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Salivary Testosterone and Cortisol Concentrations, and Psychological Societe Francaise de Medecine du Sport Overtraining Scores as Indicators of Overtraining Syndromes among Elite Soccer Players[1]

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Abstract

Overreaching (short-term overtraining) and overtraining syndrome (OTS) are caused by a chronic imbalance between training and recovery and can lead to prolonged fatigue and decrements in athletic performance. Though research on OTS has increased greatly over the last decade, there is still a lack of consensus about its etiology and a precise diagnosis of its occurrence. The purpose of the study was to examine the relationship between psychological scores and OTS markers in elite soccer players. Three samples of unstimulated saliva (2 ml) were taken on rest days (8:00 am, 11:00 am, and 5:00 pm) from 30 elite male soccer players (age: 24.1±3.8 years (mean±SD)) and analyzed for cortisol and testosterone. They were also asked to complete the Societe Francaise de Medecine du Sport (SFMS) overtraining questionnaire. Results of zero-order correlation indicated that the SFMS overtraining scores had a significant positive correlation with cortisol concentrations at 8:00 am ($r = 0.66$; $p<0.001$), 11:00 am ($r = 0.62$; $p<0.001$), and 5:00 pm ($r = 0.40$; $p< 0.05$), mean cortisol concentrations of the entire day ($r = 0.60$; $p<0.001$). Psychological overtraining scores were also positively correlated with testosterone concentrations at 8:00 am ($r = 0.39$; $p=0.015$) and 5:00 pm ($r = 0.37$; $p< 0.05$), but negatively correlated with the T/C ratio at 8:00 am ($r = -0.38$; $p=0.020$). It should be concluded that the SFMS overtraining questionnaire may be considered as a cost-effective and useful tool for monitoring (and thus preventing) overtraining in soccer players.

Keywords: anabolic, catabolic, functional overreaching, overtraining syndromes, psychological overtraining

The overtraining syndrome (OTS) is a complex and multifaceted phenomenon that affects millions of athletes. Both overreaching (short-term overtraining) and overtraining syndrome (OTS) are caused by a chronic imbalance between training and recovery and can lead to prolonged fatigue and decrements in athletic performance. However, while overreaching is an acute condition that can lead to overtraining, OTS is considered a chronic condition (Meeusen et al., 2013). While research on the OTS has increased significantly over the last decade, there is still a lack of consensus about its etiology and a gold standard for the diagnosis of OTS (Meeusen et al., 2006). Researchers in general concur that OTS is a chronic situation resulting from the imbalance between stress and recovery. Further, OTS is characterized by impaired and lengthened recovery periods, inability of sustaining intense training sessions, and a chronic decrement in athletic performance (Urhausen and Kindermann, 2002). For this reason, the need to constantly monitor the training load and the condition of the athletes are critical to diagnose and prevent OTS from occurring, especially in elite soccer players (Naessens, Chandler, Kibler, and Driessens, 2000). The need to diagnose and prevent OTS from occurring in soccer players is especially critical in that it has previously been found that while an alarming 60% of soccer players were found to be overreached, a further 20% of the same sample suffered from OTS (Naessens et al., 2000). Other studies have put this value much higher and have demonstrated that more than 50% of professional soccer players have been found to have OTS (Armstrong and Vanheest, 2002).

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It has been conjectured that hormonal variations are one of the potent markers of OTS, and that the measurements of blood or salivary hormones could assist in the detection of OTS (Meeusen et al., 2013; Naessens et al., 2000; Pfattheicher, 2017; Urhausen, Gabriel, and Kindermann, 1998). Since testosterone has anabolic effects and cortisol has catabolic effects, these hormones and their ratio (T/C ratio) have been proposed to be effective markers of OTS. Similarly, while traditional theories propose that testosterone increases dominance and other status-seeking behaviors, this hormones' effect depends on cortisol, which has been implicated in psychological stress and social avoidance (Mehta and Josephs, 2010; Pfattheicher, Landhäußer, and Keller, 2014; Pfattheicher, 2017), hence the need to asses both these hormones in deterring OTS. Although recent research supports the dual-hormone hypothesis, the conditions under which the dual-hormone interaction is likely to emerge in OTS are not clearly understood. This has made testosterone one of the most studied markers of OTS since it is evident that this hormone is affected by OTS as a result of maladaptation in HPG axis caused by intense long-term physical and mental stress (Johnson and Thiese, 1992; Maso, Lac, Filaire, Michaux, and Robert, 2004) . In this regard, while there are undoubtedly individual differences, Adlercreutz et al. (1986) has previously suggested that athletes should be considered to be exhibiting OTS if their T/C ratio has dropped by more than 30% from baseline (Adlercreutz et al., 1986). Although testosterone and cortisol changes are deemed to be markers of OTS, the measurement of these hormones for monitoring the training load and athletic status is not always feasible due to following reasons: (a) the prohibitive costs of such testing, (b) the time-consuming nature of the testing, (c) the need for trained laboratory experts, and (d) the risks of working with body fluids (Duclos et al., 1998; Meeusen et al., 2004; Meeusen et al., 2006).

