Insulin’s Effects on Testosterone, Growth Hormone and IGF-I Following Resistance Training
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Summary
Nutrition supplements with a combination of carbohydrate and protein (with a ratio of 3:1 respectively) cause the greatest insulin elevations following resistance training. Insulin spikes following resistance training do lead to lower levels of testosterone in the blood but it unclear why. It could be due in part to increased testosterone uptake in active skeletal muscle. Recent work “Diet and hormonal responses: potential impact on body composition” has shown that the meal-induced decrease in testosterone after resistance exercise corresponds with an increase in skeletal muscle androgen receptor content. Insulin spikes also lead to increased levels of growth hormone following resistance training and some studies have shown an increase in IGF-I during insulin spikes.

Nutrition supplements that create elevated levels of insulin in the blood, after resistance training can produce a more favorable anabolic environment during recovery that may be favorable to muscle growth by stimulating insulin and growth hormone elevations.

Recovery Nutrition Recommendation
Immediately after workout- Muscles are the most receptive to producing new glycogen within the first few hours following resistance training. During this time cells are the most sensitive to insulin and insulin promotes glycogen synthesis in the cell. A combination of carbohydrate and protein should be taken immediately following a workout. The best type of carbohydrate for refueling is carbohydrate with a high-glycemic index because it will be rapidly absorbed. The ideal ratio of carbohydrate to protein appears to be 3:1 respectively based on current research. [Kleiner 2007]

Articles reviewed
Hormonal Responses to Consecutive Days of Heavy-Resistance Exercise With or Without Nutritional Supplementation. (Kraemer, Volek et al. 1998)

They compared the hormonal responses to consecutive days of resistance training with and without nutritional supplementation. Subjects drank either a carbohydrate-protein supplement 2 hours before and immediately after their workout or a placebo. Blood was taken before and
0, 15, 30, 45 and 60 minutes after the workout. Lactate, growth hormone, and testosterone were significantly elevated immediately postexercise. The lactate level was significantly lower during the 2nd and 3rd day of supplementation. Growth hormone and prolactin responses on day 1 were significantly higher during supplementation. After exercise, testosterone declined below resting levels during supplementation. Glucose and insulin were significantly elevated by 30 minutes during supplementation and remained stable during placebo. Insulin-like growth factor-I was higher during supplementation on days 2 and 3. Protein-Carbohydrate supplementation before and after training can alter the metabolic and hormonal responses to consecutive days of heavy-resistance training.

Dietary Supplements affect the anabolic hormones after weight-training exercise. (Chandler, Byrne et al. 1994)

Examined the effect of carbohydrate and/or protein supplements on the hormonal state of the body after weight training exercise. Subjects consumed either a control (water), protein, carbohydrate, or carbohydrate-protein drink immediately and 2 hours after a resistance training workout. Blood samples were drawn before and immediately after exercise and during 8 hours of recovery. Exercise induced elevations in lactate, glucose, testosterone, and growth hormone in all groups. The carbohydrate and carbohydrate-protein stimulated higher insulin concentrations that protein alone and the control. Carbohydrate-protein led to an increase in growth hormone 6 hours post exercise which was greater than protein and control. Supplements had no effect on insulin-like growth factor-I but caused a significant decline in testosterone. Testosterone levels fell below resting levels 30 minutes postexercise during all supplement treatments compared to the control. The decline in testosterone was not associated with a decline in luteinizing hormone, suggesting an increased clearance of testosterone after supplementation. The results suggest that nutritive supplements after weight-training exercise can produce a hormonal environment during recovery that may be favorable to muscle growth by stimulating insulin and growth hormone elevations.

Effects of meal form on composition of plasma testosterone, cortisol, and insulin following resistance exercise. (Bloomer, Sforzo et al. 2000)

They compared postexercise consumption of whole food and an isocaloric and isonitrogenous supplement drink. Subjects consumed each immediately, 2 hours and 4 hours after resistance training. Insulin, testosterone and cortisol were measured pre-exercise and during 24 hours of recovery. The drink yielded a greater response for insulin. The control (nothing) demonstrated the greatest values for testosterone at 2.5 and 4 hours following exercise. Cortisol did not vary between conditions.
The lower levels of testosterone could be due in part to increase testosterone uptake in active skeletal muscle. Recent work “Diet and hormonal responses: potential impact on body composition” has shown that the meal-induced decrease in testosterone after resistance exercise corresponds with an increase in skeletal muscle androgen receptor content measured 60 minutes after exercise.

The Effect of a Carbohydrate and Protein Supplement on Resistance Exercise Performance, Hormonal Response, and Muscle Damage. (Baty, Hwang et al. 2007)

Purpose was to determine if resistance training performance and postexercise muscle damage were altered by consuming a carbohydrate and protein supplement before, during and after the workout. Supplement was consumed 30 minutes prior to the workout, immediately prior to exercise, halfway through the workout and immediately following the workout.

There was no significant difference in performance during the single bout of resistance training. Cortisol was significantly elevated in the placebo group at 24 hours post exercise.

Insulin was elevated immediately pre-exercise, after the fourth lift, immediately postexercise, 1 hour, and 6 hours post exercise in the supplement group.

Both Myoglobin and Creatine Kinase levels were elevated in the placebo group.

The carbohydrate and protein supplement increased insulin levels during and after the exercise bout and appeared to reduce muscle damage and soreness.

