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Effects of competition and its outcome on serum testosterone, cortisol and prolactin

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Abstract

In various species, competitive encounters influence hormonal responses in a different way depending on their outcome, victory or defeat. This study aimed to investigate the effects of sports competition and its outcome on hormonal response, comparing it with those displayed in situations involving non-effort and non-competitive effort. To this end, serum testosterone (T), cortisol (C) and prolactin (PRL) were measured in 26 judoists who participated in three sessions (control, judo fight and ergometry). The relationship between hormonal changes and psychological variables before and after the fight were also analysed. Our results showed a hormonal response to competition, which was especially characterized by an anticipatory rise of T and C. Depending on outcome, significant higher C levels were found in winners in comparison to losers through all the competition but not in T or PRL, both groups expending a similar physical effort. Furthermore, similar hormonal responses to the fight and to a non-competitive effort with the same caloric cost were found, other than with PRL. Winners showed a higher appraisal of their performance and satisfaction with the outcome, and perceived themselves as having more ability to win than losers, although there were no significant differences in motivation to win. Finally, the relationships found between T changes in competition and motivation to win, as well as between C response and self-efficacy suggest that in humans hormonal response to competition is not a direct consequence of winning and losing but rather is mediated by complex psychological processes.

Keywords: Competition; Outcome; Social-stress; Testosterone; Cortisol; Prolactin

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1. Introduction

Competitive interactions seem to affect hormonal responses in numerous species, these responses being different depending on the outcome, victory or defeat (Archer, 1988; Brain, 1990). Experiments carried out with rodents show that single or repeated defeats lead to a hyperactivation of the hypothalamic-pituitary-adrenal (HPA) axis with increases in ACTH and corticosterone, as well as decreases in prolactin (PRL) and testosterone (T), although not always such T decreases have been found. At a behavioural level, social stress produced by defeat leads to changes in a wide variety of aspects, including increased anxiety and decreased aggressive behaviour (for review, see Martínez et al., 1998). It has been hypothesized that hormonal changes resulting from social interactions may modify the future behaviour in order to maximise the possibilities of survival (Leshner, 1980; Bernstein et al., 1983; Mazur, 1985). From an evolutionary point of view, the biosocial hypothesis (Mazur, 1985; Mazur and Booth, 1998) suggests that there is a feedback loop between an individuals T level and his/her posterior efforts to improve or maintain the social status. It states that aggressive behaviour leads to more or less stable endocrine adaptations, which can determine future behaviour. Thus, winning would lead to an increase in T, which, in turn, stimulates competitiveness. Conversely, defeat would involve a decrease in T that should reduce the possibilities of engaging in new potentially damaging encounters.

The effects of competitive encounters and their outcome on hormonal levels can be studied not only by means of an experimental approach but also by observing spontaneous interactions which occur in natural social situations (Sapolsky, 1991). In humans, some researchers have analysed sports competitions considering them socially acceptable situations where individuals compete in such a way that the outcome affects their sports status. In a first study, Mazur and Lamb (1980) reported increases in the plasma T levels of winners and decreases in losers of tennis matches and concluded that these androgenic variations depended on the individual's mood. Later, Booth et al. (1989) also reported differences, although not statistically significant, in T when comparing samples obtained 15 min before tennis matches with others obtained immediately afterwards. In contact sports, results have not been unanimous. Comparing blood samples obtained 10 min before and 10 min after wrestling bouts, Elias (1981) found that winners showed significantly greater percent changes of T and higher levels of cortisol (C) than losers. However, non-significant differences depending on the outcome were found comparing samples collected 10 min before and 45 min after a judo fight (Salvador et al., 1987, 1990b). In the mentioned studies, significant hormonal differences were found close to the end of the event, thus these variations could also be due, at least in part, to differences in the physical effort developed. Obviously, the stress due to competition is added to the physiological stress caused by exertion, which in itself is a powerful stimulus capable of affecting numerous hormones (Howlett, 1987; Sutton et al., 1990).

Bearing all this in mind, the first aim of this study was to investigate the hormonal response to a sports competition and compare it with those shown in

non-competitive effort and in non-effort situations. The second purpose of this study was to investigate the effects of outcome on endocrine response and the potential role of physical effort in this response. A further aim was to examine the relationships between hormonal responses and psychological aspects (such as the motivation to win, self-efficacy, performance self-appraisal, and satisfaction with the outcome) as well as the influence of outcome on these aspects. In order to get a more complete background of the endocrine response in humans, not only did we study T and C but also PRL levels which have been seen to be modified by competition in other species.

