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Journal of Sport and Health Science 3 (2014) 279–283
www.jshs.org.cn

Original article

Stress hormonal analysis in elite soccer players during a season

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Received 22 October 2013; revised 5 December 2013; accepted 11 March 2014
Available online 14 July 2014

Abstract

Purpose: The purpose of this study was to evaluate the changes in some hormonal parameters (cortisol, testosterone, ratio of testosterone/cortisol (T/C)) in professional soccer players during a season.
Methods: Fifteen professional players from a soccer club of the first division of the Greek soccer league participated. All sport medical examinations were conducted four times: before the re-building period, post re-building period, mid-season, and after finishing the competition phase.
Results: For testosterone, significant differences were observed between the end season and post re-building period (11.6%; $p < 0.05$) and mid-season (12.1%; $p < 0.05$). The cortisol concentration increased at mid-season by approximately 23%, and this change differed significantly from all other measurements for this hormone. The T/C ratio increased at the post re-building period and decreased at the middle of the season.
Conclusion: These hormones and their ratios could be used as stress and recovery state indicators. Coaches can use these parameters in combination with other indicators to optimize workloads, and to avoid overreaching and overtraining.

Keywords: Cortisol; Ratio testosterone/cortisol; Soccer; Testosterone

1. Introduction

Two very important hormones in the biochemical assessment of athletes are testosterone and cortisol. Testosterone is a steroid hormone that is the most potent naturally-occurring androgen, and regulates the development of the male reproductive system and secondary sex characteristics. Testosterone is produced mainly in the testes.[1] Cortisol is a principal steroid hormone produced by the adrenal cortex. It regulates carbohydrate metabolism and the immune system, and promotes gluconeogenesis, glycogen synthesis, and protein synthesis in the liver.[1] Cortisol belongs to the group of glucocorticoid hormones, and testosterone to the androgen family. A high cortisol concentration may cause inhibition of the immune system and proteolysis, and for this reason it is related to the control of catabolic processes in the body.[2] Testosterone has anabolic effects in the body, and thus it has been related to the control of anabolic state.

Exercise has been used in many studies as a stress factor to activate various body systems like the endocrine system.[3] It has been reported in the literature that plasma cortisol increased after acute exercise which exceeded 60% of the VO_{2max}, and also after intense resistance exercise.[2,4] Systematic training has resulted in higher concentrations of cortisol at rest as compared to non-exercisers. This measurement of cortisol can be used as an indicator of physical stress.

If one wanted to increase the concentration of testosterone, the exercise intensity and duration should be increased.[3,5,6] The effect of regular exercise on the concentrations of testosterone is less clear, but also in this case, the intensity and duration play a significant role. In some cases, runners had lower rest values of testosterone than non-athletes.[1] Testosterone promotes protein synthesis[7–9] and therefore is used as an indicator of anabolic processes in the body. However, it has been reported that during exhaustive exercise, the concentration of this hormone decreases.[10]

Another parameter used to evaluate athletes is the resting ratio of testosterone/cortisol (T/C). This ratio has been

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Peer review under responsibility of Shanghai University of Sport.

http://dx.doi.org/10.1016/j.jshs.2014.03.016

associated with overtraining syndrome. In this syndrome, an accumulation of training and/or non-training stress results in a long-term decrement in performance capacity with or without related physiological and psychological signs and symptoms of maladaptation, in which the restoration of the performance capacity may take several weeks or months.[11,12] There are studies that indicate overtraining athletes to this decreased T/C ratio was associated with increased proteolysis and decreased protein synthesis.[13,14] However, there are studies that found no correlation between this ratio and overtraining syndrome.[15–17] Despite the controversial role of this ratio, regular measurement is an indicator of the balance between catabolic and anabolic processes,[13,14,18] and suggests possible changes required in the training program of the athlete.

