Testosterone: No Strength Gains without It!

Contributed by Robbie Durand
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testosterone that was 10% lower than that of normal males whereas testosterone remained constant in the placebo group. So here is where the importance of testosterone becomes clear for muscle strength and weight loss. The goserelin group showed no changes in isometric knee extension strength after training, whereas the placebo group had increased strength gains. Body fat mass increased by 3lbs. in the goserelin group while it decreased by 1.3 lbs in placebo group. Interestingly, even though the goserelin group had below normal testosterone they still were able to gain small increases in lean mass, but not as much as the placebo group. The study demonstrates that testosterone is one of many growth factors controlling muscle growth (i.e., GH, IGF-1, intramuscular growth factors). The researchers concluded that endogenous testosterone is of paramount importance to the adaptation to strength training. So how can subject’s not having changes in resting testosterone but have increases in strength and lean mass? Researchers in the study suggested that the acute increases in testosterone produced during the high intensity weight training program may have been a key regulator of those subjects gaining strength and size. The research findings are in agreement with other researchers who have shown acute elevations in circulating anabolic hormones are potent stimulators of strength. For example, Hakkinen et al.3 reported that when subjects were divided into arm only training group and arm plus leg training group, the arm and leg group had greater increases in testosterone and growth hormones than arm training alone that resulted in greater increases in isometric arm strength compared to arm training alone. It's interesting that the even though both groups trained arms that the group that trained both arms and legs had greater increases in arm strength. Additionally, the larger gains in strength from arm and leg training were related to the larger increases in GH and testosterone produced during the exercise sessions.

The gym is filled with all sorts of people that can sabotage your workout. The guy that does a set and talks to his friends for five minutes is not going to have significant increases in testosterone from his workout. All readers of Fitness Rx for Men know that in order to stimulate testosterone during a workout, training sessions must have short rest periods (30 seconds or less) with multiple sets, a training volume with 65-80% of a 1-RM, repetitions between 10-12 reps, and use large muscle mass exercises. Large muscle mass exercises as deadlifts, squats, and jump squats have been shown to produce large increases in testosterone compared to small muscle mass exercises as arm curls18, 22. Back in 1990, Bill Kraemer reported research that changed the way men needed to exercise with weights. In that study, men trained with an equal weight training volume except one group trained with moderate exercise (using a weight they could lift for ten reps) and short rest periods (1 minute) while the other group used heavy exercise (5 reps) with 3 minute rest periods. The results were that men using high reps with short rest periods had increases in both GH and testosterone whereas the group using heavy weights with long rest periods had no changes in either testosterone or GH2. Muscular hypertrophy and strength gains following resistance exercise are thought to be dependent on the intensity of exercise, in a way that an intensity of 65% of a 1-RM is required to achieve a substantial effect2. Although it may seem that testosterone is a no-brainer for increasing muscle mass and strength, the data on the effects of testosterone on muscle performance are somewhat contradictory.

The "Intramuscular Growth Factor" Camp

Elevated testosterone levels have been reported to occur in occur in some studies 2, 7, 8, 9whereas several studies have shown no difference10, 11, 12, 13 or even reductions6, 15. Not all studies in aging older men have shown that testosterone replacement therapy increases muscle strength33, 34. It should be mentioned that some studies have used low dose testosterone gels and creams which are not as effective as shots for increasing testosterone which may negatively obscure results; additionally different dosages have been used in different studies. Some researchers have even gone on to believe that the gains in strength and size are all related to "intramuscular growth factors" that are independent of testosterone. A paper presented by Dr. Goldberg in 1975 stunned scientists about the relationship between muscle growth and testosterone. In his research, he castrated rats so that they could not produce testosterone and put their leg muscle on tension overload. Surprisingly, the rat's leg muscles grew in size suggesting that mechanical overload increases muscle hypertrophy independent of testosterone17. Research scientists are now discovering the signaling pathway by which mechanical stimulation of contracting muscle and intramuscular growth factors as IGF-1 activity leads to changes in satellite cells, muscle DNA content, increased muscle protein synthesis, increased muscle

