

Research article

Psychophysiological responses in the pre-competition period in elite soccer players

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Abstract

This study investigated pre-competition physiological and psychological states of eighteen elite soccer players. Salivary cortisol was assessed during a non-training day and before three league games. Affective states (unpleasant and pleasant, somatic and transactional emotions) were evaluated using the Tension and Effort-Stress Inventory before the three league games. Participants formed 2 groups, 11 starters and 7 non-starters, depending on the starting list established by the coach. All players reported more intense pleasant transactional and somatic emotions than unpleasant ones prior to all games ($p < 0.05$), and relatively stable profiles of these psychological responses were observed across the three league games. However, salivary cortisol levels increased during pre-game for all players in comparison with the non-training day ($p < 0.001$). This anticipatory rise was only related to unpleasant somatic emotions ($p < 0.001$). This demonstrates that cortisol can be used as an index of emotional response to competition.

Key words: Emotions, affect, salivary cortisol.

Introduction

This paper focuses on the relationships between psychological and physiological responses (i.e., salivary cortisol concentration) during the pre-competition period in elite soccer players. Cortisol is the primary human glucocorticoid hormone and is essential for glucose regulation (Munk et al., 1984). It is also responsive to a wide range of stressors (Dienstbier, 1989; Kirschbaum and Hellhammer, 1989). The production of cortisol in response to stress is dependent on the psychological state of the organism.

Specifically, literature suggests that the Hypothalamic-Pituitary-Adrenocortical axis activation, with the release of cortisol, is particularly reflective of the affective component of the individual's experience (Frankenhaeuser, 1986; 1991). Thus, many studies have shown that increases in cortisol can be expected in anticipation of stressful stimulation (Gaab et al., 2005; Lovallo et al., 1990). This is especially relevant in situations inducing ego-involvement, novelty, unpredictability and uncontrollability (al'Absi and Lovallo, 1993; Levine and Weiner, 1989), leading to negative affective states (Buchanan et al., 1999; Lovallo et al., 1990). In addition, other studies have documented negative relationships between positive affect and cortisol response to stressors (see Buchanan et al., 1999, for a review).

The conceptual framework proposed by Frankenhaeuser (1991) takes into account the modulating influence of individuals' characteristics as well as social support systems. A key concept is the individual's cognitive assessment (Lazarus and Folkman, 1984), a process which involves weighing the importance and the severity of the demands against one's own coping abilities. A lack of balance between demands and resources, or a poor person-environment fit evokes negative emotions, which in turn, trigger physiological reactions. This interplay between cognition, emotion and physiology is a dynamic process, commonly labeled 'stress'. Of crucial importance to this mechanism is the dichotomous conceptualization of stress, where the term stress refers only to perceptions that are emotionally negative. A further component of stress, labeled as challenge, refers to that aspect of the interaction that results in positive emotional responses. Frankenhaeuser (1991) states that the ideal pattern of cortisol in conditions of challenge is one where the base rate is low and the response is depressed and delayed, whereas elevated levels of cortisol are induced by conditions of perceived stress. Although literature (Frankenhaeuser, 1991) and experimental studies (Buchanan et al., 1999; Lovallo et al., 1990) suggest different relationships between cortisol and affective states, little is known about such relationships in natural conditions.

Competition is a challenging situation, which usually stimulates intense responses from participants. From an endocrinal point of view, the response to competitive situations is elicited even before the competitive activity starts. The organismic control of resources, including hormonal responses, in order to adjust to changing anticipated demands, has strongly been emphasized within the framework of the 'allostasis' (Schulkin et al., 1994). In fact, the existence of an anticipatory cortisol response prior to stressful events of a physical nature has been recognized (Mason et al., 1973). More recently, it has been reported that the anticipatory response to competition includes elevations of cortisol (Filaire et al., 2001a; 2001b; 2007; Passelergue and Lac, 1999; Salvador et al., 2003; Suay et al., 1999). This acute increase has a preparatory purpose, which is specific to the competitive setting (Kivlighan et al., 2005). However, mixed results have been found in soccer players. It has been pointed out that this anticipatory rise, while present in each athlete, was higher in starters compared to non-starters in collegiate soccer players (Haneishi et al., 2007), whereas no significant difference was noted in intercollegiate American football (Hoffman et al., 2002).

It has been proposed that sport competition is an anxiety-arousing situation, including both physiological and psychological stressors (Salvador et al., 2003). Considering the anxiety research that indicates the potential importance of anxiety affect, two studies have provided empirical support for the contention that hormonal responses to competitive sport were linked to athletes' pre-competition affective experience. In their study, Eubank et al. (1997) assessed hormonal (plasma cortisol) and anxiety interpretations prior to competition in elite marathon canoeists. In general, their results lent support for predictions based on Frankenhaeuser (1991). Athletes who perceived their anxiety as facilitative for performance demonstrated relatively more stable, lower levels of cortisol than those who perceived their anxiety as debilitating for performance. However, their results were partially supported by Thatcher et al. (2004) who found that salivary cortisol pre-competition response was matched with elite field hockey players' perceptions of anxiety as facilitative for performance; but not with debilitating perceptions. These results call for more research to provide a better understanding of relationships between affective states and cortisol response in the pre-competition period.

