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Annals of Biological Research, 2012, 3 (3):1452-1460
(*http://scholarsresearchlibrary.com/archive.html*)

ISSN 0976-1233
CODEN (USA): ABRNBW

The effect of different types of exercise on the testosterone/cortisol ratio in untrained young males

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ABSTRACT

One of the main goals of exercise training is to improve adaptations and performance in the training. There are more kinds of exercises that effect to the physical fitness. The influences of resistance and endurance training, depend of the type of diet provided, resistance training results in a positive energy balance, hypertrophy and strength gains. The goal of this study was to investigate the effect of simultaneous strength and endurance training on the ratio of testosterone to cortisol in young untrained males. This study was performed on 24 untrained males who were divided into strength, endurance and concurrent groups. Each group had an equal number of subjects (n=8) and were studied during a time course of 12 weeks. Blood samples were drawn from the left brachial vessel at 0, 6 and 12 weeks to determine the total and free concentrations of testosterone and cortisol system and muscular performance.

Keywords: Concurrent training, Anabolic and catabolic hormones, Serum testosterone/ cortisol ratio.

INTRODUCTION

Resistance training is aimed at increasing an individual's lean body mass and strength. Conversely, endurance training is usually undertaken to improve cardiovascular fitness and physical endurance. Resistance and endurance training are sometimes undertaken concurrently in an attempt to improve both endurance and aerobic fitness, while maintaining or increasing strength [26, 15]. Hickson et al. (1980) showed that when the performance of concurrent training was compared to resistance-only training, there was a negative effect on the augmentation of strength [18]. Later, Kraemer et-al, showed that while both resistance and concurrent training, strength increased to a greater extent in the resistance training group [25, 17]. In contrast, MacCarty and Sale observed a similar level of strength improvement in both the resistance and concurrent training groups [13, 19]. These authors also noted that concurrent training did not alter the coordination and adaptation that are normally produced by endurance training [24, 28].

Kraemer and colleagues suggested that, in addition to improving performance, concurrent training may result in a more rapid rehabilitation in response to injury and potentiate improvements in the maintenance of the cardiovascular efficiency [25]. Comparing the influences of resistance and endurance training, which likely depend of the type of diet provided, resistance training results in a positive energy balance, hypertrophy and strength gains [2, 20].In contrast, endurance training often results in a temporary negative energy balance, which is a catabolic situation, that inhibits hypertrophy and does not improve strength [14, 3]. The ratio of testosterone /cortisol is considered to be a suitable biomarker for monitoring the relative anabolic/catabolic state [16]. Concurrent resistance and endurance training would alter the balance of anabolic and catabolic hormones, likely reducing or even opposing the muscular hypertrophy that is normally produced by resistance training [9]. Nevertheless, the ratio of testosterone/cortisol would likely provide a good marker for the relative anabolic/catabolic effects that concurrent training has on an individual. This ratio might even be used to modify the amount of resistance or endurance training that is performed [4]. However, there is little published information regarding the hormonal response to concurrent training compared with the hormonal response to resistance-only or endurance-only training. Therefore, the purpose of this study was to investigate how these three training regimens alter the ratio of testosterone/cortisol in young men.

MATERIALS AND METHODS

Twenty four students were randomly selected from among 86 volunteers and completed an introductory questionnaire in Federation of- Medical-Sports of Tehran in summer 2009. The 24 participating untrained male were assigned to one of three homogeneous groups: 1- the Endurance (E), 2-Resistance (R) and 3-Concurrent (C) groups. The groups were matched according to the age, physical status, Vo_{2max}, and one repetition maximum (1RM) of the participants (Table 1). Based on the data provided in the questionnaire, the participants had no history of injury, drug usage, hospitalisation, special disease, or regular training in the three months prior to the study. The participants were instructed not to change their physical activity routines or dietary patterns during the course of the study. The descriptive statistics of the subjects' anthropometric and physiological characteristics are presented in Table 1.

