Int J Sport Stud Hlth. 2019 April; 2(1):e87635. doi: 10.5812/intjssh.87635.

Published online 2019 January 15. **Research Article**

Effects of Aerobic Exercise on Testosterone and Cortisol Hormone of Blood Serum of Sedentary Male Students

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Received 2018 December 15; **Accepted** 2018 December 23.

Abstract

Objectives: The aim of this research was to determine the effect of two months of intermittent aerobic exercise on cortisol and testosterone hormones.

Methods: Twenty healthy sedentary volunteer male subjects (age: 22.2 ± 3.2; height: 174.5 ± 4.6 cm) participated in this research. They were randomly assigned into two groups of experimental and control conditions. Fasting blood sample was drawn prior to the start of the exercise program from both groups. The experimental group participated in 8 consecutive weeks of intermittent aerobic exercise running 4 distances of 200 meter with rest interval between each run. The running distance increased 400 meter weekly. At the end of the program, fasting blood samples was obtained to measure the testosterone and cortisol hormone.

Results: The results of analysis indicated that no significant changes occurred in the mean value of serum testosterone of both groups in the experimental and control group ($P > 0.05$). However, the exercise condition caused a significant change in the mean value of serum cortisol in the exercising group ($P = 0.0001$).

Conclusions: The significant change in cortisol was associated with significant weight loss in the exercise group suggesting that this condition caused inflammation in addition to the fat catabolism in the exercised group.

Keywords: Exercise, Cortisol, Testosterone.

1. Background

Human circulating blood contains many chemical components including hormones. Cortisol is one of the important hormones secreted into blood stream. It is a catabolic hormone secreted from the adrenal cortex in response to physical and psychological stress (1). Metabolism is affected by cortisol's release when cortisol maintains the blood glucose levels during physical exercise; the mechanism involved refers to the increase of amino acid and lipid mobilization by skeletal muscle and adipose tissue (2, 3). Cortisol facilitates the mentioned process by stimulating the liver to crate the enzymes involved in the gluconeogenic and glycogenetic pathways permitting the change of amino acids and glycerol into glucose and glycogen (1). Testosterone is considered as a key anabolic hormone with numerous physiological capacities in the human body. In males, testosterone is primarily created and secreted from the Leydig cells of the testes. With regard to exercise, testosterone plays a key role in the development and strength of skeletal muscles, bones, and red blood cells (4). Cortisol and testosterone and DHEA have been prescribed as great markers of training stress. Testosterone and cortisol hormones are sensitive to exercise. In spite of the fact that an acute bout of endurance exercise regularly increases circulating testosterone and cortisol in an intensity-dependent manner, the responses can be modulated by the intensity, volume and duration of exercise (5, 6). It is obvious that intensive intermittent and continuous running exercises could also stimulate the endocrine system, and the hormonal secretion involved in the pituitary-testicular axis (testosterone, LH, FSH) and the adrenal cortex (cortisol), differently in middle distance runners compared with marathon runners (7). Venous blood cortisol levels have also been shown to increase significantly after repeated 100 m run sprints in trained males (7), after five 15-second Wingate tests (8), and during and after brief, all-out sprint exercise in type 1 diabetic individuals (9). Somewhat similar to cortisol, testosterone increases linearly in response to exercise once a specific intensity threshold is reached with peak concentrations usually occurring at the end of exercise (10). Kindermann et al. (11) measured cortisol following 50 minutes of aerobic exercise at the anaerobic threshold (i.e., 4 mmol/L of lactate) and anaerobic exercise (156% of maximal capacity) to exhaustion. Cortisol increased 35% after the anaerobic exercise, with 12% of that increase occurring during the recovery period. There was a 54% increase observed after the aerobic exercise. The authors concluded that the increase in cortisol is affected by intense prolonged exercise (11). The most pronounced changes in testosterone concentration after training are the decreased basal levels (12, 13). However, the testosterone response to sub maximal exercise is attenuated (13) and is more pronounced after maximal exercise training (13). McMurray and Hackney (12) stated that a critical intensity of 50% - 60% of VO_2 max must be reached for cortisol to be increased. These authors also stated that the final cortisol levels change during exercise are dependent on the total duration of the exercise bout. It is well documented that the rest interval periods between the sets as an important factor would affect the work performed in subsequent sets (14), the metabolic (15) and hormonal responses to exercise training (16), and training adaptations (17, 18). However, acute response of cortisol and testosterone to different rest interval is not well known. The changes in testosterone and cortisol hormone level of serum following aerobic exercise are not very clear.

