of statements (*I feel calm; I feel tense*; *I am upset*; *I feel relaxed*; *I feel content* and *I am worried*). The questions contained in the STAI-6 were then followed by a series of additional statements, using a six point Likert scale (1-2 less than usual, 3-4 same as usual, 5-6 more than usual) which asked participants how they felt compared to their usual self with regard to five adjectives (*aggressive*, *confident*, *anxious*, *focussed* and *effective*). These items were adapted from previous research with soccer players [18].

Insert Table 2 here

3.3. *Results*

A repeated measures 3x2 analysis variance for venue (training/home/away) and time (before/after match) showed a significant effect $F(1,10) = 4.94$, $p=.05$, $\eta p^2 = .33$ for time, with C higher after (M=5.73) than before (M=3.28) competition. A significant interaction $F(2, 10) = 9.56$, $p=.001$, $\eta p^2 = .63$ with post hoc matched pairs t-tests showed home C higher after than before competition (see Figure 2), with no such differences in C for the training and away conditions. No main effect for venue was found.

T was not significantly different at home (M=75.38 pg/mL), away (M=75.26 pg/mL) or training (M=72.38 pg/mL), $F(2, 22) =.19$, $p=.12$), nor were any other effects significant. No

effects for psychological mood states were found, nor were significant Pearson correlations observed between any of the psychological states and hormones in any of the conditions.

Insert Figure 3 and Figure 4 Here

C displays a pronounced diurnal pattern, with elevated levels immediately upon waking, which then continuously decline throughout the day leading to a nadir in the evening [50]. Due to games taking place at two different times of day, paired sample t-tests were conducted for C between the 3pm and 7:45pm samples. No significant differences were found for the respective afternoon and evening C means of 3.10 and 2.69 (pre-home), t=1.85, p=.11; 10.56 and 9.15 (post-home), t=.48, p=.65; 5.50 and 5.40 (pre-away), t=1.34, p=.21; and 5.40 and 6.57 (post-away), t=.75, p=.47.

3.4. *Discussion*

The results from this second experiment were consistent with those of the first study in that players' levels of C showed a significant rise from pre-game to post-game when playing at home compared to playing away. In this second study, measures of C before and after training were also taken, and these showed the same unchanging pattern as the away fixture. It should be noted that in contrast to study 1 this particular team studied lost all four matches in which saliva was sampled.

In keeping with study 1 there were no T effects for venue or time. And, players' ratings of their own psychological states in the present study were not related to any of their T or C measures.

4. General Discussion

In the light of previous literature, these results highlight the complex and variable relationship between hormonal changes in relation to venue. While the hypothesis predicted that T and C levels would be higher at home for all players, the results showed only an increase in post-game C levels for players at home. This occurred in both studies, regardless of outcome. Given that the teams were also different in age, level, status and career aspirations, the replicated effect sheds some light on the relevance of hormonal processes.

This post-game C effect could be explained by the challenges associated with playing at home. Not only are dominance encounters being decided, but the competition is occurring in a public setting with hopeful, vocal spectators witnessing the competition. Perceived pressure to entertain and play dynamically in front of their own fans might thus represent a challenge to players [51], with the high expectations communicated by the crowd resulting in perceptions of threat and thus bringing about higher C levels [8, 52].

The current study provides support for the findings of Arruda et al. [41] who also found this greater post-match C response when playing at home. The authors attributed this rise to both psychological and physiological stress demands in Futsal competition. Moreover, the authors acknowledged that playing at a home venue could elicit a higher level of psychosocial stress attributed to the perceived social evaluation and pressure of playing at their own facility. A study of elite hockey players [15] suggested that the expected challenge of playing at home can arise even before the game begins, as a trend for higher levels of C prior to home than away games was found. Though measures of C were not taken after the games, this finding could be interpreted in the context of a higher level of perceived challenge at home, resulting in greater effort and energy expenditure during home competitions. Allen and Jones [8] alluded to the possibility of higher stress appraisal at home than away and noted that analyses [53, 54] show that under some exceptionally critical

circumstances, playing at home can actually result in a home disadvantage. It is worth noting that the games under scrutiny in the present investigation were not particularly critical matches. Future research might investigate the extent to which C also increases after home matches during games when a positive result is vital, such as in a Cup Final or relegation battle.

The overall lack of effect with regard to T was unexpected, given that previous research found increases in T before home games and after victories. Cuniffe et al. [40] also reported an absence of differences in T in rugby union players and speculated that perhaps from a psychological perspective players did not regard playing at home as more significant than playing away.

