Journal of Physical Education and Sport ® (JPES), 18 Supplement issue 2, Art 147, pp. 995 - 1000, 2018
online ISSN: 2247 - 806X; p-ISSN: 2247 – 8051; ISSN - L = 2247 - 8051 © JPES

Original Article

Pre and post-competition cortisol in athletes from the brazilian confederation of aquatic sports

GLAUBER CASTELO BRANCO SILVA[1] ,JOSÉ ROBERTO ANDRADE DO NASCIMENTO JUNIOR[2], , ANTÔNIO CARLOS LEAL CORTEZ[3], FABRIZIO DI MASI[4], ESTÉLIO HENRIQUE MARTIN DANTAS[5] , GISLANE FERREIRA DE MELO[6]
[1]Physical Education Course of Piauí State University, Barros Araújo Campus – Picos PI - BRAZIL
Catholic University of Brasília – Graduate Physical Education Program – Brasília – DF - BRAZIL
[2]Federal University of Vale do São Francisco (Univasf) – Petrolina – PE - BRAZIL
Graduate Physical Education Program (PPGEF-UNIVASF) – Petrolina – PE - BRAZIL
Graduate Psychology Program (CPGPSI-UNIVASF) – Petrolina – PE - BRAZIL
[3]University Center Santo Agostinho (UNIFSA), Teresina PI - BRAZIL
Graduate Nursing and Biosciences Program (PPgEnfBio) – Doctorate from the Federal University of Rio de Janeiro State (UNIRIO), Rio de Janeiro - RJ - BRAZIL.
[4]Federal Rural University of Rio de Janeiro (UFRRJ), RJ- BRAZIL
[5]Health and the Environment Graduate Program (PSA) of Tiradentes University (UNIT), SE -BRAZIL; Nursing and Biosciences Graduate Program (PPgEnfBio) – Doctorate from the Federal University of Rio de Janeiro State (UNIRIO), Rio de Janeiro – RJ – BRAZIL.
[6]Physical Education Course of the Catholic University of Brasília (UCB) – Brasília - DF -BRAZIL
Physical Education Program – UCB) - Brasília – DF –BRAZIL, Gerontology Graduate Program – UCB) - Brasília – DF -BRAZIL

Published online: July 31, 2018
(Accepted for publication June 13, 2018)
DOI:10.7752/jpes.2018.s2147

Abstract
The competitive levels expose the athletes to stressful factors that influence in their performance. Emotional changes following competitive stress trigger endocrine responses that can prepare the body for imminent challenges, therefore the importance of knowledge of these reactions to the organism.The present study investigated pre- and post-competition cortisol differences between sexes and swimming specialties (sprinter, middle-distance and long-distance). A total of 44 swimmers (28 men and 16 women), mean age of 15.2±1.4 years, were assessed. Saliva was collected pre (15 minutes before) and post competition (immediately), using the Elisa method, Salivette® / kit DSL-10-671000 ACTIVE® (EIA). Descriptive measures and split-plot ANOVA were applied, using the Statistical Package for the Social Sciences (SPSS) – IBM 22.0. There were no intergroup pre and post-competition differences between the sexes or specialties [F=(1, 42)2.42, p=0.12] and [F=(2,41) 1.58,p=0.21]. There was a significant pre and post-competition intergroup difference between the sexes and specialties [F=(1, 42) 23.15, p=0.001] and [F=(1, 41) 31.43, p=0.001]. The swimmers' endocrine (cortisol) response to competitive stimuli were similar. Therefore, this indicates that other factors may influence the cortisol secretion, beside those that were presented here, suggesting new research in this area, to demystify the real responses of cortisol to exercise and competition.
Key Words: **Athlete; Swimming; Aquatic Exercise, Hormone, Stress.**

