Acute Response of Testosterone to Muscular Endurance Resistance Exercise in Obese vs. Lean Children

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ABSTRACT

Background: Following resistance exercise of sufficient intensity, adult males display an acute increase in testosterone (T); such increase appears diminished in obesity. While the predominant source of T production in men is the testes, adrenocortical production of T makes up a greater relative proportion of boys' T. Adrenocortical production of both T and cortisol respond to stress such as exercise. Although obesity diminishes testicular T production, obesity increases activity of the hypothalamic-pituitary-adrenal (HPA) axis. **Methods:** Subjects consisted of eight obese boys (age 9±1yr, height 142±7cm, mass 48±9kg, lean mass 27±4kg, body fat 40.5±5.0%) and six lean boys (age 9±1yr, height 143±8cm, mass 32±5kg, lean mass 26±4kg, body fat 15.0±3.1%). Participants first warmed up for five minutes on a cycle ergometer, and then performed six sets of ten repetitions per leg of step-ups while wearing a weighted vest; subjects rested 1 minute between sets. Step height was adjusted to 20% of each subject's height, and the vest was weighted with 50% of each subject's lean body mass as measured by DEXA. Blood samples for serum concentrations of T and cortisol were obtained from an indwelling catheter pre-exercise (PRE) and immediately post-exercise (IP). **Results:** T concentrations increased from PRE to IP in obese boys (+14%; p=0.018) however T concentrations did not change over time in lean boys (-8%; p=0.173). Obese boys displayed a greater percent change in T compared to lean boys (p=0.014). The percent change in concentration of T was correlated to the percent change in concentration of cortisol for all boys (ρ=0.604, p=0.022). **Conclusion:** T concentrations were increased following exercise in obese boys and changes in T correlated to changes in cortisol in all boys. Increases in T following exercise in obese boys may be the result of greater activity of the HPA axis.

PURPOSE

Obese men have lower resting concentrations of testosterone (T)[1], and we have observed that obese men also have a smaller acute T response to the exercise protocol used in this study. However the majority of T in men is produced by adult Leydig cells in the testicles which are not differentiated until puberty.[2] Another source of T is from the zona reticularis of the adrenal cortex, which increases production of glucocorticoids and androgens during adrenarche that occurs around age 7-8 independent of puberty.[3] Obesity increases the adrenocortical hypothalamic-pituitary-adrenal (HPA) axis activity and responsiveness to stress.[4] The purpose of this study was to determine whether boys would display an acute response in T to a bout of muscular endurance resistance exercise, how obesity would affect this response, and how the T response would relate to changes in cortisol.

METHODS

- Participants:
  - 8 obese boys, (body fat above 95th percentile); Puberty developmental stages: 5 stage I, 2 stage II, 1 stage III
  - 6 lean boys, (body fat below 85th percentile); Puberty developmental stages: 3 stage I, 2 stage II, 1 stage III
  - Medical survey, informed consent, and assent
  - Dual-energy X-ray absorptiometry measured body composition
- Protocol for Testing:
  - Subjects reported in the morning after eating a standardized breakfast and refraining from exercise for ≥ 24hrs
  - Indwelling catheter placed in antecubital fossa, followed by 30 minutes of seated rest
  - Pre-exercise blood sample (PRE) after resting but prior to exercise
  - Five minute warm up on cycle ergometer followed by guided active stretching
  - Six sets of ten repetitions per leg of weighted step-ups performed with one minute rest between sets
    - Weight vest was standardized to 50% of subject's lean body mass
    - Step height was standardized to 20% of subject's height
  - Heart rate and rate of perceived exertion were recorded following each set
  - Final blood samples were obtained with subject seated immediately post-exercise (IP)
  - Serum testosterone concentrations determined using ELISA (ALPCO)
- Statistical Analysis:
  - Between group comparisons of subject characteristics, exercise characteristics, and physiological responses to exercise using independent samples t-tests
  - Within group comparisons of PRE vs IP hormone concentrations using Wilcoxon ranks tests
  - Between groups comparisons of percent change in hormones using Mann-Whitney tests
  - Correlations between percent changes of hormones using Spearman's rho and Pearson's r

ACKNOWLEDGEMENTS:

