Human Growth Hormone: Does it Enhance Physical Performance?

By: Sean Casey

Table of Contents

Cover Photo for ebook taken by Zaldylmg and obtained on 9-11-2010 from: http://www.flickr.com/photos/8499561@N02/2756332192/

About the Author

Sean Casey is a graduate of the University of Wisconsin-Madison with degrees in both Nutritional Science-Dietetics and Kinesiology-Exercise Physiology. Sean graduated with highest academic honors as one of the top students in both the Nutritional Science and Kinesiology departments.

During college, Sean was active with the UW-Badgers Strength and Conditioning Department. He has also spent time interning at the International Performance Institute in Bradenton, FL where he worked with the USA U-18 National Men's Soccer team. He also interned and later worked at Athletes Performance. While at these locations he had the opportunity to train football, soccer, baseball, golf and tennis athletes. Sean is also active in the field of sports nutrition where he has consulted with a wide variety of organizations including both elite (NFL's Jacksonville Jaguars) and amateur athletic teams.

Currently, Sean Casey is the president of CasePerformance, an organization focused on providing its clients research based physical performance and sports nutrition advice. He can be reached though his website http://www.caseperformance.com/.

Growth Hormone-Part I: Does it enhance physical performance?

Quick Hit Summary

Human Growth Hormone (HGH) has been shown to improve body composition in individuals clinically deficient in the hormone. Thus, many athletes have designed their workouts around maximizing the release of this hormone. However, current research does not support the theory that HGH stimulating workouts actually increase muscle protein synthesis. HGH workouts may increase fat loss but more research needs to be completed in this area. Multiple studies have also looked at if specific oral amino acids (L-arginine, L-ornithine, GABA, lysine) can enhance natural HGH production. Currently, very little evidence supports their use in young or old individuals.

Human Growth Hormone

Human growth hormone (**HGH**). Is there a hormone over the past 10 years that has gained more attention in main stream media? During this time period, it has gone from a word generally reserved for the scientific community to a common household term. Much of this can be attributed to well known athletes such as Barry Bonds, Roger Clemens, Marion Jones and others who have been linked to this performance enhancing drug. Even non athlete celebrities, such as Sylvester Stallone, swear by it. Due to its name, many individuals commonly believe that human growth hormone (HGH) will improve muscle size and strength. Furthermore, HGH has been shown to improve body composition (ie- lean body mass, % body fat) in those *clinically* deficient in the hormone[1]. For these reasons, HGH has piqued the interest of both competitive athletes and exercise enthusiast.

The Effects of Exercise Induced Human Growth Hormone on Muscle Hypertrophy and Strength

Single Training Session

HGH is naturally produced by the body in response to intense workouts that are characterized by high rep sets and short rest intervals (ie- the same type of workouts that create a "burning" sensation in your muscles due to lactic acid buildup)[2]. These workouts have been shown to significantly increase circulating HGH concentrations for up to 30 minutes post-exercise in both men and women. Recently, West et al. analyzed the relationship between exercise induced HGH elevations and muscle growth. In the first of their 2 studies, 8 healthy, untrained males (mean age- 20 years) completed 2 separate resistance training sessions; one was a high hormone (**HH**) session that significantly increased HGH release (single arm preacher curls followed by intense leg training) and the other was a low hormone (**LH**) session which failed to increase circulating HGH levels (preacher curls only; completed on the arm opposite of the one used in the HH session)[3]. Following each session, researchers measured the rate of myofibrillar protein synthesis (**MPS**) in the bicep of the respectively trained arm. {For reference, **myofibrillar proteins** are the proteins which are responsible for generating force in the muscle during muscular contraction. Via resistance training, one increases the synthesis of myofibrillar proteins, leading to gains in both muscle strength and size.}. **Results indicated that despite increasing circulating HGH levels (~800%), the hormone stimulating workout failed to significantly improve MPS vs. the arm only training session**.

