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Testosterone, Cortisol, and Mood in a Sports Team Competition

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In humans, hormonal responses to winning/losing and their relationships to mood and status change have mostly been examined in individual athletic competitions. In this study, the salivary testosterone (T) and cortisol (C) and mood responses to a real match between two professional basketball teams were investigated. Data about individuals' contributions to outcome, performance appraisal, and attribution of outcome to internal/external factors were also collected. Results did not show statistically significant different T and C responses depending on the outcome. Negative mood was significantly enhanced, especially in the losers, while winners showed a better appraisal of team performance and a more internal attribution. T response did not show a significant relationship with mood changes, but it correlated positively with the "score/time playing" ratio, an indicator of individual participation in the outcome. Furthermore, T response correlated negatively with external attribution in winners and positively in losers. These results indicate that in a real, highly competitive situation, T changes are not directly a response to the outcome, but rather to the contribution the individual makes to it and to the causes he attributes.

Key Words: **testosterone; cortisol; outcome; saliva; competition; sports.**

Competitive encounters elicit hormonal changes which in turn are influenced by the outcome, victory or defeat, in various species (Archer, 1988; Brain, 1990). In humans, several studies have employed sports confrontations to study hormonal response to competition; however, the results obtained are far from conclusive. In tennis matches, different testosterone (T) responses, depending on the outcome, were reported in association with mood and status changes, although results were not statistically significant (Mazur and Lamb, 1980; Booth, Shelley, Mazur, Tharp, and Kittok, 1989). More recently, Mazur, Booth, and Dabbs (1992) found salivary T increases in winners and decreases in losers which reached statistical significance immediately after the game in the last weeks of a city chess tournament. They also described anticipatory T rises, especially in the more serious tournament.

In contact sports, the results have also been contradictory. Elias (1981) reported significantly greater serum T and cortisol (C) increases in winners than in losers 10 min after wrestling bouts. However, nonsignificant differences between winners and losers were found in these hormones after a judo combat, although T response differed according to the level of expertise of judo fighters (Salvador, Simón, Suay, and Llorens, 1987). Later, this finding was replicated only in the superior category, in this case the Spanish National Judo Team (Salvador, Suay, and Cantón, 1990).

This topic has also been studied in laboratory settings by researchers who have examined the related subjective variables more closely. Gladue, Boechler, and McCaul (1989) found statistically significantly higher and more stable increases in the salivary T of winners than in losers in a time reaction task which was manipulated by the experimenter. In addition, depression was lower in winners than in losers when the victory was clear, whereas anxiety was not sensitive to the outcome. Again these authors (McCaul, Gladue, and Joppa, 1992) found greater T increases and more positive mood in winners than in losers when involved in a task entirely controlled by chance (coin tossing). They emphasized the reinforcing power of mood, among other yet unclarified elements, and concluded that the perception of winning or losing, regardless of actual performance or merit, differen-

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TABLE 1
Mean ± SEM of Some Characteristics of Winners and Losers

	Winners	Losers
Age (years)	23.63 ± 1.22	22.86 ± 1.82
Weight (kg)	93.04 ± 3.84	94.59 ± 3.49
Height (cm)	195.78 ± 1.95	195.41 ± 2.6
BMI (kg m^{-2})	24.22 ± 0.75	24.74 ± 0.62
$VO2_{max}$ (ml/kg · min)	43.69 ± 1.11	42.31 ± 1.53
% Body fat	10.19 ± 1.19	11.46 ± 0.92

tially influenced T levels. This latter study contrasts with the lack of significant differences between lottery winners and losers previously reported by Mazur and Lamb (1980).

The competitiveness involved in the laboratory tasks reported is very different from that originated in sports competitions and other everyday competitive situations. Moreover, human competitions usually involve cooperative and coordinated work among members of a group in order to cope with confrontations with other groups. This study aimed to analyze the effects of outcome on T and C responses in two professional basketball teams in a real match with a high level of competitiveness and to explore their relationships to different psychological variables such as mood, performance appraisal, and individual contribution to the outcome.

METHODS

Sample

Of the 21 subjects, only the 16 participants in the match were considered, 8 from each team. All subjects were professional male basketball players belonging to two teams of the National Basketball League (EBA League). All were informed about protocol and gave written consent approved by the local Committee of Medical Ethics. Sample characteristics are shown in Table 1.