Introduction

The stress attributed to competition can trigger a number of emotional feelings in athletes, eliciting neuroendocrine responses capable of acutely and/or chronically changing organic function (Maso et al., 2003; Salvador; 2003; Gimeno, Buceta and Llantada, 2007; Teixeira et al., 2009). According to Labrador and Crespo (1994), cognitive, behavioral and physiological responses to stressor agents allow better situational perception of demands and needs, in order to prepare the body to act rapidly and vigorously. The response to a threatening or challenging stimulus triggers a series of physiological reactions in the body mediated by the hypothalamics-pituitary-adrenal (HPA) axis, sympathetic-adrenal-medullary (SAM) system and hypothalamic-pituitary-gonadal (HPG) axes (Myers et al., 2014; Herman et al., 2016). In particular, the HPA responds to a stimulus by releasing hormones such as corticotropin-releasing hormone (CRH), arginine vasopressin (AVP) and adrenocorticotropic hormone (ACTH) (Koob and Bloom, 1991). These hormones are directly associated with the mobilization of energy reserves to face a real imminent (reactive response) or expected challenge (anticipatory response) (Herman et al., 2016).

Known as the stress hormone, cortisol exhibits a pulsatile secretion pattern with higher levels in the morning, declining throughout the day and reaching its lowest point at night (Hofstra; De Weerd, 2008;

Corresponding Author ANTÔNIO CARLOS LEAL CORTEZ, E-mail: antoniocarloscortez@hotmail.com

Kalsbeek et al., 2012). In non-stressed adults, the average cortisol secretion rate is around 12-15 µ/dL (Van Reeth et al., 1994), and extra-circadian variations have been observed under physical or psychological stress (Hellhammer et al., 2009). Its presence in the organism can be measured using blood, urine and saliva collections, the last being more accessible, simple and currently the most widely used (Silva, Mallozi and Ferrari, 2007).

Research involving cortisol in sport has focused on the cortisol response in different sports (Jurimae et al., 2004; Maso et al., 2002; Elloumi, 2008), sexes (Kivlighan et al., 2005; Salvador, 2001), competitive situations (social) (Arruda et al., 2014; Arruda et al., 2017; Hasegawa et al., 2007; Jiménez et al., 2012), moments of the competition (before, during and after) (Filarie et al., 2009; Kim et al., 2009; Mclellan et al., 2010; La Pense et al., 2010), training sessions, exercise types and intensities (Atlaqui et al., 2003; Minetto et al., 2008; Bougth et al., 2006; Luigi Di L et al., 2006; Crewther et al., 2010).In the competitive context, Salvador et al. (2001) reported an anticipatory effect of cortisol before the competition, highlighting the importance of increased cortisol levels in the psychophysiological preparation for competitive challenges. Earlier studies confirmed this effect when basal levels were compared between training sessions and competition (Salvador et al., (2003); Carré et al., (2006); Elloumi et al., (2008); Filarie et al., (2010)). Significantly higher hormone levels were also observed after competition (Salvador et al., 2003; Filarie et al., 2010; Arruda et al., 2014; Li et al., 2015). The aforementioned investigations clearly demonstrate an anticipatory effect and an increase between pre and post-competition, in addition to different hormone concentration patterns to competitive stress. According to Cook & Crewther (2012), these differences are caused primarily by the intensity, duration and nature of the stimulus.

Another point of discussion is the cortisol response between men and women in sport. Current findings show that differences in cortisol responses as a function of sex remain inconclusive, with contradictory results (Kviglan et al., 2015; 2005; Filarie et al., 2009; Li et al., 2015). Assessing 239 elite gymnasts of both sexes, Georpoulos et al. (2011) found higher cortisol levels in the basal state and post-competition in one of the sexes. On the hand, authors such as Kvlighan et al., (2005), Le Panse et al., 2012 and Li et al., (2015), obtained similar pre and post-competition hormonal responses between men and women. These results are inconsistent with the real sex-related behavior of cortisol and, given the lack of consensus on the release of the hormone, further clarification on the issue is required. Considering the assumptions regarding the release of cortisol between specialties and sexes, the present study investigated the possible influence of sex and the characteristics of swim races on pre- and post-competition cortisol concentrations.

