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Full Length Research Paper

Testosterone responses to exhausting exercise in male and female students

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ABSTRACT

Previously most studies indicated that high intensity training is a powerful stimulus to acute increases in blood testosterone hormone levels in males. The testosterone responses to exercise in females are controversial; while some studies have shown increases, others have suggested no change. The aim of this study was to determine alterations in serum concentrations of testosterone after an exhausting exercise in males and females. Eight physically active male students (age: 22.25 ± 1.49 yr; height 177.62 ± 1.87 cm; weight 74.97 ± 3.32 kg) and eight physically active female students (age: 19.87 ± 1.45 yr; height 161.87 ± 3.18 cm; weight 57.91 ± 7.33 kg) who were studying at School of Physical Education, Kastamonu University, voluntarily participated in this study. The subjects performed an incremental exercise test until exhaustion using a cycle ergometer (Monark, Stockholm, Sweden) at a constant pedal speed of 60 rpm with stepwise increments of 15 W every minute after a warm-up at 15 W for 3 min. The 5 cc. venous blood samples were obtained from an antecubital vein at pre and immediately after the exhaustion exercise. The Wilcoxon Signed Rank Test was used for determine the differences within groups results at a significance levels of $p < 0.05$. In conclusion, our study demonstrates that exhausting exercise has some effects on the total testosterone profile both males and females.

Keywords: Total testosterone, free testosterone, exhausting exercise.

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INTRODUCTION

The sexual hormone in men is testosterone while they are oestrogen, progesterone and relaxin in women. It stimulates sperm production with follicle-stimulating hormone (FSH) and luteinising hormone (LH). It is vital for development and permanency of male sexual organs. Moreover, it stimulates development of secondary sexual characteristics (Koz et al., 2016). Testosterone is one of the most powerful androgenic-anabolic hormones that are naturally released (Vingren et al., 2010) and it is very effective on energy metabolism (Bosco et al., 1996) and protein synthesis (Cadore and Kruel, 2012; Griggs et al., 1989; Vingren et al., 2010). Testosterone that is traditionally accepted as primary androgen is synthesised and released by Leydig cells of testis via hypothalamic-hypophysis-gonadal axis and small amount of it is provided from ovary, adrenals and transformation of other androgens (such as androstenedione) (Crewther et al., 2006). Although many studies in the literature have mentioned positive effects of exercise on testosterone levels (Bosco et al., 1996), there are also many studies highlighting that exercise didn't have statistically significant effect (Huang et al., 2004) or led to negative effects (Kilic et al., 2006). Especially in athletes exposed to aerobic exercises, decrease in testosterone levels related to increase in cortisol can be determined (Cadore and Kruel, 2012). It is reported that long-term exercise performed at a concentration of 75% of maximum oxygen intake gives greater cortisol responses than short-term high-intensity exercise (Kindermann et al., 1982). There are many studies reporting a negative correlation between cortisol and testosterone (Avanaki et al., 2013).

Some anabolic hormones (such as testosterone) are of great importance for response and adaptation to exercise (Kraemer and Ratamess, 2005). It is well known that testosterone release increases with high intensity and strength training (Kraemer and Ratamess, 2005; Ahtiainen et al., 2004; Kraemer et al., 1999). Acute increases in testosterone levels can reduce the negative effects of fatigue on the muscles (Dent et al., 2012). Furthermore, though acute responses to high intensity exercises are almost the same in men and women, changes or increases in women athletes are suggested to be not so high as those in men athletes (Linnamo et al., 2005, Vingren et al., 2010). Some studies explained this situation with less muscle activation for an activity or women's inability to use their muscles as effectively as men athletes (Linnamo et al., 2005). It has been also indicated that plasma testosterone levels increased in young and old men following an acute exercise, trained individuals presented more androgen response to maximal exercise, testosterone response was related more to effort intensity rather than effort duration and total workload, plasma testosterone levels increased in women with exercise despite being lower compared to men (Koz et al., 2016).

Examining acute testosterone responses can be important to better understand the chronic adaptation process and to see how the intensity of exercise affects the androgen receptors (Cadore and Kruel, 2012). Thus, the aim of this study was to investigate testosterone responses in men and women following an acute strenuous exercise with cycle ergometer and contribute to the literature.