Researchers interested in studying affect together with cortisol release in sport have a number of state-measure to choose from. The Tension and Effort Stress Inventory (TESI; Svebak, 1993) was preferred in this study for three reasons. First, it is balanced between pleasant and unpleasant emotions; thus, supporting existing literature that highlights a need to account for a wide range of pleasant and unpleasant emotions prior to competition (Cerin et al., 2000; Hanin, 2000). Second, it is considered advantageous to use scales based on established psychological theories (e.g., Ekkekakis and Petruzzello, 1999) and the instrument proposed by reversal theory to evaluate subjective experience of stress is based on reversal theory, a general theory of motivation, personality and emotions. Third, the TESI can be used on a 'face value' basis without involving the conceptual assumptions from reversal theory that helped define and structure the content of the inventory (Kerr et al., 2005). This instrument assesses the sixteen core emotions defined by this theory (a more detailed description of reversal theory can be found in Apter, 2001). Succinctly, eight pleasant and unpleasant emotions (relaxation, excitement, placidity, provocativeness, anxiety, boredom, anger and sullenness) arise in conjunction with different levels of 'felt arousal'. These are emotions directly related to the experience of one's body as a source of stressors where felt arousal is central to the intensity of the actual emotional experience. Similarly, eight emotions occur in conjunction with the 'felt transactional outcome' variable, and give rise to another group of eight pleasant and unpleasant emotions (pride, modesty, gratitude, virtue, humiliation, shame, resentment, guilt). These are known as transactional emotions because they arise from interactions between an individual and others and are related to the degree to which a person feels that he or she is winning or losing in a transaction. If felt level (e.g., perception of the situation) and preferred level (e.g., if one prefers low or high arousal, or if one is gaining or losing in transactional outcome) match each other, one experiences

positive emotions. However, if a mismatch occurs, the person experiences negative emotions. Not does only reversal theory allow for emotions resulting from somatic or bodily reactions to certain events or situations, but it can also account for transactional emotions that may result from interaction with others. These are important elements in team sports, and this may help to understand the transactional nature of psychophysiological relationships in relation to social support, as suggested by Frankenhaeuser (1991).

In regard to pre-competition affective states, previous studies in various sport activities have shown that in high level athletes, pleasant emotion levels in the pre-competition period were consistently higher than unpleasant ones, whatever the subsequent performance (Cerin and Barnett, 2006; Kerr and Pos, 1994; Legrand and Le Scanff, 2003). Moreover, it has been stated that these emotional profiles seem to be relatively stable throughout a season of competition in elite athletes (Males and Kerr, 1996). However, little is known about the affective responses in team sports and non-starting players in the pre-competition period. In fact, only one study has shown that non-starter softball players may not share the same psychological profiles as their peers who start (Coker and Mickle, 2000). Non-starters experienced more intense negative moods (e.g., anger, confusion, tension, and depression) than starters.

Thus, the current paper presents a brief report of preliminary findings from an examination of athletes' psychological and hormonal responses and relationships between these responses in the pre-competition period in elite soccer players. One aim of this study was to examine the anticipatory hormonal and psychological responses to competition during the period preceding the game. A second aim was to compare these responses between starting and non-starting elite soccer players. Finally, our main goal was to investigate relationships between cortisol levels and affective states. In line with previous findings (Cerin and Barnett, 2006; Kerr and Pos, 1994; Legrand and Le Scanff, 2003; Males and Kerr, 1996), it was hypothesized that considering the high level of athletes in this study, pleasant somatic and transactional emotion levels in the pre-competition period would be consistently higher than unpleasant ones; and that stable profiles of these emotions would be observed across the three league games for both starters and non-starters. However, according to previous findings (Coker and Mickle, 2000), and due to uncertainty of the situation, specifically the transactional nature of starting a match versus not starting a match (e.g., feeling that one has impressed the coach enough to play, or not, etc.), we expect that non-starters should experience more unpleasant emotions, particularly transactional ones, and less intense pleasant emotions than starters. As reported by previous findings (Filaire et al., 2007; Salvador et al., 2003), we expected that participation in competition would lead to increased salivary cortisol concentrations in all players, but that this anticipatory rise would be higher in non-starters compared with starters. Moreover, based on previous findings (Eubank et al., 1997; Thatcher et al., 2004) and theoretical predictions (Frankenhaeuser, 1991), we expected that this anticipatory rise would be positively associated with unpleasant

Table 1. Descriptive characteristics of starter and non-starter professional soccer players. Data are means (\pm SD).