In addition, it could be that the complex relationship between T and C needs to be further investigated in the home advantage context; for example, one suggestion made by Aguilar et al. [55] is that physical exertion could act as an inhibitor of post-game T levels. Studies of physical exercise have also shown that increases in C concentrations can reduce the synthesis of T [56]. In support, West et al. [57] reported in professional rugby union players that C concentrations increased from baseline by 56 and 59% at 12 and 36 hours respectively, and over the same time period T decreased by 26 and 15% respectively. These findings can perhaps explain why the current study failed to yield any significant results in relation to T levels and venue, given that in both studies C values were significantly higher post-game irrespective of result. This finding is clearly an area which warrants further study, and future investigations should try to include additional measures of exertion (e.g. GPS data) where practically possible

A major advantage of the present study is that data were collected in naturalistic competitive settings. While laboratory studies can provide a rigorously controlled

environment, the competitive situation examined in the present studies represents a 'real-life' situation within which the hormonal responses to actual uncontrived challenges can be evaluated. Laboratory-based tasks involving social stress have not always provided clear evidence for the activation of the HPA axis in response to psychological stress. A possible explanation relates to the argument that the HPA axis may only be activated in response to conditions of true social evaluation [58].

Notwithstanding, one potential shortcoming of the naturalistic approach is that the sample size is restricted to one team in order to control additional confounding variables, and it is not possible to adopt a multiple sampling procedure; in an ideal world samples would have been taken at two time points before game kick off, at the half time interval and several times post-game. However, this would have imposed a high level of intrusiveness for players striving to win matches. Also, due to the nature of competitive soccer and the scheduling of home and away games, samples were spread across the season; this may have led to some seasonal variations in hormones [59]. Finally, due to the repeated measures design, the sample size inevitably decreased as the study progressed as a result of rotation systems and injury. Overall, though, the advantages of a study taking place in a natural competitive environment are believed to outweigh these costs.

Another issue to consider is that C was considerably higher in the first study of Academy players than the second of semi-professionals. This is probably due to diurnal variations, as it is known that C typically peaks during the morning and reduces across the day [50, 60]. The fact that the first study's games took place in the morning and the second in the afternoon and evening is likely to account for the difference in values. Nevertheless, this remains an interesting avenue for exploration in terms of the same observed post-game rise of C at home which occurred in the later matches. Future studies should continue to examine the timing of

matches in relation to both venue and performance outcomes. This may be of particular interest when preparing for and recovering from matches due to potential elevation and disruption of circadian rhythms; multiple measures of T and C could be taken across the course of the day in order to capture the full diurnal profiles of these hormones during morning and afternoon matches.

Subjective ratings provided by players did not relate to hormones at home and away. It is possible that precise individual performance levels are difficult to distinguish due to the amount of activity and expectations involved. Nor did self-reports of psychological state correlate with hormones. This is in keeping with previous research where difficulty has occurred regarding the elicitation of psychological changes using psychometric measures [18, 33, 39]. The competitive soccer environment is such that players may not have wanted to reveal variability in their mood states across situations. It is possible that assurances of anonymity and confidentiality were doubted, or the recognition of negative states could be threatening to the players' self-image. It could also be that the measures selected were not sensitive enough to find relationships between hormones and complex mood states. If this is to be addressed in future studies, researchers may want to explore alternative measures in relation to various psychobiological states prior to participation in important team competitions.

In conclusion, the results offer some interesting insights into the psychobiological responses associated with venue. Non-player factors such as referee bias [61] cannot be overlooked as potential explanations for the home advantage; thus, future studies might examine psychobiological responses to referee decisions. The increased C found in home players after competition in the present studies could very well be an indicator of somatic stress, although given that teams win more games at home, it could be suggested that players

may experience or deem this as facilitative rather than debilitative stress. This notion could be of interest to coaches and players with regard to their strategy and preparation. For example, closer monitoring of behavior on the pitch at home and away might be useful in identifying whether specific relevant aspects of performance tend to differ, such as amount of activity, speed and attacking play. It could be that psychological interventions could be adopted to help players to approach their away games more optimistically and put in the same amount of effort as at home, even if they perceive away venues in a negative light. Players could also benefit from knowing how venue affects specific aspects of their performance and use cognitive-specific interventions such as relaxation training, self-talk and imagery (see [62]). This could help them to be more cognizant of where improvements are needed and encourage them to take steps to overcome the problems of playing in unfamiliar environments, where they are likely to be the target of hostile reactions from audience members.

