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The Effect of Submaximal Treadmill Running on Serum Testosterone Levels

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Reference Data

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ABSTRACT

This investigation compared concentrations of circulating serum testosterone before, during, and after a submaximal treadmill run (30 min at 80% $\dot{V}O_2$max) with samples obtained on a baseline (nonexercise) day. Baseline testosterone concentrations were obtained from 6 men (mean age 24 yrs) via an indwelling catheter in the median cubital vein. An initial sample of blood was followed 10 min later by 10 subsequent samples each taken at 10-min intervals. Blood samples were obtained at similar times and intervals on the day of the treadmill run. There was a significant ($p < 0.05$) increase in serum testosterone concentration immediately after the treadmill run when compared to baseline concentrations. No other significant differences were found between baseline and postexercise samples up to 60 min. These results indicate that submaximal treadmill running caused an increase in circulating serum testosterone immediately postexercise that was greater than baseline levels.

Key Words: aerobic exercise, hormones, blood sampling

Introduction

The results of investigations on the effect of maximal and submaximal exercise on testosterone are conflicting. Testosterone concentrations have been shown to increase (4, 7, 9, 11, 17, 24, 26, 31, 35, 36), decrease (7, 11), or remain unchanged (3, 18, 36) in response to both maximal and submaximal exercise. The discrepancies in the literature regarding testosterone response to aerobic exercise may be due in part to insufficient numbers of blood samples, differences in the timing of collecting blood samples, and/or failure to establish baseline values on nonexercise days.

Failure to establish normative values on nonexercise days could lead to erroneous conclusions because normal testosterone concentrations may vary significantly (2, 8, 13, 28–30) with fluctuations observed at varying intervals (28, 29). In this regard, it is essential to obtain multiple serial blood samples on a nonexercise day as well as during and after exercise bouts over the same times in order to obtain valid data (10, 29). Thus, serious consideration must be given to daily fluctuations in testosterone that occur in the absence of an exercise intervention. The objective of this investigation, therefore, was to compare concentrations of testosterone obtained before, during, and after a submaximal treadmill run with samples collected at the same period of time on a nonexercise day.

Methods

Six men (mean age 24.0 ± 1.79 yrs) volunteered for this study and gave written informed consent prior to any testing. They were novice runners (<10 miles a week) and were not engaged in other aerobic activity. Based on responses to a questionnaire, none had taken anabolic steroids during the previous year.

The subjects went to the laboratory 3 times, 24 hours apart, and all blood samples were obtained at the same time of day. The subjects were normally hydrated at all testing sessions. Baseline (Day 1, no exercise) testosterone concentrations were determined via a flexible indwelling catheter in a median cubital vein kept patent with physiological saline and flushed with a small sample of blood prior to each collection. After the catheter was inserted, the subjects were allowed to talk, study, and walk freely about the laboratory for an hour. Afterward they lay quietly on a padded table and an initial (zero sample) 10 ml of blood was taken 10 min later, followed by 10 subsequent samples each taken at 10-min intervals. Similar 10-min samples were obtained 10 min before, immediately preexercise, during, immediately postexercise, and for 60 min following a 30-min treadmill run at 80% $\dot{V}O_2$ max.

Blood samples in one aliquot were allowed to coagulate; the serum was extracted and immediately refrigerated at –4°C. A second aliquot was used to determine hematocrit immediately before and after the treadmill run. All samples were assayed in duplicate and the average of the two assays was used as the measure of serum testosterone concentration. A solid phase ^{125}I

radioimmunoassay technique (polyclonal antibody) was used to determine serum testosterone concentration utilizing kits from Medical Technology Corp. (Billerica, MA). The sensitivity of this assay is 0.1 ng · ml^{-1}. The coefficient of intra-assay variation was 6.99%, which is similar to values reported by other investigators (1, 14).

Maximal oxygen consumption ($\dot{V}O_2$ max) was determined via a continuous incremental treadmill test 24 hours after baseline blood samples. The treadmill test began at 6.4 km · hr^{-1} and increased 1.6 km · hr^{-1} every 3 min up to 14.5 km · hr^{-1}. Intensity was then increased by raising the treadmill grade 2% every 3 min until volitional exhaustion.

Throughout the test the subjects breathed through a Hans Rudolph valve with gas volume (V_E) and concentrations (F_EO_2) analyzed using a calibrated MMC Horizon metabolic cart (SensorMedics Corp., Anaheim, CA). $\dot{V}O_2$ max was defined as the highest that was measured given a plateau with increased work intensity and/or a respiratory quotient ≥1.15 (27). Heart rate values were monitored throughout the test using a UNIQ CIC heartwatch system (23). The submaximal test (30 min at 80% $\dot{V}O_2$ max) and associated blood samples were run on Day 3. The subjects began the submaximal test immediately after the 2nd preexercise blood sample (Imm pre in Table 1).

Results

The results of a 2 × 11 repeated measures (within-subjects design) ANOVA comparing baseline (no-exercise day) with submaximal exercise testosterone values are presented in Table 1. A significant ($p < 0.05$) interaction was followed with post hoc comparisons between baseline and submaximal values for each blood sampling time using the procedures described by Keppel (19). The post hoc pairwise analyses indicated there were no significant differences between baseline and submaximal values for the first 4 sampling times (10 min pre through 2nd exercise sample). At the 5th sampling time (immediate postexercise = Imm post), submaximal testosterone concentrations were significantly greater than at baseline.

No further differences were found between baseline (no-exercise day) and submaximal running during the final 60 min of postexercise blood sampling. Post hoc power analysis (19) indicated that the pairwise comparisons ($df = 1,5$) had power values of approximately 0.40; a power of 0.80 would have required a minimum of 25 to 30 subjects. In addition, there was no significant change in blood volume as a result of the submaximal exercise as determined by hematocrit measurements and the equation of van Beaumont (34).

