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Androgen receptor content following heavy resistance exercise in men

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Abstract

The purpose of the present investigation was to examine androgen receptor (AR) content in the vastus lateralis following two resistance exercise protocols of different volume. Nine resistance-trained men (age = 24.3 ± 4.4 years) performed the squat exercise for 1 (SS) and 6 sets (MS) of 10 repetitions in a random, counter-balanced order. Muscle biopsies were performed at baseline, and 1 h following each protocol. Blood was collected prior to, immediately following (IP), and every 15 min after each protocol for 1 h. No acute elevations in serum total testosterone were observed following SS, whereas significant 16–23% elevations were observed at IP, 15, and 30 min post-exercise following MS. No acute elevations in plasma cortisol were observed following SS, whereas significant 31–49% elevations were observed for MS at IP, 15, and 30 min post-exercise. Androgen receptor content did not change 1 h following SS but significantly decreased by 46% following MS. These results demonstrated that a higher volume of resistance exercise resulted in down-regulation of AR content 1 h post-exercise. This may have been due to greater protein catabolism associated with the higher level of stress following higher-volume resistance exercise.

Keywords: Testosterone; Cortisol; Squat; Muscle biopsy; Down-regulation

1. Introduction

Resistance exercise presents a potent stimulus to the musculoskeletal system. This type of stress elicits a wide variety of physiological responses and subsequent adaptations instrumental for increasing muscular strength, power, hypertrophy, and endurance [1]. One such physiological system vital to acute resistance exercise performance and tissue remodeling is the neuroendocrine system. Hormonal increases in response to resistance exercise take place in a physiological environment that is quite unique. Several studies have shown acute elevations in circulating hormones (e.g., testosterone and cortisol) during and immediately following resistance exercise [2–4]. However, acute hormonal elevations are without context unless subsequent interaction with a specific membrane-bound or nuclear receptor occurs and the appropriate signal is transduced.

In particular, the androgen receptor (AR) has been extensively investigated in recent years primarily in non-skeletal muscle tissues (i.e., prostate) in animals. The AR is a 110 kD receptor that belongs to a large family of nuclear transcription factors. Modification of AR content appears to be critical in mediating the hormonal effects. That is, an increase (i.e., up-regulation) or decrease (i.e., down-regulation) in AR content influences the amount of receptor available to interact with its ligand. It has been shown that androgen administration (or an increase in circulating androgens) up-regulates AR mRNA in a dose-dependent manner, whereas castration or administration of anti-androgens leads to significant down-regulation

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[5–8]. In addition, electrical stimulation and resistance exercise have been shown to modify AR content and binding capacity [9–13]. However, little is known concerning the post-resistance exercise response in AR content in humans. It has been shown that net protein balance (i.e., difference between synthesis and breakdown) following resistance exercise is negative during the initial recovery period in the absence of nutritional intervention [14–17]. Based on these data, it may be hypothesized that the AR response to resistance exercise may be down-regulation initially followed by a compensatory up-regulation further into the recovery period. However, no studies have examined AR content in humans within a few hours following resistance exercise. Therefore, the purpose of the present investigation was to examine AR content in the vastus lateralis following two resistance exercise protocols of different volume.

2. Materials and methods

2.1. Experimental design and approach to the problem

The present investigation compared two resistance exercise protocols of different total volume (i.e., total work) on the acute hormonal response in the blood and subsequent regulation of the AR. Healthy, resistance-trained men were selected for the present investigation. Resistance exercise was chosen as the stimulus because: (1) neuromuscular stimulation affects protein metabolism and subsequent AR content [9,13]; and (2) it creates an endogenous elevation in testosterone that may potentially affect AR content [2–4,18]. In addition, limited data are available concerning resistance exercise and AR modulation. Short-term, post-exercise measurements (i.e., 1 h post-exercise) have not been performed, and important questions relating to the volume of resistance exercise have not been addressed. A randomized, counter-balanced study design was used to examine two protocols; (1) single-set protocol (SS), or (2) multiple sets (MS). The rationale for examining AR content 1 h post-exercise was due to the effects of both testosterone elevation [18] and muscle contractile activity [11] on AR stabilization and subsequent regulation. It was hypothesized that AR stabilization would not offset the catabolic effects associated with a higher volume of resistance exercise.

2.2. Subjects

Healthy, resistance-trained (minimum 3 years of experience with the back squat exercise) men (19–32 years of age) were selected for the present investigation ($n = 9$). The mean ± S.D. for subject characteristics were: (1) age = 24.3 ± 4.4 years; (2) height = 182.6 ± 7.3 cm; (3) body mass = 96.8 ± 11.0 kg; and (4) resistance training experience = 7.9 ± 3.9 years. The men selected initiated the study in a trained state, and none were taking any medications, anabolic steroids, hormonal supplements, or nutritional supplements known to affect the acute hormonal responses to resistance exercise. This study was approved by the University's Institutional Review Board and each subject signed an institutionally-approved informed consent document prior to participation. In addition, none had any physiological or orthopaedic limitation that affected lifting performance. All subjects refrained from lower-body exercise for 5–7 days prior to beginning the study. This ensured that any residual effects of resistance training (i.e., AR content modifications of the vastus lateralis) were minimal. Other subject characteristics are presented in Table 1.

Table 1
Baseline body composition and muscle strength data

Variable	Mean ± S.D.
Percent body fat (%)	18.4 ± 4.7
Total fat mass (kg)	18.2 ± 6.1
Lean body mass (kg)	75.7 ± 7.7
Bone mineral content (kg)	3.82 ± 0.34
Bone mineral density (g/cm^2)	1.39 ± 0.07
1 RM squat (kg)	150.2 ± 32.3

2.3. Strength testing

The one-repetition maximum (1 RM) squat was assessed prior to initiation of the study using a standard protocol [19]. Testing was performed using the computerized Plyo Power System (Norsearch Limited, Lismore, Australia) to afford greater quantification of the exercise protocol. All trials were performed using proper range of motion and technique, and supervised by a certified strength and conditioning specialist. Determining the 1 RM squat enabled calculation of the precise training loads used during the protocols.

2.4. Body composition

Body composition, including percent body fat, lean body mass, bone mineral density, and total fat mass, were determined at baseline with the use of dual-energy X-ray absorptiometry (DEXA). Total body scans (Prodigy^{TM}, Lunar Corporation, Madison, WI) were performed and all analyses were performed by the same technician. Quality assurance was assessed by daily calibrations and was performed prior to all scans using a calibration block provided by the manufacturer.

2.5. Acute resistance exercise protocols (AREP)

The protocols consisted of performing the squat exercise for 10 repetitions using a load ~80–85% of 1 RM. For the SS condition, only one set was performed. For the MS condition, 6 sets were performed using 2 min rest intervals [20]. Half of the participants performed the SS protocol first, whereas the other half performed the MS protocol first in a randomized, counter-balanced manner. Performance of each protocol was separated by 1 week which has been shown to be sufficient when examining the AR [9].