Design and Experimental Protocol

This study was framed into a wider project which involved a follow-up of the subjects throughout the sports season in order to analyze their psychobiological adaptation during this period. This paper focuses on a real basketball match between the two teams studied. The match was played during the first half of the sports season (a Saturday in December) between 12:15 and 13:40. Scores were very close throughout the match, the partial score being 40–42, but in the end the home team won the match with a score of 84–73 points. Both teams finished the first round of the league in the first and second positions in their group at the end of the follow-up.

Pre- and postmatch salivary samples for hormonal determinations were collected, immediately before final instructions by the coaching staff (11:30 h) and after the press communications (13:55 h), respectively. Hence, salivary samples were drawn approximately 45 min before and 15 min after the match. Simultaneously with the salivary collection, subjects completed the Profile of Mood States (POMS) inventory. After the match, they also answered several questions concerning appraisal of the team and personal performance, and the causal attribution of the outcome.

Furthermore, laboratory sessions were carried out at the beginning (August), approximately in the middle (December), and at the end (April) of the follow-up in the Sports Medical Center in Cheste (Valencia, Spain). Three or four persons were checked per day, including a salivary sample in a state of rest, between 8:45 and 10:40 AM. Afterward, subjects' performances on a cycloergometric test and other physiological and psychological measurements were registered. Hormonal data obtained in the match were only compared with those of the second laboratory session due to the temporal proximity between both events.

Hormonal Determinations

Subjects, who were drug free, received instruction on salivation at the beginning of every session. Saliva was stimulated by water and lemon juice and was directly collected from mouth to tube (Unitek R) 5 min later. Salivary samples were centrifuged and frozen at −20°C until determination. All the samples from every subject were run in duplicate in the same assay. Hormonal determinations were performed at our laboratory (Central Research Unit, Faculty of Medicine, University of Valencia, Spain).

The salivary T assay required a previous extraction phase due to low levels in saliva. The extraction was carried out by employing 3.5 ml of ether and separating the supernatant by freezing. After evaporation at room temperature, [^{125}I]testosterone tracer was added and decanted into a coated tube with a high specific antibody provided by a commercial kit (ICN Biomedicals, Costa Mesa, CA). Bath incubation was performed at 37°C for 2 h. After 10 min at room temperature,

samples were decanted and counted by gamma counter for 1 min. Duplicate internal and external control tubes were routinely included in every assay. Testosterone levels were expressed in nmol/L and intra- and interassay variation coefficients were less than 5%. Due to the adaptation of the commercial kit to salivary samples, sensitivity was recalculated as the detectable concentration equivalent to twice the standard deviation of the zero-binding value, which was below 6 pmol/L. Data on salivary T in morning basal sessions were 0.153 ± 0.012 nmol/L, which placed them in a normal low range (Read and Walker, 1984).

Salivary C was determined by a commercial kit adapted to salivary levels after dilution of the antibody in the buffer, as was recommended in the protocol (Orion Diagnostica, Espoo, Finland). The saliva sample (100 μL) was mixed with [^{125}I]cortisol tracer and the high specific antibody. The lyophilized C antiserum provided in the kit is produced in rabbits by immunizing a BSA conjugate of cortisol-3-carboxymethoxylamine. The tubes were bath incubated at 37°C for 1 h. Subsequently, polyethylene glycol was added and samples were centrifuged at 5000 rpm for 15 min (10°C). Finally, samples were decanted and counted for 1 min. C levels were expressed in nmol/L and internal and external controls were included in the assays. Good precision was obtained with intra- and interassay variation coefficients below 5% with a sensitivity of 1 nmol/L. The mean of our C data in baselines was 3.309 ± 0.337 nmol/L, in all cases including it in the normal range reported in other studies at the same hours (Kirschbaum and Hellhammer, 1992).

Psychological Variables

Mood was evaluated by the POMS inventory (McNair, Lorr, and Droppleman, 1971), which is composed of 58 items distributed into six scales: tension/anxiety, depression, anger, vigor, fatigue, and confusion. All the scales show negative mood, apart from the vigor scale. A total score is calculated by adding all scales, although the vigor scale was given a negative sign. The POMS administered was the "right now" version.

After the competition, subjects answered three questions concerning their performance and outcome. The first two were about appraisal of the team (item 1) and individual (item 2) performance. The third question referred to the attribution of outcome which included different factors regarding internal attributions (personal effort of members of the team, physical and technical abilities of the team members) and external attributions (mistakes made by the adversary, luck, and decisions made by the referees). These questions were answered using a 5-point Likert-type scale.