Table 1
Testosterone Values (nmol · L^{-1}) for Baseline and Submaximal Treadmill Running ($n = 6$)

Blood collection	Baseline		Submax run		
Min	*M*	*±SEM*	*M*	*±SEM*	*F*
0 (10 min pre)	18.91	3.77	17.41	2.07	0.01
10 (Imm pre)	19.31	3.72	18.18	2.36	0.19
20 (1st exer. sample)	19.54	3.60	19.13	3.38	0.05
30 (2nd exer. sample)	19.24	4.13	24.27	4.00	4.68
40 (Imm post)	18.08	3.21	24.90	4.37	7.62*
50 (10 min post)	20.30	4.05	27.31	4.17	6.44
60 (20 min post)	19.58	4.24	24.97	4.00	3.81
70 (30 min post)	18.92	4.92	21.71	3.12	0.48
80 (40 min post)	20.14	4.17	20.99	3.34	0.14
90 (50 min post)	19.81	4.28	20.22	2.77	0.06
100 (1 hr post)	20.08	4.11	19.17	2.49	0.18

*Significantly different from baseline, $p < 0.05$ ($df = 1, 5$; $F = 6.61$).
Note. Submaximal run at 80% $\dot{V}O_2$max.

Discussion

The concentrations of serum testosterone during the treadmill run showed a rise (20.7% above baseline, $p > 0.05$) at the 2nd exercise sample (20 min into exercise) and became significantly different (27.4%) from baseline measures immediately postexercise. There were no other significant differences between submaximal treadmill running and baseline, although the 10-min and 20-min postexercise samples remained elevated above baseline by 25.7 and 21.6%, respectively, before returning to baseline levels at 30 min postexercise.

These findings were similar to previous investigations that have reported significant increases in testosterone as a result of submaximal exercise (4, 5, 7, 9, 11, 16, 26, 31, 35, 38) and also maximal exercise (5, 7, 24, 36). In contrast, Bottecchia et al. (3) and Galbo et al. (7) found no significant changes in testosterone concentration during or after submaximal exercise, while Guglielmini et al. (11) reported no change at the end of a 20-km competitive walk.

It has been hypothesized that the testosterone response to exercise is intensity dependent (22, 33). Sutton et al. (33), for example, reported a significant rise in androgen concentrations in response to maximal exercise but not to submaximal exercise. Similar results concerning testosterone response to intensity have been reported by others (3, 7, 18). In this regard, Kraemer (20) has stated that increased concentrations of testosterone following anaerobic exercise (weight-lifting) may be related to the intensity and volume of the exercise as well as the amount of muscle mass used.

The observed increase in serum testosterone above baseline values as a result of submaximal aerobic exercise in the present study, however, was consistent with other investigations that employed exercise intensities below (7, 35, 36) or equal to (4, 26, 36) those in this study. Jensen et al. (16), using a design similar to the present study but with considerably longer blood sampling intervals, took 5 baseline (no-exercise day) blood samples at 2-hr intervals. Blood samples were also taken during the following 2 weeks on the same day of the week and at the same time of day before, during, and after a randomly assigned strength or endurance exercise session. The investigators reported a significant increase in testosterone immediately following 90 min of strength and/or endurance exercise when compared to preexercise samples. Interestingly, the immediate postexercise sample was, like the present investigation, the only sample that differed significantly from those taken at the same time during the baseline week.

A recent study comparing the effect of two intensities of weightlifting on serum testosterone also found that the only significant difference between weightlifting and baseline values occurred after the last exercise set (32). Further, Fellman et al. (6) studied the effects of 40 weeks of training on the response of testosterone to submaximal exercise. They reported significant increases in testosterone following 60-min cycle ergometer rides at 80 to 85% $\dot{V}O_2$ max and noted that training enhanced this response. Hackney et al. (12) found no significant increases in testosterone following 90 min of submaximal exercise at 65% $\dot{V}O_2$ max, and an 8-week training program did not alter the response. All comparisons in these studies, however, were based on pre- and postexercise values only, with no baseline values established.

These conflicting results might be due to variations in the timing and frequency of blood samples, the nature of the exercise protocols, and the failure of some studies to measure testosterone fluctuations on nonexercise days. Because testosterone patterns in humans vary over time without exercise intervention (3, 29, 32), the interaction between baseline and testosterone changes due to exercise may have masked the true responses to exercise in studies where only one or two samples were provided or, more important, where blood samples were obtained only prior to exercise with no true baseline measurements. The design of the present study, however, allowed comparison of blood samples during both exercise and rest at the same time of day as well as over the same time periods.

The baseline blood samples in the present study were similar to preexercise values reported by Hakkinen et al. (15) and Kraemer et al. (22) as well as within the normal range for men described by McArdle et al. (25). The greatest difference (6.8%) in baseline values in the present study occurred between the initial value and the value obtained at Minute 50 (i.e., corresponding to 10 min postexercise). Thus, baseline testosterone values remained relatively stable but the values obtained at the same time of day during submaximal exercise steadily increased, becoming significantly different from baseline at the 40-min sample (immediate postexercise).

Practical Applications

The results indicate that serum testosterone concentrations increased significantly over baseline values following 30 min of submaximal treadmill running at 80% $\dot{V}O_2$ max. These postexercise increases were similar to those reported for longer submaximal runs (16) as well as for specific intensities of weightlifting (32). The blood sampling comparisons in this study confirm previous investigations that submaximal aerobic exercise causes an increase in serum testosterone. Further studies that examine the physiological significance of the increase in testosterone as a result of exercise are warranted.

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