	Age (years)	Weight (kg)	Height (m)	% Body Fat
Starters, $n = 11$	25.7 (3.0)	77.0 (1.3)	1.81 (.05)	11.1 (.3)
Non-starters, $n = 8$	23.1 (3.4)	76.7 (1.5)	1.79 (.04)	12.8 (.9)

somatic and transactional emotions. However, positive affective states (e.g., somatic and transactional emotions) would be negatively related to this acute cortisol release.

Methods

Participants

Eighteen male elite soccer players (24.6 ± 3.3 years; 1.81 ± 0.03 m; 76.8 ± 2.1 kg), with a training history of 5.5 ± 3.1 years as a professional, agreed to participate in this study. They were all members of the same team playing in the top French professional league (first division), had been playing in this team between 2.5 ± 2.3 years and in the first division for 5.5 ± 3.17 years. As explained below, these players formed 2 groups, 11 starters and 7 non-starters. No differences were noted between starters and non-starters in their age and anthropometric data (age, weight, height and % body fat). Descriptive data can be found in Table 1.

The purpose was explained thoroughly to every athlete and a signed informed consent form, approved by the local Medical Ethics Committee, was obtained from each individual in order to take part in the investigation. They were informed that all data collected in this study were to be kept confidential and that the coaching staff would not be given access to these data.

During a brief medical history interview, participating subjects informed the scientific staff that they were not taking medication which presumably could affect hormonal levels, had no history of endocrine disorders and experienced a normal day/night sleep cycle before or during this study. These indications were confirmed by the medical staff of this team via regular medical examinations (blood and urinary samples, dietary examinations).

Testing protocol

Soccer players were invited to the medical room of the stadium for four sessions: a non-training day (T1) and before three league games (T2, T3, T4). Thus, measurements were carried out four times during the season (T1-T4):

- One day following the start of the training season (T1: June, basal day), apart from training. There was no physical activity 24h before and after this session.
- Game 1: at the beginning of the season (T2: mid-September)
- Game 2: at the middle of the season (T3: at the end of November)
- Game 3: at the end of the season (T4: in April).

These games were chosen to respect two conditions: the same hour of testing so as to compare hormone concentrations, and the starting list had been identified by the coach the day before the games to allow comparison of starters and non-starters. As starters and non-starters were the same individuals across the three games, players

formed 2 groups, comprising 11 starters and 7 non-starters. At each time of the study (T2, T3 and T4), the team and the opposing teams were nationally ranked within the top 10 of the French premier league. Between the T1-T2 measurements, the team won 55% of the games and was ranked 4th. Between the T2-T3 measurements, the team won 46% of the games and was ranked 5th. Games 1 and 2 were won whereas game 3 was lost. Prior to each session, soccer players abstained for 12 h from alcohol, nicotine and caffeine and ate a normal lunch about 2 h before the session. On arrival at the medical room on each day of testing, each player was asked to confirm compliance with dietary restrictions.

To avoid the effect of circadian rhythm and food intake variations on hormonal secretion, soccer players provided three saliva samples on a non-training day (T1): at home at 8.00 a.m. (C1), in the medical room at 3.30 p.m. (C2; the same hour of the testing days) and again at home around 5.00 p.m. (C3). The players did not train on the day before sampling. For T2, T3 and T4, measures were assessed 90 min before the start of the games which were all started at 5.00 p.m. This time was chosen in order not to disturb the pre-competition routine and above all, to avoid the potential contaminating effects derived from warming-up on cortisol concentrations (Guezennec et al., 1992). Players were asked to complete the questionnaire identified to rate their emotions prior to the game and immediately following, to salivate into tubes (C4).

Salivary cortisol

At each session, soccer players salivated into tubes (Salivette, Sarstedt, Germany) and within five minutes typically produced volumes of 5-10 ml, sufficient for subsequent preparation for radioimmunoassay. Samples were stored in a freezer at -30°C until assay. They were then analyzed at the same time by radioimmunoassay to evaluate cortisol concentrations using the method developed by Lac et al. (1993). Briefly, steroids were extracted with aliquots with 10 vol. of diethyl-ether, dry extracts were dissolved in a phosphate buffer and an immunoassay performed (Sensitivity: 15 pg, accuracy: 10.5%, intra-assay reproducibility: 6.1%). All samples were tested in the same series to avoid assay variations.

