SPORTS MEDICINE

The changes of ACTH, cortisol, testosterone and testosterone/cortisol ratio in professional soccer players during a competition half-season

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Abstract

Background: **The following up of some hormonal parameters during the professional soccer training process could be one of the indicators of the training effects. On the other hand, overreaching and overtraining as an opposite adaptation of supercompensation could be detected by following up some hormonal changes.**
Objectives: **The aim of this study is to evaluate the changes in some hormonal parameters in professional soccer players during a half-season competition.**
Methods: **We included 30 professional soccer players from a soccer club of our National Soccer League in this study. All sport medical examinations were conducted tree times: before the preparation phase, before the competition phase (after previous phase) and after finishing the competition phase.**
Results: **There were significant differences in all evaluated hormones between three phases of soccer training process, including significant decrease in T/C of more than 30% at the end of the competition phase (phase III). The decrease in muscle mass after the preparation phase and the increase in fat mass at the end of competition phase were insignificant.**
Conclusions: **The hormonal changes indicated that some indices could indicate overreaching and overtraining at the end of professional soccer competition season. Although insignificant, the decrease in muscle mass after the preparation phase and the increase in fat mass at the end of competition phase were undesirable effects for us *(Tab. 4, Fig. 2, Ref. 19)*.**
Key words: exercise and physiology, soccer, ACTH, cortisol, testosterone.

The following up of some hormonal parameters during the professional soccer training process could be one of the indicators of the training effects.

On the other hand, the overreaching or overtraining as an opposite adaptation of supercompensation could be detected by following up some hormonal changes. Some studies report that 10–30 % of professional soccer players, at the end or during competition season, have some signs of overtraining syndrome (1).

The main reasons for this syndrome are the changes in Hypothalamo-Pituitary-Adrenal Axis. Some new studies show changes in the dynamics of ACTH and cortisol blood levels found out by tests taken between two maximal exercises in the morning and in the afternoon (2, 3).

In many of these studies, depressed adrenal responsiveness to corticotrophin (4) and reduced or reversed cortisol responses in exercise (5) are the main hormonal changes connected with decreased performance and fatigue, where the positive feedback or other mechanisms increase corticotrophin secretion (6, 7).

It may be that the low testosterone level in blood (8) and the reduction of T/C of 30 % and more are the most often mentioned hormonal changes in the studies with cases of developed overtraining syndrome.

Nevertheless, must all these hormonal changes have always meant overtraining? On the other hand, from the physiological

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Tab. 1. The differences of ACTH, cortisol, testosterone blood levels and T/C between three phases of training process.

Phase of training process	I (preparatory)	II (precompetition)	III (after competition)
ACTH (pg/ml)	171.08±176.13	50.62±62.28[a]	102,86±64.16[bc]
Cortisol (mmol/l)	468.98±152.23	318.75±113.71[a]	626.93±98.31[bc]
Testosterone (nmmol/l)	27.54±7.26	32.28±6.97[a]	12.72±13.32[bc]
T/C(ratio)	0.07±0.05	0.12±0.06[a]	0.04±0.01[bc]

[a] $p<0.05$ (differences between I and II phase), [b] $p<0.05$ (differences between I and III phase), [c] $p<0.05$ (differences between II and III phase)

