Heart rate variability, salivary cortisol and competitive state anxiety responses during pre-competition and pre-training moments

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ABSTRACT: The study aimed to investigate physiological and psychological states prior to competition and prior to training in three different demanding activities. Eighteen canoe athletes, 18 street runners and 18 jiu-jitsu fighters were included in this study (n=54). The Competitive State Anxiety Inventory-2 (CSAI-2), salivary cortisol and heart rate variability (HRV) were measured at two time points (pre-training and pre-competition). Somatic anxiety ($F_{1,42} = 15.29$, $p = 0.0003$), HRV ($F_{1,42} = 23.24$, $p < 0.0001$) and salivary cortisol ($F_{1,42} = 22.96$, $p < 0.0001$) were significantly greater at the pre-competition measurement point than at the pre-training point, but without a main effect of the type of athlete on these variables. A main effect of the type of athlete was found on somatic anxiety ($F_{2,42} = 6.58$, $p = 0.0033$), cognitive anxiety ($F_{2,42} = 10.69$, $p = 0.0002$) and self-confidence ($F_{2,42} = 5.42$, $p = 0.0080$). Correlations between most CSAI-2 and physiological parameters were not significant ($p > 0.05$). In conclusion, the results indicated that both emotional indices and psychophysiological indices of stress are higher before competition than before training, with differences between emotional states between these sports. Although correlations between emotional states and psychophysiological states before competition and before training were largely non-significant, these findings reinforce the importance of psychological monitoring of athletes in association with traditional physiological markers such as cortisol and HRV in sportive training programmes as complementary resources to improve both competition performance and the training routine.

INTRODUCTION

The moments immediately prior to training routines and sports competitions and their influence on performance are of great interest to researchers, mainly due to the behavioural process and emotional aspects, such as stress and anxiety [1]. The preliminary studies of the 1970s and 1980s indicated that athletes with high levels of anxiety in competitive situations exhibited negative effects on performance [2, 3]. In the 1990s, the development of psychometric questionnaires such as the "Competitive State Anxiety Inventory-2" (CSAI-2) [4] made it possible to categorize three different aspects of anxiety – cognitive anxiety, somatic anxiety and (lack of) self-confidence – which contribute to better understanding of this construct and its application.

Based on the multidimensional theory of sport anxiety, cognitive anxiety is defined as the mental component of anxiety and is caused by negative expectations about success or by negative self-evaluation. Somatic anxiety refers to the physiological and affective elements of the anxiety experience that develop directly from autonomic arousal. A third subcomponent is the individual difference factor of self-confidence. This encompasses the athlete's global perceptions of achievement [5].

Bearing in mind the complexity of people's emotional nature, it has been suggested that the concurrent administration of a psychological data and physiological analysis could be an adequate and more accessible monitoring system of the stress-recovery

state to optimize performances and results in many areas [6]. This topic is now being discussed in light of the monitoring of the autonomous nervous system (ANS) and salivary hormones [6, 7, 8, 9, 10, 11, 12, 13, 14].

Considering ANS behaviour during a stressful situation or anxiety is important to highlight the increase in sympathetic action and adrenergic discharge in anticipation of new challenges and preparing the organism for these [15]. With the use of HRV, it has been demonstrated that changes in the emotional state are associated with changes in parasympathetic and sympathetic activities such as decreased baroreflex sensitivity and sympathovagal index (LF/HF) [16], suggesting its use as a valid, practical and non-invasive way of assessing changes in anxiety and stress in human performance [17]. For instance, Morales et al. [6], who investigated stressful situations before judo competitions among international and national athletes, found that HRV analysis is sensitive to changes in pre-competitive anxiety. Mateo et al. [13] confirmed that HRV analysis provides a complementary tool to assess competitive pressure in the BMX cycling discipline and training programmes.

