

# Effects of Altering Training Volume and Intensity on Body Mass, Performance, and Hormonal Concentrations in Weight-Event Athletes

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## Reference Data

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## ABSTRACT

Eight NCAA Division I weight-event track and field athletes (4 M, 4 F) followed a periodized training program during a 6-month competitive season. Subjects were tested preseason (W0) and then at 4-week intervals (W4, W8, W12, W16, W20, W24). Training volume was recorded daily and totaled for each 4-week period. Percent fat (%fat) and lean body mass (LBM) were determined via hydrostatic weighing. Performance measurements included the overhead shot (OS), kneeling shot (KS), vertical jump power (VJP), anaerobic power (AP), and anaerobic capacity (AC). At W8 through W24 blood was collected and analyzed for testosterone ([Test]) and cortisol ([Cort]) concentrations. Both sexes demonstrated similar responses to training with increases in LBM, OS, and KS. No changes were observed for %fat, VJP, AP, or AC. The [Test] and [Cort] were similar throughout the training period, but the [Test]:[Cort] ratio was lowest after the 4-wk interval with the highest intensity. The data indicate that varying training volume and intensity will result in increases in LBM, OS, and KS without large alterations in hormonal concentrations.

**Key Words:** testosterone, cortisol, resistance training, periodization

## Introduction

The relationship between long-term strength/power training, athletic performance, and variations in hormonal concentrations is not completely understood. It is suggested that over an extended period of time, a balance between anabolic and catabolic activity is required to elicit improvements in strength and performance (1, 7, 9, 14, 15). During prolonged resistance training, increases (7, 9), decreases (6), or no change

(2, 5, 10) in testosterone concentration have been shown to occur. Additionally, cortisol concentrations during prolonged strength and power training have been shown to decrease (6, 7, 9) or remain unchanged (5, 10).

The purpose of this investigation was to examine the effects of varying training volume and intensity during prolonged resistance training on body mass, performance, and endocrine responses in a group of well-trained track and field weight-event athletes.

## Methods

Four male and four female weight-event athletes from an NCAA Division I track and field team participated in the study. Prior to data collection the procedures were explained and the subjects provided informed consent in accordance with university policy. The mean age for the subjects at the beginning of the investigation was 20.2 ( $\pm 1.7$ ) years. All athletes were periodically drug tested throughout the training period and did not test positive for anabolic steroids.

### Training Program

The subjects participated in a 24-week resistance training program. Each training session was designed to fit into a 1-week microcycle, and a group of four microcycles formed a mesocycle. The initial four mesocycles were designed to extend through the indoor conference championships, and the final two mesocycles carried through to the outdoor conference championships. The training intensity and volume was varied throughout the 24-week program as follows: Weeks 0-4, medium intensity/low volume; Weeks 4-8, low intensity/medium volume; Weeks 8-12, medium intensity/medium volume; Weeks 12-16, high intensity/low volume; Weeks 16-20, medium intensity/medium volume; Weeks 20-24, high intensity/low volume.

Numerous strengthening exercises were employed throughout training. They included the snatch, power clean, clean and jerk, various squat lifts for the legs, pressing and pulling exercises for the arms, and other accessory exercises for selected muscle groups. In addition to the strength training program, the subjects

performed other resistance training activities such as push-ups, pull-ups, dips, crunches, leg toss, leg scissors, and sit-ups. Plyometric exercises included box jumps and rotational box jumps. Medicine ball exercises and short duration sprints of 30 to 80 m were also performed. Throughout the investigation each subject performed skill and technique work for his or her specific throwing event.

### Testing

The subjects' basic measurements were taken every 4 weeks (W0, W4, W8, W12, W16, W20, W24) beginning immediately prior to the first mesocycle. Weight (Wt) was measured on a physician's scale. Body density was determined via hydrostatic weighing, with residual volume obtained from the oxygen rebreathing method (16). The percentage of fat (%fat) was determined from the formula of Brozek and Keys (4), with lean body mass (LBM) calculated accordingly. Anaerobic power (AP) and capacity (AC) were measured using the Wingate cycle ergometer test (3). Vertical jump height was determined from a standing vertical jump test; vertical jump power (VJP) was calculated using the Harmon formula (11). Neuromuscular performance was measured via the overhead shot (OS) and kneeling shot (KS).