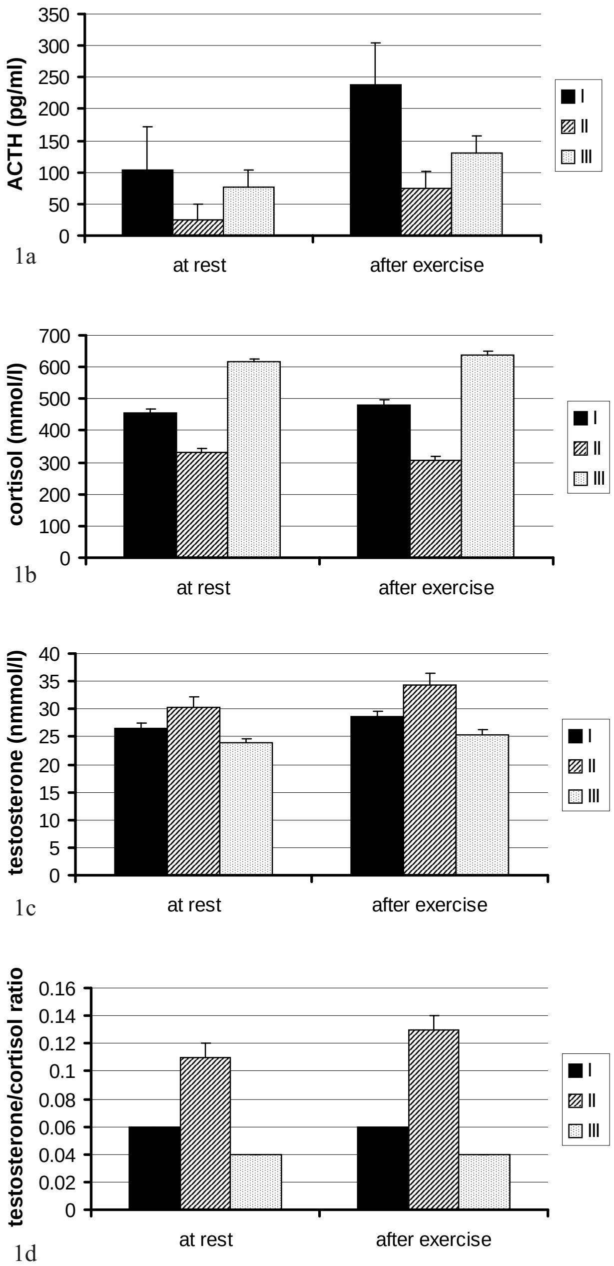

Fig. 1. Differences of ACTH (1a), cortisol (1b), testosterone (1c) blood levels and testosterone/cortisol ratio (1d) at rest and after maximal exercise test between three phases of training process.

point of view, the behaviours of testosterone and cortisol are physiological indicators of the training influence but does not necessarily indicate overtraining. Physiological meaning of altered ratio (T/C) could be different (9). For example, it could be altered by a decrease of testosterone together with a lack of cortisol increase, or by an increase in testosterone that is less pronounced than the increase in cortisol, or by a decrease in cortisol that is more pronounced than that of testosterone, etc.

Accordingly, hormonal indicators of overtraining are strong only in association with a decrease in the levels of performance and mood (10). Namely, the different work loads (intensity and volume), different types of training (endurance, strength, power), different periods of micro and mesocycles and individual adaptation bring on different hormonal responses (Bosco and Viru, 1998, 2000).

At the end, the results of training studies can only be compared if the time points for hormone determinations are similar, keeping in mind the training characteristics and performance dynamics.

Material and methods

We included 30 professional soccer players from a soccer club of our National Soccer League in this study. All sport medical examinations were conducted at the Institute of Physiology and Sports Medicine, three times:

1. Before the preparatory phase (after 3 days of introduction into this phase).
2. Before the competition phase (after the previous phase, during the week of tapering, in which the intensity and volume were down).
3. After finishing the competition phase (3 days after finishing the competition season).

The exercise tests were conducted under standard conditions for hormonal research:

– After the day of absolute rest or recovery
– Exercise testing at 22 °C, 60 % humidity and at least 2 hrs after food intake
– At the same time for each player (hormonal circadian rhythm)
– Before and after the exercise test
– Venous blood, minimizing the effect of stasis

Venous blood was taken before and after the maximal exercise test. Serum levels of testosterone (nmmol/l) and plasma levels

Tab. 2. The differences of ACTH, cortisol, testosterone blood levels and T/C between I (before exercise) and II (after exercise) phase of maximal exercise test, taking account three phases of training process.

Phase of maximal exercise test	I (before exercise)	II (after exercise)
ACTH (pg/ml)	68.52±73.98	147.85 (±148.61)*
Cortisol (mmol/l)	467.57±164.95	475.53±187.58
Testosterone (nmmol/l)	18.91±14.61	29.45±7.46*
T/C (ratio)	0.07±0.05	0.08±0.06*

* p<0.05 (differences between phase I and II)

of ACTH (pg/ml) and cortisol (mmol/l) were determined by RIA.