In response to stress, the levels of various hormones change. Of particular interest, it has been found that the plasma and salivary levels of cortisol can increase two- to five-fold during stress in humans [7]. Papacosta et al. [7] correlated salivary cortisol concentrations with responses to the CSAI-2 questionnaire and found that winning athletes had higher anticipatory cortisol concentrations compared to losers, suggesting that winners experienced higher levels of physiological arousal, higher psychological preparedness and better control of the stress response. Likewise, Filaire et al. [18] investigated the physiological and psychological states of tennis players on the day of the first match of a tennis tournament and found that the measurement of cortisol at the same time as self-report psychological indicators would provide an approach to examine changes in anxiety, and its relationship to performance.

In this context, significant correlations have been described between HRV changes [6], cortisol changes [7, 18] and anxiety states measured by the CSAI-2 and performance. However, there is still a lack of evidence supporting the association between these instruments and the data are controversial. It is as yet unclear how to integrate all the information from these tools for the benefit of athletes and their practical appliance in sports, enabling them to use their anxiety and stress states in their favour during training and competition. Moreover, it seems that the impact of the components of anxiety on performance is sport-dependent (anaerobic versus aerobic demand) [19], implying that the results for one type of sport cannot be extrapolated to another distinct sport modality, showing the specificity and differences between modalities. According to Rosa et al. [20], exercises at high intensity, with greater participation of the anaerobic metabolism and greater consumption of oxygen, tend to increase the oxidative stress, which in turn negatively affects the hippocampus and some other areas of the brain, which may cause an increase in anxiety. Thus, in an attempt to improve and modulate anaerobic and aerobic capacities, even during the training regimen (pre-competition moments), athletes are metabolically stressed in a similar way to that of competition (principle of specificity), which may distinctly affect their emotional states.

For the proposals of this study, we assessed three different sports types: 10k street runners (SR), canoe athletes (CA) and jiu-jitsu fighters (JF). In terms of physiological demand, it is important to note that SR require a higher aerobic contribution mainly for the lower limbs in a continuous period lasting from 40 min to 50 min [21]. CA require high values for maximal aerobic and anaerobic capacities and upper-body muscle strength (e.g., the aerobic contribution, expressed as a fraction of VO_2 max, was shown to be 73% for the 500 m and 85% for the 1000 m; lasting approximately 1 min 45 s and 3 min 45 s respectively) [22]. In contrast, JF can be characterized as an intermittent activity, where the athlete performs high-intensity efforts interspersed with recovery periods [23]. Intermittent activities above the anaerobic threshold tend to show progressive increases in O_2 deficit at each stimulus, resulting in greater anaerobic participation [24].

The literature suggests that activation of the hypothalamic-pituitary-adrenocortical (HPA) axis, with the release of cortisol, and ANS are particularly reflective of the affective component of the individual's experience [25]. This conceptual framework takes into account

TABLE 1. Descriptive data of participants (mean ± SD).

Variables	Canoe Athletes (n=18)	10k-Street Runners (n=18)	Jjiu Jitsu Fighters (n=18)
Age (years)	18.9 ± 1.35	21.12 ± 8.73	21.29± 4.50
Competition experience (months)	22.60 ± 12.64	34.5 ± 4.2	9.7 ± 7.0
Height (cm)	167.4 ± 8.8	174.5 ± 10.2	171.0 ± 7.7
Weight (kg)	65.5 ± 8.0	70.3 ± 9.9	74.0 ± 14.8
Body Mass Index (kg/m^2)	23.38 ± 2.43	23.02 ± 1.65	25.37 ± 4.53
Body fat (%)	18.3 ± 10.40	15.46 ± 7.72	24.33 ± 10.62

the modulating influence of individuals' characteristics as well as social support systems according to the biopsychosocial (BPS) model. A key concept is the individual's cognitive assessment, a process which involves weighing the importance and the severity of the demands against one's own coping abilities. This is especially relevant in situations inducing ego involvement, novelty, unpredictability and uncontrollability [26, 27]. Considering the athletes' reality, the competition and training routine tend to be a menacing task by potentiating innumerable extrinsic and intrinsic factors, triggering changes in the level of anxiety and physiological responses [28].

