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Response of selected hormonal markers to the exercise during training cycles in semi-endurance elite runners

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ABSTRACT: Background: High-intensity exercises cause changes in levels of Anabolic and Catabolic Serum Hormones. The purpose of this study was to determine the Response of selected hormonal markers to the exercise during training cycles in semi-endurance elite runners. Thirteen semi-endurance elite male runners with an average age of 18.92±1.7 years and Body Mass Index of 20.07±1.50 kilograms per square centimetre were selected through selective sampling. The runners participated in the selected exercise program with moderate intensity for fourteen weeks consisting of twelve sessions a week (in the morning and afternoon). Serum Testosterone and Cortisol were measured as dependent variables through Immunoradiometric Assay by means of a Gamma Counter before and after the general training period. Collected data were first tested by Kolmogorov-Smirnov test to ensure their normal distribution within a significance level of $P \leq 0.05$ then examined by repeated measures and Bonferroni post hoc test. The results show that the levels of the cortisol during preparatory period had a significant decrease; while, testosterone to cortisol ratio increased significantly during this period. Although, during competition period, cortisol increased and the levels of the testosterone decreased. While, Testosterone to cortisol concentration ratio during this period decreased significantly. Selected training, improved procedure of the anabolic process and variations of testosterone cortisol ratio mention to the anabolic compatibility that it caused by regular training, while this procedure at the competition phase was contrary. Hence, monitoring of these hormones is essential to avoid overtraining and to enhance the performance of the runners.

Key words: Testosterone, Cortisol, Selected Exercise

INTRODUCTION

The aim of sports training is to enhance physical performance, as training improves the capacity for energy production, tolerance of physical stress and subsequently improves the physical performance. The major physical changes associated with training occur in the first 6-10 weeks. The magnitude of these adaptations depends on the volume and intensity of exercise performed during training. The rate at which an individual adapts to training is limited and cannot be forced beyond the body's capacity for development (Wilmore, Costill 2004).However, training too heavily (overtraining) and under-training both have the opposite effects, that is, performance decrement (Maso, et al 2004).

Although the volume of work performed in training is an important stimulus for physical conditioning, there needs to be a proper balance between volume and intensity (Wilmore, Costill 2004). Excessive training i.e. when the training load is too intense or the volume of training exceeds the body's ability to adequately recover and adapt, the body experiences more catabolism than anabolism(Wilmore , Costill 2004). Previous research shows that the ratio between plasma concentrations of free testosterone and cortisol has been used to evaluate training responses and to predict performance capacity (Majumdar, et al 2010; Schelling, et al 2009).

The body activities and exercises have a big impact on the level of hormone serum according to the studies conducted in this research project, and they will also cause reduction and/or increase in other hormone levels compared to the rest time. In fact, these hormone fluctuations are caused by body response against exercise intensity in order to balance the homeostasis of the body(Wong , Harber 2006).

Not to mention that Cortisol has also an important role in balancing homeostasis(Brownlee, et al 2005; Thomas, et al 2009). Although, exercise at 60% or more of an individual's maximal oxygen uptake (VO2max) is one of the physical stressors that can cause an increase in the secretion of cortisol. While cortisol increases during exercise, most of the changes and perhaps effects of this hormone occur after exercise during the early recovery(Brownlee, et al 2005).Testosterone is considered one of the most important hormones in males which increase in amount as a reflex response to exercising, and with respect to exercise, testosterone is especially important in the growth and maintenance of skeletal muscle, bone, and red blood cells(Brownlee, et al 2005; Hazar, et al 2011). It should be noted, however, even low intensity exercise, if prolonged enough in duration, can result in significant elevations in testosterone (the same is true for cortisol). Previous research has established that under certain circumstances a negative relationship exists between the hormones cortisol and testosterone(Brownlee, et al 2005; Hazar, et al 2011).Moreover, a single period of exercise induces transient changes in the anabolic-catabolic balance, depending on the intensity and duration of the exercise periods. Repeated heavy endurance exercise without a sufficient period of recovery can cause a persistent disturbance in the balance. As testosterone and cortisol are playing a significant role in metabolism of protein as well as carbohydrate, the testosterone/cortisol ratio is used as an anabolic/catabolic balance (Filaire, et al 2001).The testosterone/cortisol ratio is used as an anabolic/catabolic balance (Schelling, et al 2009).

