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Full Length Research Paper

The effects of maximal aerobic exercise on cortisol and thyroid hormones in male field hockey players

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Some metabolic and endocrine functions might be influenced by exercise and it leads to changed concentrations of hormone secretions in humans. In order to determine the changes of thyroid hormones (THs) related to shuttle run exercise (SRE), 14 field hockey players and their thyroid stimulating hormones (TSH) free T3 (fT3), free T4 (fT4) were included in this study, and cortisol levels were measured three times; before the exercise, just after the exercise and one hour later after exercise. The results of this study showed that there were no statistically significant differences among three measurements in the serum levels of TSH and thyroid hormones. However, both fT3 and TSH were significantly decreased in one hour later after exercise, whereas no change was observed in fT4. Cortisol concentrations were slightly increased immediately after SRE. In conclusion, serum levels of thyroid stimulating hormone and thyroid hormones were affected by maximal aerobic exercise.

Key words: Thyroid hormones (THs), thyroid stimulating hormone (TSH) free T3 (fT3), freeT4 (fT4), cortisol, shuttle run exercise (SRE).

INTRODUCTION

Exercise affects the activity of many glands and the production of their hormones. Thyroid hormone levels influence the skeletal and cardiac muscle function, pulmonary performance, metabolism, and the neurophysiologic axes. Hypothalamus secretes thyroid releasing hormone (TRH) for stimulation of anterior pituitary gland to release thyroid releasing hormone (TSH). TSH causes thyroid gland to secrete two aminoacid based hormones: Three iodine atom containing triiodothyronine (T3) and four iodine atom containing thyroxine (T4). Thyroid hormones have many important biological effects. It controls how quickly the body burns energy, makes proteins, and how sensitive the body should be to other hormones. These hormones regulate the rate of metabolism and affect the growth and rate of function of many other systems in the body (Wartofsky, 1995; Bernet and Wartofsky, 2000; McMurray and Hackney, 2000).

The secretion of thyroid hormones T3 and T4 are controlled by negative feedback loops. When the level of thyroid hormones (T3 and T4) in the blood is high, by regulatory negative feedback loop TSH production is reduced. Both T3 and T4 exist in unbounded (free) and bounded forms (McMurray and Hackney, 2000).

Cortisol is a glucocorticoid and synthesized by adrenal gland. Its primary functions are to increase protein breakdown, inhibite glucose uptake and increase lipolysis. The level of serum cortisol is effected by many factor such as intensity, duration and timing of exercise, type of exercise, age, altitude, environmental temperature and psychology (Bernet and Wartofsky, 2000; Deligiannis et al., 1993).

In spite of the fact that many studies have been reported on the effect of exercise on neuroendocrine secretions, there were disagreements among the results of these studies. While the level of THS was constant in some studies ((Bernet and Wartofsky, 2000; Deligiannis et al., 1993), there was an increase in its level in the other studies (Burtis et al., 2008; Deligiannis et al., 1993; Ciloglu et al., 2005). Some studies (Bernet and Wartofsky, 2000; Siddiqui et al., 1983) reported that free T4 level was unchanged, whereas there were an increase (Bernet and Wartofsky, 2000; Deligiannis et al., 1993; Ciloglu et al., 2005; Licata et al., 1984) and a decrease in its level after exercise (Bernet and Wartofsky, 2000; Limanova et al., 1983; Hackney and Dobridge, 2009). Free T3 levels following exercise were found as increased (Bernet and Wartofsky, 2000;

Table 1. Mean values of subjects for age, body height and body weight (n = 14).

Variable	Age (year)	Body height (cm)	Body weight (kg)
MSD	19.50±1.22	176.00±5.53	68.78±6.29

Table 2. Levels of THS, fT3, fT4 and cortisol in association with pre- (Assay 1), just after (Assay 2) and one hour after exercise (Assay 3), and P values.