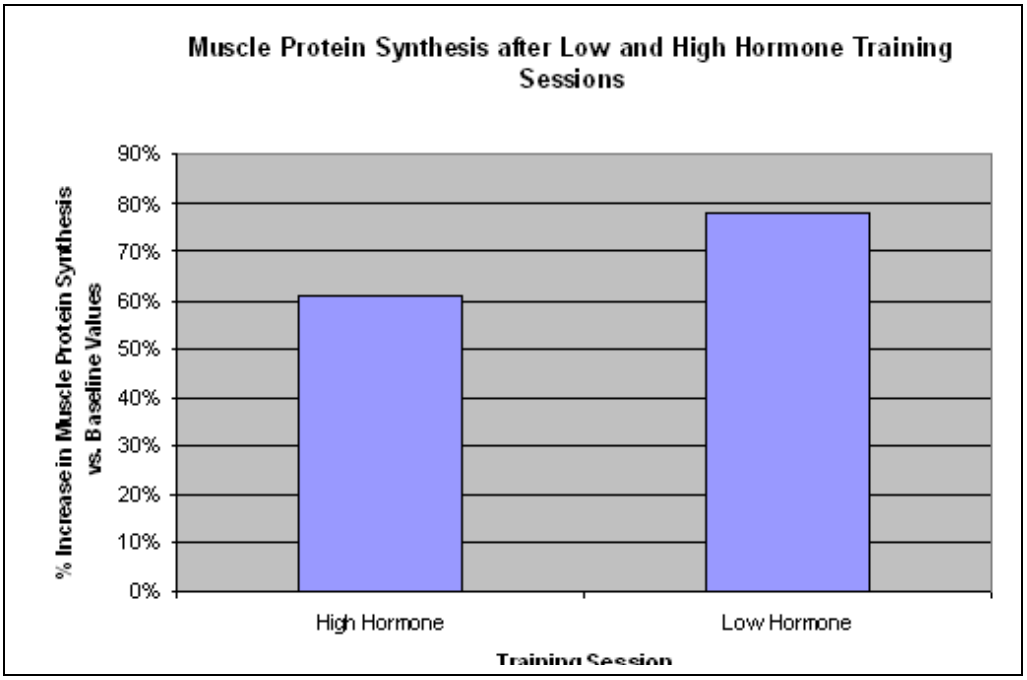

Figure 1 % Increase in muscle protein synthesis after high and low hormone training sessions. As you can see, the low hormone session increased muscle protein synthesis by 78% whereas the high hormone session increased it by 61%. These differences were not statistically different from each other.[3]

Please don't misinterpret the graph… If one quickly looks at the graph, he/she may assume that the LH session increases muscle protein synthesis vs. HH session. However, I must emphasize that these differences were not statistically significant.

Chronic Training

The aforementioned study only looked at how a single session influenced the rate of muscle protein synthesis. One may naturally wonder what would happen if this protocol was repeated over an extended time period. Maybe, the cumulative effects of elevating HGH levels would influence MPS. Thankfully for us, this very question was answered in a 2nd study completed by West et al[4]. The design and exercise routine of this study was similar to their previously mentioned study except participants (12 untrained males; mean age 21.8 years) completed 15 weeks of training using the following routine:

- Weeks 1-6: exercised 3x/week alternating between HH (single arm preacher curls and LH routines every other training day.

- Weeks 7-15: exercised 4x/week alternating routines every other training day.

Pre- and post- workout protein shakes have been shown to influence muscle growth[5] and are commonly used by athletes. Thus, each participant received 18 grams of whey protein just prior and again 90 minutes following each session to mimic real life training[4]. At the completion of the 15 week training period, West et al. examined increases in muscle size and strength of each arm. **Both biceps, regardless of if it was trained under the HH or LH conditions, experienced similar increases in both muscle size (Figure 2, page 6) and strength gains (Figure 3, page 7)**.