Assessment of affective state

A French translation of the state version (Legrand, 2002) of the Tension and Effort-Stress Inventory (TESI; Svebak, 1993) was used in this study. Participants were requested to respond to a list of 16 unpleasant and pleasant emotions from reversal theory. Four coherent groupings of scores can be computed. These include unpleasant somatic (anxiety; anger; boredom; sullenness) and transactional (humiliation, resentment, shame, guilt) emotions, and pleasant somatic (relaxation, excitement, placidity, provocativeness) and transactional (pride, gratitude, modesty, virtue) emotions. According to reversal theory, in a team sport, transactional emotions are related to a mastery

state, dominance and competition that players entertain between each other, and thus are an important element in team sport. Participants were asked to estimate how they were 'feeling at that moment' and to respond to each of the items on the TESI by circling the appropriate figure on a scale of 1-7 ranging from 'not at all' to 'very much', placed alongside each item.

The TESI has demonstrated face validity and the measure's construct and predictive validity were established in a study of examination performance (e.g., Svebak, 1993). The validity of the TESI was confirmed in a number of medical studies (e.g., Bru et al., 1997; Svebak et al., 1991) and in sport and exercise contexts (e.g., Kerr et al., 2005; Legrand & Le Scanff, 2003; Males & Kerr, 1996). With respect to internal reliability, in the Males and Kerr study Cronbach alpha values (Cronbach, 1951) were calculated for pleasant and unpleasant emotions and found to be satisfactory: .88 and .75, respectively. In addition, from an ethical point of view, the TESI was thought to be particularly suitable for use in the present study with a unique sample close to games. The measure can provide a quick review of subjective experiences related to emotions with minimum intrusion.

Statistical analysis

Preliminary data analysis: Following procedures advocated by Tabachnick and Fidell (2001), the data were first inspected for accuracy of data entry, missing values, and outliers. Next, fit with the assumptions associated with multivariate analyses (e.g., normality, linearity, homogeneity of the variance-covariance matrices, and multicollinearity) and was found to be mostly satisfactory. However, given the relatively small number of participants and the repeated measures design, which was used, the conservative Greenhouse-Geiser epsilon adjustment was uniformly applied on MANOVAs to correct degrees of freedom on all these tests.

Psychological responses in pre-competition period: *Psychological profile on the three league games and differences between starters and non-starters.* MANOVAs, 2 (Group: starters/non-starters) \times 3 (Time: game 1, game 2 and game 3) with repeated measures on the last factor were used to examine differences in affective states (unpleasant somatic, unpleasant transactional, pleasant somatic, and pleasant transactional emotions) across the three games and between starters and non-starters for the three games. Effect size and power statistics were also calculated. Type 1 error rate was controlled across the 4 MANOVAs by Bonferroni adjustments (0.05/4), the significance level was set at $\alpha = 0.001$.

Affective states in the pre-competition period. *T*-tests were applied to determine differences between unpleasant and pleasant pre-competition affective states for each of the three games. After Bonferroni adjustment, the significance level was $\alpha = 0.001$.

Hormonal response in the pre-competition period: A MANOVA, 2 (Group: starters/non-starters) \times 4 (Time: basal, game 1, game 2 and game 3) with repeated measures on the last factor, was used to examine differences in hormonal concentrations and differences between starters

and non-starters. Effect size and power statistics were also calculated. Post-hoc comparisons of means with Bonferroni corrected *t*-tests were used to interpret significant main effects revealed by the MANOVA; the significance level was $\alpha = 0.005$.

Psychophysiological relationships. Intra-individual measurements of cortisol concentrations ($\text{nmol}\cdot\text{L}^{-1}$) were performed by correcting the level measured during the game for the individual baseline circadian cortisol level recorded at the corresponding time of the day. For each player and each game, the basal cortisol value was subtracted from the pre-competition cortisol concentrations. The rationale for expressing and analysing cortisol data as a difference concentration was to evaluate the change in cortisol in response to the stress of the competition (Salvador et al., 2003).

All emotion scores and cortisol variations were then standardized within participants using *z*-score transformations and then collapsed across participants yielding a total of 54 data points (18 participants \times 3 games). This method was used in order to control for individual variations for each player, and thus obtain a bigger sample of participants to conduct regression analysis. A stepwise regression analysis was used to determine relationships between psychological variables and variations in cortisol concentration.

Results

Descriptive statistics

In the baseline session, all the players showed a pronounced diurnal pattern with a peak at 8.00 a.m. ($18.0 \text{ nmol}\cdot\text{L}^{-1} \pm 3.8$), then the concentrations decreased during the afternoon ($6.5 \text{ nmol}\cdot\text{L}^{-1} \pm 1.66$ at 3.30 p.m.), reaching a nadir in the late afternoon ($5.9 \text{ nmol}\cdot\text{L}^{-1} \pm 0.9$ at 5.00 p.m.), in all cases remaining in the normal range reported in other studies at the same hours (Kirschbaum and Hellhammer, 1989).