Variable	Trial			Summary of two groups comparisons		
	Assay 1	Assay 2	Assay 3	p (1-2)	p (2-3)	p (1-3)
TSH (µIU/ml)	2.12±1.58	2.21±1.44	1.29±0.73	0.54**	0.002*	0.016*
fT3 (pg/ml)	3.86±0.55	4.28±1.25	3.42±0.61	0.52**	0.015*	0.018*
fT4 (ng/dl)	1.70±0.29	1.50±0.27	1.50±0.22	0.06**	0.92**	0.031*
Cortisol (µg/dl)	17.12±7.15	22.96±7.47	18.93±4.6	0.018*	0.11**	0.26**

*p<0,05 significant, **p>0.05, non-significant.

Siddiqui et al., 1983) and decreased (Deligiannis et al., 1993) or unaffected (Ciloglu et al., 2005; Siddiqui et al., 1983; Licata et al., 1984).

Static or isometric exercise, usually of short duration but of high intensity, uses previously stored energy whereas more prolonged exercise must use energy generated by the normal metabolic pathways. The changes in concentrations of analyzes as a result of exercise are largely due to shifts of fluid between the intravascular and interstitial compartments, changes in hormone concentrations stimulated by the change in activity and loss of fluid due to sweating (Burtis et al., 2008). Progressive shuttle run test is suitable for endurance athletes and players of endurance sports including football, rugby and field hockey and its objective is to monitor the development of the athlete's maximum oxygen uptake (Mackenzie, 2005). Here, the effects of exhaustive exercise on cortisol and thyroid hormones (THs) were investigated before, immediately and one hour after exercise.

MATERIALS AND METHODS

The researcher used the quasi-experimental approach with one-group design and measurements were taken pre- post and one hour after the exercise. Post sample was purposefully chosen from 14 elite male field hockey players that participated in this study. The mean age of the participants was 19,50±1,22 years, mean height was 176.00±5.53 cm, mean weight was 68.78±6.29 kg. The average training experience of the participants was 7,21±1,36 years (Table 1).

Blood sample collection

Blood samples were obtained following an overnight fasting state. Samples were withdrawn three times (at rest, immediately after exercise and 1 h post exercise) from antecubital vein into blood tubes and separated from the cells by centrifugation at 3000 rpm for 10 min. Serum samples were stored at -70°C and then they were analyzed.

Measurement of thyroid hormones

Samples were analyzed three times (Assays 1, 2 and 3) for thyroid stimulating hormone (TSH), free triiodotironin (fT3), free thyroxine (fT4) and cortisol by using commercial kit and analyzer (Immulite 2000, BioDPC, USA) with chemiluminescence method.

Exercise protocol

Progressive shuttle run test was conducted to ensure the maximal exhaustion of the participants (Ciloglu et al., 2005).

Statistical analysis

Results were presented as mean±SD. SPSS 10.0 program was used for statistical analysis. Comparison among multiple assays was performed by non-parametric test Mann Whitney-U. A 2-tailed p value p<0.05 was considered statistically significant.

RESULTS AND DISCUSSION

Demoghraphic charasteristics of subjects were presented as mean±SD in Table 1. Mean±SD serum TSH, fT3, fT4 and cortisol concentrations were presented in Table 2 and Figures 1 and 2.

Mean serum TSH and fT3 of Assay 2 were higher than Assay 1 (p>0.05). Mean serum fT4 of Assay 2 was lower than Assay 1 (p>0.05). Mean serum TSH and fT3 of Assay 3 were lower than both assays 2 and 1 (p<0.05). Mean serum fT4 of Assay 3 was lower than both Assay 2 (p>0.05) and Assay 1 (p<0.05). Mean serum cortisol of Assay 2 was significantly higher than Assay 1, (p<0.05) mean serum cortisol of Assay 3 nonsignificantly lower than Assay 2 (p>0.05) and insignificantly higher than

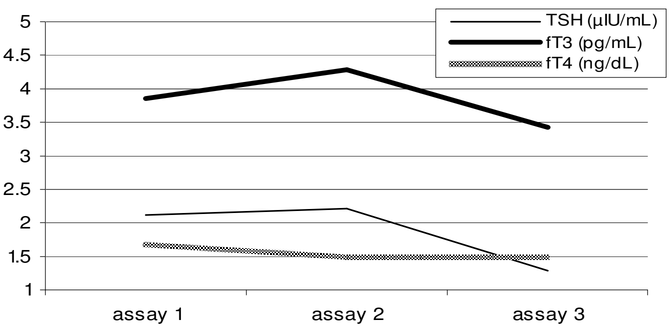

Figure 1. Graph of changes in THS, fT3, fT4 and cortisol levels.