Individual Contribution

Not all players contributed equally to the outcome of the match. Some parameters such as time playing, individual score, the "score/time playing" ratio, or court position could be useful indicators of this participation and could be related to hormonal and mood changes. Time playing was registered by technical staff as a usual register of players' statistics and referred to time spent on the court, including short pauses due to referee decisions (fouls, free throws, etc.). Time outs and time on the team bench were discounted. Score was the number of points obtained, including free throws. Score/time playing ratio was calculated by dividing score by the time played [(score/time playing) × 100].

Field position modulates probabilities of getting goals. Although polyvalent players are also more and more frequent in European basketball, there were three clearly delimited court positions in the two teams included in this study: forward, guard, and center. Forwards were the scorers, guards the strategists and organizers of the game, and the centers were the rebounders. Offensive capacity was especially favored in the forwards in the teams in this study.

Statistics

Analyses of variance (ANOVA) of repeated measures, with outcome (winner/loser) as the between-subjects factor, were applied to hormonal levels and mood in the match and when levels prior to the laboratory session and to the match were compared. T data on one subject (winner) were rejected in the repeated measurement comparisons due to the fact that his prematch salivary sample was too scarce. Hormonal and mood responses were estimated as the difference between pre- and postmatch values and compared by the Student's *t* test. The effects of court position were explored by one-way ANOVAs and Newman–Keuls contrasts. Spearman or Pearson correlations were carried out where appropriate.

Descriptive data are expressed as mean ± SEM. All statistical analyses were performed by SPSS for Windows. An alfa-level of 5% was employed in

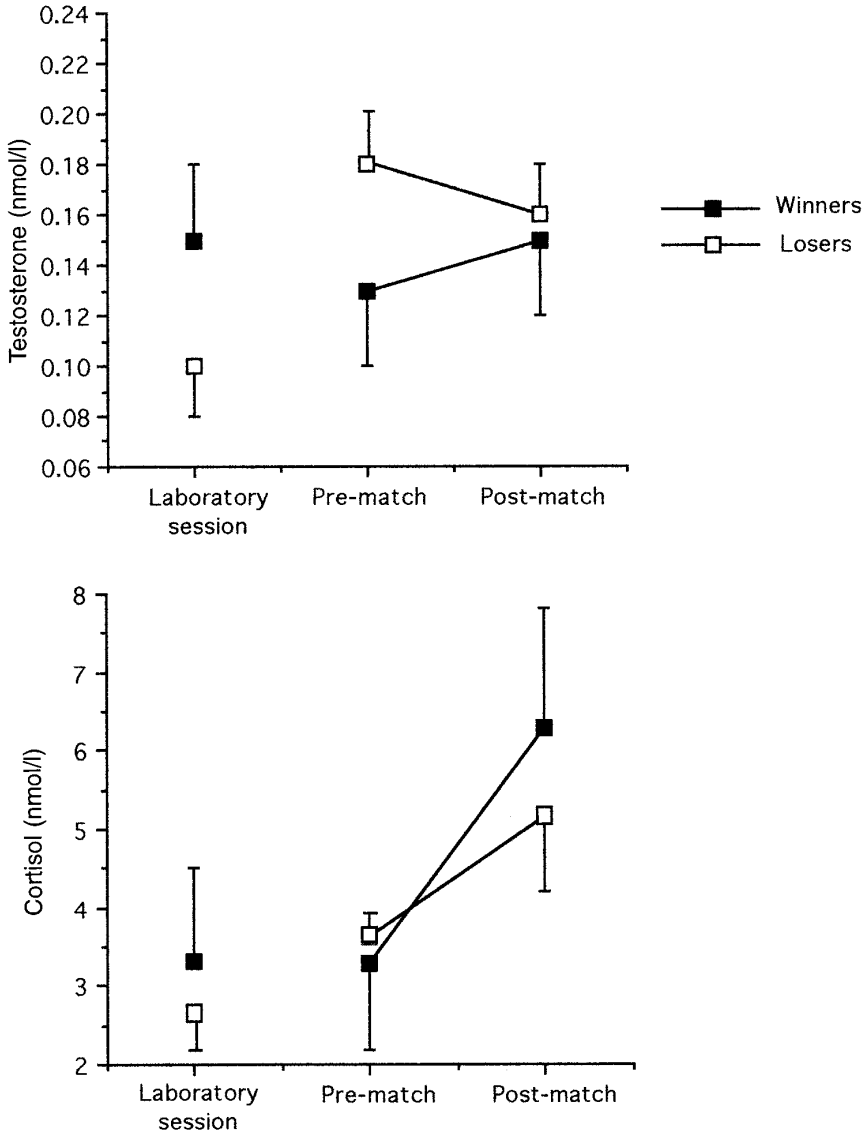

FIG. 1. Mean ± SEM of hormonal levels before the laboratory session and before and after the match (for all $n = 8$, except for winners' T levels, $n = 7$).

all analyses; two-tailed significance levels are reported.