Descriptive data for the psychological characteristics scores are presented in Table 2. Cronbach's alpha values, for pleasant and unpleasant emotions, computed with the sample used in the present study were found to be acceptable (between 0.70 and 0.89) at each time.

Psychological responses in the pre-competition period

Psychological profile of the three league games and differences between starters and non-starters. MANOVAs, 2 (Group: starters/non-starters) \times 3 (Time: game 1, game 2 and game 3) showed a significant effect of Group for unpleasant transactional emotions, indicating that non-starters were experiencing more intense unpleasant emotions than starters in the pre-competition period across the three games. This was observed for unpleasant transactional emotions ($F(1, 16) = 7.0$; $p < 0.05$; power = 0.70; effect size = 0.31), but not for unpleasant somatic emotions ($F(1, 16) = 4.2$; $p > 0.05$; power = 0.48; effect size = 0.21). However, when Bonferroni adjustments were applied, these results were not significant.

No Time main effect or interaction between Time and Group were noted, thus indicating that pre-competition emotions remained relatively stable across games for all players.

Table 2. Pre-competition emotions for starters and non-starters for the three league games. Data are means (\pm SD).

	Game 1		Game 2		Game 3	
	Starters	Non-starters	Starters	Non-starters	Starters	Non-starters
PSE	4.8 (1.3)	4.3 (0.86)	3.8 (1.3)	4.1 (0.96)	4.2 (1.5)	4.5 (0.6)
USE	1.6 (0.5)	2.7 (1.3)	1.9 (1.1)	2.1 (0.7)	2.2 (0.9)	2.5 (1.3)
PTE	5.4 (1.1)	4.7 (0.7)	4.5 (2.2)	4.2 (1.6)	5.1 (1.3)	4.9 (1.1)
UTE	1.7 (0.9)	2.2 (1.1)	1.1 (0.2)	1.6 (0.8)	1.5 (0.4)	1.8 (0.8)

Abbreviations: N: Starters, NS: non-starter players, PSE: Pleasant Somatic Emotions, USE: Unpleasant Somatic Emotions, PTE: Pleasant Transactional Emotions, UTE: Unpleasant Transactional Emotions.

Affective states in the pre-competition period. *T*-tests revealed that in the pre-competition period, unpleasant somatic and transactional emotions were significantly lower than pleasant ones for each of the three games (see Figure 1). Thus, players were experiencing more intense pleasant somatic emotions rather than pleasant somatic ones for game 1 ($t(17) = 6.5, p < 0.001$), game 2 ($t(17) = 4.8, p < 0.001$), and game 3 ($t(17) = 4.7, p < 0.05$). The same differences were noted for transactional emotions, pleasant emotions were higher than unpleasant emotions before the game 1 ($t(17) = 9.5, p < 0.001$), game 2 ($t(17) = 6.65, p < 0.001$), and game 3 ($t(17) = 11.5, p < 0.001$).

Hormonal response in the pre-competition period

MANOVA, 2 (Group: starters/non-starters) \times 4 (Time: basal, game 1, game 2 and game 3) with repeated measures on the last factor showed a main effect of Time on cortisol concentration ($F(2.06, 32.99) = 39.9, p < 0.001$; power = 1.00; effect size = 0.71).

T-tests showed that cortisol concentrations measured in the pre-game periods were significantly higher before game 1 ($t(17) = -9.89; p < 0.001$), game 2 ($t(17) = -16.0, p < 0.001$) and game 3 ($t(17) = -9.31, p < 0.001$), compared with the baseline values at the same time. Changes in cortisol concentrations are shown in Figure 2.

Psychophysiological relationships

A significant positive relationship emerged between cortisol variations (difference concentration between basal and

game mentioned previously) and unpleasant somatic emotions ($R^2_{aj} = 0.34, F = 9.07, \beta = 0.59, p < 0.001$).

Discussion

This study explored athletes' psychophysiological responses in the pre-competition period. The predictions were based on previous research that has examined emotional and cortisol responses, in starter and non-starter players, and psychophysiological relationships in the pre-competition period. Partial support was provided for all the research predictions under investigation. Specifically, in the context of emotional responses, players experienced more pleasant than unpleasant affective states in the pre-competition period, across all league games. This finding compares favorably with existing comparisons of subjective experience in the pre-competition period (Cerin and Barnett, 2006; Legrand and Le Scanff, 2003). In fact, it seems that this lack of negative affect is likely to be due to the athletes' expertise in this study. Elite athletes report using a combination of cognitive confidence management strategies (Hanton et al., 2004; Neil et al., 2006), including mental rehearsal, thought stopping, and positive self-talk, and arousal-based strategies (e.g., to enhance or diminish arousal intensity), to protect against the potential debilitating effects of stressful situations such as competition. Moreover, these positive subjective interpretations are also possibly due to their experience of sport competition at this level, which is associated with the

