

The Ultimate Anabolic Guide to Testosterone (FULL ARTICLE)

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No anabolic reference guide would be complete without the mention of the most anabolic of all hormones: testosterone! GH and testosterone work synergistically together when produced in conjunction with intense exercise. It seems the increases in both GH and testosterone results in the greatest increases in muscle mass and reductions in bodyfat. For example, when the effects of GH or a combination of GH and testosterone on lean muscle mass and fat mass were compared, a combination of GH and testosterone resulted in superior increases in lean muscle mass and reduced fat mass compared to GH or testosterone alone²⁶, ²⁷. The effects of GH and testosterone on lean body mass appeared additive, suggesting that both GH and testosterone are synergistic yet increase muscle hypertrophy thru different mechanisms.

Testosterone:
The King of Muscle
Building

Testosterone is the king of anabolic hormones, don't expect much increases in size or reductions in bodyfat without increases in testosterone. For example, one study administered a drug that suppresses natural testosterone production to a group of healthy men which reduced circulating testosterone levels to sub-normal levels and found that testosterone decreases in protein metabolism, decreased lean muscle mass, decreased strength, and increased adiposity. If that's not bad enough, there was a decrease in gene expression for IGF-1 in muscle²⁸. One of the major mechanisms that testosterone is suggested to increase protein synthesis and subsequent muscle growth is through the stimulation of satellite cell number and an increase in the actual binding of satellite cells to muscle fibers. Testosterone administration has been shown to increase satellite cell number. Several factors appear to influence the acute serum total testosterone responses to resistance exercise. The magnitude of elevation of testosterone during resistance exercise has been shown to be affected by the muscle mass involved (i.e. exercise selection), intensity and volume, nutrition, and training experience. A bout of resistance exercise produces acute changes in testosterone have been linked to those cellular processors involved in protein turnover and muscle growth², ²⁹.

In brief, elevated testosterone concentrations produced during intense exercise increase testosterone-receptor interactions, thereby initiating a cascade of events leading to the acute (e.g. protein metabolism) and chronic (e.g. muscle growth) adaptive response to training. Acute elevations in serum free testosterone occur after high intensity exercise in both young and elderly men after resistance exercise. However, the magnitude of elevation was greater after 10 weeks of progressive

resistance exercise stimulus; thereby suggesting that a resistance training base may enhance the acute response to a workout. In addition, a significant elevation in resting serum free testosterone was observed in the young men³⁰. Testosterone is thought to be the predominant factor that produces greater hypertrophy in men than women when placed on identical training regimens. Strength protocols which take prolonged rest periods produce smaller testosterone responses than short rest period hypertrophy schemes. Such a notion is supported by the larger muscle fiber sizes of bodybuilders versus power-lifters/Olympic lifters, which may be attributed to the training methods employed by these athletes (bodybuilders =hypertrophy schemes, power/Olympic lifters = strength schemes) and associated testosterone responses.

More Explosive Power with Testosterone

Like feeling strong...it's your testosterone levels! Higher testosterone levels are correlated with maximal strength levels and higher resistance levels of fatigue in weightlifters⁸. Additionally, testosterone levels are directly related to how high a person can jump and how fast a person can run²³. Testosterone appears to augment power activities and activities with high force output. For example, work from Bosco and colleagues tested 97 high level athletes involved in various sports. They found that the highest values of testosterone were for jumping performance in sprinters, while the lowest values were in cross-country skiers, and intermediate values were found in soccer players²³. They also found that testosterone was directly related to both the height in the countermovement vertical jump and average sprinting speed. What is most fascinating is that actual increase in testosterone concentrations in a maximal continuous vertical jumping test for 60 seconds in professional soccer players was directly correlated with average power output¹⁵. One study documented that without testosterone, you can expect impaired strength gains from a heavy resistance training protocol. In the study, young men performed several weeks of performing a resistance training program while receiving a medication that turn blunts the production of testosterone. The strength-training period of eight weeks included exercises for all major muscles (three to four sets per exercise x six to 10 repetitions) and one-minute rest periods between sets. The protocol was designed to cause acute increases in testosterone, which has been validated by previous investigations. The subjects who received the testosterone suppression medication had a decrease in testosterone that was 10 percent 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 group that received the testosterone suppressing medication showed no changes in strength after training, whereas the placebo group had increased strength gains. Body fat mass increased in the testosterone suppression group while it decreased by 1.3 pounds in normal group. The testosterone blunting medication group made a small gain in lean mass, but not as much as the placebo group²⁴. So this study demonstrates that maintaining or increasing testosterone levels are essential for strength gains.