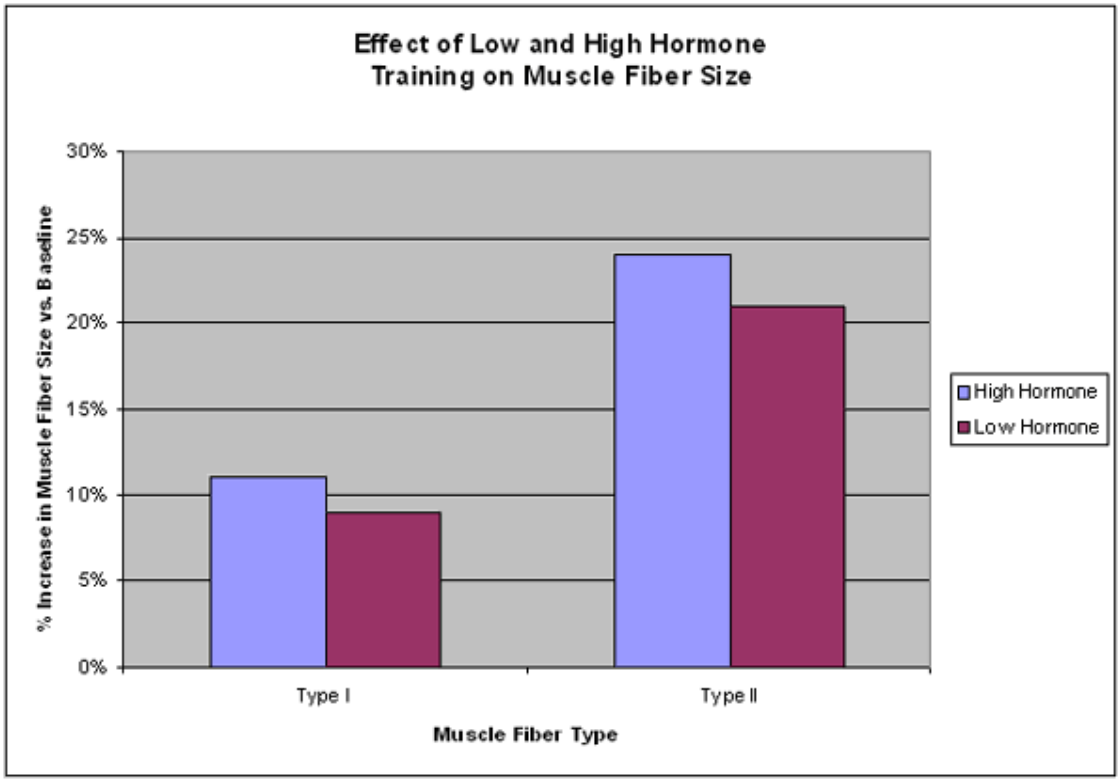

Figure 2. % Increase in Type I and Type II muscle fiber size following 15 weeks of a high or low hormone training protocol. The method of training (high hormone, low hormone) had no effect on changes on either type 1 or 2 muscle fiber size.[4]

For reference, Type 1 are "slow" twitch muscle fibers and used primarily for endurance based training and smaller in size. Type II are "fast" twitch muscle fibers and used primarily for max strength/power based contractions. They are much larger in size vs. Type I. Also, there were no significant differences in muscle fiber size between groups at the start of the trial.

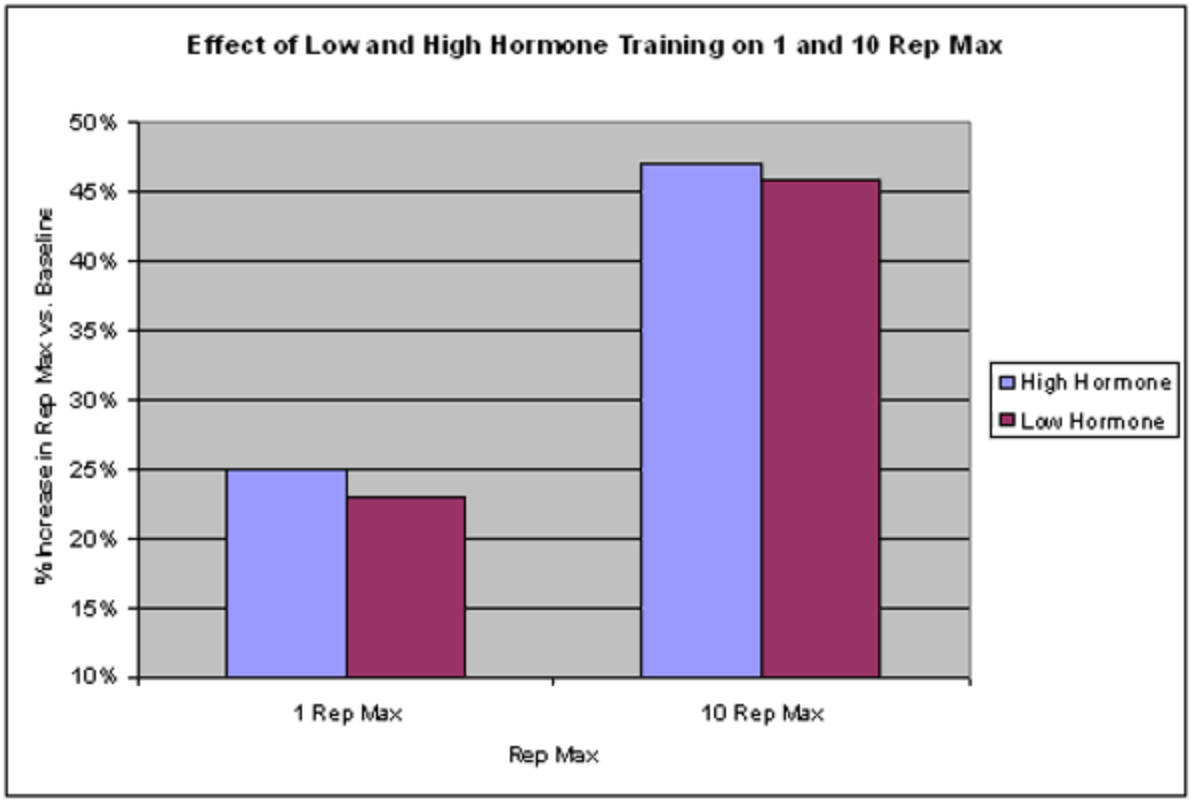

Figure 3. % Increase in 1 rep max and 10 rep max following 15 weeks of a high or low hormone training protocol. The method of training (high hormone, low hormone) had no effect on changes on either type 1RM or 2RM. For reference, there were no significant differences in 1 or 10 rep max between groups at the start of the trial.[4]