Although the literature [25, 26, 27, 28] suggests different relationships between HPA and ANS with affective states, little is known about such relationships in natural conditions such as pre-competition and mainly pre-training states. Therefore, the aim of this study was to evaluate the relationships between psychological (CSAI-2 indicators) and physiological responses (autonomic cardiovascular responses using HRV and salivary cortisol) at the moments immediately prior to training and competition in SR, CA and JF. To our knowledge, this is the first time that a study has examined the association between HRV, cortisol and responses to the CSAI-2 to clarify the anxiety and stress levels related to these individual sport modalities. It was hypothesized that: (i) state anxiety and stress generated mainly by competition alter cardiac autonomic functioning and cortisol levels; (ii) athletes in different sport modalities show psycho-physiological differences; (iii) the physiological and psychological measurement instruments present good correlations.

MATERIALS AND METHODS

Participants

In all, a convenience sample composed 54 male athletes was chosen to participate in this study (Table 1). All participants belonged to the same category and respective state confederations in their sport modalities: SR: 10 km race distance; CA: 500 m canoe sprint; and JF: purple belt and middle weight. Also, they were informed in advance of the nature of the research and gave their written informed consent. All procedures were approved by the University Research Ethics Committee and were carried out in accordance with the Declaration of Helsinki and Brazilian legislation on research involving human beings.

The participants were not taking any drugs or medications and had no history of endocrine disorders before or during this research (information collected by medical history – anamnesis). They were familiarized with the sampling and survey procedures 3 days prior to the actual testing.

Experimental design

The study consisted of two parts (measurements I and II in Figure 1). For both the pre-training and pre-competition measurements, the experimental procedures took 30 min. Approximately 10 min was reserved for completing the CSAI-2 questionnaire. HRV was obtained over a period of 15 min, with the participants in the supine position
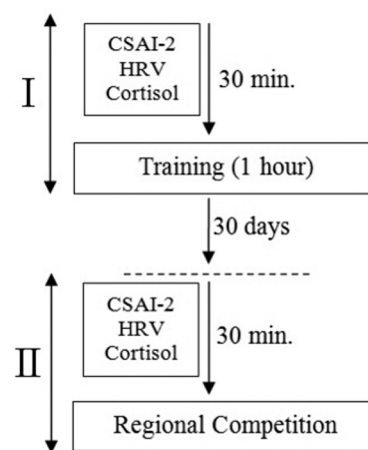

FIG. 1. Experimental design.
Note: I: pre-training measurement; II: pre-competition measurement.

and a head elevation of 30°. Then, salivary cortisol was taken. For all sport modalities, similar training demands and times before a regional competition were considered (training lasting 1 hour and 30 days before the competition). Competitions and training occurred at the same time of day (starting at 9:00-10:00 a.m.) and the level of importance of the competition from the athletes' point of view was very similar. For this purpose, a scale with three levels of importance of the competition was applied: preparatory competition, intermediate competition and the most important competition of the year. All participants indicated an intermediate competition.

Instruments

CSAI-2 anxiety questionnaire

The CSAI-2 was used to measure pre-training and pre-competition cognitive anxiety, somatic anxiety and self-confidence among the participants. The CSAI-2 comprises 27 items, with 9 items in each subscale. Participants were asked to rate the intensity of each symptom on a scale from 1 (not at all) to 4 (very much so), resulting in scores ranging from 9 to 36 for each subscale [4]. For the analysis, the scores were converted to percentages, such that a higher percentage indicates a higher level of anxiety [29]. This instrument shows homogeneity, reliability and sensitivity in measuring psychological characteristics in athletes [4, 29]. Satisfactory internal consistency for the intensity of the subscales has been reported previously with Cronbach alpha coefficients ranging from 0.79 to 0.90 [30].