RESULTS

Hormones and Outcome

Only the main effect of "moment" was significant on C levels ($F(1, 14) = 7.15$, $P < 0.02$), which increased after the match (Fig. 1). According to the outcome, winners showed T increases (0.013 ± 0.04 nmol/L) and losers exhibited decreases (−0.031 ± 0.03 nmol/L). Cortisol rose in winners (3.07 ± 1.31 nmol/L) and losers (1.59 ± 1.15 nmol/L). However, the differences between groups were not statistically significant for both hormones.

TABLE 2
Mean ± SEM of the Mood Scores before and after the Match

	Winners		Losers	
	Before	After	Before	After
Tension	5.63 ± 1.15	5.13 ± 1.89	7.38 ± 1.29	11.33 ± 2.69
Depression	1.63 ± 0.68	3.38 ± 2.68	1.25 ± 0.49	14.5 ± 4.42
Anger	4.13 ± 1.03	5.38 ± 2.99	6.71 ± 2.04	24 ± 5.8
Vigor	12.75 ± 0.84	10.25 ± 1.21	21.5 ± 1.48	12.17 ± 1.74
Fatigue	2 ± 0.53	5.38 ± 1.57	1.13 ± 0.35	11.5 ± 2.32
Confusion	3 ± 0.76	3.25 ± 1.26	2.13 ± 0.48	7 ± 1.51
Total	3.63 ± 3.61	12.25 ± 9.52	−3.57 ± 1.73	56.17 ± 15.07

Mood

Competition enhanced negative mood and decreased vigor more in the losers than in the winners (Table 2). Specifically, the effect of "outcome × moment" interaction was significant in anger, confusion, depression, fatigue, and vigor as well as in the total score ($P < 0.03$ for all). Furthermore, anger and tension were significantly higher in the losers than in the winners before and after the match ($P < 0.05$ for both) while vigor was higher only before the match ($P < 0.002$).

No significant correlations were found between hormones and mood, apart from a positive correlation between C response and vigor in winners ($r = 0.79$, $P < 0.02$) which was not found in losers.

Performance Appraisal and Causal Attribution

Both aspects were different depending on the outcome. The winners showed a better appraisal of team performance than losers ($P < 0.05$), but not about their individual performance. In addition, winners attributed their results more to the physical and technical fitness ($P < 0.04$) and less to the referees' decisions ($P < 0.05$) than the losers.

Only postmatch T showed significant correlations with both these aspects, although they differed depending on outcome. It was negatively related to attribution to luck ($r = -0.80$, $P < 0.02$) and to referees' decisions ($r = -0.82$, $P < 0.01$) in winners. However, in losers it was positively related to this latter item ($r = 0.84$, $P < 0.03$) and negatively related to performance self-appraisal ($r = -0.92$, $P < 0.008$).

Individual Contribution to the Outcome

Time playing was positively related to postcompetition POMS total ($r = 0.56$, $P < 0.04$) and fatigue ($r = 0.77$, $P < 0.001$). The score/time playing ratio was negatively related to prematch T ($r = -0.66$, $P < 0.008$) and positively related to the T changes ($r = 0.56$, $P < 0.03$).

Winners and losers did not show significant differences in time playing and scores. However, winners presented a higher score/time playing ratio than losers, which approached significance ($P > 0.06$).

A significant effect of position × moment interaction was found on T levels ($F(2, 12) = 8.97$; $P < 0.004$). Likewise, the position factor showed a significant effect on T changes ($F(2, 14) = 8.97$; $P < 0.004$), with increases only in forwards (Fig. 2). The effect of position on C levels did not reach statistical significance before or after the match ($P > 0.07$ for both). No position effects were found on C changes, mood, appraisal, attribution, scores, and score/time playing ratio.