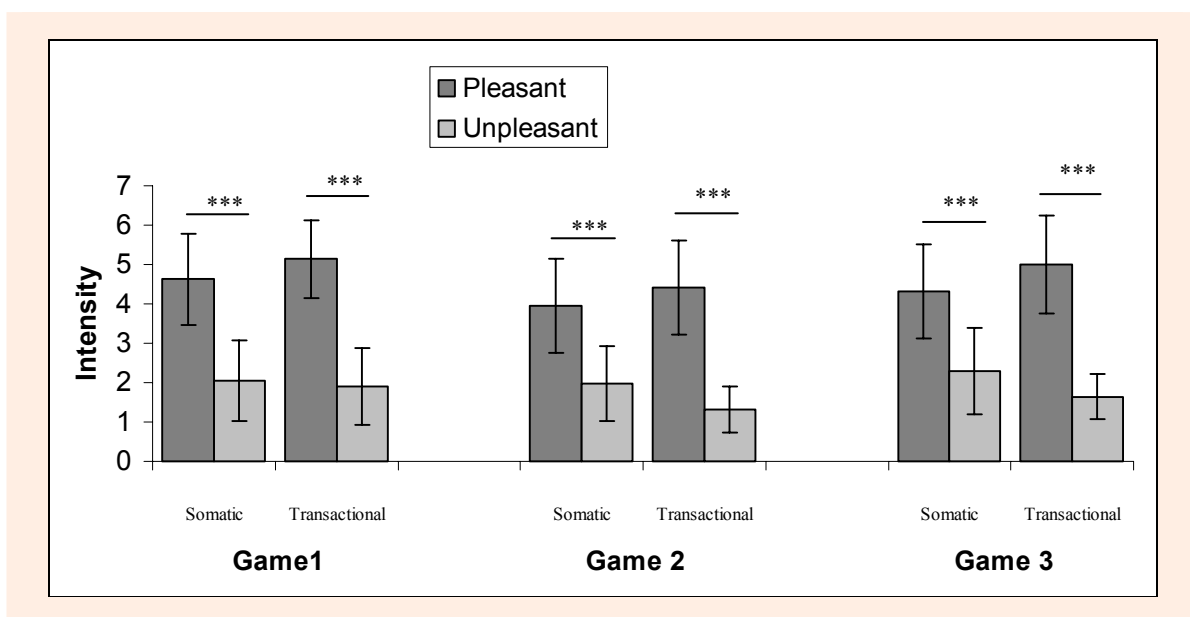


Figure 1. Pleasant and unpleasant, somatic and transactional emotions intensities before the three league games. Data are presented as means \pm SD. *** $p < 0.001$ pleasant versus unpleasant emotions.

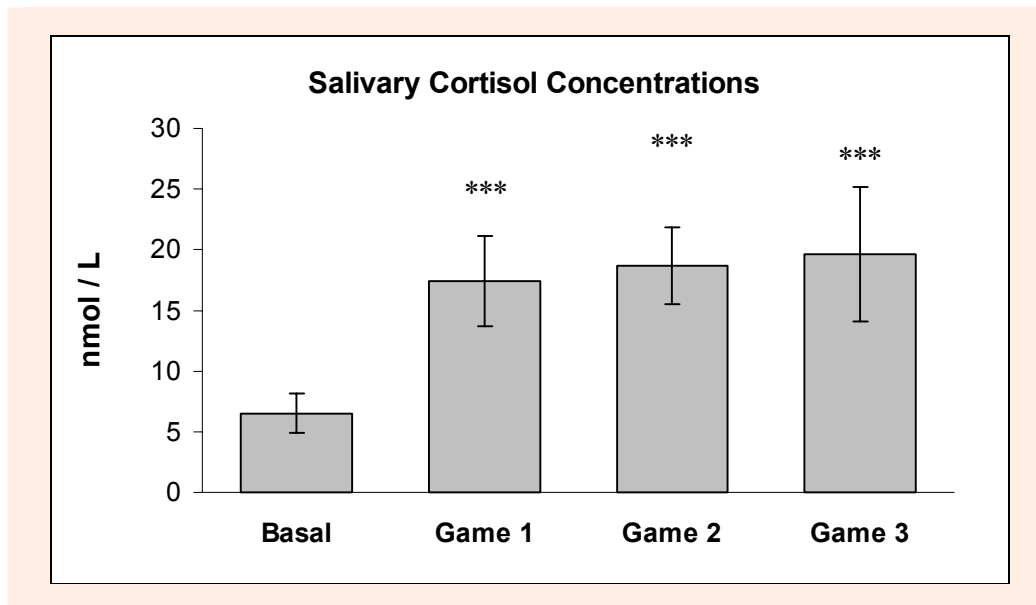


Figure 2. Players' cortisol concentrations ($\text{nmol}\cdot\text{L}^{-1}$) at 3.30 p.m. the basal day (non-training day) and before the three league games at the same hour. Data are presented as means \pm SD. *** $p < 0.001$ game versus basal.

familiarity/unfamiliarity of the situation to the individual (Cerin et al., 2000; Mellalieu et al., 2004).