It has long been acknowledged that OTS not only affects physiological factors such as hormones, but also interferes with psychological aspects such as mood disturbances, tension, depression, anger, fatigue, and confusion (Johnson and Thiese, 1992; Meeusen et al., 2013). Hence, it has been suggested that self-reports of training load and fatigue following exercise training may help to monitor or even prevent OTS (Maso et al., 2004). However, systematic studies of psychological aspects and OTS did not begin until the construct and development of standardized scales or questionnaires (Meeusen et al., 2013). One such psychological questionnaire for the assessment of overtraining was devised by the Consensus Group on Overtraining of the French Society of Sport Medicine which allows for the calculation of a score that may indicate the level of tiredness in athletes carrying out a heavy training program (Benhaddad et al., 1999; Maso et al., 2004).

In an attempt to ensure the reliability of such psychological tools in diagnosing OTS, there is a need to establish the relationship between the results obtained from the Societe Francaise de Medecine du Sport and similar tools and other aspects of OTS, such as physiological-, immunological-, and performance-related measures (Benhaddad et al., 1999; Amiri, Pirani, and Esfahani, 2011; Maso et al., 2004). The inclusion of objective endocrine markers and their relationship with subjective monitoring is sorely lacking from the literature and an important issue to address. Accordingly, the aim of the present study was to examine the relationship among salivary testosterone and cortisol concentrations, the T/C ratio, and the results of a clinical questionnaire of OTS among elite soccer players.

Methodology

Participants

Thirty 30 elite and apparently healthy, male soccer players from the Iranian Premier League were purposefully recruited to participate in the study using homogeneous purposive sampling. Physical characteristics of the participants are presented in Table 1. All participants had been training in a soccer club for at least eight years, and were free of all relative and absolute contraindications to exercise and exercise testing. Participants participated in 16 hours of soccer training and played at least one competitive game per week, and had not taken any medications and drugs that could have affected measurements, as indicated by self-report. The subject's recruitment was based on a previous study that indicated that about 10 to 30 percent of professional soccer players engaged in strenuous exercise and stressful competitive games show some symptoms of OTS at the end of the season (Handziski et al., 2006). As such, subjects who were under above-mentioned condition during the season were purposefully recruited. The present study was conducted in accordance with the Helsinki Declaration (Kargarfard et al., 2016). All participants and their respective clubs were given a detailed verbal and written explanation of the experimental procedure prior to signing a written informed consent form.

Table 1.
Baseline Characteristics of Iranian Elite Male Soccer Players (N = 30)

Variable	Mean±SE
Age (years)	24.1±3.8
Stature (cm)	180.0±7.3
Body Mass (kg)	75.2±8.1
BMI (kg.m^{-2})	22.9±1.2
Body Fat (%)	14.7±2.3
VO_{2max}(ml.kg^{-1}.min^{-1})	53.3±2.8

SE =Standard Error

Experimental Procedures

Participants' body mass was assessed to the nearest 0.1 kg and height to the nearest 0.1 cm (Seca, Hammer Steindamm 9-25, 22089 Hamburg, Germany) while wearing light clothing with shoes removed. Body Mass Index (BMI) was calculated by dividing the participant's body mass (kg) by stature squared (m^2) and expressed as kilograms per square meter ($kg.m^{-2}$). Body fat percentage (%BF) was calculated using the equation of Durnin and Womersley (1974) from the skinfold measurements of the biceps, triceps, subscapular, and suprailiac (Harpenden John Bull, British Indicators Ltd., England) (Durnin and Womersley, 1974). Anthropometric measurements were carried out according to previous methods (Shariat, Kargarfard, Danaee, and Tamrin, 2015; Shaw, Shaw, and Mamen, 2010). Maximal oxygen uptake (VO_{2max}) was estimated using the Bruce protocol (Kargarfard et al., 2015).