Materials & methods

Participants

A total of 44 swimmers (28 men and 16 women) with an average age of 15.40±0.49 years, from the five regions of Brazil (North, Northeast, Center West, South and Southeast) took part in the study. The athletes, selected by nonprobability convenience sampling, were assessed during the 2016 Brazilian Juvenile Swimming Championship held by the Brazilian Swimming Confederation (CBDA). All the athletes and legal guardians of individuals younger than 18 years of age signed an informed consent form. The study was approved by the Research Ethics Committee of the Catholic University of Brasilia, under protocol no. 1319640 and CAAE 50596715.2.0000.0029.

Procedures

On the day of the competition, the swimmers were instructed to fill out the anamnesis questionnaire containing objective questions on sex, subjective health, number of weekly training sessions, years of competition, number of training hours, main competitive event and participation in events.

Saliva was collected while the athletes waited to be called to the race and afterwards at a location determined by the competition organizers. Cortisol was measured in saliva samples using a plastic tube and SARSTEDT Salivette® cotton swab and analyzed with a DSL-10-671000 ACTIVE® Cortisol Enzyme Immunoassay (EIA) kit. In line with the ELISA protocol, the athletes rinsed their mouth with distilled water before placing the cotton swab in the oral cavity. The swab remained in the mouth for 1 to 2 minutes, was placed in the plastic tube and stored in a refrigerator at -15 degrees ºC for laboratory analysis.

Collection proceeded as follows: 1. The stopper of the Salivette® tube was removed. 2- The cotton swab was placed on the athlete's tongue for 1 to 2 minutes. They were asked to masticate lightly to stimulate salivary flow to obtain between 0.5 and 1.5 mL de saliva. 3. During collection no food or liquid was ingested. 4. Next, the researcher removed the cotton swab from the athlete's mouth with a sterilized glove and reinserted it into the Salivette tube. Analyses were conducted by Analisis Laboratório Clínico e Infantil, located at Av. Camilo de Holanda 564, in João Pessoa, Paraíba state, Brazil.

Statistical Analysis

Mean and standard deviation were used to characterize the sample and the Shapiro-Wilk test was applied to test normality. Split-plot ANOVA, at a 5% significant level, was used to compare cortisol as a function of sex pre and post-competition and specialty (sprinter, middle-distance and long-distance), applying the Statistical Package for The Social Sciences (SPSS) – IBM 22.0.

Results

The table 1 demonstrates the characteristic of the swimmers: exhibited similar age, training frequency and number of years competing, with a difference between men and women only during training. The table 2 demonstrates that there was no significant pre and post-cortisol difference between the sexes [F=(1,42) 2.42, p=0.12], nor did cortisol vary significantly between specialties [F=(2,41) 1.58, p=0.21].

Table 1. Swimmer characteristics.

Swimmers (n=44)	Mean ± SD
Age	15.2±1.4
Freq. (days/week)	7.03±1.5
Training duration	144.84±33.5
Number of years competing	6.2±2.11
Pre cortisol	0.37±0.11
Post cortisol	0.49±0.16

SD= standard deviation.

Pre and post-assessment of each variable showed differences between men (Δ% =38%, p=0.001) and women (Δ%= 21%, p=0.001). Pre and post-competition differences were also found between sprinters (Δ% = 28%, p= 0.001), middle-distance (Δ%= 24%, p=0.001) and long-distance swimmers (Δ%= 51%, p=0.001). There was no association between training characteristics and cortisol levels, weekly pre (r=0.029) and post frequency (r=0.19), pre (r=0.04) and post-training duration (r=0.25), and pre (r=0.26) and post-competition (r=0.18).

Table 2. Cortisol levels of the swimmers.