Indeed, mental skill acquisition appears to be a gradual progression over athletes' careers with initial experiences of cognitive and somatic symptoms associated with competition viewed invariably as debilitating to performance. Later, however, the development of cognitive skills and strategies underlying the facilitative interpretation of symptoms are acquired via natural learning experiences and various educational methods. This suggestion is reinforced by the fact that players from this study showed relatively stable pre-game mental states, in terms of experienced pleasant and unpleasant, transactional and somatic emotions, profiles across games. It is possible that this profile, which is typical for experienced high-level athletes (Males and Kerr, 1996), reflect players' optimal mental preparation before competition.

Interestingly, no differences in pre-competition affective states were noted between starter and non-starter players. There may be several reasons for this counterintuitive finding. First, although the current study examined differences between players, it is quite possible that there was not a certain degree of intra-team competition that took place before the game leading to different subjective experience. Changes occur regularly during the season, depending on the line up of the opposing team. Therefore, starters and non-starters very often vary from one match to the next. Thus, it may be that players were not vying for status and this may partly explain why affective experiences were similar for these players. Another explanation for this finding is that these games may have been perceived as less important for the team as the opposing team was close in ranking or these games were all league games. Although speculative, it is possible that a greater degree of rivalry between players is at stake when the team competes in more important games, such as European league games.

Relative to cortisol concentration, it was predicted that participation to competition would lead to an increase

of cortisol concentrations from baseline to game, and that this anticipatory rise would be more important for non-starters. Partial support was found for these predictions in the current investigation. Briefly, no differences in cortisol concentrations were observed between starters and non-starters in the pre-competition period. This is in accordance with Hoffman et al. (2002) who failed to find significant differences in intercollegiate American football players in the pre-competition period. However, the pre-competition cortisol response for all players was greater than baseline values. This indicates that only the independent variable of condition (game versus basal), and not the status (starter versus non-starter) influenced the acute cortisol response in these athletes. The existence of anticipatory cortisol response prior to competition has been recognized for some time (Eubank et al., 1997; Filaire et al., 2001a; Filaire et al., 2007; Passelergue and Lac, 1999; Salvador et al., 2003; Suay et al., 1999). Moreover, it has long been established that cortisol is increased in an intensity-dependent manner in response to an exercise stimulus (Few, 1974). Of particular interest is the greater cortisol response to game compared with basal day. In this study, cortisol concentrations (C4, C5, and C6) measured 90 min before the games were higher than those from basal assessment at the same time (game 1, + 166 %; game 2, + 186 %, and game 3, + 200 %, compared with basal values). This is in agreement with other studies which reported similar effects of competition compared with baseline in salivary cortisol responses, with large increases in cortisol during rugby games (Maso et al., 2002), wrestling matches (Kraemer et al., 2001), judo competition (Salvador et al., 2003), weightlifting competition (Passelergue et al., 1995), and paragliding competition (Filaire et al., 2007), although none of these acute cortisol responses were as great as in the present study. This is because soccer is a sport that requires high levels of both aerobic and anaerobic abilities. The total distance covered by a male player averages about 10 km in 90 min, which is about 6.6 km per hour, and sprints occur once

about every 30-90 seconds (Kirkendall, 2000). Thus, it seems that because of these physiological demands and the 90 minute duration of a soccer game, this hormone response to competition is greater than for many other sports. Therefore, this anticipatory rise in cortisol can be seen as a preparatory response to competition.

In real sports competition, warming-up makes it very difficult to collect saliva samples closer to the start without overlapping pre-competition and hormonal variations due to exercise. In our case, since warming-up was performed after the salivary sample was obtained, cortisol response was clearly independent of the physical activity completed by participants. Examination of the relationship between pre-game psychological states and salivary cortisol rise revealed a significant positive association between unpleasant somatic emotions and cortisol. This supports the hypothesis that cortisol release is linked to the athlete's affective state prior to competition (Eubank et al., 1997; Thatcher et al., 2004). Specifically, results showed that negative subjective states were associated with acute cortisol release, which is consistent with the literature (Frankenhaeuser, 1986, 1991). The relationship between self-ratings of negative affective states and cortisol has been well documented in several studies using aversive situations (see Lovallo and Thomas, 2000, for a review). The current findings also support the hypothesis that negative affect has a predominant relationship with the HPA axis, as no significant relationship was found between positive affective states and cortisol release. Therefore, this supports the need to focus on negative affect together with cortisol release in studying psychophysiological relationships in the pre-competition period. It is important to note that participation in the game produced cortisol response in relation to negative states evoked by somatic processes rather than transactional processes (e.g., impress the coach enough to play, feeling bounding with teammates, etc.). Thus, this finding supports the concept that perceived psychological responses, such as somatic processes, and actual physiological responses, such as hormone response, are related.