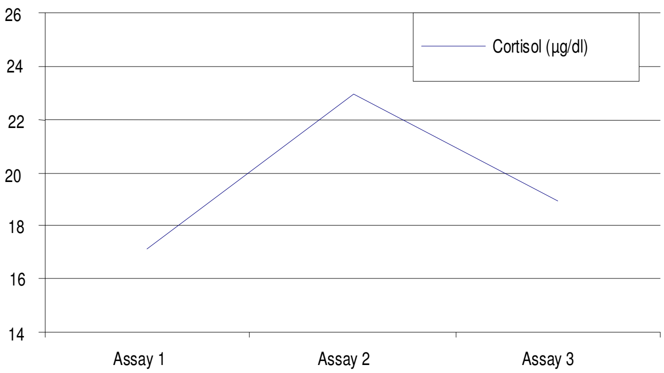

Figure 2. Graph of changes in cortisol levels before (Assay 1), immediate (Assay 2) and one hour (Assay 3) after exercise.

Assay 1 (p>0,05) (Table 2 and Figure 1).

The hormonal response to exercise involves increased sympathoadrenal activity, increased somatotropin, corticotropin, β-endorphin, prolactin, vasopressin, and possibly TSH secretion. The extent of these changes is related to training, nutrition, and state of health; all of the endocrine responses are reduced by exercise training (Licata et al., 1984, Limanova et al., 1983).

A major function of thyroid hormones is their control of the basal metabolic rate and calorigenesis through increased oxygen consumption in tissue via the effects of thyroid hormone on membrane transport and enhanced mitochondrial metabolism (Burtis et al., 2008).

The effects of the exercise on circulating thyroid hormone values remain controversial. The relationship between exercise and thyroid hormone metabolism has been studied by several groups of investigators previously.

In a study carried out by Fortunato et al. (2008), they classified rats into five groups to elucidate the effects of a session of acute exercise on the treadmill at 75% of maximum oxygen consumption on thyroid function of rats: Control (without exercise), and killed just after (0 min) or 30, 60, and 120 min after the end of the exercise session. They reported that a significant increase in T3 occurred just after the exercise, with a gradual decrease thereafter so that 120 min after the end of the exercise, serum T3 was significantly lower than that of controls. Total thyroxine T4 increased progressively reaching values significantly higher than the control group at 120 min. T3/T4 ratio was significantly decreased 60 and 120 min after exercise, indicating impaired T4-to-T3 conversion. Brown adipose tissue (BAT) type 2 deiodinase activity (D2) was significantly lower at 30 min, but pituitary D2 have remained unchanged. No change in serum thyrotropin was detected, while serum corticosterone was significantly higher 30 min after exercise. They concluded that decreased liver D1 and BAT D2 might be involved in the decreased T(4)-to-T(3) conversion detected after an exercise session on the treadmill (Hackney and Dobridge, 2009).

In an earlier study, Krotkiewski et al. (1984) measured thyroid hormones before, during and after acute exercise (60 min) or physical training (3 months) in obese women; thyroid stimulating hormone concentration increased during acute work and decreased immediately after. No changes were seen during the two following days. T4 concentrations showed no changes. T3 decreased slightly immediately after acute exercise, and after three months of physical training (Fortunato et al., 2008).