Swimmers (n=44)	Sex		Specialty		
	Male (n=28)	Female (n=16)	Sprinters (n=20)	Middle distance (n=14)	Long distance (n=10)
Freq. (days/week)	7.00±1.57	7.08±1.44	6.50±1.12	7.22±1.91	7.75±1.49
Training duration	154±33.64*	131±28.23	135±25.64	143±35.35	163±37.70
Number of years' experience	7.00±1.57	7.08±1.44	5.71±2.47	5.71±2.43	5.38±1.9
Pre cortisol	0.36±0.13	0.38±0.06	0.38±0.10	0.37±0.14	0.33±0.08
Post cortisol	0.50±0.17*	0.46±0.16*	0.49±0.16*	0.46±0.16*	0.50±0.15*

p* ≤0.05 Pre vs post-competition cortisol

Discussion

The aim of the study was to compare the cortisol (endocrine) response between the sexes and competitive specialties of young Brazilian swimmers. There were no significant pre and post-competition differences between the sexes. These results are similar to those reported by Kvlighan et al., (2005), and Le Panse et al., (2010), both conducted with individual sports.

According to Kvlighan et al., (2005), the main difference between the sexes is the psychosocial response to competitive stress, whereby cortisol in men is more strongly associated with mental preparation and competitive focus, while women show a greater relationship with accepting and judging group performance. Filarie et al. (2009) reported that men and women exhibit a similar response pattern between rest and pre-competition, but differences between pre and post-competition. In general, the anticipatory effects of cortisol were demonstrated regardless of sex and sport specialty (Bateup et al., 2002; Carré et al., 2006; Elloumi et al., 2008). For the pre and post-competition state, the results of studies are inconsistent, exhibiting similar (Kvlighan et al., (2005); Li et al., (2015); Le Panse et al., 2012) or different pre and post-competition responses (Filarie et al., 2009; Le Panse et al., (2010)), with higher cortisol levels in women at one of the moments.

In a non-competitive context, Gallucci et al., (1993) found that women display increased tonus in the central stress system and generally have higher basal cortisol levels than men. Evidence reported in earlier studies shows greater CRH secretion in women, due to functional estrogen response elements (EREs), which may hinder the negative feedback of the cortisol response (Frederiksen et al., 1991; Turner, 1990). Furthermore, the female hormone seems to increase adrenal sensitivity to ACTH (Figueiredo et al., 2007). According to Weiss et al., (1999), women show greater variability in HPA activity after induced stress, suggesting a difference in feedback mechanisms between the sexes. Goldstein et al. (2010) reported that in stress situations, women instinctively interpret their cerebral activity of a stressor event, associated with a biosocial interpretation of external factors.

During physical exercise, Davis et al., (2000) found similar cortisol concentrations between the sexes, showing variations in metabolic and autonomic activity. As such, it is believed that there is little variation in cortisol under exercise-induced stress between the sexes, underscoring the possibility of specific pathways for HPA activation. The same behavior can be observed in a competitive situation.

With respect to swimming specialties, participants showed no significant differences, but long-distance athletes experienced greater cortisol increases in relation to the pre-competition state. According to Filaire et al., (2001), cortisol variations depend on the activation of physiological parameters, such as exercise intensity and duration. Secretion of the hormone during exercise tends to be higher with increased intensity, in both aerobic and strength exercises (Raastad, Bjoro, Hallen, 2000). Activation of the HPA is proportional to exercise intensity and more significant in high-intensity anaerobic activities (Hackney, Premo, McMurray, 1995; Ahtiainen et al., 2004; Crewther et al., 2010). Physiological changes in blood lactate, angiotensin II and interleukins have been reported as possible mechanisms responsible for HPA activation in response to increased exercise intensity (Fellmann, Bedu and Boudct, 1992; Hãkkinen K, Pakarinen, 1995).