Blood samples were collected at the final five measurement times: W8, W12, W16, W20, W24. Following 1 day of reduced training and a 12-hr fast, blood was collected from an antecubital vein. Total testosterone ([Test]) and cortisol ([Cort]) concentrations were determined by radioimmunoassay using reagent kits from Diagnostic Products Corp. (Los Angeles) and Boehringer Mannheim Corp. (Indianapolis), respectively. Training volume was logged daily. The number of sets  $\times$  repetitions performed  $\times$  resistance used was recorded for each free-weight exercise during the daily workout.

Weekly volume was computed and totals for each 4-week cycle were calculated.

### Statistical Analysis

All data are reported in mean values  $\pm$  SD. Zero order correlations for selected dependent variables were determined using the Pearson correlation procedure and percentage change scores from the data. The significance level was established at  $p \leq 0.05$ .

### Results

The physical characteristics of the subjects are presented in Table 1. Mean weight for the men ranged from  $106.4 \pm 5.3$  kg at W0 to a high of  $109.9 \pm 4.7$  kg at W20. The women exhibited a similar pattern, with a low of  $83.2 \pm 12.9$  kg at W0 and a high of  $84.8 \pm 9.8$  kg at W20. There were no notable alterations in %fat. The LBM response paralleled the change in body weight. The men increased LBM by 2.9% from W0 ( $91.9 \pm 9.7$  kg) to W20 ( $94.7 \pm 9.0$  kg). The women increased their LBM by 3.7% from W0 ( $62.9 \pm 6.4$  kg) to W20 ( $65.3 \pm 5.5$  kg). Training volume (TV) was similar for each mesocycle except for the 4-week period between W16 and W20. During this period it was the highest for both groups.

The men increased performance in the OS (W0 =  $13.2 \pm 1.5$  m to W24 =  $14.5 \pm 2.3$  m) and the KS (W0 =  $5.8 \pm 0.5$  m to W24 =  $6.0 \pm 0.5$  m). The women demonstrated a similar pattern, improving in the OS from W0 ( $11.1 \pm 1.5$  m) to W24 ( $12.4 \pm 1.7$  m). They also increased their performance in the KS (W0 =  $5.3 \pm 0.7$  m to W24 =  $5.8 \pm 0.9$  m). No changes in performance were observed for AP, AC, or VJP.

The serum [Test] and [Cort] of the subjects are presented in Table 2. [Test] peaked for the men during W24 ( $21.8 \pm 5.3$  nmol  $\cdot$  L<sup>-1</sup>) and for the women during

Table 1  
Physical Characteristics and Training Volume for Weight-Event Athletes During Training

	W0		W4		W8		W12		W16		W20		W24	
	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
WT (kg)														
Male	106.4	5.3	108.3	5.8	109.2	5.8	109.5	4.2	109.6	5.5	109.9	4.7	109.4	4.9
Female	83.2	12.9	83.9	10.2	83.9	10.1	84.1	10.2	84.1	9.8	84.8	9.8	84.5	8.6
% Fat														
Male	13.5	8.4	13.6	8.0	13.9	7.3	14.1	7.7	14.4	7.8	13.8	8.2	13.7	7.5
Female	23.8	6.4	24.1	5.3	23.4	5.6	23.9	4.5	24.2	4.5	22.7	5.2	23.4	4.3
LBM (kg)														
Male	91.9	9.7	93.4	9.1	94.0	8.8	94.0	8.6	93.8	9.1	94.7	9.0	94.3	8.8
Female	62.9	6.4	63.3	5.3	64.0	5.7	63.7	5.2	63.5	5.0	65.3	5.5	64.6	5.2
TV (kg)														
Male			125,156	16,986	154,994	44,527	117,961	16,264	90,580	40,355	165,968	35,251	115,120	32,201
Female			101,511	31,546	83,835	41,235	80,226	41,162	73,320	15,376	130,897	39,622	97,014	20,660

Note.  $n = 4$  for male and female.