HRV testing

For HRV testing, a Polar RS800CX monitor (Polar Electro OY, Finland) was used, with a humidified electrode positioned approximately at the sternum, at the level of the xiphoid process. All participants were asked to refrain from ingesting beverages containing caffeine or alcohol during the 48 hours preceding the tests. After an adaptation
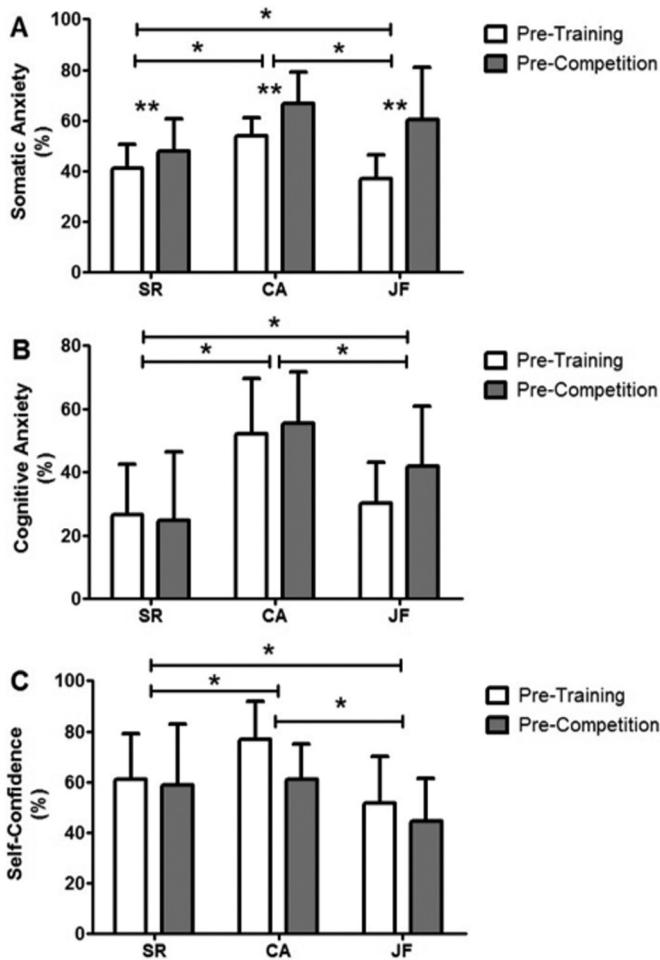
FIG. 2. Percentage scores for the Competitive State Anxiety Inventory-2 (CSAI-2) domains.
Note: A: Somatic; B: Cognitive; C: Self-Confidence. SR indicates street runners; CA indicates canoe athletes; JF indicates jiu jitsu fighters. *p < 0.05 differences between the athletes; **p < 0.05 pre-training compared to pre-competition.
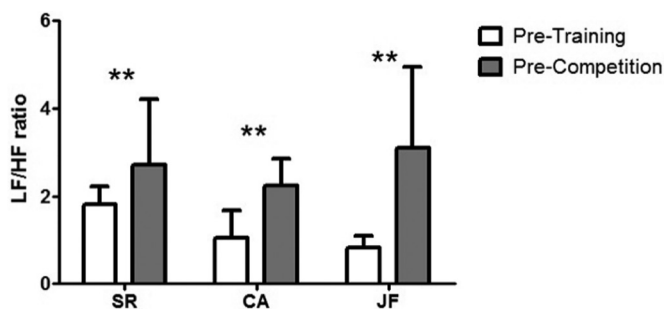

FIG. 3. LF/HF ratio.
Note: SR indicates street runners; CA indicates canoe athletes; JF indicates jiu jitsu fighters.
**p < 0.05 pre-training compared to pre-competition.

period of 5 min in supine decubitus, data acquisition was performed for 10 minutes in the same position, in the absence of noise and with no negative atmosphere. The participants were asked to remain silent and attempt to maintain their breathing rate as low as possible, without speaking or moving at all. The data collection was always performed by the same researcher, who maintained the same conditions for, and gave identical instructions to, all the participants [11].