2. Objectives

In this research, it was aimed to examine the changes of these hormones following two months of increasing intensity aerobic exercise.

3. Methods

In this quasi experimental research, 20 healthy sedentary volunteer male participants participated in an exercise protocol. They completed a human consent form and were assigned randomly into two equal groups of experimental and control conditions. Both groups attended a pathology lab where a fasting blood sample was drawn prior to the start of the exercise program. Then the health history of them was assessed by completing a questionnaire containing demographic as well as having any medication in the month prior to the start of the project. Any participants with a history of drug consumption within the past month or health complication restricting physical activity were excluded. Maximum oxygen consumption (VO_2 max) of the subjects was assessed in order to insure the homogeneity of the endurance capacity of the participants (3). Weight, height and blood pressure of the participants was measured at the beginning and termination of the protocol. Table 1 presents the demographic characteristics of the participants. Blood tests were performed by Biochemistry Analyzer Hitachi No. 717. Blood press was measured by sphygmomanometer model Hartman. Iron level was measured at mic/d liter and ferritin at nanogram/mL. weight was measured bare footed by Seca scale with minimum cloth on and inflexible tape was used to measure the height. Body mass index (BMI) was calculated by weigh in kilogram divided to squared height measure in meter.

3.1. Subjects

Aerobic capacity test of running-walking was employed to determine the maximum oxygen consumption of the subjects one week prior to the start of the protocol (19). Following the screening of the subjects qualified to participate in the exercise program, 20 individuals with BMI over 25 were selected and then randomly assigned into two groups of equal size (n = 10). All the subjects received instruction to attend in a pathology lab for drawing 5cc of their fasting blood at 8 am. Radioimmunoassay was employed and Ca. No. 68628 kite made by Spectria Co. was used to test testosterone in laboratory and radioimmunoassay using cortisol Im 1841 made in Czech was employed to measure the serum cortisol. Both testosterone and cortisol hormones were measured by using nano gram per milliliter scale in a pathology lab.

3.2. Exercise Protocol

The exercise program included twice a week running 4 consecutive distance of 200-meter running with rest interval between each run. The subjects were instructed to run at intensity equal to 60 to 75 percent of their reserved heart rate (20, 21). The heart rate was monitored by a polar watch carried by each subject. The running distance was then increased by 400 meter ($2 \times 200 = 400$m) every week. Overall, the participants ran a total distance of 35200 meters in the eighth week. Following the termination of the last exercise session, both groups attended the pathology lab the next day at 8 am and similar procedure to collect blood at the start of the protocol was employed to draw blood samples.

4. Results

Descriptive statistical index including mean and standard deviation for the demographic data of age, height, systolic and diastolic blood pressure were calculated. These results are presented in Table 1. In addition,

Table 1. Characteristics of the Exercise and Control Groups

Variables	Experimental (Mean ± SD)	Control (Mean ± SD)
Age, y	22.23 ± 3.2	21.5 ± 2
Height, cm	174.5 ± 4.6	175.3 ± 4.8
Systolic blood pressure (mmHg)	110 ± 2.6	115 ± 2.1
Diastolic blood pressure (mmHg)	76 ± 2.2	85 ± 2.7