Table 1. Descriptive characteristics of experimental groups

	Endurance (n=8)	Resistance (n=8)	Concurrent (n=8)	*F*	*P*
Age(y)	22.6±1.9	21.9±1.7	21.8±1.8	1.38	.274
Weight(kg)	74.42±7.20	78±7.57	76±3.38	.655	.530
Height(cm)	174.6±0.31	174.6±4.73	177.5±1.92	1.03	.374
Vo_{2max}(ml.kg-1.min-1)	43.96±3.14	43.1±3.03	44.18±3.05	.340	.716
1Repetition maximum(kg)	84.06±10.27	88.16±11.77	89.4±7.87	.612	.552

Values are means ±STD for 24 students

Training program: Endurance training (-E-)

A calibrated Monark cycle ergo–meter (Varberg, Sweden) was used for all aerobic power measurements of maximal oxygen consumption. An initial work load of 60 Watts (W) was performed for five minutes. The overload was determined progressively based on a percentage of the steady heart rate every 4 weeks (first 4 weeks, 4 repetitions of 3 minutes, at 75% of the steady heart rate), (second, 4 weeks, 6 repetitions of 3 minutes at 80% of the steady heart rate), (third 4 weeks, 8 repetitions for 3 minutes at 85% of the steady heart rate). The heart rate was recorded at the end of each workload. Cycle ergo-meter VO_{2max} was determined by-one of the following: a plateau or decrease in oxygen consumption with a subsequent increase in workload, by obtaining the age-predicted maximum heart rate or volitional fatigue. A brief cool-down period followed the test. The students wore a Polar heart rate monitor (made in Finland) during all tests.

Resistance training (-R-)

The strength training program was performed for 12 weeks with 3 sessions per week. Every 4 weeks, the main overload prescribed was progressively based on the maximum percentage of additional strength [10]. The program of each active resistance training session included a brief warm up period of the additional strength gained prior to each training session that, consisted of 2 to 3 sets of 10 repetitions at approximately 50% of the student's 1RM. Five working sets (1Leg press, knee bending and extension and thigh abductor and adductor muscles) were performed during each training session following the warm-up period. The strength training protocol was periodised by 1RM loads over the course of the 4-week training program. Each training session included 12, 10 and 8 repetitions for each successive movement using 70, 80 and 85% of the 1RM, respectively. All working sets were separated by 3 minutes of rest. The specific resistance training loads were prescribed based on the maximal strength of the participant, as calculated using each participant`s 1RM. We used the Brzycki formula to calculate the 1RM [18].

Brzycki Formula: $1\,rep\max = \dfrac{weight\ lifted}{1.0278 - (0.0278 * \#of\ \ reps)}$

As with the 1RM trial, strength training was performed in the seated position. The participants were instructed to maintain the speed of contraction at a medium level and were able to do this by looking at the indicator on the instrument.

Concurrent training (-C-)

This program was performed for 12 weeks with, 3 sessions per week. The training program for the concurrent group consisted of half of the endurance and half of the resistance training load that was determined by the resistance training machine and cycle ergo–meter. The strength training protocol was periodised by 1RM loads over the course of the 4 week training program. Each training session included 10 repetitions for each successive movement at 80% of the 1-RM. All working sets were separated by 3 minutes of rest. The overload in endurance training was determined based on the percentage of the steady heart rate every 4 weeks (first 4 weeks, 2 repetitions of 3 minutes, at 75% of the steady heart rate), (second 4 weeks, 3 repetitions of 3 minutes at 80% of the steady heart rate), (3^{rd} 4 weeks, 4 repetitions of 3 minutes at 85% of the steady heart rate). A brief cool-down period followed the test. In the concurrent group, strength and endurance training were performed alternately in each session.

Blood collection

Blood was collected three times in the morning between 8:00 and 8:30 am after 12 hours fast, 6 hours before each training session (before the sessions, at the 0^{th}, 6^{th} and 12^{th} weeks). While subjects were in a relaxed position, a 10 ml blood sample was drawn from the left anticubial vain and collected in a blood tube. The sample was then centrifuged for 15 minutes (1000 rpm), and the serum was separated and then poured into the labelled test tube. It was stored at -80°centigrade for future analysis.

Hormone assay

Total testosterone was measured in ng/ml using the Diaplus kit (made in the USA). Free testosterone was measured in pg/ml by the IBL kit (made in Germany). Cortisol was measured in μg/dl by the Monobind kit (made in the USA), using the ELISA method. The Colter Cismex 1300 instrument was used to measure CBC. To omit the short term effects of physical exercise on the blood indices, the volume changes of blood plasma (Hb and Hct) were measured using the Dill and Costill formula [19].

$$\Delta PV\ (\%) = 100 \times [\ (HbB\ (1\text{- } Hct_A \times 10^{-2})] / [Hb_A\ (1\text{- } Hct_B \times 10^{-2})] - 100$$

The tests were performed over two successive days to insure the accuracy of the results.