This ratio decreases in relation to the intensity and duration of physical exercise, as well as during period of intense training or repetitive competition and can be reversed by regenerative measures (Mujika, et al 1996). In this case, Brownlee and colleagues (2005) reported that there was not a significant connection among the total amounts of Testosterone and Cortisol, or free testosterone and cortisol during the rest time. However, there is a significant connection in recycling time after exercising among these items. They stated that an exercise with an intensity of 65% to 75% of oxygen consumption causes a negative significant connection between Cortisol and free Testosterone (Brownlee, et al 2005).

Majumdar and colleagues (2010), pointed out in their research on 17 swimmers (12 half-stamina swimmers, 4 stamina swimmer, and 1 speed swimmer), it was concluded that the ratio of testosterone to cortisol decreases significantly, while cortisol follows its rapid rise even after the season which might be caused by the intensity or the volume of the exercise (Majumdar, et al 2010).

Hazar and colleagues (2011) reported that after doing some maximum aerobic exercise, there was a noticeable increase in the levels of testosterone; while they could not spot a big difference in cortisol levels (Hazar, et al 2011). According to a study, which was conducted on eight men during one basketball season, Schelling and colleagues (2009) concluded that testosterone amounts increased after 3 to 4 days of rest, and this amount decreased by the end of the season (Schelling, et al 2009).This happened while there was not any sign of a significant change in cortisol amounts during the season. The ratio of testosterone to cortisol had a significant decrease by the end of the season (Schelling, et al 2009).The results of investigations on the effect of maximal and sub-maximal exercise on testosterone are conflicting. Testosterone concentrations have been shown to increase, (Bennell, et al 1996; Rommie, et al 1996) decrease, (Guglielmini, et al 1984) or remain unchanged (Reeves, et al 2006) in response to both maximal and submaximal exercise.

Considering the importance of stress and its role in sports competitions, an understanding of physiological and psychological conditions during competitions is very crucial. Therefore, because of the conflicts in conducted research about Anabolic and catabolic hormone responses in males, the aim of this study was to investigate the response of selected hormonal markers like Cortisol, testosterone and T/C ratio during three phases of training namely preparative phase, pre-competitive phase and competitive phase in elite male runners.

MATERIALS

Subjects

This research was semi-experimental with three phases that is preparative phase, pre-competitive phase and competitive phase in one experimental group. Thirteen elite male runners (age 18.92±1.7 yr, height 177.69±5.32 cm, weight 63.49±6.65 kg, Body mass index (BMI); 20/07±1/50 kg/m2) were selected voluntarily and objectively participate in this study.

During first stage, individuals were introduced to the concept and ways of co-operating. Important notes were given on athletic exercises, nutrition, diseases, drug consumption, supplements, energy drinks, and drug abuse so that they could take necessary measures to consider them. Then, in order to make sure that none of runners was carrying any of the following diseases including the common cold, influenza, sore throat, coronary sweating, diabetes, kidney and thyroid malfunction, they filled up a self-testifying questionnaire, and after the approval of its standards, the participation and co-operation agreement form, which allowed them to be the subjects of the study, was signed by the qualified runners.

During the second stage, their height was measured in centimetres using a height determiner and their weight was calculated using a digital scale produced by a German company called Beurer (PS07-PS06). Then, the waist-hip ratio was determined. Body fat percentage was calculated using a body compound determiner (model In-body-720 made in Korea) and based on a method called bioelectrical impedance. All of these measurements were carried out while the runners had stopped eating or drinking 4 hours prior to their test, and their bladder, stomach, and bowels were totally empty.

Biochemical tests

The serum's Cortisol and testosterone of all runners was measured at three points in time: a) immediately prior to the study, b) at the end of the preparation period, c) at the before the competition period, amount of 10 millilitres of blood was taken from athletes' right-elbow vein between 15:00 to 16:00 in three stages in the research: which was a five-weeks preparation period and nine-weeks competition period.