In contrast to a longitudinal approach, the present study took the approach based on acute responses due to the limitations of working with professional soccer clubs and/or athletes preventing longitudinal studies. As such, the present study was conducted in the middle of the competition season in the Iranian Premier League and the Asian Champion's League (January to February during the 2014-2015 season). This period was selected as the time to evaluate OTS since it was in the middle of the most intensive training and competition period for the Iranian elite soccer players. All sampled players exhibited symptoms, such as performance decrements and/or psychological disturbance (decreased vigor, increased fatigue) of OTS as elucidated via the regular monitoring of the athletes' mood and the verbal self-reports provided during the season. In this regard, as a cut-off point, all players were required to display a performance decrement as reported by their coach and at least one self-reported mood disturbance (i.e. tension, depression, anger, fatigue, and/or) confusion. As such, any changes in physiological and psychological markers at this point were considered more likely to be the consequence of the chronic adaptations or maladaptations and not due to transient or acute responses. This is because although high-level soccer players need to perform every week during the season for most months of the year, it is frequently suggested that even that only represents merely a moderate load for the body (Naessens et al., 2000).

Participants' training history was that they trained for 16 hours a week and played at least one match per week. Specifically, the training sessions included: (a) endurance training (running at varying intensity below and above the anaerobic threshold), (b) FARTLEK (interval training), (c) strength training (with loads at 80-90% of one maximal repetition), (d) regular short sprint training (10- and 30-m sprints), (e) technical/tactical training (as intermittent moderate-intensity aerobic exercise, 45-75% maximal heart rate for 1 to 1.5 hours), and (f) soccer-specific training each week. Each soccer match consisted of two halves of 45 minutes each, separated by a 15-minute halftime interval.

Unstimulated saliva samples (2 ml) were collected from each participant during a rest day to negate the acute effects of exercise training. While the aim was not to evaluate the acute effects of training, the limitation of working with professional athletes resulted in participants engage in a regular exercise training session 72 hours prior to the salivary measurements, a moderate soccer-specific training session 48 hours prior to the testing, and a very light soccer-specific and tactical training 24 hours prior to sampling in preparation for their upcoming match. However, since the measurements took place approximately five months into the season and participants had already undergone rigorous mental and physical training, any changes in measured hormones could not likely be attributed to a transient response following the last training session. This is because, during the mid-season, physical conditioning was not prioritized as can be seen by the prioritizing of soccer-specific training and technical/tactical training, followed by supplemental physical conditioning. Further, given that no exhaustive activity was engaged in by the participants in the preceding 72 hours, the time-course of recovery cannot be simply considered a transient response. In addition, low-intensity exercise does not result in significant increases in cortisol levels (as seen in this study), and may actually result in a reduction in circulating cortisol levels. The saliva samples were obtained while the participants were seated and leaning slightly forward. Participants were first asked to wash out their mouths with water. Then they were asked to collect unstimulated saliva for a minute. At the end of this time, the saliva (about 2 ml) was spat into a collection tube. To further avoid any confounding effects due to variations in circadian rhythm and variations in food intake on hormonal secretion, saliva samples were taken at three different times: 8:00 am, 11:00 am, and 5:00 pm, as these specific times represent thoroughly separated parts of a day in which the body might be in different status to offset potential circadian rhythm hormonal effects. The tubes were immediately sealed, transferred to a pathology laboratory, and stored at -80° C until analysis. Salivary testosterone and cortisol concentrations were determined via radioimmunoassay using the DRG kit (Germany) for testosterone, and ELISA method and RADIM kit (Italy) for cortisol. Since there is no significant relative difference between the measurement between saliva and plasma measures of testosterone and cortisol (Cadore et al., 2008; Hough, Papacosta, Wraith, and Gleeson, 2011), the current study selected saliva sampling over blood sampling because it is a non-invasive and stress-free sampling method. In addition, samples can be easily obtained by participants as and when the need arises, and the presence of any apparatus or special training is not necessary (Shariat et al., 2015; Shariat, Kargarfard, Tamrin, Danaee, and Karimi, 2014). Finally, salivary sampling of steroid hormones can reflect the amount of circulation free hormones which is more desirable than total circulating levels confounded by the presence of circulating high affinity binding proteins (Lewis, 2006).