2. Methods

2.1. Subjects

The sample was composed of 28 male judo fighters who were recruited from several Sports Clubs of Valencia (Spain). Their technical level ranged between brown belt and 3rd Dan black belt and they trained daily for an average of 2 h. All the subjects gave written consent to participate in the study and were financially remunerated for it. They were not taking any drugs or medication and had no history or endocrine disorders before or during this study. Their main characteristics are described in Table 1.

2.2. Procedure

Subjects participated in three testing sessions (control, judo fight, and ergometry) which were carried out on different days but at the same hours (0900–1330 h) to control for the circadian variation. All testing for an individual subject was conducted at the same time of day (always 30 min between pre- and post-sample for every subject). Blood samples were collected between 0930 and 1230 h in each session. All were asked to refrain from strenuous activity 24 h prior to each testing session, to fast overnight, and have a light breakfast (without caffeine) one and a

Table 1
Mean (SEM) of the main characteristics of the sample

	Winners	Losers
Age (years)	18.86 (0.66)	17.79 (0.72)
Height (cm)	174.3 (0.03)	172.1 (0.02)
Weight (kg)	70.06 (3.09)	69.38 (3.05)
BMI[a] (kg/m^2)	22.9 (0.46)	23.3 (0.80)
Strength (kg)	152.1 (3.25)	142.8 (4.78)
VO_{2max}[b] (ml/kg per min)	52.8 (0.84)	50.4 (1.11)

[a] BMI, body mass index.
[b] VO_{2max}, maximum oxygen uptake.

half hours before the session (0730 h); all subjects confirmed this point. The session involving judo fights (FIGHT) was our main interest, the other two sessions being designed to compare competition-induced hormonal changes with the ones produced in non-effort (control) and non-competitive effort (ergometry) situations.

The control session (CONT) was carried out initially in order to get the subjects familiar with the methods and researchers. Subjects were convened in appropriate rooms at the university and, after a brief introduction to the general purpose of the study, the timetable for the following sessions was established and the conditions for participation (fasting/eating, physical activity, etc.) were repeated. In this session, subjects provided blood samples to measure hormones in a non-effort situation and completed some pencil-and-paper tests in order to give information about psychological variables and sports history. Pairs of subjects, who had previously been matched according to body weight and competitive level, provided two venous blood samples in the same order as they would compete in the next session (FIGHT).

A week later, the competitive session (FIGHT) was carried out in a Sports Club, in the presence of friends and members of the clubs involved. The judo fights were also videotaped (three videocamaras) in order to analyse more deeply the behaviour shown, offensive and defensive tactics, in relation to hormonal responses (in preparation). Every judoist engaged in a single encounter judged by an official referee following the international rules of judo competition. Venous blood samples were provided 10 min before and 10 min after the judo fight; this time interval was selected on the basis of the reported positive effects of outcome on hormones (Elias, 1981; Gladue et al., 1989; McCaul et al., 1992) and the lack of effects in posterior time (Elias, 1981; Salvador et al., 1987, 1990b). Capillary blood samples were obtained by ear lobe punction in minutes 1 and 3 of the recovery period for determination of lactate (La).

The non-competitive effort session (ERG) was carried out in the Sports Medical Centre in Cheste (Valencia, Spain), in groups of two to four persons during the following 3 weeks. Thus, the temporal period between the first and the third session was not superior to 4 weeks for all subjects. This session was designed to replicate the physical effort developed by each subject in FIGHT. The ergometric protocol consisted in a constant effort of 2.28 W/kg of body weight with six supramaximal effort peaks of 5.57 W/kg until completing a 5 min period in a Jaeger cycloergometer with a load range from 0 to 600 W. On the basis of maximum Lactate (La_{max}) measured in FIGHT, two variations of the protocol were designed. Subjects with La_{max} higher than 10 mmol/l in FIGHT made effort peaks of 15 s with reference periods of 35 s, whilst subjects with lower La_{max} in FIGHT made efforts of 10 s with reference periods of 40 s. The estimated caloric cost was 0.25 kcal/min per kg and 0.21 kcal/min per kg, respectively (Margaria et al., 1963). Ten min before and 10 min after the ergometric test, venous blood samples were collected, while capillary blood samples by ear lobe punction were obtained in minutes 1 and 3 of the recovery period.

A total of 28 judoists took part in CONT, but two who were notified to a sports concentration did not attend FIGHT; they were substituted by two others of

similar body weight and competitive category. Thus, only data from 26 subjects were used in the comparisons between the three situations.

2.3. Effort measures

Lactate, which is considered a good indicator of the intensity of the effort developed in anaerobic exercise (Williams and Eston, 1989; Billat, 1996), was determined in the capillary blood by an enzymatic method (Boehringer, Mannheim, Germany). La_{max} was the maximal level (mmol/l) reached in minutes 1 and 3 of the recovery period.