Thus, this higher percentage increase may have been influenced by race duration at submaximal intensity, since submaximal exercise over an extended time period can also effectively activate the HPA (Lutoslawska et al., 1991). It was expected that sprinters and long-distance swimmers would respond differently, during more intense training, given the greater potential to activate the HPA and the fact that they perform more constant (long-lasting) and submaximal activities. According to Akana and Dallman (1992), repeated stress in rats, both acute and chronic, reduces HPA sensitivity to negative glucocorticoid feedback. Moreover, Duclos et al., (1998) reported that elite athletes showed a decline in ACTH and cortisol responses to CRH stimuli, supporting the hypothesis of hypophyseal resistance to negative feedback. This behavior was confirmed by administering drugs that stimulate the HPA (Duclos et al., 2001). Later, Duclos, Guinot and Le Bouc (2007) demonstrated that endurance athletes develop an adaptive mechanism to protect muscles and other glucocorticoid-sensitive tissues from the harmful effects of an increase in cortisol.

Another assumption that may corroborate the hypothesis of differences between sprinters and long-distance swimmers is the positive relationship between catecholamine release and cortisol secretion, where a greater anticipatory effect was observed in high-intensity athletes (Fry, Kraemer and Ramsey, 1998). The same effect was noted before a series of high-intensity exercises, associated with mental preparation for a challenging task (Kraemer et al., 1994). Considering the aforementioned arguments, it is believed that there is a potential difference between the pre and post-competition states of sprinters and long-distance swimmers, whereby the former exhibited higher pre and post-competition cortisol levels compared to the latter. However, these results reopen an avenue for studies that examine cortisol variations in a same sport with different specialties.

One of the limitations of the present study was the non-inclusion of basal cortisol as an assessment moment, thereby precluding conclusions regarding possible differences between anticipatory responses and the basal state of the groups assessed. It is suggested that this variable be included in future research.

Conclusions

It can generally be inferred that young Brazilian swimmers respond similarly to competitive stress, with no difference between sex or specialty. The findings reinforce the hypothesis of similar pre and post-competition cortisol responses, presenting a new perspective on the response of the hormone between swimming specialties. These results suggest that sprinters and middle and long-distance swimmers activate their cortisol-regulating centers regardless of training adaptations and that the pre and post intragroup differences are due primarily to physiological adjustments made during the race. Thus, since other factors than those presented here may influence cortisol secretion, new studies are suggested in order to determine the real cortisol responses to exercise and competition.

Conflict of Interest: The authors declare that they have no conflict of interest.

References

Arruda, A. F. S., Aoki, M. S., Freitas, C. G., Drago, G., Oliveira, R., Crewther, B. T., & Moreira, A. (2014). Influence of competition playing venue on the hormonal responses, state anxiety and perception of effort in elite basketball athletes. *Physiology & Behavior*, 130, 1–5.

Arruda, A. F. S., Aoki M. S., Paludo A.C., Moreira A. Salivary steroid response and competitive anxiety in elite basketball players:

Effect of opponent level. *Physiology & Behavior* 177 (2017) 291–296.

Atlaqui, D., Duclos, M., Gouarne, C., Lacoste, L., Barale, F., & Chatard, J. C. (2004). The 24-h urinary cortisol/cortisone ratio for monitoring training in elite swimmers. *Medicine & Science in Sports & Exercise, 36*(2), 218-224.

Aguilar, R., Jiménez, M., & Alvero-Cruz, J. R. (2013). Testosterone, cortisol and anxiety in elite field hockey players. *Physiology & Behavior*, 119, 38–42.

Bateup, H.S., Booth, A., Shirtcliff, E.A., Granger, D.A., (2002). Testosterone, cortisol, and women's competition. Evol. Hum. Behav. 23,181—192.

Bought, M., Rouveix, M., Michaux, O., Pequignot, J., & Filaire, E. (2006). Relationships among training stress, mood and dehydroepian-drosterone sulphate/cortisol ratio in female cyclists. *Journal of Sports Sciences, 24*(12), 1297-1302.