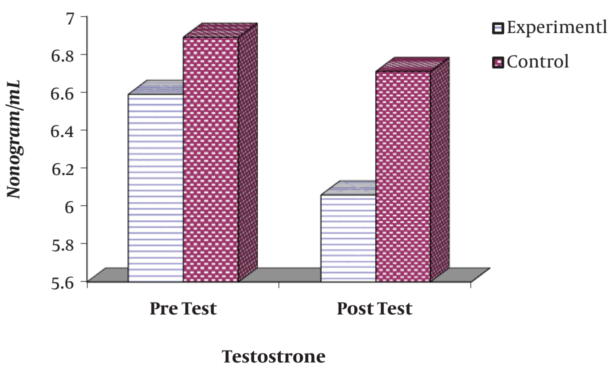

Figure 1. Comparing testosterone level changes (nanogram/mL) in experimental and control groups

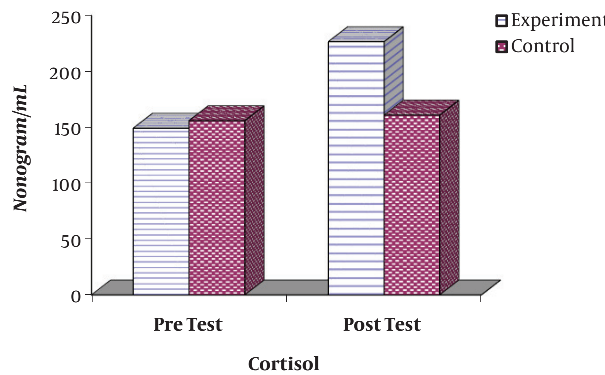

Figure 2. Comparing cortisol level changes (nanogram/mL) in experimental and control groups

Kolmogorov-Smirinov test was employed to examine the normality of the variables measured in this research. The results indicated that all the variables had normal distribution; therefore, parametric statistical procedures including dependent and independent *t*-test were employed to analyze the data. These results are presented in Tables 2 and 3 and Figures 1 and 2. The results of analysis of data related to the change in mean serum blood level of testosterone of the subjects measured at nano scale (ng/mL) showed that two months of intermittent running aerobic exercise had no significant effect on this variable (pre-test = 6.59 vs. post-test = 6.06 ng/mL; P = 0.367). Further analysis of data comparing the level of testosterone (ng/mL) in the control and exercise condition revealed that no significant differences was present between this two independent groups (exercise = 6.59 vs. control = 6.89 ng/mL; P = 0.168). The pre-test and post-test level of testosterone hormone of the control group was also compared. The results showed no significant changes in this two stages (P = 0.6.06 vs. 6.71 ng/mL; P = 0.42).

Similar analysis was performed on the cortisol hormone of the subjects. The results of analysis indicated that there was a significant increase in serum blood cortisol level of the subjects following the participation in two months of intermittent aerobic exercise running program (pre-test = 149 vs. post-test = 226 ng/mL, P = 0.001). Additional analysis of data comparing the level of cortisol (ng/mL) of control group and exercise condition indicated that there was also a significant difference between the control and exercise group (exercise = 226.7 vs. control = 156.1 ng/mL, P = 0.0001) in the post-test. The pre-test and post-test level of cortisol hormone in the control group was also compared. The results showed no significant changes in this two stages (P = 161 vs. 156.1 ng/mL, P = 0.42).

The results of analysis of data in regard to the change in the weight of the subjects also showed that there was a significant decrease in the weight of the exercised group (pre-test = 82.7 kg vs. post-test = 78.4 kg; P = 0.044). The decrease in the weight change of the control group compared to the exercise group was also significant (P = 0.035). No significant changes was present between the pre-test and post-test of the control group (P = 0.53). The results of analysis of the mean value oxygen consumption showed a significant increase for the exercise group after the termination of the exercise protocol (P = 0.0001).