Vigor and fatigue subscales from the Profile Mood States (POMS) inventory by McNair et al. (1971) were used in order to estimate the impact derived from the physical effort developed in the FIGHT and ERG sessions.

The total and actual duration of every fight was registered and controlled by the referee team. Judo fights have in accordance with the official rules a maximum duration of 5 min. Obviously, the duration of each fight was the same for both contenders, so it was not used as an indicator of the physical effort developed.

2.4. Psychological measures

Before the competition two questions were asked concerning the subjects' motivation to win (item 1), and self-efficacy or ability to win (item 2). After competition, another two questions were asked about self-appraisal of personal performance without considering the result (item 1), and satisfaction with the result (item 2). All of these questions were answered using a 5-point Likert-type scale.

2.5. Hormonal measures

Each subject provided six 10-ml blood samples from the antecubital vein which were processed to obtain the serum and then frozen at -80°C until their analysis in Laboratorios Montoro SCL (Valencia, Spain).

All samples of each subject were treated in duplicate in the same assay. T was analysed by radioimmunoassay adding ^{125}I tracer to the highly specific antibodies provided by the commercial kit (^{125}I-Testosterone Coatria Kit of Bio-Mérieux, France). C was analysed with fluorescence polarization technology using immunoassay methodology (TDx of Abbott Laboratory Diagnostic Division, Chicago, IL). Finally, PRL was determined by an enzimoimmunoassay technique with the Enzymum-Test Prolactine of Boehringer (Mannheim, Germany). All intra and interassay variation coefficients were below 9% apart from the interassay variation coefficient for T (12.2%).

2.6. Statistics

The Lillieford Normality Test showed that not all hormonal data adjusted to normal distribution, so, logarithmic transformations were carried out in order to

Table 2
Mean (SEM) of T, C and PRL in the three sessions (control, fight and ergometry)

	CONT		FIGHT		ERG	
	Pre	Post	Pre	Post	Pre	Post
T (ng/ml)	5.56 (0.05)	5.13 (0.26)	6.71 (0.46)	7.82 (0.57)	4.57 (0.47)	6.13 (0.39)
C (μg/dl)	10.20 (0.80)	14.89 (1.07)	12.23 (1.05)	18.43 (0.98)	8.25 (0.65)	14.07 (1.05)
PRL (ng/ml)	11.46 (0.83)	13.35 (0.89)	11.00 (0.78)	19.18 (1.67)	7.59 (1.16)	10.46 (1.30)

use parametric tests. MANOVAs or ANOVAS of repeated measures were used where appropriate. To compare endocrine responses experienced by winners and losers in FIGHT and ERG sessions, absolute differences were calculated for each hormone (post- minus pre-value). χ^2 tests were also carried out. Spearman-rank correlations were performed to analyse relationships between variables.

All analyses were run by SPSS for Windows. An α-level of 5% was employed in all analyses; 2-tailed significance levels are reported. All values represent the mean $\pm$ SEM.

3. Results

3.1. Hormonal response to competition

Hormonal concentrations were within reference values reported for the different kits used (Table 2); only one subject who showed very high T values before FIGHT (more than 2-fold SEM value) was discarded from the analyses for this hormone.

A MANOVA (2 (pre/post) $\times$ 3 (CONT/FIGHT/ERG)) was carried out for each hormone. Results for T revealed significant main effects of 'moment' ([$F[1,24] = 24.29$, $P = .001$), 'session' ($F[2,23] = 18.84$, $P = .001$) and 'moment $\times$ session' interaction ($F[2,23] = 7.08$, $P = .004$). As can be seen in Fig. 1, T levels were significantly higher in FIGHT than in the other two sessions; increases in FIGHT and ERG were found whereas decreases appeared in CONT.

MANOVA for C showed only significant effects of 'moment' ($F[1,25] = 72.58$, $P = .001$) and 'session' ($F[2,24] = 9.69$, $P = .001$), whereas 'moment $\times$ session' interaction did not reach statistical significance ($F[2,24] = 2.77$, $P = .08$). Similar C increases were found in the three sessions, although levels were higher in FIGHT than in the other situations.

Also for PRL, MANOVA indicated only significant main effects of 'moment' ($F[1,24] = 23.25$, $P = .001$) and 'session' ($F[2,23] = 17.55$, $P = .001$) and a tendency for 'moment $\times$ session' interaction ($F[2,23] = 2.72$, $P = .09$). PRL increased in the different sessions, the rises in FIGHT being significantly higher than those of CONT. In ERG, pre- and post-levels were lower than in the other sessions.