The runners were asked not to get involved in any serious or intense physical activity three days prior to their blood sample extraction. The plasma of their blood sample was immediately separated from their blood and was frozen in laboratories in -20 degrees Celsius. Serum was separated from the whole blood and Immunoradiometric Assay by means of a Gamma Counter method was used for the quantitative estimation of testosterone and cortisol (RIA Kits from Omega diagnostics, France). T/C ratio was measured from the value of testosterone and cortisol.

To make athletes had a common nutrition, which could have an impact on study elements; subjects were required to write down a checklist report for their three-day diet. Therefore, after collecting all the nutrition information, the amount of received calorie and supplements was distinctly clear. In addition to that, the subjects were asked to consume a common type of food with the same calorie value prior to two periods of blood testing.

Exercise Programs

The selected exercise program in this study was the same as the advanced coordinated program designed for semi-endurance male runners by the government, which was carried out every morning and afternoon, six days a week, and for 14 weeks.

The selected training during perpetration phase included: the morning exercise consisted of warm-up, flexibility, the basic moves for running tracks, and aerobic exercises with 40-60 percent of maximum heart rate reserve (MHRR). Weight training program was made up of Squat, front thighs, back thighs, standing shin, sitting shin, chest press, shoulder in three set(s) and every set was 12 repeated considering 50 percent one repetition maximum and 2-min rest between every set(s). The afternoon exercise was includes: A) warm-up exercises, Fartlek running with 6000 to 1000 m with 60% MHRR, interval training with 1 to 2 repetitions in 1200 to 200 m with fast, and even steps along with 75 percent of maximum speed, slow but steady marathon running, and or B) aerobic running for 8000 to 14000 m with 60-70% MHRR, unsteady, accelerated speed running and slope running. Furthermore, training during competition phase consisted: the morning exercise consisted of warm-up, flexibility, the basic moves for running tracks, and aerobic exercises with 55-65 percent of maximum heart rate reserve (MHRR). Weight training program was made up of Squat, front thighs, back thighs, standing shin, sitting shin, chest press, shoulder in three set(s) and every set was 8-10 repeated considering 60 percent one repetition maximum and 1.5-min rest between every set(s). Special training such as polayometric exercise with 50 percent of maximum heart rate reserve (MHRR). The afternoon exercise was included: lactate acid training (short and long interval)

with 3000 to 8000 m with 70-90 MHRR. Aerobic running for 6000 to 12000 m with 60-80% MHRR, Speed running with 2000 to 3000m with 80-90% MHRR, Fartlek's running with 6000 to 12000 m with 60-70% MHRR and performed slope running with 3000 to 4000m with 70% MHRR.

According to the MHRR for every single athlete was respectively calculated based on Karvonen equation (1) and was also controlled during exercise by a heart rate monitor (made in Finland–Polar), and maximum repetition was determined using equation (2).

Equation (1): Target rate= [%60-%70+ [(resting pulse-(age-220)]] + Resting heart rate.

Equation (2): One maximum repetition = displaced weight (kilograms)/ (0/0278 x number of repetition to exhaustion) – 1/0278

Statistical Analysis

Finally, all the data were analyzed using SPSS version 11.5. The average and standard deviation of data were calculated after checking the data distribution normalcy using Smirnoff and Levine variance method and then examined by repeated measures and Bonferroni post hoc test.

RESULTS

The average, standard deviation and results coming from within groups changes of body measures and testosterone and cortisol of selected runners is presented in table 1.

Table. Comparison of serum levels of testosterone, cortisol and T/C (Testosterone/Cortisol) ratio concentrations during the three phases of training in the elite semi-endurance (n=13)

	Phases	M±SD*	F	P
Weight (kg)	**Pre-preparation period**	**63.49±6.65**	**7.410**	**0.003†**
	Post-preparation period	**62.41±6.43**		
	Pre-competitive period	**61.58±6.24**		
Body mass index (kg/m^2)	**Pre-preparation period**	**20.07±1.50**	**15.402**	**0.000†**
	Post-preparation period	**19.65±1.44**		
	Pre-competitive period	**19.39±1.61**		
Body fat percent (%)	**Pre-preparation period**	**10.05±2.91**	**0.379**	**0.689**
	Post-preparation period	**9.61±2.21**		
	Pre-competitive period	**9.53±1.59**		
Testosterone (nmol/L)	**Pre-preparation period**	**5.84±2.42**	**1.809**	**0.185**
	Post-preparation period	**6.13±2.45**		

	Pre-competitive period	**4.82±2.14**		
Cortisol (nmol/L)	**Pre-preparation period**	**299.69±97.78**		
	Post-preparation period	**219.07±71.62**	**3.649**	**0.041†**
	Pre-competitive period	**233.9±99.0**		
T/C ratio (*1000)	**Pre-preparation period**	**0.0194±0.008**		
	Post-preparation period	**0.028±0.015**	**3.686**	**0.040†**
	Pre-competitive period	**0.021±0.011**		

*Values are mean ± standard deviation. † P < 0.05.