5. Discussion

The aim of this investigation was to examine the acute effect of participation in eight weeks of intermittent aerobic running program in nano scale changes of serum

Table 2. Comparing the Mean Values of Weight (kg) and VO_2 Max (mL/kg) of the Exercise and Control Groups[a]

Variables	Condition	Pre-Test, ng/mL	Post-Test, ng/mL	*t* Value	P Value
Weight	Intermittent	82.7 ± 4.2	78.4 ± 4.7	2.15	0.044
	Control	81.5 ± 4.6	82.9 ± 4.16	0.63	0.53
	Intermittent	-	78.4 ± 4.7	2.26	0.035
	Control	-	82.9 ± 4.16		
Condition VO_2 max	Intermittent	45.91 ± 2.14	51.34 ± 2.23	5.51	0.0001
	Control	46.13 ± 2.20	45.12 ± 1.37	1.23	0.233
	Intermittent	-	45.91 ± 2.14	5.21	0.0001
	Control	-	45.12 ± 1.37		

[a] Values are expressed as mean ± SD.

Table 3. Comparing the Mean Values of Testosterone and Cortisol (ng/mL) Level of the Exercise and Control Groups[a]

Variables	Condition	Pre-Test, ng/mL	Post-Test, ng/mL	*t* Valve	P Value
Testosterone	Intermittent	6.59 ± 2.16	6.06 ± 1.2	0.95	0.367
	Control	6.89 ± 2.12	6.71 ± 2.13	1.5	0.168
	Intermittent	-	6.06 ± 1.2	0.82	0.422
	Control	-	6.71 ± 2.1		
Cortisol	Intermittent	149.2 ± 5.52	226.7 ± 5.37	4.59	0.001
	Control	156 ± 4.82	161 ± 6.19	0.51	
	Intermittent	-	226.7 ± 5.37	24.5	0.0001
	Control	-	161 ± 6.19		

[a] Values are expressed as mean ± SD.

cortisol and testosterone level of male subjects. It has been shown that very little change in the concentration of testosterone leads to disturbance of protein synthesis, growth of muscle tissues and other anabolic activities of human organism (22). In addition, similar changes in cortisol hormone concentration can suppress the immune system; activate the inflammatory response and metabolic reactions. It has been purposed that concentration of testosterone and cortisol level of blood serum are reliable index of exercise intensity (23). In the present research, it was found that the concentration of serum testosterone level dropped from 6.59 (ng/mL) in the pretest stage of the exercise protocol to 6.06 (ng/mL) after the termination of the exercise program. Thus, aerobic exercise caused 8.04 percent decrease in the level of testosterone concentration. However, this alteration was not statistically significant. The cortisol concentration level also increased from 149.2 (ng/mL) in the pretest phase to 226.7 (ng/mL) in the post test state after two months of aerobic running activity (34.18 percent increase). The increase in the level of testosterone hormone due to two months of aerobic exercise was similar to what was reported by Maresh and associates (2006) who claimed that the type of activity, duration and intensity of exercise are determining factors in altering the testosterone level in the exercising individuals. The change in the cortisol level found statistically significant in this research was in agreement with the results of research reported by Vuorima and associates (7) and Bussau and associates (9). However, in one of these researches, 100 meters intensive running program was employed whereas in the other one, Wingate test was employed for 15 seconds (7, 9). On the other hand, it was found that participation in the intermittent exercise program caused significant change in cortisol level. Such results indicated that exercise group was subjected to physical stress which in turn experienced increase of cortisol in their serum blood while the resting group remained inactive and naturally showed no increase in the cortisol level of their blood serum. The finding of the present research was in agreement with the results reported by McMurray and associates (1997) that employed 50 to 60 percent maximum intensity exercise program to examine the alteration of cortisol level of blood serum in their research.