mass, and strength. Other recent research has demonstrated that IGF-1 increases intracellular calcium ion concentrations leading to the activation of the muscle growth signaling pathway, and subsequent muscle fiber hypertrophy15, 16. For example, in one study ten healthy men completed eight sets of maximal eccentric squats. The intramuscular IGF-I mRNA concentration increased 62% but serum testosterone showed little change35. An increase in muscle hypertrophy can lead to greater increases in muscle strength. Reports in the literature have suggested that the insulin-like growth factor I protein plays a major role in strength training-induced skeletal muscle hypertrophy and strength improvements. Some people due to differences in genetics express higher levels of IGF-1 than others, what we call "lucky bastards". One study compared those that expressed high levels of IGF-1 levels to those that did not. After 10 weeks of training, with a single-leg knee-extension strength training program, 1-repetition maximum, muscle volume, and muscle quality increased significantly for all exercising groups. , subjects whom expressed higher natural levels of IGF-1 levels gained significantly more strength than those whom did not. Thus the data suggest that the IGF-1 may influence the strength response to strength training. Hold on…before I lose you to the side of the "intramuscular growth factor" group, there are some important considerations about testosterone and strength that needs to be addressed.

Acute Increases in Testosterone after Exercise are Essential!

The magnitude of the increase in testosterone can be affected by the amount of muscle mass used during exercise18, 19, intensity and volume2, training experience20, and nutrition intake21. There are a lot of variables influencing testosterone's secretion after exercise, but it seems that acute elevations in testosterone are necessary component for strength gains. Hansen et al23. measured muscle strength changes in muscle flexion in the arms following 9 weeks of resistance exercise. One group performed muscle flexion exercises only, whereas the second group performed a lower body exercise prior to doing the elbow flexion exercises. Performing elbow flexion exercises only failed to elevate testosterone after exercise, however testosterone was significantly elevated when lower body exercise were performed before elbow flexion exercises. Muscle strength increased to a greater extent in the arms when the lower and upper body exercises that were combined that produced increases in testosterone compared to training arms only which yielded no changes in testosterone. Another study reported that the acute increase in both testosterone and free testosterone correlated with the individual changes in strength that occurred during a 6-month training period12. Although some studies have reported no long term changes in resting testosterone after resistance exercise, acute increases in testosterone which may only last for 15 minutes after exercise is essential for muscle strength and hypertrophy gains. It appears that the acute response to resistance exercise is more important to muscle growth and remodeling than chronic changes in resting hormonal changes, as many researchers have not shown a significant change in resting hormonal levels despite increases in muscle strength and hypertrophy.

Testosterone Dose-Dependently Increases Muscle Strength

During adult life, the average male produces about 7 mg of testosterone daily. The normal range of plasma testosterone in males is 300-1000ng/dl, but the average value declines by age 80 to approximately 50% of that at age 20 years of age26. The low level of anabolic hormone testosterone may be a limiting factor as why older adults tend to have lower gains in strength compared to younger men. The impressive gains in strength from testosterone can be demonstrated in which one study in hypogonadal men whom received testosterone increased muscle strength on the bench press by 22% without exercise27. Testosterone is a wonderful hormone for men, but it can’t perform miracles if you lay on your ass! NASA investigated the usefulness of using testosterone to prevent muscle atrophy and strength loss during space flight. Men were assigned to bed-rest while using low supraphysiological range testosterone. Interestingly a significant anabolic response was achieved, as both whole body nitrogen balance and leucine kinetics were improved by testosterone treatment, but there was still a decline in muscle strength. These results suggest that in the absence of daily physical activity, testosterone administration will not increase or, in the case of this bed rest model, preserve muscle strength28. The natural changes in testosterone throughout the day make measuring testosterone complex as there are several studies that have shown no change in testosterone over several weeks of training, but when pharmacological testosterone is administered in combination with resistance exercise there are clear increases in muscle strength. When supraphysiological dosages of testosterone are administered to healthy young men, there was a significant increase in muscle size and strength without exercise24. When exercise is added to supraphysiological dosages of testosterone an even greater effect on strength is achieved. The same research group conducted an interesting study on different