Carré, J., Muir, C., Belanger, J., & Putnam, S. K. (2006). Pre-competition hormonal and psychological levels of elite hockey players: relationship to the «home advantage». *Physiology & Behavior*, 89(3), 392–398.

Cook, C. J., & Crewther, B. T. (2012). The effects of different pre-game motivational interventions on athlete free hormonal state and subsequent performance in professional rugby union matches. *Physiology & Behavior*, 106(5), 683–688.

Crewther B., Lowe T., Ingram J., Weatherby R.,P. (2010). Validating the salivary testosterone and cortisol concentration measures in response to short high-intensity exercise. *The Journal of sports medicine and physical fitness*. 50(1):85-92.

Davis SN, Galassetti P, Wasserman DH, Tate D. (2000) Effects of gender on neuroendocrine and metabolic counterregulatory responses to exercise in normal man.J Clin Endocrinol Metab.Jan;85(1):224-30.

Di Luigi L., Baldari C., Gallotta M., Perroni F., Romanelli F., Lenzi A., et al. (2006) Salivary steroids at rest and after a training load in young male athletes: relationship with chronological age and pubertal development. *Int J Sports Med.* 27(9):709-17.

Duclos, M., Corcuff, J.B., Arsac, L., Moreau-Gaudry., F.; Rashedi., M., Roger, P., Tabarin, A., Manier, G.(1998) Corticotroph axis sensitivity after exercise in endurance-trained athletes. *Clin. Endocrinol.* (Oxf). 48. p. 493-501.

Duclos, M.; Corcuff, J.B.; Pehourcq, F.; Tabarin, A. (2001) Decreased pituitary sensitivity to glucocorticoids in endurance-trained men. *Eur. J. Endocrinol.* 144.p. 363-368.

Duclos, M., Guinot, M., Le Bouc, Y. Cortisol and GH: odd and controversial ideas. (2007) *Appl. Physiol. Nutr. Metab.* 32. 2007. p. 895-903.

Elloumi, M. et al. (2008) Psychoendocrine and physical performance responses in male Tunisian rugby players during an international competitive season. *Aggressive Behaviour*, New York, v. 34, p. 623-632.

Fellmann N, Bedu M, Boudet G, Mage M, Sagnol M, Pequignot JM, et al., Inter- relationships between pituitary –adrenal hormones and catecholamines during a 6 – day Nordic ski race. Eur. J Appl Physio, 1992;64:258-265.

Figueiredo HF, Ulrich-Lai YM, Choi DC, Herman JP. Estrogen potentiates adrenocortical responses to stress in female rats. *Am J Physiol Endocrinol Metab* 292: E1173-E1182, 2007.

Filaire E, Sagnol M, Ferrand C, Lac G. Psychophysiological stress in judo athletes
during competitions. J Sports Med Phys Fitness 2001;41:263–8.

Filaire E, Alix D, FerrandD, Verger M. (2009). Psychophysiological stress in tennis players during the first single match of a tournament. Psychoneuroendocrinology. 34:150-7.

Filaire, E., Portier, H., Onen, N., & Filaire, M. (2010). Physiological responses and nutritional profile during competitive female singles tennis. *Science & Sports, 25*(2), 55-60. doi: 10.1016/j.scispo.2009.11.001

Fry, A.C.; Kraemer, W.J.; Ramsey, L.T. Pituitary-adrenal gonadal responses to high-intensity resistance exercise "overtraining". Eur. J. Appl. Physiol., Vol. 85. 1998. p. 2352-2359.

Georgopoulos, N. A., Rottstein, L., Tsekouras, A., Theodoropoulou, A., Koukkou, E., Mylonas, P., Markou, K. B. (2011). Abolished circadian rhythm of salivary cortisol in elite artistic gymnasts. Steroids, 76(4), 353–357.