Statistical method

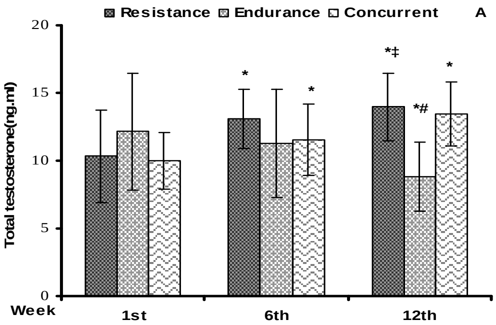
Descriptive and inferential statistics were used.The descriptions were made based on the mean of the indices and standard deviations of the data. In the inferential statistics, a Kolmogorof-Smirnof test was first used to study the normal distribution. Then a Levin test was used to study the symmetry of the data. For between group comparisons, one-way analysis of variance tests were used. To determine the significant differences between the groups, a post hoc paired ordering test (t-dependent) was used and included correction (Bonferroni). Sheffeh post hoc was used for analysis of one-way variance for each dependent variable. The Epsilon Green, Haves-Gizer, obtained from analysis of variance was used for correction of the frequent measuring rates. All of the statistical analyses were performed using SPSS, Version 16. The level of significance was set at ($P \le 0.05$).

RESULTS

Table 2. Concentrations of Hb and Hct of groups during 12 weeks

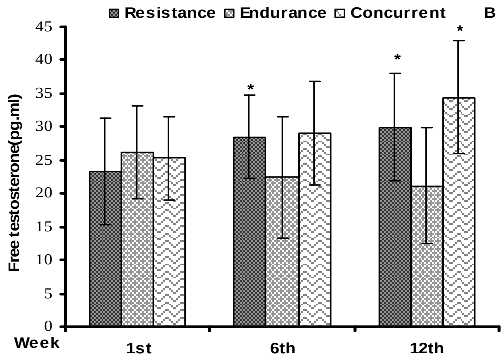
Groups	Time	Concurrent **N=8**	Resistance **N=8**	Endurance **N=8**	*F*	*p*
Hb (g/dl)	1^{th}	14.528±0.801	15.185±0.318	13.871±0.475	.114	.893
	6^{th}	14.442±0.553	14.800±0.369	13.542±0.789	.208	.813
	12^{th}	14.271±0.553	14.742±0.486	13.442±0.741	.220	.805
Hct (%)	1^{th}	44.88±2.29	42.99±2.61	45.59±2.88	.924	.412
	6^{th}	45.81±2.74	43.93±2.48	45.89±1.75	.388	.683
	12^{th}	45.78±2.52	44.88±3.34	46.88±4.08	.353	.706

Results showed that there were no significant changes in haemoglobin (Hb) and hematocrit (Hct) levels between or within the groups, (Table 2).



**Denote Significant difference to the first week*
**‡ Denote Significant difference to the endurance group*
Figure 1. Concentrations of Serum Total testosterone (nmol.ml)

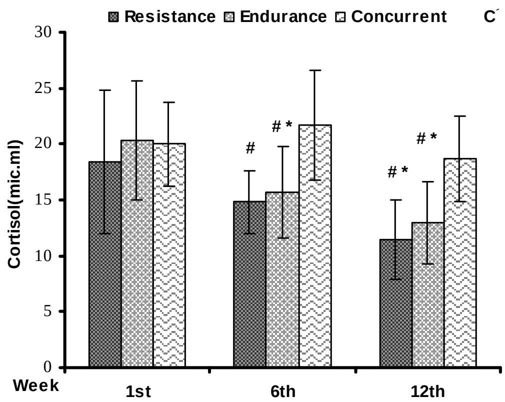
The total concentration of testosterone in the resistance group was significantly greater at the 6th and 12th weeks than at the pre-training level. Similarly, a significant increase in the concurrent group was observed only at 12 weeks. In contrast, a significant reduction in total testosterone was observed in the endurance group at week 12. Non-significant differences were observed among the three groups at the 6th week. However, a comparison of the groups showed that at the 12th week, there was a significant difference in the total serum testosterone levels between the resistance and endurance groups and between the endurance and concurrent groups



**Denote Significant difference to the first week.*

Figure 2. Concentrations of Free testosterone (nmol.ml)

Free serum testosterone levels in the resistance group showed a significant increase at the 6th and 12th weeks compared to pre-training levels, whereas a non-significant change was observed in the endurance group. A significant increase was observed in the concurrent group after 12 weeks of training. In agreement with the total testosterone data, there was no significant difference between the groups at the 6th week. However, at the 12th week, the free serum testosterone concentration in the endurance group was significantly different from the concurrent group [Figure 2].