The data obtained were transferred to an infrared interface Polar microcomputer, processed using the Polar Precision Performance software (Finland) and stored in a microcomputer for analysis. The data were subsequently exported to the Kubios HRV program (Biosignal Analysis and Medical Imaging Group, Kuopio, Finland), in which they were filtered according to the recommendations of the Task Force of Spectral Analysis from the European Society of Cardiology and the North American Society of Pacing and Electrophysiology [31].

The analysis of HRV in the frequency domain was performed using fast Fourier transform (FFT) in segments of 5 min with an interpolation of 4 Hz, overlapping by 50%. The bands of interest were low frequency (LF: 0.04–0.15 Hz), this component referring predominantly to sympathetic modulation and including also a vagal component, and high frequency (HF: 0.15–0.4 Hz), referring to parasympathetic modulation. The sympathovagal index (LF/HF) was calculated based on the normalized LF and HF values. Normalized units (nu) were obtained by dividing the power of a given component by the total power (from which the VLF was subtracted) and multiplied by 100 [15, 32].

Salivary cortisol

Salivary cortisol was obtained by passive drooling directly into a sterile glass tube to a level of 5 ml. All participants were asked to wash their mouths properly before sample collection. The salivary samples collected were centrifuged for 10 min at 2000 rpm in a refrigerated microcentrifuge (Novatecnica NT805, Brazil) and frozen at -20 °C until shortly before assay. During assay, the samples were thawed at 37 °C. The supernatant fluid thus obtained was used for cortisol estimation. Salivary cortisol was measured using an electrochemiluminescence immunoassay method (ECLIA) in a Cobas e411 autoanalyser (Roche Diagnostic, USA).

Statistical analysis

The results are expressed as means ± standard deviation (SD). The normal distribution of the data was confirmed before inferential analysis using the Kolmogorov–Smirnov test. Therefore, we applied a two-way analysis of variance (ANOVA) [athletes (3: CS, SR or JF) x measurements (2: before training or before competition)] to assess the effects of the type of athlete and the measurement points on the dependent variables related to anxiety (CSAI-2), HRV and salivary cortisol. When necessary, a post-hoc analysis (Bonferroni test) was performed. Also, Pearson's correlations (r) were calculated to verify

TABLE 2. Correlations between cortisol and LF/HF with CSAI-2 domains during pre-training and pre-competition.

CSAI-2	Pre-training		Pre-competition	
	Cortisol	LF/HF	Cortisol	LF/HF
Somatic	r = 0.14￼p = 0.53	r = -0.00￼p = 0.99	r = 0.21￼p = 0.35	r = -0.05￼p = 0.79
Cognitive	r = 0.02￼p = 0.92	r = -0.02￼p = 0.92	r = -0.05￼p = 0.80	r = -0.04￼p = 0.84
Self-Confidence	r = 0.11￼p = 0.63	r = -0.12￼p = 0.57	r = -0.47￼p = 0.02**	r = -0.14￼p = 0.50
Cortisol	–	r = 0.53￼p = 0.02**	–	r = 0.69￼p = 0.03**

Note: ** Pearson correlation (p<0,05).