Anticipatory Response to Competition

Neither T nor C levels were significantly different before the match and before the laboratory session. When they were analyzed by "outcome" (see Fig. 1), winners had slightly lower T levels; in contrast, losers showed clearly greater levels ($F(1, 12) = 7.22$; $P < 0.02$). No significant effects were found on C.

DISCUSSION

In accordance with our results, the outcome of a real sports team competition does not induce different T patterns, as was expected from Mazur's (1985) biosocial hypothesis of status. This finding agrees with some previous findings in individual sports competitions (Booth *et al.*, 1989; Mazur and Lamb, 1980; Salvador *et al.*, 1987, 1990; Suay, Salvador, Gonzalez-Bono, Sanchís, Martínez, Martínez-Sanchís, Simón, and Montoro, 1998), but contrasts with others (Elias, 1981; Gladue *et al.*, 1989; McCaul *et al.*, 1992) employing a similar period (15 min postevent) considered optimum for detecting T changes after psychological stimulation (Hellhammer, Hubert, and Schurmeyer, 1985). Cortisol increased in both teams, which confirms the lack of differences between winners and losers consistently found (Salvador *et al.*, 1987; Booth *et al.*, 1989; Gladue *et al.*, 1989; McCaul *et al.*, 1992). In fact, C has been more frequently related to "situational" stress and arousal than to status changes (Hubert and De Jong-Meyer, 1992).

In this study, winners experienced significantly less increase in negative mood than losers, in agreement

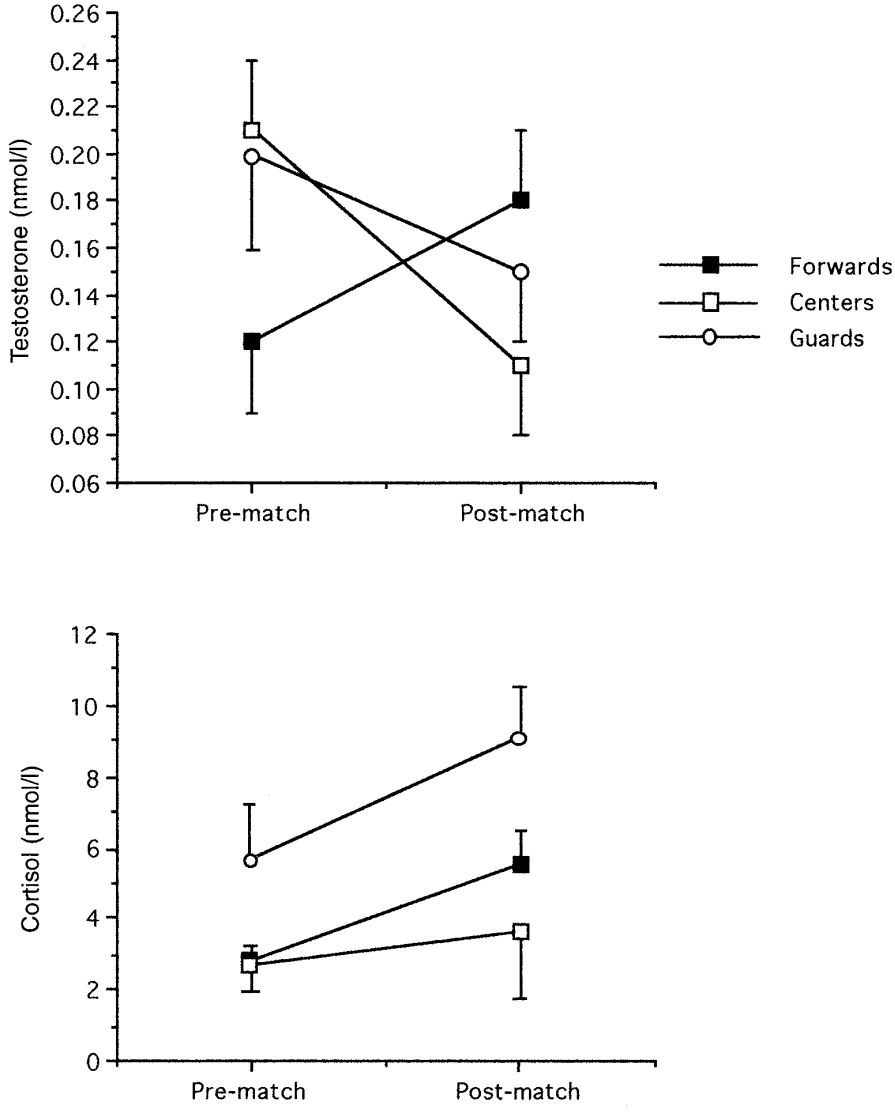

FIG. 2. Mean ± SEM of pre- and postmatch T (7 forwards, 4 centers, and 4 guards) and C levels (7, 5, and 4 subjects, respectively) by court position.