According to table, Fitness training program had a significant impact on elite runners' weights and Body Mass Index (P<0/05) in a way that during the Fitness training program, 1/7 percent of body weight and 2.1 percent of Body Mass Index suffered reduction. During the same period, body fat was reduced from 10.05 percent to 9.61 percent, which is not significant. Likewise, weights and Body Mass Index during competition phase, decrease significantly (P<0/05). Despite the fact that body fat of male semi-endurance runners reduced from 9.61 percent to 9.53 percent during the competition period, this change was not significant.

Therefore, within-group average difference of cortisol level in selected male semi-runners during preparatory period had a significant decrease; This happened while there was a noticeable increase in levels of serum testosterone and the amount of testosterone to cortisol during this period (P<0.05).Although, during competition period, cortisol increased significantly and the levels of the testosterone and T/C ratio serum reduce significantly.

DISCUSSION

In this study, 84 sessions of training had a significant effect on body weight and body mass index. In other words, during physical activity in the general preparation period runners' body weight was reduced by 1 kilogram, and as a result of that their body mass index reduced by 0.42 (kg/m^2). Furthermore, during competition phase weight and BMI (0.83 kg and 0.26 kg/m2 respective) decreased. During this exercise Nemoto and colleagues (2007) could report that the body weight and mass index reduction were caused by mild workout and strong intervals. Interestingly, body weight is something that most researchers expect to be changed during physical activity in the general preparation period; however, according to the analysis of studies, the quality of body weight changes and how it happens during fitness training program is different (Nemoto, et al 2007). Not to mention that many reviewing studies deny the existence of any significant relationship between training and losing body weight (Williams ,Thompson 2006).

In contrast, studies indicate that there is a significant correlation between physical activities in high levels, body weight, and body fat mass(Ross , Janssen 1999).It seems that one of the main reasons in losing body weight and body fat mass is the calorie limitation and the change in the length of the track used by runners. In addition to that, the change in body weight could be caused by a change in runners' psychological state(Nemoto, et al 2007).

Based on the results of this study, despite the 1 kilogram reduction in body weight, runners' body fat reduced from 10.05 to 9.61 percent during 84 sessions of training, which was not very significant. Nevertheless, runners' body fat reduced from 9.61 to 9.53 percent during competition period, which was not very significant. It seems that body composition transitions, especially body fat state during fitness training program, were not much affected by physical activity. By studying the composition of body composition carefully, one

of the reasons for body fat percentage not to change even when body weight reduction was visible is the reduction in minerals, proteins, and inner/outer cell water for athletes during training period.

According to this research, the selected training led to the cortisol level had a significant reduction and testosterone and T/C ratio serum increase significantly during preparation period ($P<0.05$).Thus, these findings correspond with findings from Lehmann and colleagues (1992), reported that decreased cortisol without variation in testosterone after 3 weeks by increase of the volume and intensity training in endurance and semi-endurance runners(Lehmann, et al 1992).Daly and colleagues (2005) examined the effect of prolonged endurance exercise in Twenty-two endurance-trained males. They found out that the amount of cortisol reduced significantly in athletes. One of the reasons for these results was prolonging training periods and reducing stress in subjects(Daly, Seegers, et al 2005).After that Fellman and colleagues (1985) reported that 40 weeks sub-maximal training could increase the amount of testosterone concentration.(Fellman, et al 1985)While Hackney and colleagues (1988) reported that participation in a sub-maximal exercise (90-minute with 65%VO2 max intensity) during 8 weeks results in not changing of serum testosterone hormone(Hackney, Sharp, Runyan, Kim, Ness 1988).