Questionnaire

To determine the psychological overtraining items, the present study used the standardized questionnaire on overtraining of the Societe Francaise de Medecine du Sport (SFMS) which could quantify early clinical symptoms of overtraining syndrome (Brun, Bouix, Fédou, El Kamar, and Orsetti, 1993; Maso et al., 2004). The SFMS overtraining questionnaire, which contained 54 items about psychological parameters, was administered on a single occasion to the participants on the same day as the saliva samples were taken, between the first (08:00 am) and the second (11:00 am) saliva collection. Each item required an answer of «yes» or «no», and the total of the positive answers («yes») was used for the participant's «score» in this study. Some sample items of the SFMS overtraining questionnaire are provided here: 1) I am not as attentive as before; 2) I do not sleep as well as before; 3) I frequently catch a cold; 4) I get irritated more easily; 5) My motivation, will and tenacity are weaker. The SFMS questionnaire was translated into Persian by the academic staff at the department of the French language at University of Isfahan, Isfahan, Iran. The necessary educational conversions were performed in accordance with the guidelines provided by the International Consensus Group. «Forward» and «backward» translations were performed. The original questionnaire was first translated into Persian by two separate translators whose native language was Persian, and who possessed a high degree of fluency in English. Appropriate minor adaptations were made at this phase to make certain conceptual correspondence. The translated version was compared by two independent translators who sought to identify differences in comparison with the original version of the questionnaire. No significant differences were identified and no concepts that did not directly translate into the Persian language. After the two versions of the translation had been compared, discussed, and adjusted, a preliminary Persian version of the SFMS was agreed upon.

A reverse translation of the raw Persian-language report into English was then performed by an independent, specialized translator who was fluent in Persian, and whose first language was English. Then, there was a comparison between the newly-translated English and the original version of the questionnaires, and a temporary draft of the Persian-language questionnaire was prepared for trial measuring intended to identify probable issues of comprehension among the general population. All the comments were gathered and applied, if relevant, and the final version of the questionnaire was formulated. The aim of cultural adaptation was to produce a version that was conceptually as close as possible to the original SFMS questionnaire. Following this, the Persian version of OTS was initially administrated to 30 soccer players (age: 20-25 years), with at least two years of soccer-playing experience, within the Faculty of Sport Sciences, University of Isfahan, Isfahan, Iran. Internal consistency reliability was computed by Cranach's alpha. The reliability of whole items of the questionnaire was obtained Cranach's alpha coefficient (α=0.896).

As any hormone has its specific circadian rhythm and the trend of hormonal changes in this study were quite similar to what that has been proposed for testosterone and cortisol, we can infer that any discrepancy in the relationship between hormones and overtraining questionnaire scores at each time point could be ascribed to the effect circadian rhythm, not a transient change caused solely by previous training session. The SFMS overtraining questionnaire has previously been shown to have high test-retest reliability and high internal consistency, and there is also evidence that supports its content and construct (Brun et al., 1993). The SFMS was translated and had culturally been adapted and validated in an Iranian population.

Statistical Analysis

Descriptive analyses for the physical and hormonal characteristics are presented as means ± standard error (SE). A one-way repeated measures ANOVA was conducted to compare the mean values of the hormones in three different time points within a day. Correlations between hormonal data and the scores obtained in the SFMS overtraining questionnaire were determined using Pearson zero-order correlation coefficients. *P* values of <0.05 were considered as statistically significant. Data were analyzed using the SPSS Version 21.0 (SPSS Inc., Chicago, IL, USA). No participants initially sampled were excluded from the data analysis.

