

In tennis matches, different T responses, depending on the outcome, were noted in relation to mood and status changes, although results were not statistically different [Booth et al., 1989; Mazur and Lamb, 1980]. Gonzalez-Bono et al. [1999] reported no significant different T and C responses depending on the outcome during a real basketball match. However, they suggested that T changes were in relation to the contribution the individual makes to it and to the causes he attributes. This last suggestion is in agreement with the statement made by McCaul et al. [1992] about the complexity of the relationship among mood, behavior, and hormones. In the same way, Williams et al. [1982] reported that the athlete's behavior pattern (Type A vs. Type B) influenced C values after performing cognitive tasks. Moreover, it has been shown that behavioral responses to stressful stimuli take account of coping strategies [Rivolier, 1987]. According to Ursin [1988], coping depends on a positive response outcome expectancy, which again depends on a high perception of control. Two types of coping strategies can be used when confronting an adverse event [Lazarus and Folkman, 1984]: emotion-focused strategies and problem-focused strategies, which can have an impact on performance [Scanlan et al., 1991]. It would therefore be interesting to find out the differences in coping strategies that can appear between losers or winners in competitive sport and that could therefore explain the different hormonal responses between losers and winners. We have chosen the "Ways of Coping Checklist" [Paulhan et al., 1994] to evaluate the coping. This coping scale assesses five specific factors (solving problem factor, avoidance with wishful thinking factor, seeks social support factor, positive reevaluation factor, and self-blamed factor) that gather emotion-focused strategies and problem-focused strategies. In addition to relationships between behavior and hormonal responses, there are some relationships between individual hormonal responses and trait anxiety level [Diamond et al., 1989; Filaire et al., 1999], which could explain the lack of consensus on the research about outcome and hormonal changes. All these results suggest that victory or defeat, as well as the participant's personality (particularity traits linked with stress response), must be taken into account when investigating an athlete's endocrine response during a competition. In the present study, we investigated the effects of outcome on T and C response and the relationships between hormonal responses and psychological aspects (such as the anxiety level, pattern behavior, and coping strategies) in a real judo competition among men. Our procedure employed a noninvasive technique for monitoring hormone levels (repeated samplings of saliva for T and C) before and after an official judo competition (regional championships). Judo was chosen because of the control of aggressiveness this sport requires and the status change it imposes.

MATERIALS AND METHODS

Subjects

Eighteen male judo competitors at the interregional level (22.2 ± 1.6 years; 175.7 ± 2.2 cm; 74.1 ± 2.4 kg) entered the experimentation after informed consent. Their mean period of practicing this sport was 10 ± 3.2 years. Their technical level ranged between 1 and third Dan black belt. These athletes trained four times (8 hr) per week and were in good physical health. Their percentage of body fat was $12.4\% \pm 0.5\%$ (means \pm SD) estimated by the method of Durnin and Rahaman [1967] from skinfold thickness measurements. None of them took drugs or medication or had a history of endocrine disorders before or during this study.

Procedure

All participants entered the regional championships hoping to qualify for the national championships. The competition began at 12 AM and finished at 5 PM. The mean time of fight per

athlete was 188 ± 20.5 sec. Judo athletes were classified as winners or losers according to an objective performance criterion based on the number of winning fights. Considered as winners, were judo athletes who won three fights. Athletes were considered as losers if they lost their second fight. Each fighter had two to four fights. There were nine winners and nine losers.

Hormonal assay. Three saliva samples were taken during a resting day (24 hr without training) that took place 3 weeks before the competition (period with no stressful situations) to get reference values at 8 AM (on wakening), 12 AM, and 5 PM.

Three saliva samples were collected the day of the competition according to the following schedule: on wakening (8 AM), 5 min before the beginning of the first fight (precompetition: 12 AM), and 5 min after the second or third fight (postcompetition) (Table I).

Subjects salivated directly into disposable tubes and within 5 min typically produced volumes of 2 ml, sufficient for subsequent preparation for radioimmunoassay.

Saliva samples, still in their collection tubes, were stored at -30°C . The assay of saliva T and C was carried out using the radioimmunological method following a technique routinely used and validated in our laboratory [Lac et al., 1993] (sensitivity: 15 pg, accuracy: 10.5%, intra-assay reproducibility: 6.1%).

Psychometric assessment. To evaluate the participant's type behavior and their trait of anxiety, four psychometric tests were used.