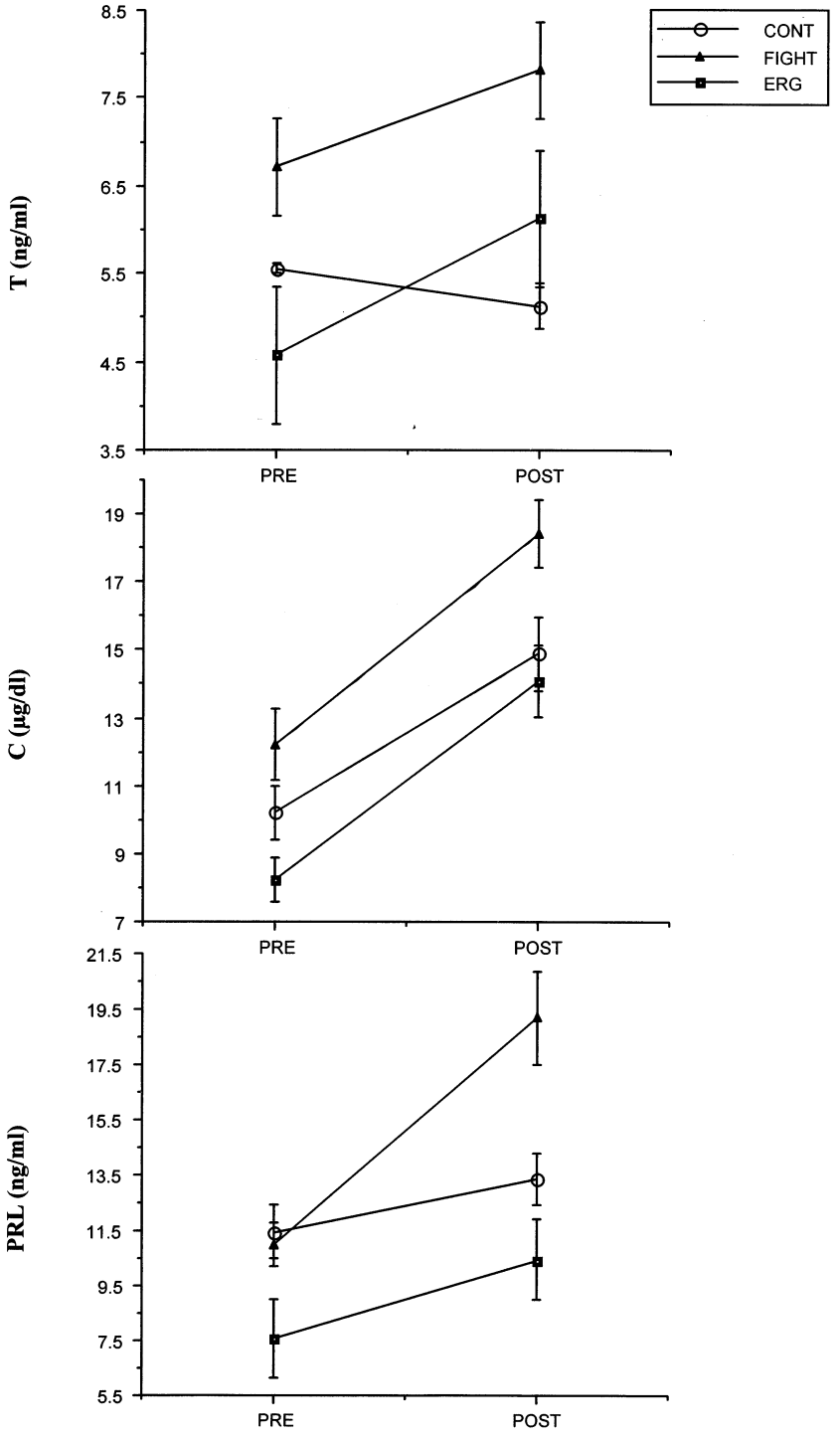

Fig. 1. Means and SEM of pre and post-combat levels of T, C and PRL in the three sessions (control, fight and ergometry).

3.2. Effects of outcome on the response to competition and role of physical exertion

There was a total of 14 fights, after which subjects were distributed into two groups: winners ($N = 14$) and losers ($N = 14$ for C and PRL, but 13 for T), in order to study the effects of victory and defeat. No significant differences between either group were found in the physical variables measured (Table 1).