EXPERIMENTAL DESIGN

Physically active 8 male students (age 22.25 ± 1.49 years, height 177.62 ± 1.87 cm, body mass 74.97 ± 3.32 kg) and 7 female students (age 19.87 ± 1.45 years, height 161.87 ± 3.18 cm, body mass 57.91 ± 7.33 kg) who were studying at School of Physical Education, Kastamonu University, voluntarily participated in this study. Participants were requested not to perform any strenuous exercise and change their daily dietary intakes 24 hours before the measurement. Female participants who were in menstrual period were excluded from the study. Following a 3 min cycling warm up with 15 W load, participants performed an incremental exercise with cycling ergometer (Monark, Stockholm, Sweden) at 60 RPM and 15 W load increase at each minute. Testosterone levels were measured before and immediately after the exercise with 5 cc blood sample taken from antecubital veins. Free testosterone (pg/ml) was determined by means of a DSL RIA kit on gamma counter. Total testosterone (ng/dl) was determined by Acces Immunoassay system test kit and Unicel DXI 800 photoanalyser. Statistical analysis was carried out with SPSS 13. The Wilcoxon Signed Rank Test was used for within-group analysis and p value was set at $p < 0.05$.

RESULTS

Table 1 shows the physical and physiological parameters of the participants.

When testosterone responses in male participants after a strenuous exercise were investigated, it increased 34% compared to resting values and as it is seen in Table 2, there is a significant change between the two measurements ($p < 0.05$). No significant change was found in free testosterone levels between pre- and post-training ($p > 0.05$).

When testosterone responses in female participants after a strenuous exercise were investigated, it increased 80% compared to resting values and as it is seen in Table 3, there is a significant change between the two measurements ($p < 0.05$). No significant change was found in free testosterone levels between pre- and post-training ($p > 0.05$).

Table 1. Some of physical and physiological parameters of the participants.

Parameters	Male		Female	
	N	**Mean ± SD**	**N**	**Mean ± SD**
Age (year)	8	22.25 ± 1.49	7	19.87 ± 1.45
Height (cm)	8	177.62 ± 1.87	7	161.87 ± 3.18
Body weight (kg)	8	74.97 ± 3.32	7	57.91 ± 7.33
Resting hearth rate (beat/min)	8	79.00 ± 3.68	7	78.25 ± 7.36
Max VO_2 (ml.kg/min)	8	48.24 ± 1.52	7	33.67 ± 4.26

DISCUSSION AND CONCLUSION

Endocrine system releases some hormones during the exercise to regulate and maintain homeostasis. Physiological function of testosterone is to maintain skeletal muscle tissues and lead to an increase in muscle mass via genomic mechanisms and thus resulting in muscle mass increase, there are some studies supporting this phenomenon (Page et al., 2005). Steroid hormones including testosterone respond to not only regular training regimes but also acute exercises (Dent et al., 2012). However, it was stated that strenuous exercises are more effective in investigating acute effect of exercise (Vingren et al., 2010). High intensity exercises

Table 2. The comparisons of the male participants' average testosterone parameters in pre- and post-exercise.

Parameters	N	Pre-exercise	Post-exercise	Z	P
		M ± SD	M ± SD		
Total testosterone (ng/dl)	8	410.50 ± 186.36	551.38 ± 267.87	-2.52	.012*
Free testosterone (pg/ml)	8	25.43 ± 10.01	26.69 ± 9.66	.000	1.00

Note: P < 0.05*.

Table 3. The comparisons of the female participants' average testosterone parameters in pre- and post-exercise.

Parameters	N	Pre-exercise	Post-exercise	Z	P
		M ± SD	M ± SD		
Total testosterone (ng/dl)	8	30.17 ± 11.94	54.11 ± 15.07	-2.38	.017*
Free testosterone (pg/ml)	8	2.55 ± 2.97	2.12 ± 0.09	-1.12	.26

Note: P < 0.05*.

are known to cause acute increases in testosterone levels in relation to acute reductions in neuromuscular function (Linnamo et al., 2005). This type of exercise causes physical stress on muscle fiber and this causes stimulation of hypertrophy mechanism. The amount of applied physical stress is thought to be parallel to the increase in testosterone level (Linnamo et al., 2005). However, there is still no consensus on whether this effect is due to hemoconcentration or an increase in production due to catecholamine (Galbo, 1983).