The absolute muscle and fat mass (kg) and relative muscle and fat mass (%) were measured by anthropometrics formulas of Mateikga, using body weight, body height, circumferences of extremities and skin folds.

Statistical analysis

Statistical evaluation of the results was performed using the computer statistical programme Statistics for Windows 5.0. Results were expressed as means±SD. Comparisons were made using one way analysis of variance ANOVA. A p value <0.05 was considered to indicate a statistical significance.

Results

Our results showed that there were significant differences in ACTH, cortisol, testosterone and T/C blood levels in between the three phases of training process (Tab. 1). ACTH and cortisol blood levels decreased significantly after the conditioning phase (phase I), with a significant increase after the finishing of the competition phase (phase III). On the other hand, testosterone blood levels and T/C increased significantly after the phase I, with a significant decrease after the phase III. The same significant hormonal changes were observed in between the three phases of training process, comparing hormonal blood levels at rest an after the maximal exercise test (Fig. 1).

Taking into account all three phases of training process together, our results showed that there were significant increases in ACTH blood levels after the maximal exercise test (Tab. 2) due to significant increases after the maximal exercise tests in all three phases of the training process (Fig. 2a). On the other hand, when taking into account all three phases of training process together (Tab. 2) and each phase separately (Fig. 2b), there were insignificant differences in cortisol blood levels after the maximal exercise test . At the same time, when taking into account all three phases of training process together, our results showed a significant increase in testosterone blood levels and T/C (Tab. 2) after the maximal exercise test, which was generally the result of their significant increase after the maximal exercise test after the conditioning phase (phase I), (Fig. 2c and Fig. 2d).

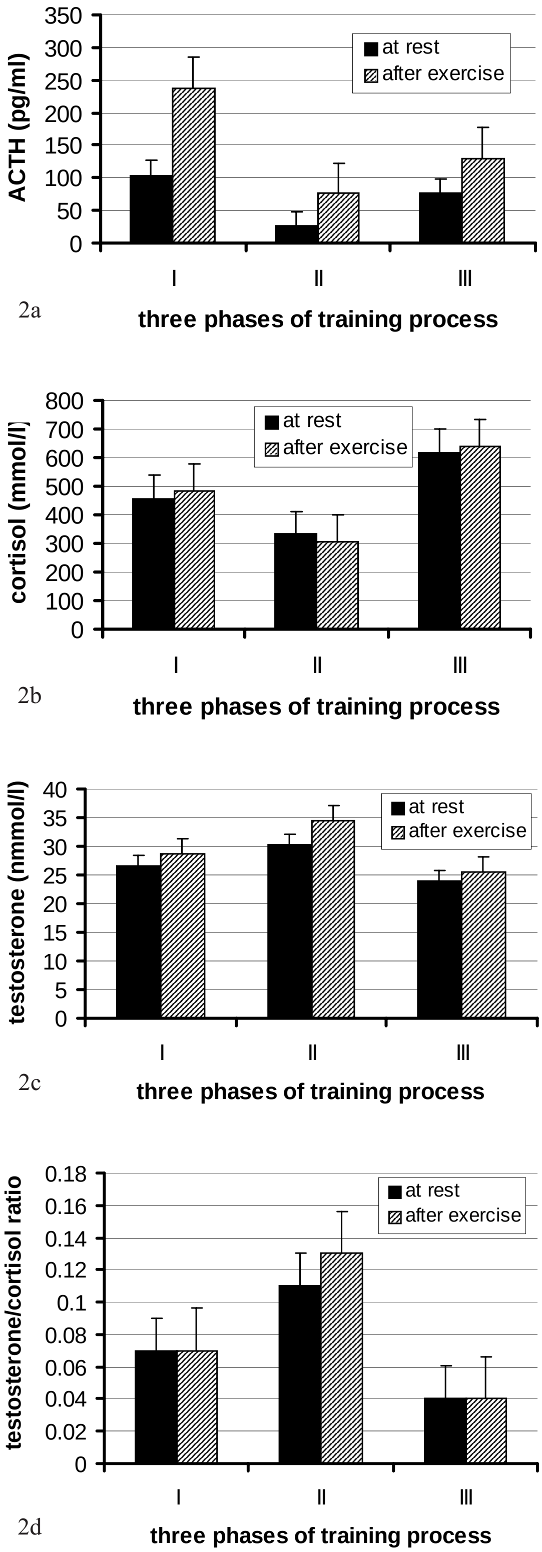

Fig. 2. Differences of ACTH (2a), cortisol (2b), testosterone (2c) blood levels and T/C (2d) between at rest and after maximal exercise test in each phase of training process.