3.2.1. Hormonal measures

Hormonal variations experienced by winners and losers in FIGHT are shown in Fig. 2. Anovas of repeated measures for each hormone in this session revealed that the main effect of 'moment' was significant for T ($F[1,25] = 30.85$, $P = .001$), C ($F[1,25] = 48.05$, $P = .001$) and PRL ($F[1,26] = 25.71$, $P = .001$), whereas 'outcome' was only significant for C ($F[1,26] = 4.11$, $P = .05$), winners showing higher levels than losers through all the session. The 'outcome × moment' interaction did not present significant effects.

Winners experienced a very homogeneous T response, with increases in 13 out of 14 judoists, whereas losers showed a greater variability, including increases and decreases (9 and 4, respectively). The χ^2-test indicated that the difference between patterns of winners and losers was statistically significant for T ($P = .03$). In contrast, C and PRL showed quite a uniform response, with increases in 92.86 and 82.14% of the subjects, respectively.

3.2.2. Physical effort measures in FIGHT

Winners and losers did not show significant differences in La_{max} measured in the competition (9.53 ± 0.84 and 10.42 ± 0.72 mmol/l, respectively). Neither vigor nor fatigue scales revealed any significant difference between groups, before or after the fight.

La_{max} was significantly correlated to C ($r = .37$, $P = .05$) and PRL ($r = .44$, $P = .02$) responses as well as to fatigue shown after the competition ($r = .53$, $P = .006$) when all subjects were considered.

3.2.3. Differences in the hormonal response to competitive (FIGHT) and non-competitive physical effort (ERG)

Non-significant main effect of 'session' on La_{max} was found. In addition, MANOVA for vigor and fatigue scores showed only significant effects of 'moment' ($F[1,21] = 7.18$, $P = .01$ and $F[1,21] = 10.61$, $P = .004$) but not of 'session'. Hence, we compared the hormonal response shown by winners and losers in both sessions (Fig. 3). Anovas of repeated measures by 'outcome' revealed non significant effects of 'outcome', 'session' and their interaction for T and C responses. For PRL response, the main effect of 'session' was significant ($F[1,26] = 24.89$, $P = .001$), a greater response was found in FIGHT in comparison to ERG.