It seem that various intensity of exercise programs lead to different types of responses in regard to the concentration of cortisol and testosterone blood serum level scaled at nano gram per milliliter. In addition, the duration of participation and the volume of activity are also important factors that can influence the concentration of cortisol and testosterone level of blood serum. Finally, it was concluded that intermittent running activity can increase the concentration of cortisol level- an inflammatory response. Therefore, individuals cannot continue their activity in a totally healthy condition. Thus, experts recommend the reduced intensity exercise to avoid harm to the immune system. In addition, despite the fact that intermittent exercise program such as the one employed in this research did not result in significant decrease in the concentration of testosterone hormone, but an 8.4 percent decrease due to the exercise activity may be considered practically significant and exert negative effect on sex hormone in the long run which finally influences the growth of bones and muscles as well as other anabolic processes. Therefore, reduced level of exercise program is recommended.

In regard to the effect of physical activity on blood chemistry changes, numerous studies have been conducted in the past (24, 25) and more are needed to determine the type, duration and intensity of workload aerobically or anaerobically for producing the desired changes. This study was limited in scope and exercise type in addition to the inclusion of other hormones. More research with larger sample size and more exercise protocol is needed to examine the effect of aerobic exercise on blood chemistry changes.

5.1. Conclusions

The significant change in cortisol was associated with significant weight loss in the exercise group suggesting that this condition caused inflammation in addition to the fat catabolism in the exercised group.

Acknowledgments

The researcher wishes to express his appreciation to the participants who fully cooperated with the completion of this research protocol.

Footnotes

Conflict of Interests: No conflict of interests.

Ethical Considerations: The research has been approved by the Ethical Committee of Kashan Medical University.

Funding/Support: No funding.

References

1. Irandoust K, Taheri M. Effect of a high intensity interval training (HIIT) on serotonin and cortisol levels in obese women with sleep disorders. *Women Health Bull*. 2018;**6**(1). doi: 10.5812/whb.83303.
2. Galbo H. Influence of aging and exercise on endocrine function. *Int J Sport Nutr Exerc Metab*. 2001;**11 Suppl**:S49–57. [PubMed: 11915928].
3. Wolfe RR. Control of muscle protein breakdown: Effects of activity and nutritional states. *Int J Sport Nutr Exerc Metab*. 2001;**11 Suppl**:S164–9. [PubMed: 11915916].
4. Buresh R, Berg K, French J. The effect of resistive exercise rest interval on hormonal response, strength, and hypertrophy with training. *J Strength Cond Res*. 2009;**23**(1):62–71. doi: 10.1519/JSC.0b013e318185f14a. [PubMed: 19077743].
5. Miranda H, Simao R, Moreira LM, de Souza RA, de Souza JA, de Salles BF, et al. Effect of rest interval length on the volume completed during upper body resistance exercise. *J Sports Sci Med*. 2009;**8**(3):388–92. [PubMed: 24150002]. [PubMed Central: PMC3763284].
6. Fry AC, Kraemer WJ, Stone MH, Warren BJ, Fleck SJ, Kearney JT, et al. Endocrine responses to overreaching before and after 1 year of weightlifting. *Can J Appl Physiol*. 1994;**19**(4):400–10. [PubMed: 7849656].
7. Vuorimaa T, Ahotupa M, Hakkinen K, Vasankari T. Different hormonal response to continuous and intermittent exercise in middle-distance and marathon runners. *Scand J Med Sci Sports*. 2008;**18**(5):565–72. doi: 10.1111/j.1600-0838.2007.00733.x. [PubMed: 18208421].
8. Hoffman JR, Falk B, Radom-Isaac S, Weinstein Y, Magazanik A, Wang Y, et al. The effect of environmental temperature on testosterone and cortisol responses to high intensity, intermittent exercise in humans. *Eur J Appl Physiol Occup Physiol*. 1997;**75**(1):83–7. [PubMed: 9007462].
9. Bussau VA, Ferreira LD, Jones TW, Fournier PA. The 10-s maximal sprint: A novel approach to counter an exercise-mediated fall in glycemia in individuals with type 1 diabetes. *Diabetes Care*. 2006;**29**(3):601–6. [PubMed: 16505513].
10. Wilkerson JE, Horvath SM, Gutin B. Plasma testosterone during treadmill exercise. *J Appl Physiol Respir Environ Exerc Physiol*. 1980;**49**(2):249–53. doi: 10.1152/jappl.1980.49.2.249. [PubMed: 7400007].
11. Kindermann W, Schnabel A, Schmitt WM, Biro G, Cassens J, Weber F. Catecholamines, growth hormone, cortisol, insulin, and sex hormones in anaerobic and aerobic exercise. *Eur J Appl Physiol Occup Physiol*. 1982;**49**(3):389–99. [PubMed: 6754371].
12. McMurray RG, Hackney AC. Endocrine responses to exercise and training. In: Garrett JR WE, Kirkendall DT, editors. *Exercise and sport science*. New York: Wolters Kluwer Company; 2000. p. 135–61.
13. Viru AA, Viru M. *Biochemical monitoring of sport training*. Human Kinetics; 2001.
14. Harris NK, Woulfe CJ, Wood MR, Dulson DK, Gluchowski AK, Keogh JB. Acute physiological responses to strongman training compared to traditional strength training. *J Strength Cond Res*. 2016;**30**(5):1397–408. doi: 10.1519/JSC.0000000000001217. [PubMed: 26439778].
15. Ratamess NA, Falvo MJ, Mangine GT, Hoffman JR, Faigenbaum AD, Kang J. The effect of rest interval length on metabolic responses to the bench press exercise. *Eur J Appl Physiol*. 2007;**100**(1):1–17. doi: 10.1007/s00421-007-0394-y. [PubMed: 17237951].
16. Hackney AC, Walz EA. Hormonal adaptation and the stress of exercise training: The role of glucocorticoids. *Trends Sport Sci*. 2013;**20**(4):165–71. [PubMed: 29882537]. [PubMed Central: PMC5988244].
17. Sadeghi R, Irandoust K, Taheri M. The effect of spirulina supplementation and combined aerobic-strength training on serum homocysteine of sedentary females. *Asian J Sports Med*. 2018;**9**(4). doi: 10.5812/asjsm.79628.
18. Taheri M, Irandoust K, Noorian F, Bagherpour F. The effect of aerobic exercise program on cholesterol, blood lipids and cigarette withdrawal behavior of smokers. *Acta Medica Mediterr*. 2017;**33**(4):597–600.
19. Baechle TR, Earle RW. *NSCA's essentials of personal training*. Human Kinetics: Champaign, IL; 2004.