Results

One-way repeated measures ANOVA indicated that both testosterone and cortisol levels were higher at 8:00am, but lower at 5:00 pm. The salivary testosterone, cortisol, and T/C ratio concentrations at the different times of day (8:00 am, 11:00 am, and 5:00 pm) are depicted in Table 2. The mean score of the SFMS overtraining questionnaire was 11.9±3.8 (range: 7-19). The SFMS overtraining scores showed a significant positive correlation with cortisol concentrations at 8:00 am (r = 0.66; p<0.001), 11:00 am (r = 0.62; p<0.001), and 5:00 pm (r = 0.40; p< 0.05), and mean cortisol concentrations of the entire day (r = 0.60; p<0.001). SFMS overtraining scores were also positively correlated with testosterone concentrations at 8:00 am (r = 0.39; p=0.015) and 5:00 pm (r = 0.37; p< 0.05), but negatively correlated with the T/C ratio at 8:00 am (r = -0.38; p=0.020). Results of the zero-order correlation between the hormonal data and the scores obtained from the SFMS overtraining questionnaire are presented in Table 3. The scatter plots showing the relationship between the SFMS physiological scores and the mean cortisol concentration, mean testosterone concentration, and mean T/C ratio are displayed in Figures 1, 2, and 3, respectively.

Table 2.
Salivary Testosterone Concentrations, Cortisol Concentrations, and Testosterone/Cortisol Ratios of Elite Soccer Players (N = 30)

	8:00am Mean±SE	11:00am Mean±SE	5:00pm Mean±SE	Average Mean±SE
Testosterone (ng.ml^{-1})	0.9±0.53	0.8±0.54	0.8±0.56	0.8±0.07
Cortisol (ng.ml^{-1})	12.3±5.50	10.5±4.50	9.1±4.60	10.6±1.60
Testosterone/Cortisol Ratio	0.1±0.03	0.1±0.033	0.1±0.04	0.1±0.01

SE =Standard Error; ng.ml^{-1}= nanograms per milliliter

Table 3.
Zero-Order Correlation between SFMS Overtraining Scores and Salivary Testosterone and Cortisol Levels

	Cort 8am	Cort 11am	Cort 5pm	Mean Cort	Testo 8am	Testo 11am	Testo 5pm	Mean Testo	T/CR 8am	T/CR 11am	T/CR 5pm	Mean T/CR
SFMS Score	0.662**	0.623**	0.404*	0.596**	0.387*	0.344	0.374*	0.371*	-0.383*	-0.297	0.071	-0.341
Cort 8am		0.926**	0.810**	0.958**	0.560**	0.523**	0.493**	0.529**	-0.568**	-0.392*	-0.196	-0.503**
Cort11am			0.898**	0.982**	0.480**	0.396*	0.362*	0.417*	-0.532**	-0.556**	-0.373*	-0.553**
Cort5pm				0.934**	0.345	0.274	0.231	0.286	-0.500**	-0.521**	-0.581**	-0.580**
Mean Cort					0.490**	0.425*	0.388*	0.438*	-0.559**	-0.504**	-0.385*	-0.565**
Testo8am						0.961**	0.958**	0.984**	0.195	0.325	0.424*	0.058
Testo11am							0.990**	0.993**	0.176	0.418*	0.462*	0.032
Testo5pm								0.992**	0.192	0.431*	0.509**	0.068
Mean Testo									0.192	0.395*	0.470**	0.055
T/CR 8am										0.802**	0.597**	0.616**
T/CR 11am											0.783**	0.522**
T/CR 5pm												0.478**

*Testo = Testosterone; Cort = Cortisol; T/CR = Testosterone/Cortisol Ratio. * P<0.05; ** P<0.01*

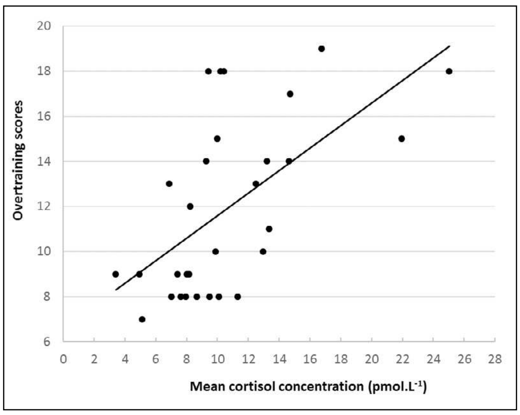

Figure 1.
Relationship Between Mean Salivary Cortisol Concentration and Overtraining Scores