‡ Denote Significant difference to the endurance group.*
 # Denote significant difference to the concurrent group.

Figure 3. Concentrations of Cortisol (nmol.ml)

Serum cortisol concentrations in the resistance trained group were significantly lower at the 12th week compared to the pre-training concentration. The serum cortisol concentrations at the 6th and 12th weeks in the endurance group compared to the concentration obtained at the start of the training period was reduced significantly. Non-significant changes were observed in the concurrent group. In addition the serum cortisol concentrations in the resistance group at the 6th and 12th weeks were significantly different compared to the concurrent group. Similar results were found between the endurance and the concurrent groups [Figure 3].

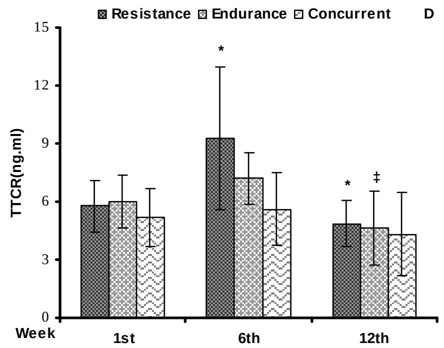


Figure 4. Concentrations of TT/CR (nmol.ml)
**Denote Significant difference to the first week.*
‡ Denote Significant difference to the endurance group

The total serum testosterone/cortisol ratio in the resistance group at the 6th week was increased compared to the first week but was decreased significantly by the 12th week. This ratio in the endurance group at the 12th week was significantly decreased compared to the 6th week. A non-significant difference was observed in the concurrent group. Non-significant differences were observed for this ratio at the 6th and 12th weeks among the three groups [Figure 4].

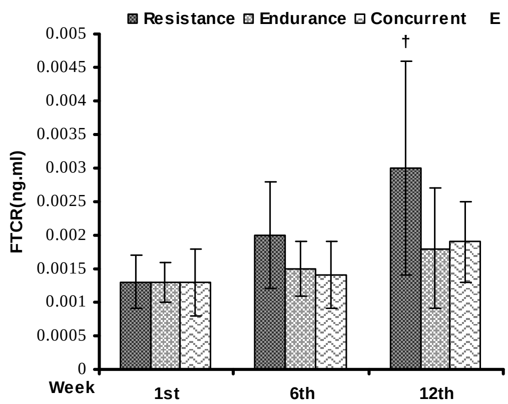


Figure 5. Concentrations of FT/CR (nmol.ml)
†Denote Significant difference to the strength group

The free serum testosterone/cortisol ratio in the resistance group was significantly higher at the 12th week compared to the pre-training ratio. No other significant differences were observed [Figure 5].

DISCUSSION

The primary finding of this study was that 6 and 12 weeks of active resistance training lead to a significant increases in the total serum testosterone concentration. This finding suggests that the total testosterone response is dependent on the severity and volume of training. For this reason, the concentration of testosterone at the 6th week was significantly increased compared to the 1st week. This process of testosterone alteration continued until week 12, which was significantly greater than that at week 6. The observed increase in testosterone concentration with training duration is in agreement with the work of Hakkinen et al, who also showed that serum testosterone concentrations changes with the severity and different volumes of resistance training [8]. Others report similar results; however, these studies included over 21 weeks of training [22]. These results suggest that some of the increases in muscular strength with training can be attributed to the increase in resting testosterone levels. Testosterone encourages muscular hypertrophy by increasing the rates of protein synthesis, and may also increase functional strength via neuromodulator synthesis (an effect on the nervous system). Although the mechanism(s) of the increase in resting testosterone following exercise training is not clear, researchers have suggested multiple possible mechanisms. These mechanisms include a stimulation of testosterone secretion by promoting the dilatation of vessels and increased blood flow in the testes, increased LH production [6, 1] and, an increase in lactate accumulation and its direct stimulatory effect on testosterone secretion [21]. It has also been suggested that an increase in sympathetic function due to training, which may lead to a more rapid testosterone response [7, 27].