Testosterone and Resistance Training Intensity

An intense bout of resistance exercise produces acute changes in testosterone which have been linked to those cellular processors involved in

protein

synthesis and muscle growth. Resistance training routines, that incorporate short rest periods between sets, produce higher testosterone concentrations than training protocols that use the same workload and prolonged rest periods. For example, male strength athletes performed two different training intensities while maintaining similar rest periods (3 minutes).

The first session consisted of maximal strength training session (20 sets x 1 RM x 100 %), while one week later they performed a sub-maximal bodybuilding training session (10 sets x 10 RM x 70%).

Testosterone levels with maximal training (20 sets x 1 RM) did not change immediately and 1-hour post exercise, however testosterone and cortisol responses to submaximal training (10 sets x 10 RM) increased during after and 1 hour post-exercise with the submaximal training loads¹. It was concluded that high intensity resistance exercises can stimulate testosterone production, while low intensity heavy resistance exercise does not. If

you perform a high intensity bout of heavy resistance exercise, not matter what your previous training experience you will increase testosterone production.

One study compared bodybuilders and powerlifters of the same age, size, and experience to an intense resistance training protocol, which shorted rest periods. The experimental sessions

consisted of 3 sets of 10 repetitions for 10 exercises with 10-second rest periods between sets and 30 to 60 second rest periods between exercises.

Testosterone increased in both groups, but regardless of previous training experience, both bodybuilders and powerlifters had similar increases in testosterone concentrations².

Bodybuilding Protocols Increase Testosterone Greater than Powerlifting Protocols.

Testosterone responses

to resistance training in men are less with low intensity resistance training protocols than those that use high intensity. Raastad et al. compared testosterone responses to two protocols, which utilized different intensities of squats, front squats, and leg extensions yet workload remained constant. One protocol was a moderate intensity (70% of a 1-RM) and the other protocol was a high intensity workload (100% of a 6-RM). Testosterone responses were higher during and one hour after the 70% protocol compared to the 100% protocol³. So now you are understand that training intensity should be at least 70% or more to stimulate sufficient rises in testosterone production.

Testosterone Increases with Large Muscle Mass Exercises

Testosterone levels are also influenced

by the amount of muscle mass activated in response to exercise. Olympic lifts, jump squats, and deadlifts all produce large increases in testosterone^{31,32}. Although most people would rather perform a bench press than jump under a squat bar, the bench press is not going to increase testosterone production like a squat.

For example researchers investigated the effects of 5 sets of 10 repetitions of bench press versus 5 sets of 10 repetition jump squats, with 2 minutes rest between sets in 12 resistance trained men. Testosterone was raised higher following the jump squat (15 %) then the bench press (7%). This suggests

that exercises which recruit the most substantial amounts of muscle tissue will cause the greatest increases in testosterone³². It also reinforces the order of exercise principles. Generally exercises that recruit large muscle groups (squats, deadlifts, chin-ups) should be performed before isolation exercises (leg extensions, leg curls, ect). As testosterone is concerned, the larger exercise may raise testosterone levels and exert its effects on the smaller isolation type exercises. It

has been suggested that large muscle mass exercises be performed prior to small muscle-mass exercises. The performance of large muscle-mass exercises (i.e. squat, deadlift, power clean) early in