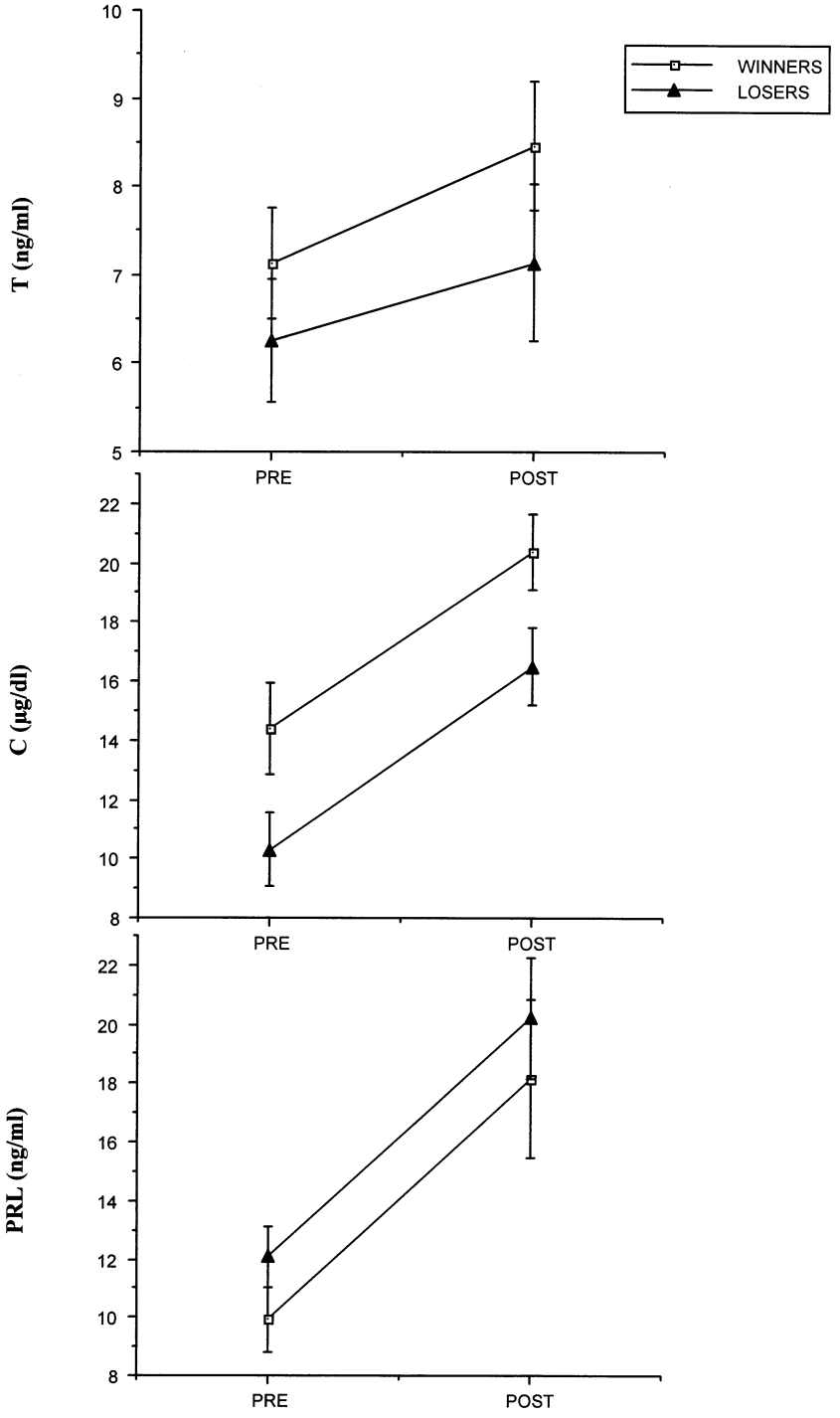

Fig. 2. Means and SEM of pre and post-combat levels of T, C and PRL in winners and losers.

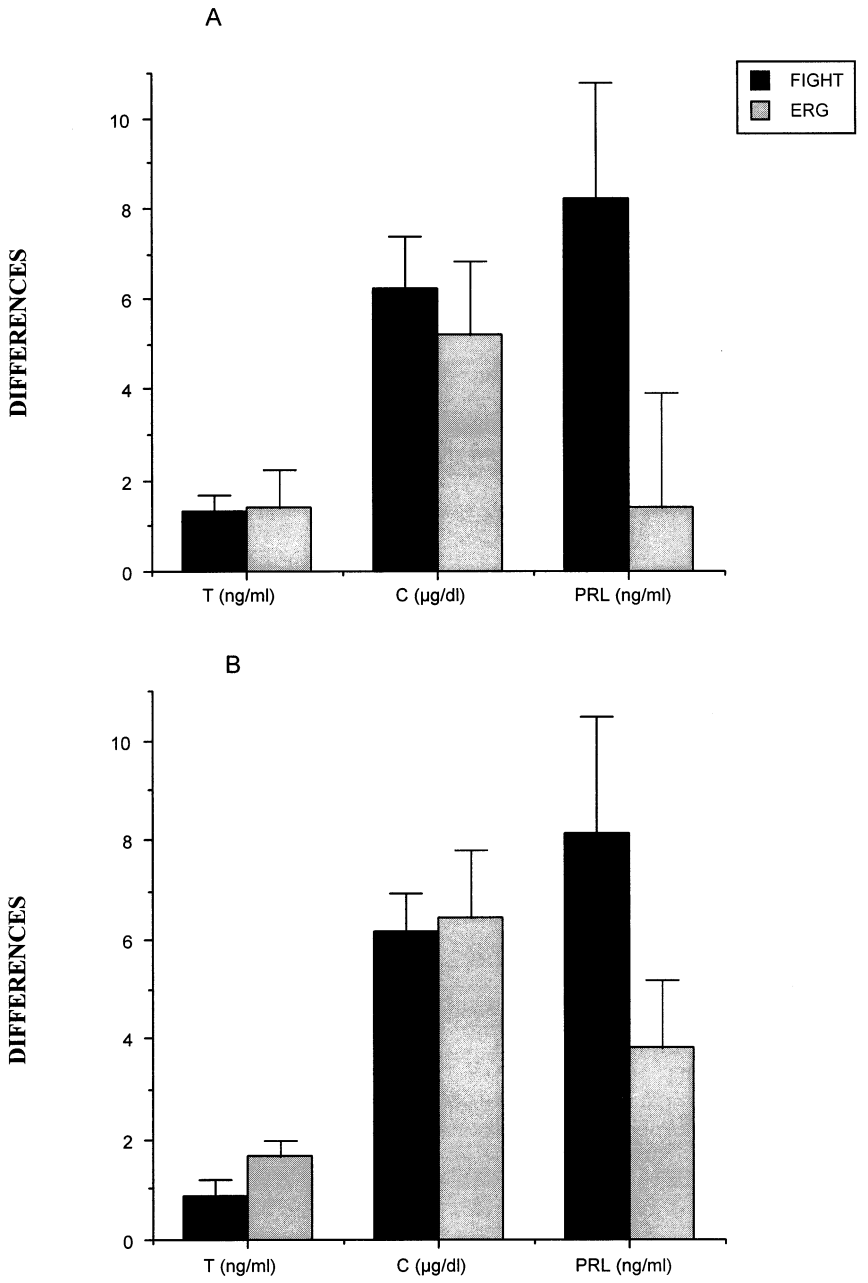

Fig. 3. Change scores of T, C and PRL in winners (A) and losers (B) in the FIGHT and ERG sessions.