The total testosterone present in the blood circulation forms a complex with the globulin of sex hormones or albumin. This complex, due to having high molecular weight (MW), cannot pass through the capillary endothelium and penetrates the nuclear membrane of cells to react with the neural factors and regulate their function. For this reason, total testosterone might possess a dynamic homeostatic pattern in response to endurance training. Intensive training programs, such as a high volume exercise, medium to high intensity with short resting periods, metabolically impose high training loads on the body, and results in the greatest acute cortisol response and quantitative changes compared with ordinary resistance training. Long-term resistance training causes a reduction or no change in the resting cortisol concentration [29]. There are different mechanisms that might explain the change in the resting level of cortisol following physical exercises, including: hypothalamus; pituitary and adrenal stimulation; HPA; and ACTH secretion; central temperature changes; pH changes; sympathetic nervous system mechanisms; lactate accumulation; hypoxia; and stress. In addition to other mechanisms involved in the increase of resting cortisol levels, the incomplete recovery period following intensive training results in, an increased sensitivity of the ACTH receptors, lactic acid accumulation and a decline in metabolic clearance in the liver; β endorphin increases and body dehydration have also been suggested to cause the increase in resting cortisol. Kraemer did not find any changes in cortisol levels after 7 weeks of endurance training. Previous studies stated that adrenal gland hypertrophy and an increase in cellular structures that produce glucocorticoids, as a result of an increase in the velocity of adrenal cortex cells, is the reason for adaptation and a lack of change in the resting level of this hormone [23, 12]. It seems that an increase in the volume of exercise leads to a reduction in endurance performance reduction the secretion of catecholamine`s and sympathetic function. An increase in cortisol secretion is dependent on the training condition (the intensity, volume and duration of exercise) of the individual [26]. The present study showed that the power gain in the resistance and concurrent groups over 12 weeks was approximately the same. Variation of the types and methods of training, particularly of the intensity and volume of training, is associated with the specific hormonal and neuro-muscular adaptations. In addition, the type of muscles the load, the number of sessions and the training time differs between the studies. Studies conducted on endurance training prior to the resistance training, have shown that some remaining tiredness may be observed after resistance training [26, 15]. Carik showed that, lower trunk power declined, when endurance training was performed prior to resistance training.

In the current study, by changing the sequence of training over the 12-weeks, no disruption of power gain was observed in the concurrent group. The results obtained from the endurance, resistance and concurrent training showed that the increasing nature of the training in the three groups resulted in an observed increase in the power gained and endurance in the groups. The highest power was gained in the strength group, then in the concurrent group, with lower power gain in the endurance group. This augmentation was associated with an increase in the resting, total and free testosterone levels in both the resistance and concurrent groups.

Our results emphasise that the performance of concurrent resistance and endurance training dose not impair the anabolism process or the improvement of muscular power in the concurrent group. Muscle hypertrophy was not measured in this study, we could speculate that during the 12 weeks of the study, the endurance training did not fully blunt the increase in muscle synthesis associated with resistance training. After the initial 6-weeks period, increases in strength were most likely a function of increased muscular cross-sectional area because, neural adaptations enhance the strength plateau at approximately 6 weeks. By increasing the training volume (at the end of the 12^{th} week compared to the 1^{st} week), the mean serum testosterone significantly increased while the mean of serum cortisol significantly declined. The serum testosterone/cortisol ratio significantly declined at the end of the 12^{th} week compared to the 1^{st} week. The disagreement in the available reports regarding this effect can be explained by the difference in the groups under study, the evaluation procedures, the measurement of the intensity and duration of training, the type of training programs, the time of blood collection and the gap between the training sessions. These findings have shown that the resting level response of serum testosterone and cortisol depends on the intensity, type and duration of the training period. Hormonal adaptations during the 6^{th} to 12^{th} weeks reached a peak level. Considering the current data, concurrent training, as a new training method that has drawn the attention of many researchers in recent years, is likely an effective and useful method for increasing strength and endurance compared to only endurance training. According to the results of this study, without considering other factors that have an effect on the endocrine system, it is likely that concurrent training maintains hormonal adaptations as unchanged in active muscles. In addition, adaptation improves the endocrine system and muscular performance.

Acknowledgments

I would like to acknowledge all of those individuals who spent countless hours working on various parts of this project : as members of The Federation of- Medical-Sports for their many hours of training and testing subjects and the use of the isokinetic testing device at all hours of the day; the Department of Clinical science & Biochemistry at the Shahid Beheshti University MC, Tehran, Iran, for their help and support for this project; and all the undergraduate students who willingly donated their time to make this project a success.

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