Hormonal responses and cognitive appraisals during the pre-competition phase have received little attention in the literature. However, research into this area would provide a better understanding of the mechanisms responsible for performance under stressful environmental conditions. Increases in cortisol appear to be important in preparing for mental and physical demands and may affect performance, and thus, have potential to indirectly influence the outcome (Salvador et al., 2003). The anticipatory cortisol rise could be considered as physiologically advantageous, since it facilitated greater energy availability during the start of the effort, which is considered to be a part of physiological preparation for activity (Arthur, 1987). Research indicates that moderate elevations in the hormone help individuals deal with challenge in three ways that may apply to competition (Kivlighan et al., 2005, p.60). First, it marshals resources needed for physical activity (e.g., moving blood from the extremities to the large muscles). Second, it positively affects memory, learning, and emotions that are important in performing effectively. Third, cortisol serves a homeostatic function by regulating other stress sensitive systems. How-

ever, psychological stress can increase physiological activation beyond metabolically necessary levels (Roth et al., 1990). Therefore, extreme elevation in cortisol concentrations leads to poor performance because it interferes with some cognitive processes (Kivlighan et al., 2005, p. 60). Concretely, it has been suggested that the optimal response to a challenge would be characterized by a moderate cortisol response (Dienstbier, 1989; Eubank et al., 1997). A pre-competition pattern of hormonal response characterized by cortisol increases has been described in a subgroup of elite canoeists (Eubank et al., 1997), who also appraised their somatic anxiety as enhancing their subsequent competitive performance. In contrast, in this study, players' anticipating response cortisol was related to negative somatic emotions, but they were experiencing greater pleasant affective states than unpleasant ones and they were actually winning their games (two of these three games were won). Thus, we may speculate that their psychobiological response to the competition was adequate or facilitating.

Although the present study provides some evidence for psychophysiological relationships in the pre-competition period, there are some limitations that need to be addressed. First, this study concerned elite soccer players only and so further studies need to be conducted on different competitors and events. For example, this could include the experience level of the elite athlete, which seems to be related to increases in cortisol levels (Kivlighan et al., 2005) and influences how individuals interpret competitive emotions (Mellalieu et al., 2004). Second, the values obtained in the pre-competition period have been compared with a basal values sampled at just one time, perhaps a non-representative day. Thus, a fitting control condition would perhaps benefit from using several basal sessions during the season. This would ensure control over annual intra-individual variation and establish the participants' basal levels more accurately (Salvador et al., 2003). Furthermore, another limitation was the cross-sectional nature of the design, which precluded the inference of causality between psychological states and salivary cortisol. However, taken collectively with the existing empirical research that has considered these relationships, the findings of the current study provide the basis to indicate that certain psychological states (e.g., unpleasant somatic emotions) are associated with physiological changes such as cortisol release in the pre-event phase of competition.

Conclusion

The findings of this study suggest that participation in competition is perceived as a challenging situation for elite athletes, in which they experience greater pleasant affective states compared to negatives ones in the pre-competition period. This profile is relatively stable over a season of games, possibly due to their experience of competition at this level. The findings also confirmed the anticipatory cortisol rise prior to competition that could be facilitating for performance by enhancing energy availability. However, physiological stress (e.g., anticipatory rise) was related to negative emotions, and more specifically somatic ones. This study therefore provides support

for the contention that a relationship between psychological and physiological states does exist, and may provide a key to understanding stress in competition. Also, the model of stress and emotion provided by reversal theory, emphasizing that there are many kinds of emotional stress, seems to offer a new approach when investigating psychophysiological relationships in such conditions. The contribution of such studies is to provide a broader measurement approach in the study of competitive stress and has implications for the use of cortisol as a measure of emotional response in future studies.

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Key points

- Elite athletes perceive the participation to competition as a challenging situation as they experience more pleasant emotions than unpleasant ones in the pre-competition period. This profile is relatively stable across three league games, which is possibly due to the athletes' experience at this level.
- Participation to competition lead to anticipatory acute response of cortisol in the pre-competition period, which potentially prepares the athlete to perform.
- These responses are not related to status player (e.g., starter versus non-starter)
- Physiological stress (e.g. anticipatory rise in cortisol concentrations) is related to negative somatic emotions.
- Cortisol may constitute a measure of emotional response in pre-competition period.

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