3.3. Psychological measures and their relationships with hormonal response.

Before the competition, no statistically significant differences were found between winners and losers in motivation to win, although winners appraised themselves as more capable of winning ($F[1,26] = 10.62$, $P = .003$). Afterwards, winners felt more satisfied with their performance ($F[1,27] = 17.19$, $P = .001$) and with the outcome ($F[1,27] = 84.43$, $P = .001$) than losers.

Spearman-rank correlations were calculated between these item scores and the hormonal response in the competition. A positive correlation was found between motivation to win and T response ($r = .42$, $P = .03$) in the entire sample. In addition, in losers the appraised ability to win (self-efficacy) correlated positively with C response ($r = .59$, $P = .02$).

In order to analyse more deeply the role of mood in hormonal response, winners who felt good about winning and losers who felt bad about losing were identified based on their answers to the questions about self-appraisal of performance and satisfaction with the result (1–2 vs. 4-5 scores). Hormonal changes of both groups were compared, but no significant differences were found in either question.

4. Discussion

Higher T and C levels were found during the competition than in non-competitive physical effort and non-physical effort situations. These higher levels appeared before the events, confirming an anticipatory response of these hormones to competitive situations. Anticipatory C responses before different stressful events including muscular exercise and sports competitions have been described (Mason et al., 1973; Booth et al., 1989; Sutton et al., 1990). More recently, T rises in anticipation to competitive encounters have been reported, which have been related to a preparatory purpose (Booth et al., 1989; Mazur et al., 1992, 1997).

In addition, T increases in the competitive situation were slightly less than expected based on the response displayed in the non-competitive effort situation in spite of the same physical effort developed, which could be related to situational stress or, perhaps, to elevated basal levels. With regard to C, similar rises were found in the competitive and the non-competitive effort situations, but not in the non-effort session; although in this latter session there were important C increases showing that different stimuli (venipuncture, unknown site, investigators, tests, etc.) probably acted as important stressors which produced increases in the C concentration, and precluded the decrease in levels due to circadian rhythms. PRL showed increases of different magnitude in the three sessions; only when responses shown in the competitive and the non-competitive effort situations were compared, was a significantly greater response observed in the former situation, as could be expected due to the more stressful nature of the situation. PRL has been frequently linked with stressful experiences (it is often called a ‘stress hormone’), however, the findings that confirm this relationship are far from being unanimous. Increases in PRL were reported in response to severe stress such as hypoglycemia, physical

exercise or surgery (Noel et al., 1972) but more recently it has not been clearly associated with more commonplace stressors (Brooks et al., 1986; Semple et al., 1988; Malarkey et al., 1991). Curiously, more PRL and T levels were found to be associated with high rank position in men in a study with a small sample (Jeffcoate et al., 1986).

Subjects who resulted winners as well as those who lost displayed a similar motivation to win, although, before the competition, the winners showed higher self-efficacy than losers. After the fight, neither group was significantly different in the objective (La_{max}) and subjective (vigor and fatigue) measures of the effort impact, and, as was expected, the winners presented a higher appraisal of their performance and more satisfaction with the outcome obtained than losers. The effect of the outcome was statistically significant just for C, winners showing higher levels than losers. Similarly, Elias (1981) found higher post-competition C levels in winners in comparison to losers, although non significant differences have usually been reported (Salvador et al., 1987; Booth et al., 1989; Gladue et al., 1989; Salvador et al., 1990a; McCaul et al., 1992; González-Bono et al., 1999). PRL also rose during the competition, no differences being presented in function of the outcome.

Concerning T, our results did not show significant differences between changes experienced by winners and losers in the competition as would be expected from Mazur's biosocial theory (Mazur, 1985). Other studies have found significant T differences depending on the outcome (Elias, 1981; Gladue et al., 1989; McCaul et al. 1992) using a similar period to that used here, which has been considered optimum to detect T changes after psychological stimulation (Hellhammer et al., 1985). It must be pointed out that various previous studies (Mazur and Lamb, 1980; Elias, 1981; Booth et al., 1989) used less conservative statistical tests than the ones used here. Moreover, other studies were carried out in the early afternoon (Gladue et al., 1989; McCaul et al. 1992) with more stable and lower values of T than those obtained in the morning (Dabbs, 1990), which may also be contributing to the results. Fasting has been suggested to be a confounding variable, which could explain the lack of effects of winning/losing on T levels (Booth et al., 1993). In the present study, however, the lack of differences between winners and losers was not attributed to fasting; no judoist restricted their food and water intake the day before or the day of competition to compete in the lowest weight class since, as is described in Section 2, subjects were matched at the beginning of the study.

