

Effect of Motive Patterns on Serum Cortisol Levels, Testosterone and Testosterone to Cortisol Ratio of Active Young Men

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Abstract: The purpose of the present study was determining and comparison responses of cortisol and testosterone hormones and also testosterone to cortisol ratio serums in three aerobic activity sessions by three various sport devices including treadmill, ergometer and elliptical in active young men. Nine active young men of Tehran city with mean age of 24.11 ± 3.88 years old, 178.77 ± 6.47 cm height, 72.1 ± 10.12 kg weight participated in three activity sessions consisting 25 min aerobic activity with intensity of 85% maximal heart beat rate by three devices (treadmill, ergometer and elliptical). Before and immediately after each activity session, blood samples were collected and for each sample, values of cortisol, testosterone and testosterone to cortisol ratio were gauged and calculated. In order to compare between three activity sessions, variance analysis test with repeated measurements and LSD post-hoc test were utilized and to investigate each activity session T paired test was implemented. There wasn't any significant difference between cortisol, testosterone and testosterone to cortisol ratio by three devices (treadmill, ergometer and elliptical). Treadmill didn't generated any significant difference in variants. Ergometer made a significant increase in testosterone serum ($p < 0.031$), but it didn't make any significant variation in two other variants. Elliptical caused a significant decrease in cortisol ($p < 0.02$), a significant increase in testosterone ($p < 0.002$) and a significant increase in testosterone to cortisol ratio ($p < 0.01$). Hormonal response following activity with elliptical was more anabolic than activities with treadmill and ergometer. So, in the possible manner it's recommended to use elliptical for aerobic activities. Of course, the differences between the three sessions weren't significant and this recommendation is understood from inner-session investigation. By the way, rather researches are still required to propose more suitable sport devices with more confide.

Key word: Cortisol • Testosterone • Motive Pattern • Aerobic Activity • Sport Device

INTRODUCTION

During physical activity, homeostasis would be disturbed. Hence, physiological requirements change temporarily. This issue leads to arise many physiologic changes itself. Because of subsistence, homeostasis must be kept invariant. As the activity become more intense, preservation of homeostasis would be rather difficult [1]. Many required regulations are done by neural system, during sport.

There's another system which is really connected with the whole body cells. This system is the endocrine glands system that implements its control by releasing hormones [1].

Some of the most important hormones secreted during and following physical activity are anabolic and catabolic hormones (In this study, testosterone and cortisol were rather paid attention). Testosterone is an anabolic key hormone with multiple physiological performances in human body [2,3].

In men, testosterone generally generated and secreted in testis and play roles in growth and stability of skeletal muscles, bones and red cells of blood [2,3]. This hormone increases linearly in response of an enough intense sport, until turns to balanced situation. This situation usually occurs in the end of activity [2,3]. Cortisol is the most primary glucocorticoid of body and a catabolic hormone secreted from upper-renal cortex, in response of physiological and psychological stresses [4-6].

Sport with 60% maximal oxygen consuming is a physiological stress and a boundary intensity which increases cortisol secretion [5,6]. During physical activity, releasing of cortisol to attempt preserving blood sugar levels, affects on metabolism and this effect is implemented by action on skeletal muscles and lipid tissues, to increase burning of Amino acids and lipids [5,6].

Also, cortisol stimulates liver to fortify production processes of enzymes which are engaged in sugar generation, like gluconeogenesis and glycogen enzymes that permit transformations of Amino acids and glycerol to glucose and glycogen, respectively [6]. Previous studies show a negative relation between cortisol hormones and testosterone ones in particular situations [7]. A direct controlling effect resulting from glucocorticoid high doses on performance of lydigcells in rats has shown which leads to decrease in production of testosterone [7]. A similar relation has found in human, too [7].

The concerned researchers thought cortisol disrupted testosterone generation in testicles [7]. Previous studies determined a reversed negative relation between cortisol and testosterone, the further ones couldn't still prove this relation clearly [7]. Studies have shown, testosterone to cortisol ratio is a very useful primary factor to determine the balanced situation between tissue anabolism and catabolism [8]. Hence physical activities cause important changes in hormonal levels that depend to intensity [5] and the kind of physical activity [9].

Hormonal response is a function of these factors. Meanwhile, the effect of difference in motive patterns were paid less attention and the present study might be the only research that investigated it. The meaning of difference in the motive patterns of activity is variation in the activity engaged muscles. Any kind of activity demands particular groups of muscles engaged, itself. Perhaps, this event leads to different hormonal responses.