the workout produce elevations in testosterone, which potentially may expose smaller muscles to a greater response than that resulting from performance of small muscle mass exercises only. For example, one study measured muscle strength changes in the bicep strength following 9 weeks of resistance training. However, one group performed a workout consisting of bicep curls only and a second group performed squats prior to bicep curls. Performing bicep curls exercises only failed to acutely elevate testosterone significantly. However, testosterone was significantly elevated when squats were performed first, and muscle strength increased to a greater extent as well when both lower- and upper-body exercises were performed³³. These data provide support for performing large muscle mass, multiple-joint exercises early in a workout and smaller muscle mass exercises later in the workout when training to enhance muscle strength.

World renowned Russian strength coach

Pavel Tsatsouline wrote in his book, that if he had to choose one exercise to perform it would not be the squat, but the barbell deadlift. The deadlift recruits not only the legs, but the arms, abs, and lower back as well.

It has been reported that significant increases in testosterone occur after deadlifts in college age men; however, maximal and submaximal efforts in the bench press resulted in smaller increases in testosterone⁷ you can still perform isolation exercises such as bicep concentration curls, just perform these exercise after the larger exercise.

For example, if an athlete performs squats before biceps curls, the biceps may be exposed to higher levels of circulating testosterone. Dynamic power schemes, often employed to maximize explosive power have also produced significant androgen responses. Dynamic power schemes, often employed to maximize explosive power and functional performance, have also produced significant androgen responses. For example, total (18%) and free TST (30%) increased in response to half-squat lifts performed with a load of 50% 1RM²⁹. If

you are looking to put on size and strength walk right past that leg extension to the squat rack. Testosterone levels did not increase from pre to post exercise for younger and older men to upper and lower body isolation-type (leg extension) resistance exercise on a Nautilus machine consisting of 3 sets of 10-repetitions⁴. Contrary to these finding, significant increases in testosterone responses of older and younger men in response to a high intensity large muscle mass squat (large muscle mass) protocol⁵.

What are the Stimulators of Testosterone?

So here is the million dollar question researchers are asking: What is the mechanism or how does intense exercise stimulate testosterone production? Testosterone levels under resting conditions are influenced by a hormone called leutinizing hormone (LH), which stimulates Leydig cells (cells located in the testes) to secrete testosterone, however during brief intense resistance exercise testosterone levels have been reported to increase despite no increases in LH¹⁰. This suggests that testosterone is not being increased thru normal physiological stimulation but other means such as changes in blood volume which result in a super concentration of blood particles.

Decreased Plasma Volume during Exercise Increases Testosterone

A proposed mechanism for increased testosterone levels during exercise is what is called a plasma volume shifts, which concludes that during high intensity resistance exercise as you muscles become pumped with blood, water or plasma is displaced from your circulatory system, as a result your blood becomes more concentrated with active metabolites (in this case testosterone). For example, testosterone levels have been found to increase after sitting in a sauna²⁵. Testosterone levels are not actually increasing, changes in blood volume due to sweat loss result in a supersaturation of testosterone levels in the circulatory system. Kraemer et al. reported that after a resistance training protocol of three sets of bench press, lat-pulldowns, leg extension, and leg curls performed at a 10-RM load for 10 repetitions or until muscular failure resulted in a significant increase in testosterone levels, but when he corrected for the plasma volume shifts or the amount of fluid lost from blood and found that there was no change in testosterone¹². However, even if there are no actual increases in testosterone that occurs with resistance exercise the elevated levels in the blood have more availability to bind with androgen receptors in muscles producing a superior anabolic response.

Can Lactic Acid Stimulate Testosterone?

The absent response of LH to an acute bout of resistance exercise despite an increase in testosterone has led researchers to speculate other mediators are influencing testosterone production. Possible mechanisms for increasing testosterone levels during high intensity exercise are due to increased circulating lactic acid levels that are being produced from high intensity training. Lactic acid has been shown to stimulate testosterone release in vitro (i.e. which means in the test tube)¹¹. Researchers exposed the testosterone producing portion of the cell (i.e. Leydig cells) to lactic acid and found that administration of lactic acid dose-dependently increased the basal testosterone production.