**Table 2**  
**Testosterone and Cortisol Concentrations for Weight-Event Athletes During Training**

	W8		W12		W16		W20		W24	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
[Test] (nmol · L <sup>-1</sup> )										
Male	19.8	2.4	14.8	2.1	17.6	3.0	20.0	3.0	21.8	5.3
Female	2.5	0.8	1.5	1.3	1.7	0.7	1.7	0.7	1.6	1.1
[Cort] (nmol · L <sup>-1</sup> )										
Male	404	69	429	118	549	18	368	73	401	72
Female	516	130	519	153	630	196	473	75	540	119

Note. *n* = 4 for male and female.

W8 ( $2.5 \pm 0.8$  nmol · L<sup>-1</sup>). The [Cort] response was similar for both sexes, with peak concentrations occurring at W16 (males,  $549 \pm 18$  nmol · L<sup>-1</sup>; females,  $630 \pm 196$  nmol · L<sup>-1</sup>). The [Test] : [Cort] ratio was lowest at the W16 measurement. No meaningful significant correlations were observed among the percentage change values for [Test], [Cort], [Test] : [Cort], TV, LBM, OS, or KS.

## Discussion

The data from this investigation indicate that alterations in training volume and intensity affected hormonal concentrations and performance similar to results reported previously (5–9). The serum total [Test] for both sexes not differ following periods of high intensity (W16) or high volume training (W20). This type of response is similar to other investigations using well-trained strength athletes (5, 6, 9, 10).

Recent evidence indicates that long-term changes in anabolic hormone concentration may not be as important as day-to-day variations. It has been suggested that high intensity resistance training results in acute responses of both the neuromuscular and endocrine systems that may not be detectable in long-term observations (8). The concentrations of active unbound hormones may be extremely important for improvements in neuromuscular performance (9). Changes at the cellular level in receptor number and affinity may also play a role in hormonal effectiveness (12). Changes in receptor number may allow for greater binding without changes in circulating hormone concentration. Also, the athletes' resistance training protocol may have had a profound impact on short-term growth factor responses (13).

The pattern of change for [Cort] was similar for both sexes: the measurement at W16 was the highest for both. The elevated response at W16 followed the period with the lowest training volume; however, the training intensity during that 4-week period between W12 and W16 was the highest of any mesocycle.

The [Test] : [Cort] ratio in this investigation decreased between W8 and W16. This change may suggest a fluctuation in anabolic/catabolic activity; however, the lack of any significant changes in the [Test] : [Cort] ratio of weight trained athletes has been demonstrated elsewhere (7, 8, 10).

The combined slight increase in total body weight with virtually no change in %fat allowed for increases in lean body mass over the training period. The change in lean body mass provides potential for increased force generating capabilities in these athletes. Small changes in total body mass and %fat following prolonged power training (>16 wks) in well-trained athletes is supported by other investigations (5, 6, 9).

The OS and KS were used to evaluate upper body neuromuscular performance. There were improvements in both the OS (males, 8.9%; females, 10.0%) and KS (males, 3.3%; females, 8.6%). The small performance improvements in well-trained strength athletes is supported by other investigators who have reported slight but nonsignificant increases in weight-lifting results (5, 6, 7).

When the performance related parameters (LBM, OS, KS, AP, AC, and VJP) were correlated with absolute hormonal concentrations and percentage change in the hormonal concentrations, no systematic relationship was observed. This may be due to the small sample size, as other investigations have demonstrated significant correlations between performance measures and changes in hormonal concentrations (6, 7, 10).

## Practical Implications

It is difficult to determine the anabolic/catabolic state of an athlete. Daily variation in hormonal concentrations can be affected by fluctuations in hormone synthesis, transport protein concentrations, clearance rates, fluid shifts, and receptor interactions. In addition, working with female athletes calls for the consideration and monitoring of menstrual phase and contraceptive use status. Future research in this area

must consider the measurement of both free and bound concentrations of hormones, daily diurnal variations, and changes that occur postexercise. Consideration of these issues may help determine the physiological significance of alterations in hormone concentration following strength/power training.

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