Also, sub-maximal aerobic activities are the activities that the public should use to maintain competence of heart and veins system, improve life quality and create a healthy life style on the other hand, in company with mechanizing human life, trade companies have made sport equipments for home physical activities. In company with increasing growth of sport facilities and equipments, treadmill, ergometer and elliptical are such sport means which utilized by many athletes and ordinary people in sport clubs and houses. Therefore, it's necessary to investigate the influence of each sport device on body physiological responses of body, especially hormonal system and compare these influences with each other to help decision about choosing these sport means.

The purpose of the present study was determination and comparison responses of cortisol and testosterone hormones and also testosterone to cortisol Serum ratio in three aerobic activity session by three various sport devices including treadmill, ergometer and elliptical.

MATERIALS AND METHODS

Participants: The subjects involved nine active young men of Tehran city with mean age of 24.11 ± 3.88 years old, 178.88 ± 6.47 cm height, 72.77 ± 10.12 kg weight, body mass index (BMI) of 22.98 ± 2.25 (kg/m^2) and maximal consuming oxygen of 44.88 ± 4.80 ($\text{ml}/\text{kg}/\text{min}$). By announcement of the targets of the research, in universities of Tehran city nine active qualified volunteers participated in research. The participants had averagely two weekly regular physical activity sessions last year, they didn't have any disease record and their healthiness was approved by physician. Before research execution, they have been completely informed about research execution and studied and signed the approval form.

Sport Activity Schedule: At first, the participants attended at Iran National Olympics Academy Complex, then their aerobic power were evaluated by Bruce treadmill test in the presence of physician [10]. After 48 hours, the participants had been presented in the first sport activity session and so three aerobic activity sessions were executed with rest intervals of 48 hr in order to avoid misleading results which outcome from disturbing influences of sport activity session on each other, the orders of execution of sport activity sessions determined for each person randomly. Three activity sessions included 25 min aerobic activity with intensity

of 85% maximal heart beat rate with three devices (treadmill, ergometer and elliptical). Maximal heart beat rate has concluded by equation $208-(0.7 \times \text{age})$ [11]. Each session started at 14 O'clock and finished his three sport activity sessions in definite times to control influence of night and day rhythm on hormonal response. The participants avoided any physical activity between activity sessions.

Blood Samples Collection and Hormonal Analysis: Before and immediately after each activity session, blood samples were Collected. The participants sat in a constant situation and 5 cc blood collected from the middle vein by syringe. The collected samples were poured in tubes containing clot activators and remained some minutes in the room temperature. The Serum separated from Plasma by centrifuge pump in span of 10 min and revolution of 3500 RPM. The samples were preserved in -20°C , until arrived to lab.

Concentration of serum testosterone was measured by chemiluminescence method utilizing US DiaSorin kit with sensitivity of 0.05 (ng/nl) and accuracy of 0.26 (ng/nl). Concentration of serum cortisol was gauged by radioimmunoassay method using France Monotech kit with sensitivity of 20 ($\mu\text{g}/\text{dl}$) and accuracy of 10 ($\mu\text{g}/\text{dl}$).

Also, testosterone to cortisol ratio was calculated after unit conversion of both hormones to (nmol/l). For unit conversion of testosterone, formula $(T/100) \times 3.47$ was used and for unit conversion of cortisol, formula $0.0276 \times C$ was utilized.

Statistical Method: At first, by using average and standard deviation, outcome data of the study were described. Then, in order to confide in being natural of data distribution and determine statistical test in kinds of parametric or non-parametric, before comparison and investigation of variant changes, kolmogorov-smirnov was used. The results indicated a natural distribution.

Therefore, in both pre-test and post-test times of three activity sessions by three various devices, in order to compare between variables, variance analysis test with repeated measurements and LSD post-hoc test were utilized. These comparison were also done between pre-test and post-test times of three activity sessions.

Data sphericity was investigated simultaneously with variance analysis, to implement Greenhouse-Geisser correction on degree of freedom in necessary cases. In order to investigate variants changes from before to immediately after activity by each sport device, T paired test was used. The significance level for the whole statistical tests considered as $P \leq 0.05$. All of statistical calculations were performed by the famous statistical software SPSS v.17.

RESULTS

Mean and standard deviations of under study variables of the present study have reported in table 1.

In order to compare values of the variants between three activity sessions, statistical results of variance analysis test with repeated measurements have reported in table 2.

In order to investigate changes of variables from before to immediately after the sport activity sessions, statistical results of T paired test have reported in table 3.

There wasn't any significant difference between values of cortisol, testosterone and testosterone to cortisol ratio of 3 sport activity sessions in both pre-test and post-test.