Testosterone Stimulation thru Adrenaline?

Catecholamines or adrenaline is a possible stimulator of testosterone in men as well. It has been reported that men competing in competition and win have increased testosterone production which is also takes place with large increases in adrenaline which may be stimulating testosterone secretion 13, 14. Robert Sapolsky a world renowned endocrinologist who studies male apes reports that when male apes fight other apes for females, the winning ape has large increases in testosterone while the losing ape has lowered testosterone. He reports that in ape's testosterone could be increased by other mechanism than the LH pathways which may be true in humans as well¹⁵. He suggested that sympathetic stress enhances the secretion of adrenaline, which has a stimulatory effect on testosterone within minutes, whereas cortisol released from the adrenals also inhibits testosterone production from the testes just as quickly. Thus he suspects the adrenaline rush of winning increases testosterone while losing increases cortisol which decreases testosterone. Researchers put the adrenaline and testosterone theory to the test in young males. The heavy weight lifting consisted of four sets of six squats at 90-95% of a six-repetition maximum (RM), while the moderate weight lifting consisted of four sets of 9 or 10 repetitions at 60-65% of a 1-RM. The weight and number of repetitions were manipulated such that the total weight lifted for the two sessions were equal. Schwab hypothesized because the exercise bout was brief, possibly epinephrine and norepinephrine, which have been shown to increase during exercise to the magnitude of the intensity of the exercise, could have significantly increased testosterone levels in response to the exercise bout¹⁶.

Training to Failure Every Set Is Not Conducive to Testosterone

For years, personal trainers and fitness experts told lifters that every set must be performed to absolute failure. This type of advice should be revised as recent research reports that training to failure every set leads to reductions in anabolic hormones such as IGF-I and testosterone and caused larger increases in cortisol compared to lifters who don't train to failure. The subjects in the study trained twice a week using a periodized weight training program for 16 weeks. One group trained to complete muscular failure for each set while the other group trained did not complete sets to muscular failure. The researchers defined muscular failure when the subjects could not perform a full extension or the weight was paused for more than 1 second during a repetition. At the end of the 16 week study, training to failure over the 16 week study resulted in reductions in circulating IGF-I concentrations. In addition, the group that did not train to failure had reduced resting cortisol concentrations and an elevation in resting serum total testosterone concentration after 11 weeks of training. Additionally, the group that did not train to failure had similar increases in 1-repetition maximum strength gains in the bench press, parallel squat, and muscle power output of the arms and legs extensor muscles³⁶. If you are trying to maximize size, than not training to failure may lead to enhanced testosterone and lower catabolic activity such as reduced cortisol. The reduction in anabolic hormones (IGF-I and testosterone) from training to failure goes against decades of advice to train to failure for maximal muscle growth.

Overtraining Decreases Testosterone

Acute increase in testosterone occurs with resistance exercise but prolonged workouts with insufficient rest and recovery can lead to overtraining and reduced testosterone. When subjects performed a high volume resistance training protocol which consisted of 50 total sets of upper and lower body exercise with repetitions of 5 and 10 RM loads with 90-second rest periods between sets resulted in no change in testosterone during exercise and immediately after exercise; shockingly there was a concomitant lower LH secretion and suppressed total and free testosterone for up to 13 hours after exercise¹⁰. Another study monitored elite Olympic lifters testosterone concentrations to twice daily training for 1 week. Elite Olympic weightlifters trained twice a day using similar volume (> 90% of a 1-RM) but different exercises. The morning session (9:00 a.m. to 11:00 a.m.) consisted of Olympic snatches, clean & jerks, and front squats, while the afternoon session (3:00 p.m. to 5:00 p.m.) consisted of power snatches, power cleans, and back squats. Testosterone started to decrease after the first training day and continued to systematically decrease over the course of the training period. When the training stress was reduced to one training session a day, serum testosterone concentrations started to increase, and after 1 full day of rest, values returned to the pre-training level¹⁸.