Trait scales of the "State-Trait Anxiety Inventory" (STAI-Y-2) were used 3 weeks before the competition, during a resting baseline period with no stressful situations, to measure participant's self-reported anxiety [Spielberger et al., 1989]. Trait anxiety is defined as the general tendency of an individual to be upset in stressful situations, or as the average level of anxiety during a longer period. It is considered a personality trait. The scale includes 20 items. Responses to each item are on a scale ranging from 1 (not at all) to 4 (very much). The pattern of behavior was evaluated during the same period using the Bortner Test [Bortner, 1969]. This scale contains 14 items consisting of two behavioral extremes, Type A and Type B. Participants rated themselves on a 24-point scale on each of the 14 items, and the points on each of the 14 items were summed. Type A behavior is motivated by an intense need to maintain personal control over the environment. Those displaying Type A behavior are ambitious, impatient, react to frustration with hostility, and feel pressured for time [Jenni and Wollersheim, 1979]. Moreover, behavior Types A

TABLE I. Means \pm SE of Cortisol (C) and Testosterone (T) Concentrations 3 Weeks Before the Competition (Resting Day) and During the Competition (8 AM on Wakening; Precompetition: 12 AM; Postcompetition: 5 PM) in Winners and Losers

	Resting day		Competition	
	Losers (n = 9)	Winners (n = 9)	Losers (n = 9)	Winners (n = 9)
T, pmol/l ⁻¹				
8 AM	572.3 \pm 21.2	562.7 \pm 18.7	568.3 \pm 30.8	542.9 \pm 28.7
12 AM	540.2 \pm 21.4	536.4 \pm 8.6	589.0 \pm 36.6	561.8 \pm 42.4
5 PM	515.8 \pm 15.4	506.5 \pm 23.2	609.7 \pm 26.7*	510.5 \pm 23.3
C, nmol/l ⁻¹				
8 AM	14.8 \pm 1.3	13.9 \pm 1.5	20.1 \pm 0.9**	21.1 \pm 1.3**
12 AM	9.5 \pm 1.1	10.2 \pm 0.7	23.1 \pm 1.8***	23.2 \pm 1.3***
5 PM	4.1 \pm 1.0	4.8 \pm 0.8	21.5 \pm 2.1***	22.0 \pm 1.3***

* $P < .05$ compared with winners.

** $P < .01$ compared with the resting day.

*** $P < .001$ compared with the resting day.

and B differ in their psychophysiological responses during exercise, Type A's evidencing a greater neuroendocrine response (C) than Type B's [Hardy et al., 1989]. Type B's behavior pattern is defined as the relative absence of Pattern A characteristics. A person is classified as Type A when the global score is greater than 13.57 [Etienne and Fontaine, 1992]. This questionnaire has demonstrated a high order of replicability [Bortner, 1969].

Form Y-1 of the STAI was conducted 5 min before the first fight. This inventory assessed state anxiety and consisted of 20 items. State anxiety is defined as momentarily experienced anxiety. On the state scale, subjects indicate how they feel at the moment. The STAI has been shown to possess construct validity and has been found to be effective in sport settings.

Another sport-specific inventory was administered just before the first fight: the multidimensional "Competitive State Anxiety Inventory-2" (CSAI-2) [Martens et al., 1990]. This inventory is a self-report psychometric inventory of A-state consisting of 27 items. The CSAI-2 assesses two components of state anxiety, cognitive worry (cognitive A-state) and somatic anxiety (somatic A-state), and a related construct, self-confidence, with nine items representing each subscale. Examples of cognitive anxiety include "I am concerned about performing poorly" and "I am concerned that others will be disappointed with my performance"; somatic anxiety items include "my heart is racing and I feel nervous". Each subscale is rated on a scale from 1 = "not at all" to 4 = "very much so," relating to extremes of intensity. Thus, each subscale has a range from 9 to 36. Higher scores on cognitive and somatic anxiety indicate higher levels of anxiety, whereas higher scores on the self-confidence subscale correspond to higher levels of self-confidence. The CSAI-2 has been shown to have good internal consistency and construct validity [Martens et al., 1990].

Five minutes after the last fight, each judo athlete completed the "Ways of Coping Checklist" [Paulhan et al., 1994]. The coping inventory that was employed contains 29 scales, each scale having four items, scored on a 4-point Likert-type scale (1 = did not do this at all, 4 = did this a lot). The "Ways of Coping Checklist" has been shown to have good internal consistency and construct validity [Paulhan et al., 1994].

Statistical Analyses

Means and standard errors were presented. Analyses of variance (ANOVA) of repeated measures, with outcome (winner/loser) as the between-subjects factor, were applied to hormonal levels. Differences among psychological components between losers and winners were evaluated using an ANOVA, and the Scheffe's post-hoc test was used to identify significantly different group means. Pearson correlations were performed to analyze relationships between variables. An alpha level of 5% was employed in all analyses. All statistical analyses were performed by Statview for Windows.