Effects of Liquid Carbohydrate Ingestion on Markers of Anabolism Following High-Intensity Resistance Exercise. (Thyfault, Carper et al. 2004)

Purpose was to examine the effects of liquid carbohydrate supplementation on markers of anabolism following high-intensity resistance exercise. Subjects consumed supplement 10 minutes prior to exercise and again immediately following the workout. Cortisol, Insulin, ammonia, and glucose were measured before, immediately after exercise and 1.5 hours and 4 hours after exercise. There was a significant difference in insulin levels immediately after and 1.5 hours after exercise. There were no significant differences in the other variables tested between groups. The increase in insulin in the supplement group creates a more favorable anabolic environment immediately following a resistance exercise workout.

Effects of Recovery Beverages on Glycogen Restoration and Endurance Exercise Performance. (Williams, Raven et al. 2003)
They compared the restorative capacities of a high carbohydrate-protein beverage and a traditional 6% carbohydrate-electrolyte sports drink following glycogen depleting exercise. Postexercise consumption of the carbohydrate-protein supplement resulted in a 55% greater time to exhaustion during a subsequent exercise bout. The carbohydrate-Protein supplement resulted in a 17% greater plasma glucose response, a 92% greater insulin response and a 128% greater storage of muscle glycogen compared to the sports drink. These results suggest that the rate of recovery is coupled with the rate of muscle glycogen replenishment.

**Effect of Post-Exercise Supplement Consumption on Adaptations to Resistance Training.** (Rankin, Goldman et al. 2004)

They compared body composition and muscle function response to resistance training using either a carbohydrate supplement or milk following each training session. Muscle strength, body composition, fasted, resting concentrations of serum total and free testosterone, cortisol, IGF-I and resting energy expenditure were measure before and after training. Milk increased body weight and fat free mass more than the carbohydrate supplement. **Resting total and free testosterone concentrations decreased from baseline values in all subjects. There were no significant changes in fasting IGF-I, cortisol, and resting energy expenditure for either group.**

**Overview of Hormone Functions**

**Insulin** – anabolic hormone- (Pancreas) Stores glycogen and promotes glucose entry into cells; involved in protein synthesis. (Baechle and Earle 2008)

In skeletal muscle, the anabolic effects of testosterone and insulin counter cortisol’s catabolic effects. (Baechle and Earle 2008)

Insulin resistance and obesity-25% of the population is insulin resistant, a condition where the pancreas over secretes insulin to maintain normal blood levels of glucose after a carbohydrate-dense meal. This over secretion theoretically causes carbohydrate to be stored as body fat. While this may be true for sedentary populations, it is not the case with athletes and other active populations. Exercise makes cells more sensitive to insulin and insulin triggers receptors to help glucose enter the cell and replenish glycogen stores. (Kleiner 2007)

**Insulin-Like growth factor** – anabolic hormone- (Liver) Increases protein synthesis in cells.

Insulin-like growth factor I is a 70-amino acid polypeptide, and IGF-2 is a 67-amino acid polypeptide. Growth hormone stimulates liver cell DNA to synthesize IGF’s and then they are secreted, a process that takes about 8 to 29 hours. IGF-I has been the primary focus of research of IGF’s due to its prolific role in protein anabolism. (Baechle and Earle 2008)
Responses of IGF-I to heavy resistance training remain unclear. Recent research indicates that changes are based on the starting concentrations of IGF’s before training (i.e., if IGF levels are low, there is an increase; if IGF levels are high, no change or a slight decrease). (Baechle and Earle 2008)

**Testosterone** – anabolic hormone- (Testes) Stimulates growth, increases in protein anabolism, and development and maintenance of male sex characteristics. Can promote growth hormone responses in the pituitary. Testosterone values are typically highest in the morning and decrease throughout the day. Also involved in the regulation of IGF’s. (Baechle and Earle 2008)

**Growth Hormone (aka somatotropin)** – anabolic hormone- (Anterior Pituitary gland) Stimulates insulin-like growth factor I, protein synthesis, growth, and metabolism. GH enhances cellular amino acid uptake and protein synthesis in skeletal muscle in response to resistance training. The anabolic effect of GH caused by resistance training can be direct as well as mediated through the production of IGF-I by the liver and other cells. (Baechle and Earle 2008)

Supplementing diet with carbohydrate and protein before and after workouts has been shown to increase growth hormone levels. (Baechle and Earle 2008)

The effects of long term resistance training on growth hormone levels in athletes have yet to be determined. (Baechle and Earle 2008)

Main roles of GH are....

- Decreases glucose utilization
- Decreases glycogen synthesis
- Increases amino acid transport across cell membranes
- Increases protein synthesis
- Increases utilization of fatty acids
- Increases fat breakdown
- Increases availability of glucose and amino acids
- Increases collagen synthesis
- Stimulates cartilage growth
- Increases retention of nitrogen, sodium, potassium, and phosphorus
- Increases renal plasmas flow and filtration
- Promotes compensatory renal hypertrophy
- Enhances immune cell function

All four are anabolic hormones (hormones that promote tissue building) and block the negative effects of catabolic hormones (hormones that degrade cell proteins to support glucose synthesis) such as cortisol and progesterone. These are four of the major anabolic hormones involved in muscle tissue growth and remodeling. (Baechle and Earle 2008)
Works Consulted