Activity by treadmill didn't cause to any significant change in each under study variant ($P < 0.05$). Indeed, activity by treadmill caused non significant decreases in cortisol and testosterone and non significant increase in testosterone to cortisol ratio.

Table 1: Average and standard deviation of variables before and after exercise sessions

Variables	Exercise Sessions	Before Exercise	After Exercise
Cortisol ($\mu\text{g}/\text{dl}$)	Elliptical	15.33 \pm 4.28	11.6 \pm 4.81
	Ergometer	12.32 \pm 4.02	14.68 \pm 4.59
	Treadmill	14.67 \pm 4.57	11.72 \pm 5.85
Testosterone (ng/dl)	Elliptical	396.88 \pm 141.09	473.77 \pm 123.52
	Ergometer	513.33 \pm 147.52	575.44 \pm 138.68
	Treadmill	457.44 \pm 131.81	447.77 \pm 130.92
Testosterone to Cortisol Ratio	Elliptical	0.0363 \pm 0.020	0.057 \pm 0.024
	Ergometer	0.0573 \pm 0.025	0.0521 \pm 0.0116
	Treadmill	0.0430 \pm 0.022	0.0584 \pm 0.028

Table 2: Statistical results of variance analysis test with repeated measurement, in order to compare values of the variants between 3 sport activity sessions

Variables	Time of Exercise	F	df	P
Cortisol	Pre	1.73	2	0.20
	Post	1.98	2	0.17
	D	0.07	2	0.92
Testosterone	Pre	1.31	2	0.29
	Post	2.52	2	0.11
	D	0.70	2	0.51
Testosterone to Cortisol Ratio	Pre	2.26	2	0.13
	Post	0.27	2	0.76
	D	0.84	2	0.84

D is difference between pre-test and post-test

Table 3: Statistical results of T-paired test, in order to investigate changes of variables from before o immediately after sport activity sessions

Variables	Exercise Sessions	T	P
Cortisol	Elliptical	2.89	0.02 *
	Ergometer	1.17	0.27
	Treadmill	2.08	0.07
Testosterone	Elliptical	4.37	0.002 *
	Ergometer	2.55	0.03 *
	Treadmill	0.21	0.83
Testosterone to Cortisol Ratio	Elliptical	2.98	0.01 *
	Ergometer	0.50	0.62
	Treadmill	1.78	0.11

Activity by ergometer caused significant increase in testosterone ($P < 0.03$), non significant increase in cortisol and non significant decrease in testosterone to cortisol serum ratio.

Activity by elliptical caused significant changes in all of three variants. Indeed, activity by elliptical led to significant decrease in cortisol ($P < 0.02$), significant increases in testosterone ($P < 0.002$) and testosterone to cortisol serum ratio ($P < 0.01$).

DISCUSSION AND CONCLUSION

According to the results of the present study, there wasn't observed any significant difference between responses of cortisol, testosterone and testosterone to cortisol ratio in aspect of aerobic activity by 3 devices (treadmill, ergometer and elliptical). It seems, there're significant differences between 3 sport devices in aspect of the mentioned hormones responses.

However, based on understandings of the research, aerobic activity by treadmill didn't cause any significant change in under study variables. In contrast, aerobic activity by ergometer caused significant increase in testosterone serum, though didn't generate any significant variation in two other variants. Eventually, aerobic activity by elliptical led to significant changes in all of the three under study variables.

In a manner that activity by elliptical would cause significant decrease in cortisol and significant increases in testosterone and testosterone to cortisol serum ratio. Indeed, hormonal responses following activity by elliptical were more anabolic than ones following activity by treadmill and ergometer. By the way, the inter-group comparison didn't show any significant difference. Requirements for rather researches are felt more than anything. cortisol decreased following activities by treadmill and elliptical which was only significant by elliptical. Though, following activity by ergometer led to non significant increase in cortisol. Although, increase in cortisol following activity by ergometer wasn't significant, but when decreases in cortisol following the use of the two other devices were observed, this increment couldn't be ignored. More researches are required for this understanding. Perhaps, activity by ergometer imposed more stress on body than other activities, so this increase occurs.