When total and free testosterone responses to acute strenuous exercise in our study were investigated, there was positively significant difference in total testosterone levels both in male and female participants ($p < 0.05$). Nevertheless, no significant changes were reported in free testosterone levels in both sexes ($p > 0.05$).

Linnamo et al. (2005) investigated acute hormonal responses to submaximal and maximal heavy resistance and explosive exercises in men and women and stated that testosterone levels increased significantly in men who were exposed to maximal resistance exercises ($p < 0.05$). As a result, they reported that the amount of muscle mass involved in the activity was an important factor in the increase of testosterone responses and that high-intensive strenuous exercises were more valid for testosterone increase due to the stimulation of the hypertrophic mechanism. Since the results for women are more uncertain than men, they are suggested to add exercises with low loads in training as well as heavier loads. This phenomenon was explained with increase in lactate accumulation during maximal resistance exercise compared to other exercise methods. In addition, increasing adrenergic activity parallel to the intensity of the exercise can be a factor that increases the serum testosterone ratio (Linnamo et al., 2005). Hakkinen and Pakarinen (1993) applied a 10 set of 10 repetition exercise protocol to men at submaximal load (70%) and suggested that testosterone levels significantly increased ($P < 0.05$). They found that the results increased by 23% for total testosterone and 22% for free testosterone (Hakkinen and Pakarinen, 1993). Moreover, Raastad et al. (2000) applied different strength training protocols to 9 male athletes and suggested that high intensity method resulted in higher testosterone levels compared to moderate intensity method (Raastad et al., 2000). Mathur et al. (1986) implemented a study to 7 male long-distance runners and 5 sedentaries where participants cycled till exhaustion on a cycle ergometer and researchers stated that testosterone levels in both groups increased significantly compared to pre exercise levels (Mathur et al., 1986). Kraemer et al. (2003) studied leptin and testosterone responses of high intensity exercises in trained men and found significant increases in testosterone levels as a result of 40 minutes of strenuous treadmill run in 60, 75, 90 and 100% of Max VO_2 (Kraemer, 2003). In a study by Bosco et al. (2000) on male and female sprinters, they studied neuromuscular activity and hormonal responses after acute endurance exercise and suggested that adequate testosterone level may reduce the negative effects of fatigue on neuromuscular activity (Bosco et al., 2000). Shafiei et al. (2011) implemented a continuous exercise protocol until exhaustion to 32 male cyclists after zinc and selenium consumption and found significant difference in free testosterone, total testosterone and lactate accumulation between groups with and without supplementation (Shafiei et al., 2011). These results suggest that this situation resulted from increasing contribution of anaerobic glycolysis mechanism in energy production during high intensity exercises. In some studies, positive correlation was found between increasing lactate accumulation and testosterone levels (Linnamo et al., 2005; Lu et al., 1997; Shafiei et al., 2011). When testosterone responses to high intensity and exhausting exercises are investigated, total testosterone levels increased in parallel with our and abovementioned studies (Bosco et al., 1996; Mathur et al., 1986; Ronsen et al., 2001; Cinar et al., 2011; Kindermann et al., 1982; Häkkinen and Pakarinen, 1995). As well as, some findings suggest that exhausting exercises did not result in significant increase in free testosterone levels (Daly et al., 2005). However, there are also studies suggesting that maximal and exhausting exercises decreased testosterone levels in athletes (Kilic et al., 2006; Hackney et al., 1997).

It has been generally accepted in the literature that efforts especially involved in higher anaerobic metabolism lead to an increase in testosterone levels. However, studies have brought forward controversial results. These different results may stem from individual differences such as age, sex, dietary intake, training status as well as content, intensity of the exercise programs. Considering our results, we can conclude that exhausting exercise on a cycling ergometer resulted in increased total testosterone levels in men and women.

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