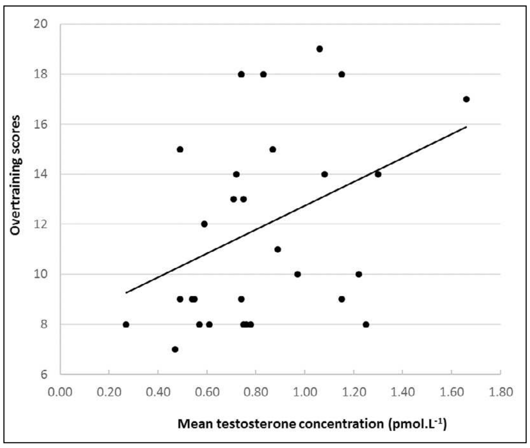

Figure 2.
Relationship Between Mean Salivary Testosterone Concentration and Overtraining Scores

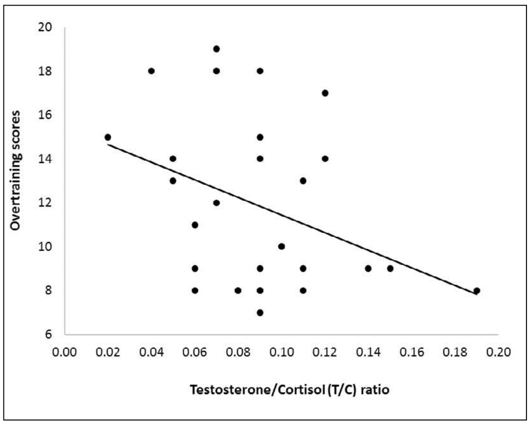

Figure 3.
Relationship Between Testosterone/Cortisol (T/C) Ratio and Overtraining Scores

Discussion

The purpose of the study was to examine the relationship between salivary testosterone and cortisol concentrations and psychological overtraining scores. The mean SFMS overtraining score (11.9±3.8) in this study was higher than other studies using the same questionnaire (Benhaddad et al., 1999; Maso et al., 2004) and it may be that the high scores reflected the intense level of the competition and the specific population sampled (i.e. elite male soccer players). This is so since when compared to non-elite players, elite players are more prone to overreaching and OTS due to a greater training load (Fry et al., 2000; Martial and Fighter, 2013). In this regard, the incidence of OTS in elite long distance runners has been reported at 60% and 64% in females and males, respectively, with the rate dropping to 33% in non- elite women runners (Fry et al., 2000; Martial and Fighter, 2013). In addition, it may also be that the correlations of substantial size reported for cortisol (r = 0.40-0.66) too are strongly related to the intense level of the competition and the specific population. This is so since high level sport is known to cause an increase in cortisol, while testosterone concentration responses are more variable and could be increased or decreased (Maso et al., 2004). In this regard, samples were collected in the middle of the league season. The high SFMS overtraining scores were in conjunction with high cortisol concentrations of the athletes when there were significant positive correlations between the SFMS scores and the cortisol concentrations at 8:00 am, 11:00 am, and 5:00 pm. These results are consistent with previous findings that indicate strenuous exercise training can cause chronic maladaptation in hypothalamic-pituitary-adrenal axis (HPA), characterized by the increase in cortisol concentration above the normal values even during rest (Hackney, Kraemer, and Hooper, 2016; Hackney and Lane, 2015; Kreher and Schwartz, 2012; Meeusen et al., 2013). In addition, the stronger relationship between the SFMS overtraining scores and cortisol concentrations in the morning (8:00 am and 11:00 am) indicated the higher level of stress in the morning than in the afternoon (5:00 pm). Previous research supports the notion that elevated cortisol levels in the morning are indeed linked to higher levels of depressive symptomatology (Lupien et al., 2013).

The present findings that SFMS scores have a significant moderate correlation with testosterone concentrations at 8:00 am and 5:00 pm, but not at 11:00 am are not unexpected. The main reason is that, unlike cortisol, testosterone concentrations following exercise training are less predictable (i.e., can show either increases or decreases in response to exercise training). It should be said that unlike cortisol, which has a quite predictable pattern of change during the day (increase in the morning and decrease in the afternoon), the pattern of testosterone variation is not as straightforward as cortisol according to the available literature (Adlercreutz et al., 1986; Fry et al., 2000).