RESULTS

CSAI-2

Two-way ANOVA showed a main effect of the measurement point only on somatic anxiety ($F_{1,42} = 15.29$, p = 0.0003), indicating a higher percentage for the pre-competition than the pre-training condition (pre-training: 41.31 ± 9.18 (SR), 54.02 ± 7.02 (CA), 37.0 ± 9.36 (JF) vs. pre-competition: 48.10 ± 12.60 (SR), 66.6 ± 12.57 (CA), 60.43 ± 20.48 (JF)), as shown in Fig. 2A. However, cognitive anxiety ($F_{1,42} = 0.76$, p = 0.3872) and self-confidence ($F_{1,42} = 2.65$, p = 0.1108) showed no differences between measurement points (pre-competition vs. pre-training). A main effect of the type of athlete was also found on somatic anxiety ($F_{2,42} = 6.58$, p = 0.0033), cognitive anxiety ($F_{2,42} = 10.69$, p = 0.0002) and self-confidence ($F_{2,42} = 5.42$, p = 0.0080), as illustrated in Fig. 2A–C. Pairwise comparisons showed that CA have higher somatic anxiety, cognitive anxiety and self-confidence than SR and JF, regardless of the measurement point. Also, JF showed higher somatic and cognitive anxiety than SR. Finally, SR showed higher self-confidence than JF (Fig. 2).

HRV

Two-way ANOVA showed a main effect of the measurement point on the LF/HF ratio ($F_{1,42} = 23.24$, p<0.0001), indicating a greater value in pre-competition than in the pre-training period (pre-training: 1.81 ± 0.40 (SR), 1.05 ± 0.63 (CA), 0.81 ± 0.26 (JF) vs. pre-competition: 2.72 ± 1.47 (SR), 2.23 ± 0.61 (CA), 3.10 ± 1.84 (JF)). However, no such effect was found for the type of athlete ($F_{2,42} = 1.41$, p = 0.2555) (Fig. 3).

Cortisol

Two-way ANOVA showed a main effect of the measurement point on salivary cortisol ($F_{1,42} = 22.96$, p < 0.0001), indicating a great-er concentration for the pre-competition than the pre-training condition (pre-training: 5.45 ± 2.12 (SR), 4.77 ± 1.73 (CA), 3.65 ± 1.66 (JF) vs. pre-competition: 8.06 ± 2.26 (SR), 7.37 ± 4.81 (CA), 9.91 ± 2.68 (JF)). However, no main effect was found for the type of athlete on salivary cortisol ($F_{2,42} = 0.34$, p = 0.7144) (Fig. 4).

Correlations between measures

Table 2 shows the Pearson's correlation (r) values for the CSAI-2 domains, salivary cortisol and the LF/HF ratio at the pre-training and pre-competition measurement points. Only cortisol concentration and self-confidence were significantly negatively correlated at the pre-competition measurement point. All other comparisons showed weak correlations and were not significantly correlated (p > 0.05).

Pearson's correlation (r) values for the salivary cortisol and the LF/HF ratio at the pre-training and pre-competition measurement points are also presented in Table 2. These comparisons showed moderate correlations and were significantly correlated (p < 0.05).
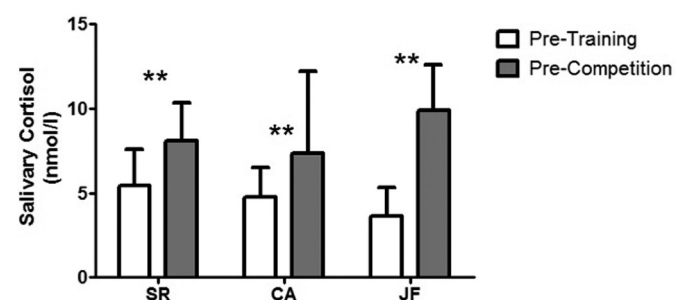

FIG. 4. Salivary cortisol concentrations.
Note: SR indicates street runners; CA indicates canoe athletes; JF indicates jiu jitsu fighters.
**p < 0.05 pre-training compared to pre-competition.

DISCUSSION

This investigation provides insights into the physiological and psychological status at two important moments in athletes' routines (pre-training and pre-competition). To our knowledge, this is the first study involving SR, CA and JF from this perspective. The initial hypothesis that the moments immediately preceding training and competition promote different physiological and psychological responses was confirmed by the cortisol level and the LH/HF ratio, as well as the somatic anxiety results, regardless of the type of athlete. On the other hand, only psychological anxiety aspects differed between the modalities and there were no good correlations between CSAI-2 indicators and physiological variables.