Long Distance Running- Chemical Castration

Research has shown that men who have performed chronic endurance exercise training for many years have lower circulating basal concentrations of free and total testosterone³⁴. It has been reported that basal testosterone concentrations of long-distance runners were only 55-70% lower than those found in age-matched controls³⁵. The observed suppressed testosterone response may be due to a reduced number of LH receptors on the Leydig cells of the testis or a compromised testosterone conversion process in the testis. Investigators have speculated that the high cortisol produced during long endurance runs can suppress testicular function) or other physical events (i.e., increased testicular temperature due to thermic effects of exercise).

Dietary Cholesterol Increases Testosterone Production

Cholesterol is a pre-cursor for testosterone so increasing cholesterol production may promote more conversion into testosterone. An abstract presented at Experimental Biology reported that the conversion of cholesterol to testosterone may be important for muscle hypertrophy. Adults were placed on a 12-week weight-training program and tested them before and after for changes in muscle mass and strength. While all subjects ate a diet that was moderate in protein, about half consumed a low-cholesterol diet (1.6 mg per pound of bodyweight or about 150-250 mg per day) while the other half consumed a high-cholesterol diet (2.6 mg per pound of bodyweight or about 250-450 mg per day). After 12 weeks of weight training, the lower-cholesterol group did not increase muscle mass but strength

increased by 35%. The higher-cholesterol group, on the other hand, saw an increase in muscle mass of about 5 pounds and increased strength by about 90%. Although the researchers were not sure exactly why cholesterol influences muscle and strength gains, the reason can be speculated: Cholesterol is important for testosterone production as well as maintaining the integrity of muscle cell membranes. In other words, cholesterol isn't all bad and may be necessary for building muscle and strength. The increase in cholesterol could have lead to a boost in testosterone production.

Monounsaturated and Saturated fats Increase Testosterone

In addition to cholesterol, the type and amount of fat consumed regulate testosterone production as well. Reducing dietary fat from (>30 percent calories from fat and low fiber < 20 g/day) to a low fat diet (<15 percent calories as fat and 25-30g fat per day) significantly reduced total and free testosterone levels and adrenal androgens (androstendione and DHEA-S)⁴¹. It has been reported that when men consumed isocaloric diets (i.e. diets containing the same amount of calories) from low fat diets from vegetarian sources (~25% kcals from fat) resulted in significant decreases in testosterone and the nocturnal release of testosterone, compared to men receiving moderate fat diets (~40% kcals from fat)⁴². Additionally, middle aged men fed a low fat (<25 %), high fiber diet for 6 weeks, during a crossover intervention, experienced a significant decrease in testosterone and free testosterone. These participants experienced a return of testosterone and free testosterone levels to baseline when the subjects were reassigned to the moderate-fat diet (37 % fat)⁴³.

Total dietary fat, saturated fatty acids, and monounsaturated fats have been found to be positively correlated with resting T concentrations in men, whereas diets that are high in polyunsaturated fats are shown to be inversely correlated with T levels^{13, 36,37, 38}.

Additionally, rats that are fed diets rich in monounsaturated fats had greater 17 β -dehydrogenase activity (a key enzyme in the testosterone synthesis pathway in the male rat) and plasma androgen concentrations compared to rats fed diets rich in saturated and polyunsaturated fats³⁹. It has been shown that when isocaloric meals that contain different proteins and different quantities and type of fat are administered to subjects, meals with a high polyunsaturated to saturated fats ratio result in significant reductions in testosterone levels. Hamalainen et al. reported that there was a 15% reduction in serum T concentrations accompanied by a significant decrease in androstenedione levels when subjects were switched from a diet rich in animal fats to a diet low in saturated fats and high in polyunsaturated fats⁴⁰.

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