Gimeno, F; Buceta J. M; Llantada M.C.P. (2007). Influencia de las variables psicológicas em el desporte de competición: evaluación mediante el cuestionario Caracateristicas psicológicas relacionadas com el rendimento desportivo, *Psicothema*, v.19, n.4, p. 667-672.

Goldstein, J. M.,Jerram Matthew., Abbs B., Gabrieli S. W., Ph.D., Nikos. (2010) Sex Differences in Stress Response Circuitry Activation Dependent on Female Hormonal Cycle. J Neurosci. Jan 13; 30(2): 431–438.

Hackney AC, Premo MC, McMurray RG. (1995) Influence of aerobic versus anaerobic exercise on the relationship between reproductive hormones in men. J Sport Sci, 13. 305-311.

Hakkinen K, Pakarinen A (1995) Acute hormonal responses to heavy resistance exercise in men and women at different ages. Int. J. Sport Med. 16; 507-513.

Hasegawa, M; Toda, M; Morimoto, K. (2008). Changes in salivary physiological stress markers associated with winning and losing. *Biomedical Research*, Tokio, 29(1):43-46.

Herman JP, Figueiredo H, Mueller NK, Ulrich-Lai Y, Ostrander MM, Choi DC, Cullinan WE. Central mechanisms of stress integration: hierarchical circuitry controlling hypothalamo-pituitary-adrenocortical responsiveness. Front Neuroendocrinol. 2003 Jul;24(3):151-80.

Herman JP, McKlveen JM, Ghosal S, Kopp B, Wulsin A, Makinson R, Scheimann J, Myers B (2016) Regulation of the hypothalamic-pituitary-adrenocortical stress response. *Compr Physiol* 6:603–621.

Hellhammer, D. H., Wüst, S., & Kudielka, B. M. (2009). Salivary cortisol as a biomarker in stress research. Psychoneuroendocrinology, 34(2), 163–171.

Hofstra WA, de Weerd AW. How to assess circadian rhythm in humans: a review of literature. *Epilepsy Behav*. 2008 Oct;13(3):438-44.

Jiménez, M., Aguilar, R., & Alvero-Cruz, J. R. (2012). Effects of victory and defeat on testosterone and cortisol response to competition: evidence for same response patterns in men and women. Psychoneuroendocrinology, 37(9), 1577–1581.

Jurimae, J., Maetsu, J., Purge, P., & Jurimae, T. (2004). Changes in stress and recovery after heavy training in rowers. *Journal of Science and Medicine in Sport, 7*(3), 334-339.

Kalsbeek A, van der Spek R, Lei J, Endert E, Buijs RM, Fliers E. Circadian rhythms in the hypothalamo-pituitary-adrenal (HPA) axis. *Mol Cell Endocrinol* 349: 20-29, 2012.

Kim, K. J., Chung, J. W., Park, S., & Shin, J. T. (2009). Psychophysiological stress response during competition between elite and non-elite Korean junior golfers. *International Journal of Sports Medicine, 30*(7), 503-508. doi: 10.1055/s-0029-1202338

Kivlighan, K. T., Granger, D. A., & Booth, A. (2005). Gender differences in testosterone and cortisol response to competition. Psychoneuroendocrinology, 30(1), 58–71.

Koob GF, Bloom FE. Corticotropin-releasing factor and behavior. Fre Proc, 1991;44:259-263.

Maso, F., Cazorla, G., Godemet, M. O., Michaux A. G., Lac, A., & Robert, A. (2002). Influence d'une compétition de rugby sur le taux de cor-tisol salivaire. *Science et Sports 17*(6), 302–305.