RESULTS

Hormones and Outcome

The mean C and T concentrations during the day of rest and during the competition are presented in Table I for winners ($n = 9$) and losers ($n = 9$). The C levels measured the day of the competition were significantly higher than the resting values (8 AM: $P < .05$; precompetition: $P < .001$; postcompetition: $P < .001$) in losers as well as in winners.

According to the outcome, no differences between winners' and losers' C concentrations were observed whatever the hour of taking.

The competition did not induce statistically significant increases in T levels in winners or losers. According to the outcome, significant differences between T concentrations in losers and

winners were observed in postcompetition ($P < .05$), the values noted in losers being greater. However, in losers, the differences between pre competition and postcompetition were not statistically significant.

Anticipatory Response to Competition

The C levels were significantly higher before the competition (12 AM) ($P < .001$) in winners as well as in losers compared with the resting day. No significant differences were found on T.

Psychometric Variables

Psychometric variables in the investigated men are presented in Table II. Winners were characterized by Type A behavior and by greater trait anxiety level than losers, whereas Type B characterized losers. State anxiety level and cognitive anxiety just before the competition were significantly higher in losers.

Concerning the coping, self-blamed factor, wishful thinking avoidance factor, and social support approbation factor were significantly higher in losers, whereas positive reevaluation factor was higher in winners (Table II).

No correlation was found between hormonal and psychological variables.

DISCUSSION

Our results showed that there was no significant effect of winning or losing on C levels. This finding replicated early reports [Salvador et al., 1987; Booth et al., 1989; McCaul et al., 1992; Gonzalez-Bono et al., 1999]. On the other hand, data here demonstrated that the judo competition led to a strong response of C, as shown by the values noted, whatever the hour of taking and

TABLE II. Means \pm SE of the STAI-Y2 and Behavior Pattern Obtained During the Resting Period, of the STAI-Y1 and CSAI Components Obtained Just Before the First Fight, and of the Coping Strategies Obtained Just After the Last Fight[†]

	Losers (n = 9)	Winners (n = 9)	General population
Y-2 (trait anxiety)	35.2 \pm 1.3	42.3 \pm 1.4*	38.0 \pm 1.2 ^a
Behavior pattern (Bortner)	12.1 \pm 0.8 (Type B)	15.1 \pm 0.6* (Type A)	12.8 \pm 2.8 ^b
Y-1 (state anxiety)	45.7 \pm 1.7	38.2 \pm 1.3*	27.9 \pm 1.8 ^a
Somatic A-state/28	13.0 \pm 0.7	14.2 \pm 1.4	11.2 \pm 1.5 ^c
Cognitive A-state/28	16.0 \pm 1.2	11.2 \pm 0.9*	13.6 \pm 2.8 ^c
Self-confidence/36	16.2 \pm 1.3	22.0 \pm 1.5*	30.3 \pm 3.5 ^c
Types of coping strategies			
Solving problem factor/32 (problem-focused strategies)	20.1 \pm 3.7	21.66 \pm 2.5	24.7 \pm 8.3 ^d
Self-blamed/16 (emotion-focused strategies)	13.7 \pm 1.3	8.9 \pm 1.1*	4.3 \pm 2.4 ^d
Avoidance/28 (emotion-focused strategies)	20.2 \pm 0.9	14.4 \pm 1.1*	12.8 \pm 5.3 ^d
Social support approb/20 (emotion-focused strategies)	14.5 \pm 1.2	10.2 \pm 1.0*	8.8 \pm 3.6 ^d
Positive reevaluation/20 (emotion-focused strategies)	11.5 \pm 1.5	15.2 \pm 0.8*	12.7 \pm 5.9 ^d

[†]For comparison, general population values are listed.

* $P < .05$ compared with losers' scores.

^aFrom Diamond et al. (1989).

^bFrom Pichot et al. (1977).

^cFrom Davids and Gill (1995).

^dFrom Vitaliano et al. (1985).

whatever the outcome of the competition. It showed that C is related more to “situational” stress and arousal than to status changes [Hubert and De Jong-Meyer, 1992]. In fact, the C increases linked to exercise are well known. In particular, the more exhausting the exercise, the higher is the increase. During judo competition, the energetic component is rather low, as is the case in numerous sports consisting of short-duration bouts of exercise. In this study, the mean time of fight per athlete was 188 ± 20.5 sec; therefore, the amount of work was too low to provoke a high response of C after the last fight (postcompetition level) as noted here: about five-fold resting values (Table I). We have also to note that on wakening (8 AM) as well as at precompetition (12 AM), judo athletes’ salivary C level was elevated, which is similar to findings by Passelergue and Lac [1999], meaning that the psychological arousal linked to these conditions acts on the hypophyso-pituitary-adrenal axis (HPAA). Evidence supporting the influence of this axis activation was that judo fights were below the threshold to elicit an exercise-related HPA response.