Simsch et al. (2002) have investigated the influence of different training intensities on Leptin and the hypothalamic-thyroid-axis in highly trained rowers. They measured TSH, fT3 and fT4 and reported that there was no change of fT4 level and a significant reduction in TSH and fT3 after resistance training. A significant increase of TSH was found after endurance training (Simsch et al., 2002).

In Huang et al. (2004) research, Twenty-six healthy male military recruits aged 23 to 27 years with a mean of 25 years have been studied. All subjects had maintained identical diet and physical activity for a week before the test. Serum samples had been drawn before (baseline) and immediately, 1, 4, 24, 24 and 48 h after maximal exercise (on a treadmill with Bruce protocol). Specimens had been analyzed to measure T3, T4, fT3, fT4 and TSH in the same assays. No significant changes of serum mean TH values before and after exercise have been found except for TSH, which had increased significantly immediately after exercise (1.72 vs. baseline 1.42 IU/L, $p < 0.01$). They have reported that maximal treadmill exercise had not greatly affected the determination of concentrations of circulating THs (Huang et al., 2004).

It is known that measurements of changes in hormone values after exercise may reflect only acute transcapillary movements of water, which resolve shortly after exercise ceases. The hemodynamics return to baseline within minutes following termination of exercise. Exercise can cause hemoconcentration (Beaumont, 1972).

In this study, circulating TSH and fT3 levels increased immediately after exercise followed by a significant decrease until the end of the study period. Our results were consistent with other reports suggesting that hemoconcentration could be a cause of changes in circulating TSH and fT3 (Krotkiewski et al., 1984; Sowers et al., 1977; Schmid et al., 1982).

Physical exercise has been reported to stimulate the peripheral deiodination of T4 and an increased uptake of T4 in the liver during exercise (Opstad et al., 1984). Increased conversion of T4 to T3 by peripheral tissues during training is improbable since there were no significant changes in serum fT3 concentrations after immediately exercise in the present study. Moreover, both cortisol and catecholamine actions initiated by exercise will also stimulate peripheral T4 deiodination (Chopra et al., 1975; Nauman et al., 1980). Whether the accelerated deiodination resulted in the increase in fT3 and minimal decrease in fT4 values observed immediately after exercise (Assay 2) remains to be clarified.

It has been reported that the type, intensity and duration of the training regimes, as well as the training background of the subjects, play a role in the changes taking place in serum T4 and fT4 levels have suggested that training may slightly impair thyroid function (Pakarinen et al., 1988). The main findings of the present study were the slight decrease in serum concentration of fT4, slight increases in serum concentration of fT3 and TSH immediately after exercise. One hour after exercise, both fT3 and TSH have significantly decreased, fT4 remained unchanged. Since these changes were all within the reported normal ranges for reference values, they cannot have any clinical significance.

Although no statically significant differences have been reported between pre- and post- exercise serum levels of thyroid hormones in a study including 20 patients with coronary artery disease (Siddiqui et al., 1983;), in our study, in which 14 field hockey players were included, while the concentrations of fT4 decreased, the concentrations of TSH and fT3 immediately increased after exercise.

The level of serum cortisol is effected by many factor such as intensity, duration and timing of exercise, type of exercise, age, altitude, environmental temperature and psychology (Bernet and Wartofsky, 2000; McMurray and Hackney, 2000). In this study, cortisol concentration significantly increased immediately after exercise. High serum levels of cortisol generated by the stress procedure might also contribute to the post-stress (exercise) depression of TSH levels (Sowers et al., 1977).

Conclusion

There were no statically significant differences between pre- and just after the exercise serum levels of TSH and thyroid hormones. It has been appeared that the plasma thyroid hormones and TSH are not highly affected imediately after exercise. However one hour after the exercise, both fT3 and TSH significantly decreased. fT4 was also affected. Cortisol concentrations slightly increased immediately after maximal aerobic exercise. The previously studies is consistent in respect to plasma cortisol level response to exercise. This can be explained by the plasma level of cortisol effected by several factors such as type, intensity, duration and timing of exercise, age, gender, altitude, environmental temperature, blood glucose level, focus of attention etc.

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