Supported by USAMRAA Award W81XWH-08-1-0025

RESULTS

Table 1. Participant characteristics * Presented as: mean ± SD *

	Obese (n=8)	Lean (n=6)
Age (years)	9 ± 1	9 ± 1
Height (cm)	142 ± 7	143 ± 8
Body Mass (kg)	**48 ± 9**	**32 ± 5**
Body Mass Index (kg/m^2)	**24 ± 3**	**16 ± 1**
Body Fat Percentage	**40.5 ± 5.0**	**15.0 ± 3.1**
Resting HR (BPM)	73 ± 9	77 ± 11

Note: **bold** values are significant at $p < 0.05$

Table 2. Exercise protocol characteristics and physiological responses to exercise protocol * Presented as: mean ± SD *

	Obese (n=8)	Lean (n=6)
Weight of Vest (kg)	13.5 ± 2.1	12.9 ± 2.0
Height of Step (cm)	27.6 ± 1.5	28.7 ± 1.5
Time to Complete (min)	12.8 ± 2.4	12.8 ± 1.9
Mean Rating of Perceived Exertion	6.0 ± 1.9	5.4 ± 2.5
Mean Exercise Heart Rate (BPM)	162 ± 15	153 ± 24
Final Rating of Perceived Exertion	8.1 ± 1.7	6.8 ± 3.1
Final Exercise Heart Rate (BPM)	169 ± 18	163 ± 24

Note: no values in table 2 were significant at $p < 0.05$

Table 3. Hormone Total Serum Concentrations (nmol/L) * Presented as: Median (25th percentile ↔ 75th percentile) *

		Testosterone	Cortisol
Obese	PRE	**2.795 (0.330 ↔ 5.637)**	299.2 (141.7 ↔ 388.2)
	IP	**3.333 (0.471 ↔ 6.171)**	286.8 (212.9 ↔ 333.9)
	p value	**p = 0.018**	p = 1.00
Lean	PRE	0.956 (0.182 ↔ 1.740)	220.6 (156.7 ↔ 298.5)
	IP	0.819 (0.146 ↔ 1.608)	212.8 (170.8 ↔ 263.7)
	p value	p = 0.173	p = 0.463

Note: p values calculated using Wilcoxon signed ranks test

Table 4. Comparisons of PRE→IP % change in hormone concentrations * Presented as: Median (25th percentile ↔ 75th percentile) *

	Testosterone	Cortisol
Obese (PRE→IP %change)	**16.5 (8.1 ↔ 29.3)**	−0.8 (−10.2 ↔ 9.6)
Lean (PRE→IP %change)	**−12.5 (−20.6 ↔ −0.6)**	−1.2 (−10.1 ↔ 0.5)
Mann-Whitney test	**p value = 0.014**	p value = 0.755

Table 5. Correlations between PRE→IP % changes of concentrations in testosterone and cortisol

	Spearman's rho	Pearson's r
All Boys (n=14)	**ρ = 0.604; p = 0.022**	**r = 0.903; p < 0.001**
Obese (n=8)	**ρ = 0.929; p = 0.001**	**r = 0.978; p < 0.001**
Lean (n=6)	ρ = 0.143; p = 0.787	r = 0.457; p = 0.362

DISCUSSION

The majority of research on the T response to resistance exercise has been in lean men. The only previous study in children found T increases of 10% following a short bout of exercise in children Tanner stage II (n=6) and stage III (n=6), but not in stage I (n=7), although these changes were not statistically significant.[5] The precise mechanisms by which obesity leads to decreased basal T concentrations and potentially decreased T responses to resistance exercise are not yet understood. However, because the majority of T in men comes from the testes, the mechanism(s) for this effect of obesity in men likely involve the hypothalamic-pituitary-gonadal (HPG) axis. Conversely, studies in women have found that T concentrations are increased with obesity.[4] Vincennati et al. has proposed that the reason T concentrations in women are increased by obesity is because obesity increases activity of the HPA axis as seen in Cushing's syndrome.[4] Since the boys in our study were old enough to be post adrenarche but not yet have mature testes, we hypothesized that an increase in T following exercise would be primarily due to the HPA axis, rather than the HPG axis as in men. This study showed a significant increase in T following exercise in obese boys but not in lean boys. As anticipated, T concentration changes were significantly greater in obese boys than lean boys. Although changes in cortisol were not statistically significant, the changes in T significantly correlated to changes in cortisol in all boys, and especially in obese boys. These results tentatively support our hypothesis that increased activity of the HPA axis would be associated with a greater T response to exercise in obese compared to lean boys.

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