The T levels during the competition observed at 8 AM and 12 AM were not different than those noted on the resting day, whatever the outcome (Table I). Recently, Suay et al. [1999] noted that T rises in anticipation to judo competition, confirming an anticipatory response of this hormone. The lack of anticipatory T responses in our study could perhaps be related to elevated basal levels. Even if our results did not show significant differences between changes experienced by winners and losers at the beginning of the competition, the T values after the last fight were significantly greater in losers than those obtained in winners. This result is in the opposite direction to several other studies. In fact, most studies in competitive situations found significantly greater T increases in winners [Elias, 1981; Mazur et al., 1992]. It was also the case in a time reaction task that was manipulated by the experimenter [Gladue et al., 1989]. The biosocial hypothesis [Mazur, 1985; Mazur and Booth, 1998] suggests that there is a feedback between T level and the posterior efforts to improve or maintain the social status. According to this theory, 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. In our study, the numbers of winners and losers were small, which can explain the differences with the literature. Moreover, contrary to our survey, which took place during regional championships, most of studies were carried out during a nonreal competition, which can also explain the differences of results. The different number of fights between losers and winners (one to four) may have possible influence on the T responses. One can also put forward the hypothesis that psychological factors like anxiety components and coping strategies could influence the T responses in winners as well as in losers.

Consistent with the findings of Mahoney et al. [1987] and Martens et al. [1990], we found that better performance was associated with significantly lower levels of cognitive anxiety or higher levels of confidence. We also noted that trait anxiety was higher in winners than in losers. Griffiths et al. [1979] and Taylor [1987] showed a relationship between task characteristics and optimal anxiety. It has generally been accepted that tasks requiring greater explosive strength like judo would be best performed with a greater trait anxiety than tasks requiring precision and balance. Many researchers have investigated the relationship between anxiety and performance, and different theories have tried to resolve this relationship (Inverted U Theory, Zones of Optimal Functioning [ZOF], Multidimensional Anxiety Theory, or the Catastrophe Model). Inverted U Theory indicates that there is an anxiety range where performance is optimized but the optimal anxiety level should always be moderate, whereas ZOF research demonstrates that the optimal anxiety level of some athletes, regardless of the sport, can be low or high. The Multidimensional

Anxiety Theory posits that cognitive state anxiety is negatively related to performance, and somatic anxiety follows an inverted U shape. Myung Woo Han [1996] showed that the Catastrophe Model is the most appropriate model among current theories to explain the relationship between anxiety and performance in judo. The Catastrophe Model argues that performance is the result of the interaction of arousal and cognitive anxiety [Hardy, 1990]; the capacity of the athlete to manage or control cognitive state anxiety and the control of the situation (coping) being also necessary. Crocker [1989] noted that competitive athletes use a wide range of cognitive and behavioral strategies to manage stress. The problem-focused strategies seemed to be preferable to emotion-focused strategies to be successful. Pensgaard and Ursin [1998] hypothesized that high degree of perceived control was associated with high satisfaction with performance. In our study, we noted that there were significant differences between the specific types of coping strategies in relation to victory or defeat. It has also been demonstrated that the participant's personality and his/her psychological reaction to a situation affects the hormonal response [Voigt et al., 1990]. We noted that winners were characterized by Type A behavior, whereas Type B defined the losers (Table II). This result accords with the study of Pantelidis [1996], who showed that the best performances in tennis are achieved by players characterized by Type A behavior. Type A behavior is sometimes associated with problem-focused strategies [Vingerhoets and Flohr, 1984], but the results are the subject of debate [Kliwer, 1991]. In our study, no relationships between the type of coping strategies and type A behavior were found. Moreover, contrary to previous studies [Filaire et al., 1999], we noted no relationships between winner's or loser's behavior patterns and hormonal responses during competition.

Although data in the literature concerning the relationship between hormonal responses and outcome are available, our results are different because our study was carried out among men during a real competition (regional championships), whereas most of the previous results are based on research in noncompetitive situations or under experimental manipulation. This may explain the different results found in our study. We have found significant effects of the competitive situation on C levels, especially characterized by an anticipatory response to contest. It was not the case for T. In regard to the influence of outcome, our results did not show significant effects on C responses. Concerning T, our results showed significant differences between changes experienced by winners and losers after the last fight. But, our results are in the opposite direction to those found in several other studies. The small number of athletes in our study did not permit more discussion of this result. In addition, other aspects (importance of the championships, characteristics of the subjects, anxiety level, coping strategies) may influence the hormonal responses, even if no relationships were found in this study between these factors.

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