Although, strike volume increased following the activity and in intensities between 40 to 60 percent maximal capacity arrives to flat then remains constant, but when an athlete works by bicycle or ergometer, increase in strike volume continues [12]. Maybe, the recent issue had been contributed to non significant increase in cortisol after activity by ergometer in contrariety with their non significant decrease and significant decrease after activities by treadmill and

elliptical, respectively. Though, we didn't measure it, couldn't bring any reason about it. But if it'll be investigated in future researches new facts, might be discovered. Anyway, the differences between cortisol values following activity by three various sport devices weren't significant. Cortisol is influenced by intensity [13], time span [14], physical activity, conditions of activity like competition [15] or presenting psychological stimulus [16] and diary cycles [7]. Intensity of activity is the most important factor in cortisol responses to body activities [14,17]. In the present study, intensities of activities and the other above mentioned variables were controlled and were the same for the whole activities that performed by all of three activities. Maybe, cortisol is the most important parameter for nonbeing significant differences between activities by three sport devices. As mentioned, testosterone didn't show any significant difference between three sport devices, too.

However, this hormone increased significantly following activity by ergometer and elliptical though decreased non significantly following activity by treadmill. Information about variations of testosterone resulting from sport activities varies [4,6]. [4] reported evident increase in testosterone concentration after the last step of an increasing sport activity. [18] pointed that Testosterone concentration didn't increase in medium alternative activities. [2] indicated that testosterone concentration increases proportionally to intensity increment, so called the reason increase. [19] also reported intense sport activity led to immediate testosterone increment and its reduction from 30 min to 6 hr after sport.

The recent matter shows the importance of repetitious samples collecting following physical activity, in order to better understanding testosterone responses particularly and hormonal responses generally and recommended to be paid attention in further studies. As mentioned about cortisol, lack of differences in testosterone values in three sport activity sessions by three various sport devices were probably for the reason that intensity and time span of activities were same for the whole three sessions and indeed, intensity and duration of sport are the most important affecting variables on testosterone responses to sport.

Testosterone to cortisol ratio didn't show any significant between three activity sessions of the research. However, this ratio increased and decreased non significantly following activities by treadmill and ergometer, respectively. But, the ratio increased significantly following activity by elliptical. This

significant increase indicates Anabolic response to aerobic activity by elliptical in comparison with the same activities by treadmill and ergometer. Although, decrease in testosterone to cortisol ratio wasn't significant but in attention to increments of this ratio by two other devices (which was non significant and significant by treadmill and ergometer, respectively) couldn't be unimportant. For justification, this issue could be estimated by some guesses mentioned about cortisol before and perhaps, this non significant decrease indicates rather stress of activity by ergometer and strike volume contributed, too.

The only resort is more controlled researches in future in order to response to these ambiguities. Because of enduring maximum weight, it was expected concentrations of hormones would increase after activity by treadmill. Anyway, anabolic responses were observed after activity by elliptical which could be probably the result from simultaneous applying rather muscles bulk (upper limbs as hands and lower parts as feet). [20] investigated testosterone to cortisol ratio during three motive patterns (running, bicycling and rowing) with 65-75% maximal consuming oxygen and span of 60-90 min, which observed a significant increase in cortisol concentration after activity. This observation was opposed to our finding and total testosterone concentration decreased and free testosterone one increased. Measuring free testosterone could aid better understanding of facts in future studies.

However, there isn't much information about influence of differences in motive patterns of a similar activity (here an aerobic one). At present, researches have a vast study field, ahead. These investigations could aid for decision about choosing more suitable, useful and helpful devices. It could be recommended from the present study that using elliptical for aerobic trainings, in possible manners. Of course, the differences between three sessions weren't significant and this proposal is understood from inner-session investigation. By the way, rather studies with more subjects and considering other affecting variables still required, to propose more suitable sport devices with rather confidence. The necessity of performing more researches when become rather evident that observed inter-sessions comparisons weren't significant.

According to findings of the present study, there wasn't any significant difference between cortisol, testosterone and testosterone to cortisol ratio in aerobic activities by three devices (treadmill, ergometer and elliptical). It appears there're significant differences

between three sport devices in aspect of responses of the mentioned hormones. However, based on understandings of the present research, aerobic activity by treadmill didn't lead to any significant change in the under study variables. In contrast, aerobic activity by ergometer caused a significant variation in testosterone serum though it didn't lead to any significant change in two other variants. Eventually, aerobic activity by elliptical caused significant variations in the whole three under study variables, in a manner that activity by elliptical led to significant decrease in cortisol and significant increases in testosterone and testosterone to cortisol ratio. Indeed, hormonal responses following activities by elliptical were more Anabolic than ones by treadmill and ergometer.

Anyway, inter-groups comparisons didn't show any significant difference. It's recommended to use elliptical in aerobic trainings, in possible manners. Of course, the differences between three sessions weren't significant and this recommendation is concluded from inner-session investigation.

However, rather studies with more subjects and considering other affecting variants are still needed to be able to recommend more suitable sport devices with rather confidence. Because, inner-sessions comparisons weren't significant, the necessity of performing rather studies arises more evident.