Soccer at a high level is a demanding sport. Apart from technique and tactics knowledge, the participants should also be sufficiently developed in all physical abilities. The training season in soccer lasts about 11 months. Approximately 2 months are the preparation period, 8 months represents the competitive season, 1 month is a transitional period and 1 month is the players' holiday. In the re-building period, the players try to improve their physical abilities. In the next phase (in season), they have to maintain these abilities at the highest level. To improve through training, the process should be a proper balance between the volume and intensity of training with rest periods.[19] A long recovery from training may not lead to optimal adjustments whereas limited recovery for a long time will probably lead to overtraining syndrome with all of its negative effects on the player's performance and health.[18–20] Furthermore, the psychological stress that a player experiences during the season is an additional factor that can influence his physiological state. One way to protect the players is to regularly monitor the concentrations of testosterone and cortisol and their ratio during the course of the season.[21–25]

The aim of this study was to analyze the testosterone and cortisol responses in a professional soccer team that participates in a professional Greek league throughout the season. To our knowledge, this research is the only study performed in professional soccer players over an entire season.

2. Methods

2.1. Experimental approach

We studied the changes in testosterone, cortisol, and their ratio throughout a soccer season. In this way, we studied the stresses provoked by exercise through a season of competition in professional players. The team participated in 30 matches for the championship, and five matches for the cup. Samples were collected before the beginning of the re-building period, just after the re-building period, at the middle of the season, and at the end of the season (Fig. 1). The samples were collected 24 h after different matches, at 8:00 am, in the fasting state. The blood samples were collected at rest. The measurements were assessed as part of the standard anthropometric/physical conditioning testing.

2.2. Subjects

At the beginning of the study, 25 male professional soccer players were enrolled. During the season, some of them were injured and lost some training sessions. In total, 15 players participated in the study who followed the team program without having any serious injuries. All of the players had participated for at least 3 years in the first division of the Greek league. On average, the players trained 6–7 times per week and participated in a match every week.

After receiving a detailed explanation of the study's benefits and risks, each subject signed an informed consent document that was approved by the local ethics committee.

2.3. Anthropometrics

Body mass was measured to the nearest 0.1 kg (BC-418 Segmental Body Composition Analyzer, Tanita, Japan) with the subjects wearing their underclothes and barefoot. The body fat percentage was calculated from seven skinfold measurements (average of two measurements from each site) using a Harpenden calliper (John Bull, British Indicators, St Albans, UK) on the right side of the body as described by Jackson and

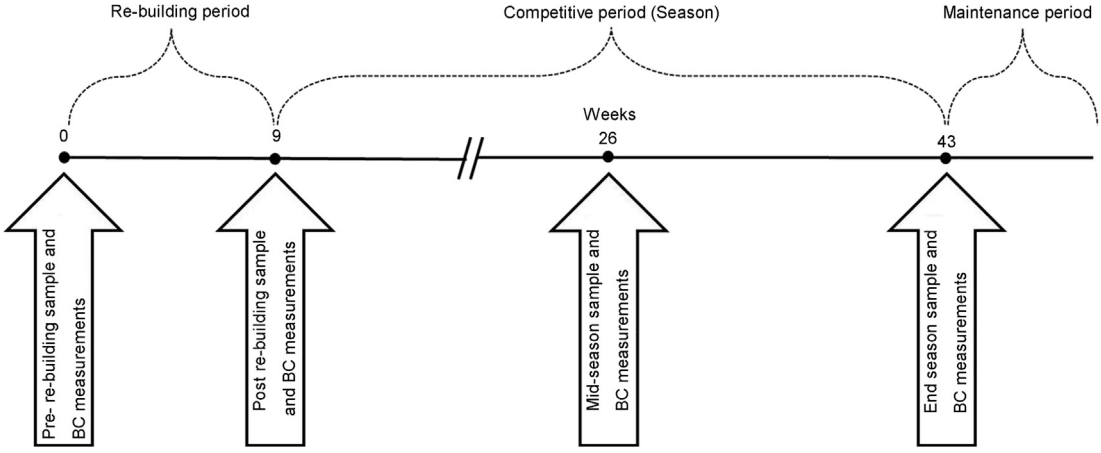

Fig. 1. Procedure for the sampling and anthropometric measurements. BC = body composition.