Some studies have reported increases in stress and anxiety levels close to competition [11, 33, 34]. Comparing the nature of competition with the nature of training, it is reasonable to assume that competition requires greater and usually maximal physiological demands associated with other psychological factors, such as the prestige of winning the competition and the challenge from other athletes, which could explain higher values for cortisol, the LH/HF ratio and somatic anxiety prior to competition. Analysing our results concerning anxiety, it has been described that intensity of both cognitive anxiety and self-confidence remain stable in the week preceding a competition whilst somatic anxiety is proposed to remain stable a few days prior to the event but show a sudden rise and reach a peak at the onset of the competition [4]. Also, it is interesting to note that values for cortisol, the LH/HF ratio and somatic anxiety during the pre-training period are compatible with a low to moderate level of stress and anxiety [16, 17], suggesting that training also promotes anticipatory psychophysiological changes.

The anxiety responses of athletes could be modulated by the specific requirements of the task demands of the sport [4]. Questionnaires/assessment scales such as the CSAI-2 are an attractive strategy to gauge training stress and readiness, since they are non-invasive, inexpensive, and easy to understand [35]. In this study, the main effect of the type of athlete was shown only using the CSAI-2 instrument. As illustrated in Fig. 2, CA show higher values for all anxiety parameters than SR and JF, regardless of the measurement point. Although some meta-analyses have already investigated the relationship between the CSAI-2 and sport performance in individual athletes, such as running, karate and judo [5,38], which show some similarity with the street runners and jiu-jitsu fighters studied in the present study, in practical terms, most of the published studies using the CSAI-2 investigated anxiety and stress in collective sport modalities. Also, we did not find any study that has applied the CSAI-2 instrument in canoeists. It has been argued that several factors, such as sport modality, measurement and individual differences, could influence the results obtained by the CSAI-2 [19, 36,37,38].

Thus, the anxiety effects of the type of athlete were considered to relate to at least two conditions: perceived stress of the performance task [28] and accumulated fatigue or anaerobic metabolism [20]. CA athletes need intense focus to coordinate their line, pace and execution with the water flow and gate location and climate aspect (e.g., speed wind), and they usually are involved mainly with anaerobic training (easily fatigable) [21]. We speculated that all of these factors combined could affect more than simply a flight-or-fight response compared with SR and JF. JF showed higher somatic and cognitive anxiety than SR, while SR showed higher self-confidence than JF. This may be because running is a more usual activity and transmits higher confidence than fighting an unknown opponent, generating lower anxiety. According to Spielberger [26] and Friedman [27], anxiety and anticipatory anxiety are directly affected by situations related to unpredictability and uncontrollability, which are more common in JF than SR. These findings suggest the importance of psychological monitoring of athletes and the need to include the variables tested in a psychological training programme. According to Doan et al. [39], monitoring seasonal data from individual athletes and their ability to cope with the anxiety level associated with the playing venue, together with their hormonal and behavioural interactions, could help in individualizing training and devising management strategies.

It has been described that the stressors (e.g., psychosocial and physical stress) mainly related to development of negative emotional states could affect distinct emotional and physiological responses in athletes anticipating sport competition. Also, there is a link between these negative emotions (e.g., anxiety) and biological responses generated by the ANS and HPA [40]. One of the key challenges in investigating the psychosocial effects of sport competition is understanding the relationship between anxiety and physiological markers.