20. Froelicher VF, Myers J. *Exercise and the heart*. 5th ed. Philadelphia: Saunders; 2006. 524 p.
21. Gill JS, Baszko A, Xia R, Ward DE, Camm AJ. Dynamics of the QT interval in patients with exercise-induced ventricular tachycardia in normal and abnormal hearts. *Am Heart J*. 1993;**126**(6):1357–63. [PubMed: 8249793].
22. Zitzmann M, Nieschlag E. Testosterone levels in healthy men and the relation to behavioural and physical characteristics: facts and constructs. *Eur J Endocrinol*. 2001;**144**(3):183–97. [PubMed: 11248735].
23. Yazdanparast B, Azarbayjani AM, Rasaee MJ, Jourkesh M, Ostojić SM. [The effect of different intensity of exercise on salivary steroids concentration in elite girl swimmers]. *Facta Univ Series Phys Educ Sport*. 2009;**7**(1):69–77. Turkish.
24. Hammouda O, Chtourou H, Chahed H, Ferchichi S, Chaouachi A, Kallel C, et al. High intensity exercise affects diurnal variation of some biological markers in trained subjects. *Int J Sports Med*. 2012;**33**(11):886–91. doi: 10.1055/s-0032-1301887. [PubMed: 22791622].
25. Abedi B, Karimi M, Mehranpour A, Sayyah M. Effects of eight-weeks of aerobic training on resistin levels and insulin resistance in sedentary middle-aged women. *J Kermanshah Univ Med Sci*. 2017;**21**(3):91–5.