As it has been proposed, a maladaptation of HPG axis in response to OTS is associated with a chronic reduction in the amount of testosterone. Therefore, we surmised that there might be a moderate maladaptation in testosterone as a result of being exposed to the strenuous exercise training for a long period of time. Due to this fluctuation in testosterone response, a definitive pattern for testosterone variation cannot be proposed (Hackney et al., 2016; King, Rosal, Ma, and Reed, 2005). This also explains why the results of the current study are different from that of Maso et al. (2004), who showed that mean testosterone concentrations are negatively correlated to psychological items of overtraining in rugby players (Maso et al., 2004). In addition, while there is consistency in these changes if the specific exercise is isolated (i.e. endurance running), when compared across multimodal sports, such as rugby and soccer, a lack of consistency is to be expected. Finally, our results also demonstrated that there was a significant negative relationship between the SFMS scores and the T/C ratio only at 8:00 am. Taken together, it seems that maladaptation in hypothalamic-pituitary-adrenal axis and hypothalamic-pituitary-gonadal axes characterized by increase in cortisol and decrease in testosterone, respectively, will result in a decrement in the T/C ratio during OTS (Kreher and Schwartz, 2012). However, it must be noted that these changes may also reflect cortisol having a more rapid recovery, whereas testosterone recovery lags behind that of cortisol, reducing the correlation beyond 8:00 am when the transient changes are perhaps greatest.

Though other elements such as substrates (e.g., lactate, ammonia and urea) and enzymes (e.g. creatine kinase) can be used to monitor OTS, the measurement of hormonal levels (e.g., testosterone and cortisol) is the most commonly employed method (Lippi et al., 2016; Maya et al., 2016; Peñailillo, Maya, Niño, Torres, and Zbinden-Foncea, 2015). It is essential to note that no significant relative difference has been demonstrated between the measurement between saliva and plasma measures of testosterone and cortisol (Cadore et al., 2008; Hough, Papacosta, Wraith, and Gleeson, 2011). This is an important finding in that saliva sampling is usually preferred over blood sampling, since it is a non-invasive and stress-free sampling method that does not require any special apparatus or training (Shariat et al., 2015; Shariat, Kargarfard, Tamrin, Danaee, and Karimi, 2014). In addition, salivary sampling of steroid hormones reflects the amount of circulating free hormones and this is more desirable than total circulating levels confounded by the presence of circulating high affinity binding proteins (Lewis, 2006).

However, the aforesaid methods, including salivary sampling, are not always convenient and available to the athletes. In this regard, a feasible method that is more cost-effective, requires less time to analyze, needs no trained laboratory technicians, and mitigates the risks of working with body fluids is necessary to monitor OTS. It is for this reason that it is essential that this alternative method be an appropriate surrogate for physiological changes and should be valid and discriminatory. The significant relationship between the SFMS psychological scores and testosterone and cortisol concentrations in this study has meaningful implications. This means that the self-report SFMS overtraining questionnaire is an economical, time-saving, and safe alternative to traditional laboratory approaches in determining OTS. However, there is a need to administer this questionnaire, and other OTS questionnaires, across multiple time points (i.e. at the same time as objective sampling) to determine if such subjective measures are stable across the day. In addition, the use of multiple OTS outcome measures (e.g., lactate, ammonia, urea, and creatine kinase), in addition to saliva and plasma measures of testosterone and cortisol, could be utilized to support the use of the SFMS overtraining questionnaire.

Conclusion

The results of this study clearly indicate that there is a strong relationship between hormonal status and psychological aspects of the OTS in soccer players. According to our results, it can also be concluded that the overtrained participants displayed a higher level of the stress hormone, cortisol, compared to the non-overtrained participants, and concerning the results of the SFMS questionnaire, the overtrained participants scored higher than the non-overtrained participants. While well-established and expensive laboratory tests are required to collect and analyze blood or salivary testosterone and cortisol samples, the self-reported SFMS overtraining questionnaire provides an economical and time-saving alternative to assess OTS. Regardless of the testing methods being used, it is suggested that coaches and athletic trainers of sports programs should monitor OTS of their athletes on a regular basis.