dosages of testosterone and how it affected muscle strength. They first gave all the healthy young men in the study a gonadotropin-releasing hormone agonist (GnRH antagonist) to suppress natural testosterone similar to the earlier study mentioned. The men then received 25, 50, 125, 300, or 600mg of testosterone for 20 weeks. The researchers discovered that testosterone was associated with a dose dependent increase in leg press strength and power. Meaning that the changes in leg press strength and power was highest for the 600 mg group and lowest for the 25 mg group. Another interesting finding was that the strength and muscle power were not correlated with serum IGF-1 levels.

How Testosterone's Enhances Muscle Power

Theoretically, testosterone should improve strength by increasing muscle mass (via increased protein synthesis, nitrogen retention and anti-glucocorticoid actions), as well as by increasing exercise motivation. Moreover, recent studies in humans indicate that testosterone may increase muscle protein synthesis, possibly through stimulation of intramuscular insulin-like growth factor-I (IGF-I) gene expression31. Testosterone may also enhance strength by altering the way neurotransmitters are produced for muscle contraction. Contraction of muscle is a duty of the central nervous system comprised of brain and spinal cord. The connection between a motor neuron (A neuron that conveys impulses from the central nervous system to a muscle) and muscle fiber is a specialized synapse called the neuromuscular junction. Upon adequate stimulation, the motoneuron releases a flood of neurotransmitters that bind to receptors and triggers muscle contractions. The first step in the sequence of events causing contraction of a muscle is the chemical messenger from a nerve (in the form of the neurotransmitter molecules, acetylcholine) to the muscle. Testosterone has been shown to alter neurotransmitter acetylcholine within motor neurons which could result in a more efficient muscle contraction. For example, castration causes a decrease in the activity of an enzyme called choline acetyltransferase, resulting in less acetylcholine which technically could result in lower force output, however if the rats are supplemented with testosterone the levels of acetylcholine return to normal, furthermore if the levels are supraphysiological elevated as with testosterone abuse the levels of the neurotransmitters are increased even further30.

Both motor neurons and muscle have androgen receptors located on them and are, therefore, potential sites of androgen action. The significance of how androgen receptors affect muscle strength can be exhibited by patients with Kennedy's disease, a degenerative disease in which androgen receptors are defective. The disease is characterized by severe muscle weakness. How testosterone interacts with the receptor is like a lock and key system. If you have lots of locks (testosterone) and no keys (receptors), it not going to do you a whole lot of good. A study in the Journal of Steroid Biochemistry and Molecular Biology reported that when resistance trained men had muscle biopsies taken the greatest predictor of males 1-RM strength was not testosterone but the androgen receptor content in the thigh muscle36. It appeared that the quantity of androgen content in muscle was a better predictor of muscle strength than circulating androgens in the men studied. Motor neurons and skeletal muscle both have androgen receptors. Testosterone causes enlargement of motor neurons causing greater force enhancement. Males have larger motor neurons than females due to the actions of testosterone. Research in rats has shown that testosterone administration causes an increase in motor size while a castration causes a decrease in the motor size of neurons29. The data suggest that testosterone may increase strength by increasing motor neuron size.

Although some studies have shown no changes in resting testosterone changes after resistance exercise more recent research has shown that the importance of acute testosterone responses and mechanical stimuli from resistance exercise as upregulators of the androgen receptor which influence muscle strength and size. Other factors as nutrition, overtraining, intensity, and rest duration all influence the secretion of testosterone during exercise. The acute increases in testosterone are associated with changes in lean muscle mass and strength.

Key Points:

• A decrease in testosterone as little as 10% below normal will impede strength gains in response to a strength training program.

• Acute elevations in testosteone are a potent stimulator of muscle mass and strength.

• Testosterone produces a dose dependent effect on muscle strength.

• Motor Neurons contain androgen receptors and increase in size in response to testosterone which may mediate muscle strength.

• Testosterone increases the neurotransmitters firing potential of muscle with may enhance force production.