There have been several reasons for changes in intensity of cortisol in body after physical activities, including Hypothalamus Stimulation, Pituitary, Adrenal (HPA), Adrenocorticotropic Release, Central Body Temperature, PH Changes, Sympathetic Nervous System, Hypoxia, and Ethacridine Lactate gathering. Vigorous body activity with 60 to 65 percent of oxygen consumption stimulates HPA axis and increases core temperature; it also causes an increase in releasing cortisol and freeing them from carrying proteins. The increase in pituitary response during vigorous exercises has a big impact on androgenic anabolic (Hosseini, et al 2009).

Another reason which might have an impact on cortisol release is Adernocorticoteropic hormone, which is the main regulator in cortisol release, and which its lack causes a decrease in serum cortisol, (Bateup, et al 2002; Kim Chung, Park et al 2009) while the release of Androgens Adrenalin small amounts is controlled by Adernocorticoteropic. According to the conducted research, the amount of cortisol release is different during days and the most amounts are released during mornings, and the closer we get to the afternoons the less the amounts of that is seen, except in stress periods in which its level does not increase(Kakooei, Zamanian Ardakani, Karimian, Ayttollahi 2009). Since the time of collecting samples was in the afternoon and the subjects were in the recess time without having any stress, these factors might have influenced the release of cortisol slightly. Adaptation index to exercises in males is used through considering the ratio of free testosterone to cortisol and the ratio of testosterone to cortisol(Mujika, et al 1996).

An increase in the ratio of free testosterone to cortisol is mainly caused by a decrease in serum cortisol levels. A decrease of cortisol after exercise is probably due to an increase in cortisol circulation removal, or Adernocorticoteropic hormone decrease(Farzad, et al 2010).

Nevertheless, in the period before the competitions the release of anabolic and catabolic hormones has been reverted in a way that cortisol levels experienced a significant increase, and the ratio of serum testosterone and testosterone to cortisol had a significant decrease, which could indicate an increase in the catabolic procedure of runners' bodies before the competitions. The result of the research shows that whenever T/C ratio reduces more than 30 percent and this situation continues to prolong, it can lead to overtraining for the athletes. Therefore, overtraining syndrome has been attributed to excessive volume or high intensity of training with inadequate periods of rest, eventually leading to an inability to train and perform at optimal levels(Majumdar, et al 2010). To our knowledge, there have been few studies which have examined overtraining and variation of the testosterone and cortisol.

Testosterone level increases most with short intense bursts, while it decreases with a prolonged activity, especially that of frequent endurance training. Because during endurance training or prolonged training period testosterone is needed to maintain muscular function, but frequent extended training does not allow for repair and recovery(Majumdar, et al 2010).Scientists showed that testosterone rise in response to exercise and the levels are higher in well trained individuals; however, the intense

and prolonged training reduces the testosterone level. It is also assumed that a transient suppressive effect on testicular luteinizing hormone receptors as a result of the exercise induced increase in cortisol, and this could be the reason that the testosterone level is decreased by endurance training or during over-training(Majumdar, et al 2010). Cortisol has been used as an indicator of catabolic state for its role in gluconeogenesis via the proteolytic pathway. Cortisol helps to mobilize glycogen and free fatty acid and rises after hard exercise as part of the stress hormone response. An equilibrium between anabolic and catabolic states in athletes is often represented by the ratio of the hormones testosterone and cortisol i.e. T/C ratio. T/C ratio has been suggested as a potential marker for insufficient recovery and overtraining syndrome in athletes as it was decreased after intensive endurance exercise and chronic high volumes of endurance training(Majumdar, et al 2010).

CONCLUSIONS

Overall, the current study has examined the changes in hormone variances in response to fourteen weeks of exercise done by selected track runners. The most important findings indicated that one selected exercise schedule during 6 sessions every week with 2 sessions every day (morning and afternoon) can improved anabolic progress during 4 weeks of preparation with high exercise volume and low intensity. Nevertheless, this amount in pre-competition period of 9 weeks can caused catabolic process along with a hyper-exercise threat for runners with low exercise volume and high intensity. Thus, trainers' and athletes' awareness of testosterone and cortisol hormone changes and the connection among them could be a of great merit for planning exercise volume in order to exploit the most from the workout and to prevent overtraining.

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