Concentración Salivar de Testosterona-Cortisol y Puntuaciones en el Cuestionario de Sobre-entrenamiento de la Sociedad Francesa de Medicina del Deporte como Indicadores de Síndromes de Sobre-entrenamiento en Futbolistas de Élite

Resumen

La sobre-solicitación (o sobre-entrenamiento a corto plazo) y el síndrome de sobre-entrenamiento (SSE) están causados por un desequilibrio crónico entre entrenamiento y recuperación, pudiendo conducir a situaciones de fatiga prolongada y a disminuciones en el rendimiento deportivo. Pese al gran incremento experimentado por la investigación en SSE durante la última década, no existe aún consenso acerca de su etiología ni tampoco un criterio diagnóstico preciso que permita detectar su presencia. El objetivo del presente estudio fue examinar la relación entre las puntuaciones obtenidas en un test de carácter psicológico y marcadores fisiológicos de SSE en futbolistas de elite. Se analizaron los niveles de cortisol y testosterona presentes en tres muestras de saliva no estimuladas (2 ml) obtenidas en días de descanso (8:00 am, 11:00 am, and 5:00 pm) en 30 futbolistas de élite masculinos (edad: 24.1±3.8 años (media±DT)). Adicionalmente, los participantes completaron el Cuestionario de Sobre-entrenamiento de la Sociedad Francesa de Medicina del Deporte (SFMD). Los resultados de las correlaciones de orden cero indicaron que las puntuaciones de sobre-entrenamiento del cuestionario SFMD se correlacionaban de forma positiva y estadísticamente significativa tanto con las concentraciones de cortisol a las 8:00 am ($r = 0.66$; $p<0.001$), 11:00 am ($r = 0.62$; $p<0.001$), y 5:00 pm ($r = 0.40$; $p< 0.05$), como con la concentración media a lo largo del día ($r = 0.60$; $p<0.001$). Además, las puntuaciones de sobre-entrenamiento psicológico estuvieron positivamente correlacionadas con las concentraciones de testosterona a las 8:00 am ($r = 0.39$; $p=0.015$) y 5:00 pm ($r = 0.37$; 100 $p< 0.05$), pero negativamente correlacionadas con la relación T/C a las 8:00 am ($r = -0.38$; $p=0.020$). Puede concluirse que el cuestionario de sobre-entrenamiento de la SFMD podría ser una alternativa asequible y útil en el control (y por tanto prevención) del sobre-entrenamiento en futbolistas.

Palabras Clave: anabólico, catabólico, sobre-carga funcional, síndromes de sobre-entrenamiento, sobre-entrenamiento psicológico

Concentrações de testosterona salivar e cortisol, e índicadores psicológicos de sobretreino da société francaise de medecine du sport em futebolistas de elite

Resumo

O *overreaching* (sobretreino de curto prazo) e a síndrome de sobretreino são causados por um desequilíbrio crónico entre o treino e a recuperação e pode levar a fadiga prolongada e ao decréscimo no desempenho atlético. Embora a investigação sobre o sobretreino tenha aumentado exponencialmente ao longo da última década, ainda não se verifica um consenso sobre a sua etiologia e um diagnóstico preciso da sua ocorrência. O objetivo do estudo foi examinar a relação entre os indicadores psicológicos e os marcadores de sobretreino em jogadores de futebol de elite. Para tal, três amostras de saliva não estimulada (2 ml) foram recolhidas em dias de repouso (8:00 da manhã, 11:00 da manhã e 17:00 da tarde) de 30 jogadores masculinos de futebol de elite (idade: 24,1 ± 3,8 anos (média ± DP)) sendo analisados os valores de cortisol e testosterona. Os participantes foram igualmente convidados a preencher o questionário de sobretreino da *Société Francaise de Medecine du Sport* (SFMS). Os resultados das correlações de ordem zero indicaram que as pontuações de sobretreino do SFMS revelaram uma correlação positiva significativa com as concentrações de cortisol às 8:00 ($r = 0.66$; $p < 0.001$), 11:00 ($r = 0.62$; $p < 0.001$) e 17:00 ($r = 0.40$; $p < 0.05$) e com as concentrações médias de cortisol de todo o dia ($r = 0.60$; $p < 0.001$). Os valores psicológicos de sobretreino também se correlacionaram positivamente com as concentrações de testosterona às 8:00 ($r = 0.39$; $p = 0.015$) e 17:00 ($r = 0.37$; $p < 0.05$), mas correlacionaram-se negativamente com o rácio T/C às 8:00 ($r = -0.38$; $p = 0.020$). Em suma, podemos concluir que o questionário de sobretreino da SFMS pode ser considerado uma ferramenta económica e útil para monitorizar (e assim prevenir) o excesso de treino em jogadores de futebol.

Palavras-Chave: Anabólico; Catabólico; *Overreaching* funcional; Síndrome de sobretreino; Sobretreino psicológico.

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