with McCaul *et al.* (1992), but, in fact, both teams suffered a worsening of their mood. Various factors could favor these increases, such as the stress derived from the uncertainty of the outcome throughout the match, and the temporal proximity of the measurements to the end of physical effort as has been reported with regard to competitive (Williams, Krahenbuhl, and Morgan, 1991) and noncompetitive exercise (Hassmen, Blomstrand, Ekblom, and Newsholme, 1994). Winners also showed a significantly better appraisal of the team performance and perceived that the outcome was due more to internal factors and less to external factors than did the losers. Moreover, winners presented a better performance (score / time playing ratio), but did not display significant differences from losers in time playing, which is important in order to discard the effect derived from physical effort. In this sense, the absence of significant correla-

tions between time and both hormones was an especially important aspect.

Mood has been suggested to be the main factor mediating the T changes induced by outcome; however, a lack of statistical tests to evaluate this mediation as well as a lack of reliable and valid measurements have led to inconclusive results (Mazur and Lamb, 1980; Booth *et al.*, 1989). In the few cases where validated psychometric tests have been used, it has been reported that mood differences are stronger and more consistent than T differences, as we have also found, and there does appear to be some divergence in their pattern (McCaul *et al.*, 1992). In our study, no significant relationships were found, supporting a dissociation between both responses.

On the contrary, T response was significantly related to score/time playing ratio, showing that the higher the contribution to the team outcome, the higher the T increases. In addition, postcompetition T in winners is negatively related to external attribution of the result, whereas in losers it relates positively to external attribution and negatively to performance self-appraisal. All these results show a clear pattern of relationhips between T and the contribution (objetive and perceived) to the outcome. This finding contrasts with the results reported by McCaul *et al.* (1992) involving a chance-controlled task, where T increases were related to outcome regardless of individual performance or merit. It is possible that individual merit becomes relevant in real, highly competitive settings, or perhaps its importance depends on the individual's competitiveness. Berman *et al.* (1993) have described the relevance of type A, characterized by an intense competitive striving for achievement among other features, in the mediation between hormones and behavior. This point stresses the differences between some selected groups and "average" persons (Gladue *et al.*, 1989). We have studied elite sportsmen probably characterized by high competitiveness and a high frequently of being faced with these types of situations, who, therefore, are not easily comparable to the general population. These characteristics would cause generalization problems and would explain the diversity of results found. Moreover, T increases were significantly greater in the forwards, with the more offensive role, than in the other two positions. Some enduring personal features (playing role, personality trait, physical condition, etc.) might have an influence on this response. Field position has recently been associated with differences in physiological (Sanchis, Valverde, Barber, and Mora, 1996) and psychological aspects (Sewell and Edmonson, 1996), but further research is necessary to examine this aspect more closely.

Finally, it has been suggested that there is a precompetition T rise in anticipation of the situation with a preparatory aim (Booth *et al.*, 1989). In our study, only losers significantly presented enhanced T, the interpretation of which in the context of the preparatory response to competition not being at all clear. It may be that the particular characteristics of the group studied, professional athletes, are relevant to interpreting this anticipatory response pattern. However, further investigation is required.

On the whole, in a real, highly competitive contest where subjects were fighting for a victory in cooperation with others and playing a particular role, and therefore in an activity which is not controlled by luck or under experimental manipulation, we have found significant effects of the outcome on subjective aspects such as mood, performance appraisal, and attribution, but not on endocrine responses. Despite the attractiveness of Mazur's hypothesis, this lack of statistical significance has been common in previous studies; clear statistically significant differences have almost always been limited to laboratory studies which allow for a greater number of subjects, and which compensate for the enormous variability in the T response. Furthermore, our results confirm the statement made by McCaul *et al.* (1992) about the complexity of the relationship between mood, behavior, and hormones. Testosterone changes did not significantly correlate with negative mood, but they appeared to be related to the participation in achieving the outcome, suggesting that, at least in highly competitive situations, personal contribution (objective and/or perceived) may be an important factor for the T response.

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