In our first study on this topic (Salvador et al., 1987) we did not find significant differences in T between winners and losers and suggested that perhaps our results might have been due to the fact that no important prize or reward was at stake; that is, subjects were not participating in a competition with change of status (championships). In both cases, we have studied judo fighters who are used to competing and do not easily accept a defeat; thus, they did take the matches seriously. In the first study, subjects received money: a small but significant amount for them (before they were consulted about this); this prize was eliminated in this study, because money is a very rare circumstance in judo competitions; however, on this occasion there was an audience fundamentally composed of friends and

members of the clubs involved who produced a 'heat' environment. Judo combats were videotaped which also increased their involvement, and a great competitiveness was observed (they are mostly black-belt judoists belonging to a similar sports category who frequently compete against each other in national and regional championships). In our opinion there was a high degree of motivation to win, ego-involvement and competitiveness. In a recent study involving professional basketball players in a real match of the League, we found significant effects of outcome on mood and satisfaction but not on endocrine response (González-Bono et al., 1999). Several studies have shown no strong effects of outcome on T (Booth et al., 1989; Mazur et al., 1992, 1997) as well as a minor role of mood in these effects (McCaul et al., 1992; González-Bono et al., 1999; Serrano et al., unpublished data) than have previously been suggested (Mazur and Lamb, 1980). In the present study, the lack of differences between winners and losers in T were maintained when both groups were selected in function of their satisfaction with the result or their appraisal of performance.

On the other hand, it is worth noting that T increases in the competition displayed by most of winning and losing judoists coincide with rises after intense, short bouts of physical effort such as those shown in the ergometer test and as has been reported in the literature (Kraemer et al., 1990; Schwab et al., 1992). In winners, the androgenic response was fairly uniform, whereas losers showed greater variability: only one winner displayed no T changes, whereas four losers presented reductions. These decreases were not justified by the physical effort developed, so other factors may be related. Some findings suggest that subjective processes about the outcome (causal attribution of outcome and self-appraisal of performance) play a more important role in hormonal responses than the fight outcome in itself (González-Bono et al., 1999; Serrano et al., unpublished data).

According to the biosocial theory, heightened T produces increases in competitiveness and dominance behaviour (Mazur, 1985; Mazur and Booth, 1998). In our case, we did not use specific competitiveness measures but we asked about the motivation to win, which showed a positive relationship with T increases. This result supports a relationship between T response and interest to win a competitive interaction, which coincides with previous findings relating T percent changes experienced in a judo fight to involvement and offensive style assessed by coaches (Salvador et al., 1990a). In this line, some studies have emphasized the importance of subjects' enduring characteristics for the T response, such as type A (Berman et al., 1993) and personalized power motivation (Schultheiss et al., 1998). With regards to C, only in losers changes in this hormone correlated positively to self-efficacy to win, that is, the more self-efficacy, the more C increases in subjects who lost. Complex psychological processes related to perception and experience with the defeat obtained could be modulating these relationships.

In sum, we have found significant effects of the competitive situation on hormonal levels, especially characterized by an anticipatory response to contest. In regard to the influence of outcome, our results showed significant effects on satisfaction but not on endocrine response: C showed higher levels in winners than in losers during all the competition, whereas T and PRL presented similar increases

in both groups. Our interest in including PRL, not previously studied in relation to this issue in humans, required blood determination, which probably contributed to the hormone response to stress found in the control session. This study was mainly designed to control for the effects of physical exertion on the hormonal variations due to outcome which appear after a sports contest. Our results show that when there were no differences in this exertion between winners and losers, no variations in T response, and in C and PRL, were observed. It is not possible to know if in the studies which found differences in hormonal response, these were due to a different degree of physical effort developed. It is worth noting that some significant differences between winners and losers' T levels have been reported after tasks without physical effort (Gladue et al., 1989; Mazur et al., 1992; McCaul et al., 1992) although these were small and less important than the effects on subjective variables. In addition, other aspects (importance of the tournament, clear or close outcome, etc.) influenced them, suggesting the complexity of this subject and the mediation of a number of variables (related to characteristics of the situation and subjects). Finally, the relationships between hormonal changes, and motivation and self-efficacy suggest that these aspects play a more important role in T and C responses than the outcome in itself and emphasize the importance of taking into account both state and trait psychological aspects in order to better understand the response to competitive situations.

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