Maso, F., Lac, G., Michaux, O., & Robert, A. (2003). Corrélations entre scores au questionnaire de Parâmetros la Société française de médecine du sport et concentrations de cortisol et testostérone sali-vaires lors du suivi d'une équipe de rugby de haut niveau. *Science & Sports, 18*, 299-301. doi: 10.1016/j.scispo.2003.09.012

Mary F. Dallman,Susan F. Akana,Karen A. Scribner,Margaret J. Bradbury,C.-Dominique Walker,Alison M. Strack, Caren S. Cascio. (1992) Stress, Feedback and Facilitation in the Hypothalamo-Pituitary-Adrenal Axis. *Journal of Neuroendocrinology* v. 4, n. 5, p. 517–526

Minetto, M. A., Lanfranco, F., Tibaudi, A., Baldi, M., Termine, A., & Ghigo, E. (2008). Changes in awakening cortisol response and midnight salivary cortisol are sensitive markers of strenous training-induced fatigue. *Journal of Endocrino-logical Investigation, 31*, 16-24.

McLellan, C. P., Lovell, D. I., & Gass, G. C. (2010). Creatine kinase and endocrine responses of elite players pre, during, and post rugby league match play. Journal of Strength and Conditioning Research / National Strength & Conditioning Association, 24(11), 2908–2919.

Myers B, McKlveen JM, Herman JP. (2014). Glucocorticoid actions on synapses, circuits, and behavior: implications for the energetics of stress. *Front Neuroendocrinol* 35: 180-196.

Labrador FJ, Crespo M. Evalución del estrés. In: Fernandéz-Ballesteros R. Evaluación conductual hoy. Un enfoque para el cambio en psicologia clínica y de la salud. Ediciones pirámide S.A – Madrid; 1994. p. 484-529.

Le Panse, B., Labsy, Z., Baillot, A., Vibarel-Rebot, N., Parage, G., Albrings, D., … Collomp, K. (2012). Changes in steroid hormones during an international powerlifting competition. Steroids, 77(13), 1339–1344.

Le Panse, B., Vibarel-Rebot, N., Parage, G., Albrings, D., Amiot, V., De Ceaurriz, J., & Collomp, K. (2010). Cortisol, DHEA, and testosterone concentrations in saliva in response to an international powerlifting competition. Stress (Amsterdam, Netherlands), 13(6), 528–532.

Li, C.-Y., Hsu, G.-S., Suzuki, K., Ko, M.-H., & Fang, S.-H. (2015). Salivary Immuno Factors, Cortisol and Testosterone Responses in Athletes of a Competitive 5000 m Race. *The Chinese Journal of Physiology,* 58(4), 263–269.

Lutoslawska G, Obminsk Z, Krogulski A, Sendecki W. (1991). Plasma cortisol and testosterone following 19-km and 42- km kayak races. *J Sport Phys Fitness*, 31:538-542.

Raastad T, Bjøro T, Hallén J. (2000) Hormonal responses to high- and moderate-intensity strength exercise. *Eur J Appl Physiol*.May;82(1-2):121-8.

Salvador, A., Ricarte, J., González-Bono, E., & Moya-Albiol, L. (2001). Effects of physical training on endocrine and autonomic response to acute stress. *Journal of Psychophysiology, 15*, 114–121. doi: 10.1027//0269-8803.15.2.114

Salvador, A., Suay, F., González-Bono, E., & Serrano, M. A. (2003). Anticipatory cortisol, testosterone and psychological responses to judo competition in young men. *Psychoneuroendocrinology*, 28(3), 364–375.

Silva M.L., Mallozi M.C., Ferrari G.F. (2007) Salivary cortisol to assess the hypothalamic–pituitary–adrenal axis in healthy children under 3 years old. *J Pediatr* (Rio J). 83:121–6.

Teixeira, V., Valente, H., Casal, S., Pereira, L., Marques, F., & Moreira, P. (2009). Antioxidant status, oxidative stress, and damage in elite kayakers after 1 year of training and competition in 2 seasons. *Applied Physiology, Nutrition and Metabolism, 34*, 716-724.

Weiss EL, Longhurst JG, Mazure CM. (1999). Childhood sexual abuse as a risk factor for depression in women: Psychosocial and neurobiological correlates. *Am J Psychiatry* 156: 816-828.