Disclosure statement

The authors report no conflict of interest.

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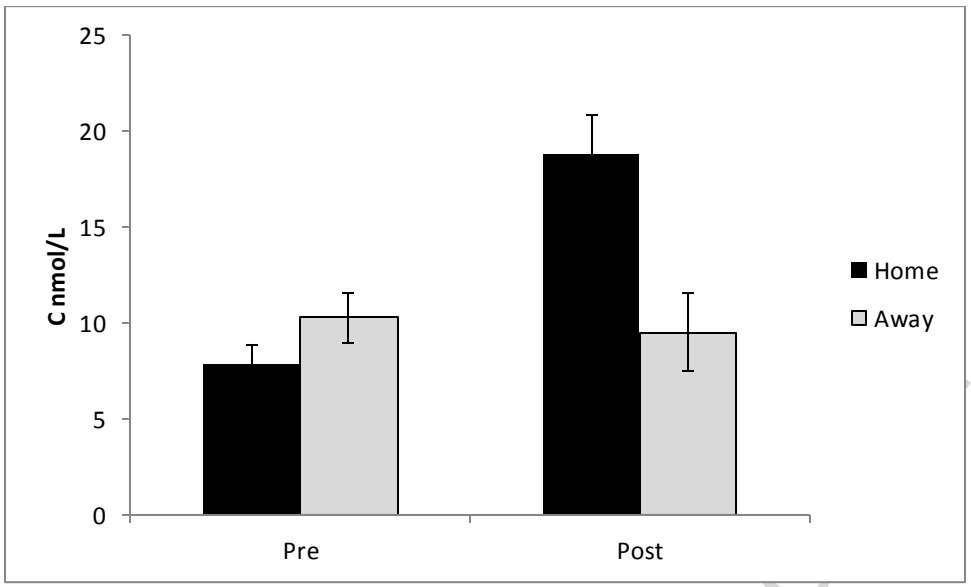

Figure 1. C at home and away, before and after matches.

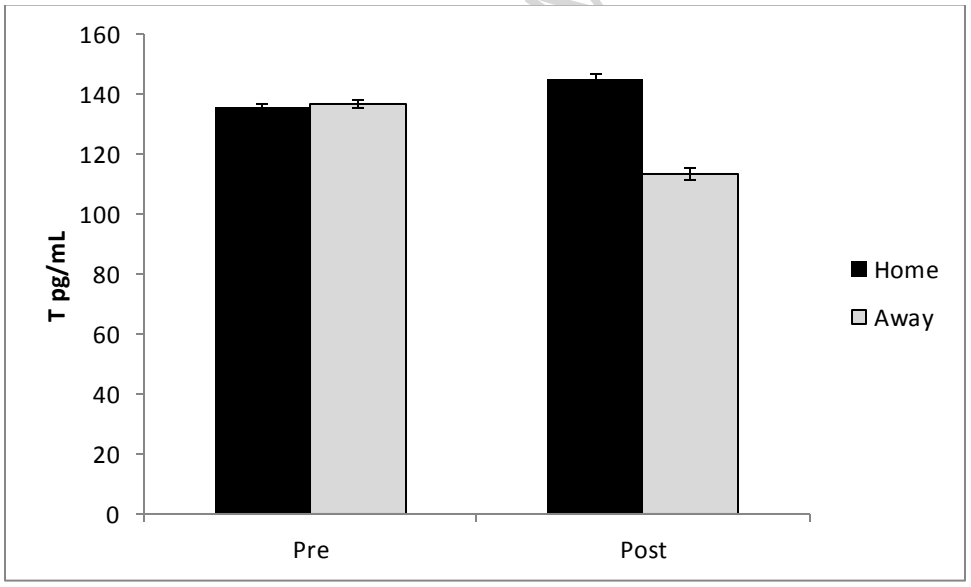

Figure 2. T at home and away, before and after matches.