Tab. 3. The differences of exercise induced answer of ACTH, cortisol, testosterone blood levels and T/C between three phases of training process.

Phase of training process	I (preparatory)	II (precompetition)	III (after competition)
ACTH (pg/ml)	130.48±133.35	55.40±82.87[a]	65.09±59.80[b]
Cortisol (mmol/ l)	109.32±85.72	92.5±75.40	83.41±64.94
Testosterone (nmmol/l)	4.95±4.34	4.57±2.86	3.04±3.68[b]
T/C (ratio)	0.02±0.02	0.05±0.05[a]	0.01±0.01[c]

[a] $p<0.05$ (differences between I and II phase), [b] $p<0.05$ (differences between I and III phase), [c] $p<0.05$ (differences between II and III phase)

Tab. 4. The differences of absolute and relative muscle and fat mass between three phases of training process.

Phase of training process	I (preparatory)	II (precompetition)	III (after competition)
MM (kg)	42.13±4.13	41.73±4.75	42.28±4.63
MMP (%)	55.19±2.04	53.92±0.69	54.26±0.93
MT (kg)	10.64±1.17	10.71±1.16	11.03±1.03
MTP (%)	13.56±0.63	13.92±0.69	14.26±0.93

$p<0.05$ There is no significance between the groups

The differences in ACTH blood levels before and after the maximal exercise test showed a significant decrease in exercise-induced response to the conditioning phase (phase I) and after the phase of competition (phase III). At the same time, the differences in cortisol blood levels before and after the maximal exercise test showed an insignificant decrease in exercise-induced response to phases I–III. The exercise-induced testosterone blood levels response showed a significant decrease after the phase of competition (phase III) with a significant increase after the conditioning phase (phase I) and significant decrease after the phase of competition (phase III) of exercise-induced T/C response (Tab. 3).

Although there were no significant differences in absolute and relative muscle and fat mass in between three phases of the training process, the absolute and relative muscle mass decreased after the conditioning phase (phase I) and the absolute and relative fat mass increased after the phase of competition (phase III) (Tab. 4).

Discussion

The significant decrease in ACTH and Cortisol, with an increase in testosterone blood levels and T/C, after the preparatory (I) phase may be connected with reflection of adaptation (13), altered interrelations between corticotrophin and lutotropin secretion (14, 15), pre-competition tapering with its masking effect of high-intensity training changes.

The significant decrease in testosterone blood levels and T/C, with a significant increase in ACTH and cortisol blood levels at the end of competition season is connected with the volume and intensity of previous working loads (amount of competitions).

Is the shift in hormonal interrelations caused by adaptation or dysadaptation?

The significant exercise induced the increase in ACTH response and suppressed or reversed the response of cortisol connected with the dysfunction of H-P-A axis (16) and indicating significant reductions in adaptation reserves (17).

The significant exercise induced an increase in responses of testosterone and T/C to the preparatory phase (I), the fact of which may be connected with current training workload and week of tapering with decreasing the cortisol blood levels (18).

When compared with other phases, the decrease in T/C of more than 30 % at the end of competition phase (III) could not have been caused by overtraining. The significant exercise-induced differences in ACTH and testosterone responses at the end of competition phase and especially the suppressed exercise-induced cortisol responses with continuous decrease as well at the end of competition phase indicated a significant reduction in the reserves of adaptation and hormonal dysfunction.

Namely, the exaggerated cortisol responses to exercise connected with high activity of the adaptation process and reaching the top performance were missing in this study.

In conclusion, without relevant and scientific data about alterations of performance and mood, these hormonal changes indicate high risk of dysadaptation (overtraining?) or stagnation of the training process (19).

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