REFERENCES

- Hakkinen, K., A. Pakarinen, M. Alen and P.V. Lomi, 1985. Serum hormones during prolonged training of neuromuscular performance. *Eur. J. Appl. Physiol.*, 53: 287-293.
- Wilkerson, J.E., S.M. Horvath and B. Gutin, 1980. Plasma Testosterone during treadmill exercise. *J. Appl. Physiol.*, 49: 249-53.
- Zitzmann, M. and E. Nieschlag, 2001. Testosterone levels in healthy men in relation to behavioral and physical characteristics: facts and constructs. *Euro. J. Endocrinol.*, 144: 183-197.
- Galbo, H., E.A. Richter, J. Hilsted, J.J. Holst, N.J. Christensen and J. Henriksson, 1977. Hormonal regulation during prolonged exercise. *Ann. NY Acad. Sci.*, 301: 72-80.
- Hakkinen, A., A. Pakarinen, P. Hannonen, H. Kautiainen, K. Nyman and W.J. Kreamer, 2005. Effects of prolonged combined strength and endurance training on physical fitness, Body composition and hormones in women. *Clin. Exp. Rheumatic.*, 23: 505-512.
- Viru, A., 1992. Mechanism of general adaptation. *Medical. Hypothesis.*, 38: 296-300.
- Diamond, G.R., B. Brisson and F. Péronnet, 1989. Trait anxiety, sub-maximal physical exercise and blood androgens. *Eur. J. Appl. Physiol. Occup. Physiol.*, 58: 699-704.
- Urhausen, A., H. Gabriel and W. Kindermann, 1995. Blood hormones as markers of training stress and over training. *Sport. Med.*, 20: 251-276.
- Viru, A., T. Smirnova, K. Karelson, V. Snegovskaya and M. Viru, 1996. Determinants and inoculators of hormonal response to exercise. *Biol. Sport.*, 13: 169-187.
- Maud, P.J. and C. Foster, 1995. Physiological assessment of human fitness. Champaign, IL: Human Kinetics.
- Tanaka, H., K.D. Monahan and D.R. Seals, 2001. Age-predicted maximal heart rate revisited. *J. Am. Coll. Cardiol.*, 37: 153-156.
- Kenny, W., J.H. Wilmore and D.L. Costill, 2011. *Physiology of Sport and Exercise 5th ed.* Human Kinetics.
- Koopman, C., S. Sephton, C. Heather, C. Classen, D. Lisa, C. Gore-Felton, A. Borggreffe and D. Spiegel, 2003. Dissociative symptoms and cortisol responses to recounting traumatic experiences among childhood sexual abuse survivors with PTSD. *J. Trauma. Dissociation.*, 4: 4.
- Budde, H., C. Voelcker-Rehage, S. Pietrassyk-Kendziorra, S. Machado, P. Ribeiro and A.M. Arafat, 2010. Steroid hormones in the saliva of adolescents after different exercise intensities and their influence on working memory in a school setting *Psycho-euro-endocrinology. E-pub*, 35: 382-391.
- Haneishi, K., A.C. Fry, C.A. Moore, B.K. Schilling, Y. Li and M.D. Fry, 2007. Cortisol and stress responses during a game and practice in female collegiate soccer players. *J. Strength. Cond. Res.*, 21: 583-588.
- Chicharro, J.L., M. Pérez, A. Carvajal, F. Bandrés and A. Lucia, 1999. The salivary amylase, lactate and electro-micrographic response to exercise. *J. Physiol.*, 49: 551-554.
- Duclos, M., J.B. Corcuff, L. Arsac, F. Moreau-Gaudry, M. Rashedi, P. Roger, A. Tabarin and G. Manier, 1998. Corticotroph axis sensitivity after exercise in endurance-trained athletes. *Clin. Endocrinol.*, 48: 493-501.

18. Jezova, M., P. Vidas, R. Tatar, K. Kvetansky, H. Nazar and S. Kozlowski, 1985. Plasma testosterone and catecholamine responses to physical exercise of different intensities in men. *Eur. J. Appl. Physiol. Occup. Physiol.*, 54: 62-66.
19. Bosco, C., J. Tihanyi, L. Rivalta, G. Parlato, C. Tranquilli, G. Pulvirenti, C. Foti, M. Viru and A. Viru, 1996. Hormonal responses in strenuous jumping effort. *JPN J Physiol.*, 46: 93-98.
20. Hackney, A.C., 1996. The male reproductive system and endurance exercise. *Med. Sci. Sports. Exerc.*, 28: 180-189.