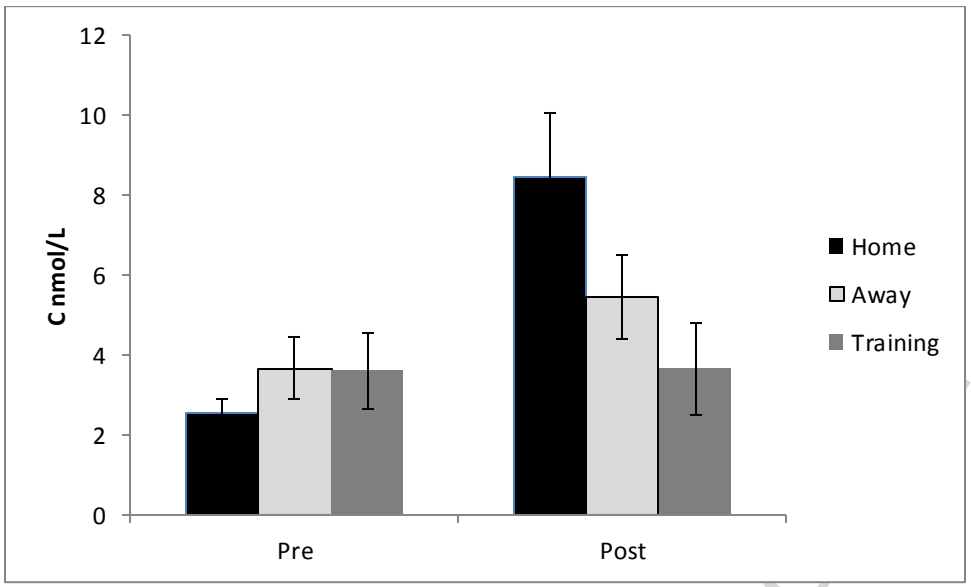

Figure 3. C at home, away and training, before and after matches.

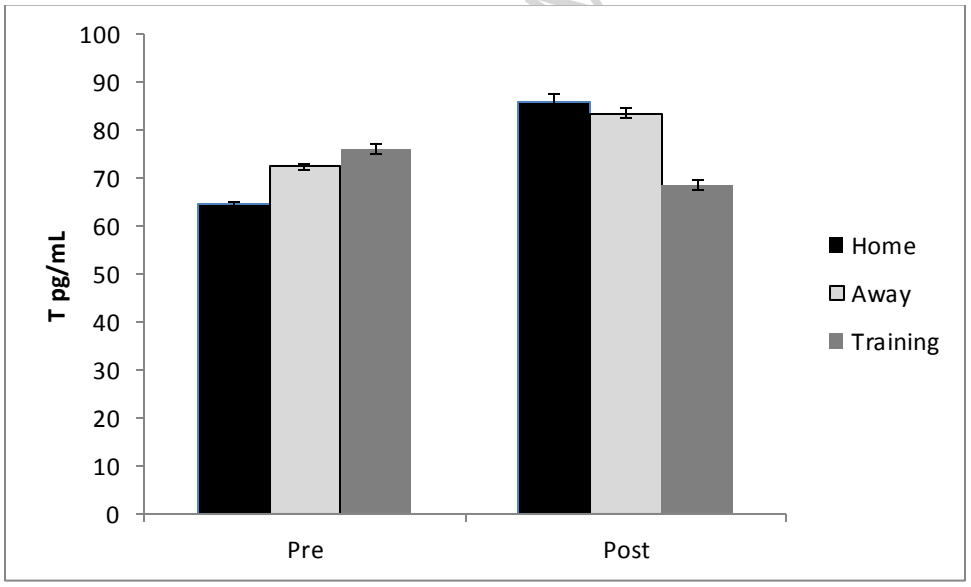

Figure 4. T at home, away and training, before and after matches.

Table 1. Schedule of Game Fixtures and Game Outcome

	Opposition	Fixture	Result
Game 1	Team 1	Home	Win 2-1
Game 2	Team 2	Away	Win 1-3
Game 3	Team 2	Home	Win 2-1
Game 4	Team 1	Away	Win 0-2

Table 2. Schedule of Game Fixtures and Game Outcome

	Opposition	Venue Location	Score
Game 1	Team 1	Away	Loss 3-1
Game 2	Team 1	Home	Loss 3-4
Game 3	Team 2	Home	Loss 0-1
Game 4	Team 2	Away	Loss 3-0

Research highlights

- The study examined testosterone and cortisol responses in relation to playing venue in soccer.
- Results revealed that cortisol responses were higher post-game at a home venue irrespective of result.
- In contrast to previous research there were no significant effects with regard to testosterone.
- The findings are discussed in relation to the home advantage and sporting competition literature, with some implications for applications.