HRV has been used as an important marker of the cardiac modulation of the sympathetic and vagal components of the ANS. In particular, monitoring this activity using the LF/HF ratio could be useful for tracking stressful situations related to higher values of this ratio [8,14]. In this study, no impact of the type of athlete on HRV values was found, but – as hypothesized – higher stress was indicated by the LF/HF ratio in the period prior to competition than that preceding training. Other studies have also found sympathetic activity when faced with stress situations indicated by an increase in percentage LF/HF parameter values [41]. Cervantes Blásquez [14] found around a 2.5-fold increase in percentage LF/HF values in the competition condition versus the training condition, suggesting, in agreement with other authors [42], a predominance of sympathetic activity over parasympathetic activity in stress situations such as sports competitions.

Based on the salivary cortisol responses observed in this study, the results also indicate that there is greater emotional stress in the pre-competition period than in the pre-training period. These data are in agreement with other previous studies of judo fighters [43, 44] and tennis players [18]. Elevations in cortisol concentrations have been noted in response to levels of stressors or physical exertion, and thus it has been suggested that the more exhausting the exercise is, the greater is the increase in cortisol [45]. Although this study did

not undertake measurements during physical effort itself, the apparently anticipatory rise in cortisol suggested that the hormonal changes were related to the contribution that the moment immediately preceding training or competition makes to such effort. This assumption can be related to the complexity of the relationship between mood, behaviour and hormones [43]. In a recent study, Chennaoui et al. [46] postulated that the stress of competition could trigger a negative mood profile, which corresponds to different responses of biomarkers related to the hypothalamo–pituitary–adrenal axis altering cortisol concentrations.

The relationship between the CSAI-2 indicators and physiological parameters (HRV and cortisol) did not demonstrate similar behaviours in this study. These results are consistent with the study of McKay et al. [47], which showed that the highest cortisol response was measured prior to the commencement of play, whilst state anxiety measures did not change significantly during golfing rounds. However, it is important to bear in mind that in the present study the participants rested for 15 min to obtain HRV data, which may have minimized anxiety and could be one factor that reduced the correlation between these three variables when anxiety measured by CSAI-2 was determined before HRV and cortisol. Univariate and multivariate analyses failed to reveal significant correlations between the psychophysiological variables. However, moderate correlations have been found in several studies investigating hormone levels [18, 47, 48] and the use of HRV [5,12], indicating that the neuroendocrine response and anxiety are related. In this study, only cortisol concentration and self-confidence were significantly negatively correlated immediately prior to competition (r = -0.47), suggesting, based on the level of cortisol, that athletes may experience a reduction in their self-confidence, which thus negatively affects their performance. As expected, moderate correlations (r>0.50) were found when correlating physiological parameters (HRV and cortisol) in both pre-training and pre-competition situations. The sympatho-adrenal medullary (ANS) and hypothalamic-pituitary-adrenocortical axes (cortisol synthesis) are the primary systems for the maintenance or reinstatement of homeostasis during stress, so that the respective contribution of the neuroendocrine and autonomic systems is tuned in accordance with stressor modality or intensity [49].

The limitations of the present study include: (i) the lack of evaluation of basal measures of psychophysiological indices, which does not allow to consider our basal measures as an anticipatory response, but only measures before the events; (ii) the participants were not asked if they had stressing events before the competition or during the days before; and (iii) the performance of these athletes was not evaluated. Could these changes in both variables evaluated in the precompetitive period in relation to the pre-training period have a negative effect on these athletes in terms of the result at the end of the competition? What are the impacts of these changes found in HRV, salivary cortisol and somatic anxiety at different times and in athletes of different modalities? Future investigations are necessary to answer these questions. Also, a long-term study could associate these variables with physical training intervention as a new possibility of monitoring loading training, favouring for instance the prevention of non-functional overreaching and overtraining.

CONCLUSIONS

In conclusion, the results indicated that both emotional indices and psychophysiological indices of stress are higher before competition than before training, with differences between emotional states between these sports. Although correlations between emotional states and psycho-physiological states before competition and before training were largely non-significant, these findings reinforce the importance of psychological monitoring of athletes in association with traditional physiological markers such as cortisol and HRV in sportive training programmes as complementary resources to improve both competition performance and the training routine.

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