The Effects of Exercise Induced Human Growth Hormone on Fat Loss

Although exercise induced HGH workouts will not enhance muscle growth, they may be useful for decreasing body fat. One of the physiological functions of HGH is to increase lipolysis (breakdown of fat for energy purposes)[6]. There has been some evidence that intense exercise, which stimulates HGH, may decrease total abdominal fat. This was demonstrated in a study completed by Irving et al. in which 27 middle aged women (mean age – 51 years) were assigned to a control, low intensity or high intensity *aerobic* training program for a total of 16 weeks[7]. Duration of each exercise session was adjusted such that individuals in the high and low intensity training groups burned equal kcal/session. At the conclusion of the study, **those participating in the high intensity training group saw significantly greater losses in visceral and total abdominal fat vs. those in the low intensity group**. Study authors hypothesized that results were due to greater release of lipolytic hormones (such as HGH). On the other hand, when men of a similar background were added to the study results, (exercise conditions held exactly the same) no differences were present between groups[8].

Study Limitations

There are two caveats worth mentioning regarding the aforementioned studies looking at high intensity aerobic workouts, HGH and fat loss. First, dietary records were not kept. Thus, differences in dietary intake may account for the changes seen. Second, Irving et al. did not present data reflecting HGH levels in the study involving the 27 middle aged women[7]. As such, there is a lack of definitive evidence indicating that exercise induced HGH release leads to greater losses in fat mass vs. exercise of equal kcal expenditure that fails to raise circulatory HGH release. Also, I'm unaware of any study which has looked at this potential benefit in a young, healthy adult population. Thus, with respect to the scientific literature, the jury is still out on the effectiveness of exercise inducing HGH workouts on accelerating fat loss vs. non HGH stimulating aerobic workouts of similar kcal expenditure.

Growth Hormone Secretagogues

If one looks on the internet, he/she can find many products that are alleged to enhance the body's natural production of HGH. These products, commonly referred to as **HGH secretagogues**, often consist of the amino acids Gamma-aminobutyric acid (GABA), arginine, ornithine, and lysine.

Gamma-aminobutyric acid

Research has indicated that Gamma-aminobutyric acid (GABA) stimulates HGH secretion in subjects at **rest**[9]. For this reason, it's been advertised to strength athletes as a natural way to "stimulate secretion of growth hormone, decrease body fat levels and increase lean muscle tissue."[10] Using this as a backdrop, Powers et al examined if 3 grams (g) of GABA would enhance both resting and exercise induced levels of HGH[11]. On four separate occasions (2 resting sessions, 2 exercise sessions), 11 resistance trained men (mean age- 23.6 years) received either HGH or a placebo treatment. Blood levels of **ifGH**, which is believed to be the biological active form of HGH, was measured for 90 minutes following ingestion. At rest, **GABA supplementation significantly increased mean ifGH levels** vs. placebo (>300%). Also, GABA vs. placebo tended to increase ifGH levels during exercise. At 30 minutes post-ingestion ifGH was significantly greater (175%) in the exercise + GABA vs. exercise + placebo. It also tended to be higher over the entire 90 minute observation period.

To my knowledge, the effect of long term GABA supplementation on body composition in active or sedentary individuals has not been studied.

Arginine

Arginine is one of the more popular amino acid HGH secretagogues. Evidence exists indicating that oral doses of 5 and 9 grams of arginine could significantly increase HGH levels in resting individuals[12]. In a classic study completed by Collier et al., the effects of arginine on resting and

exercise (including post-exercise) HGH levels were examined[13]. Their study involved 8 males (man age- 20.4 years) who participated in the following four sessions:

- Rest + Placebo
- Rest + l-Arginine (7 g)
- Exercise + Placebo
- Exercise + l-Arginine (7 g)

Circulating HGH levels were measured after each exercise or resting session. With respect to stimulating HGH release, results were as follows:

(In descending order of greatest HGH stimulation over entire measuring time frame)

#1: Exercise + Placebo

#2a. Exercise + Arginine

#2b. Rest + Arginine

#3. Rest + Placebo

Supplementing with arginine did increase HGH vs. baseline values. However, the greatest HGH levels were found after exercise-placebo session, followed by exercise-arginine session. Let me put this another way. **Arginine + exercise actually DECREASED HGH (by 50 %) vs. exercise alone when measured over the entire recording period**. Additionally, as seen in **Figure 4 (page 10)**, Arginine also blunted the peak HGH release normally seen during exercise.

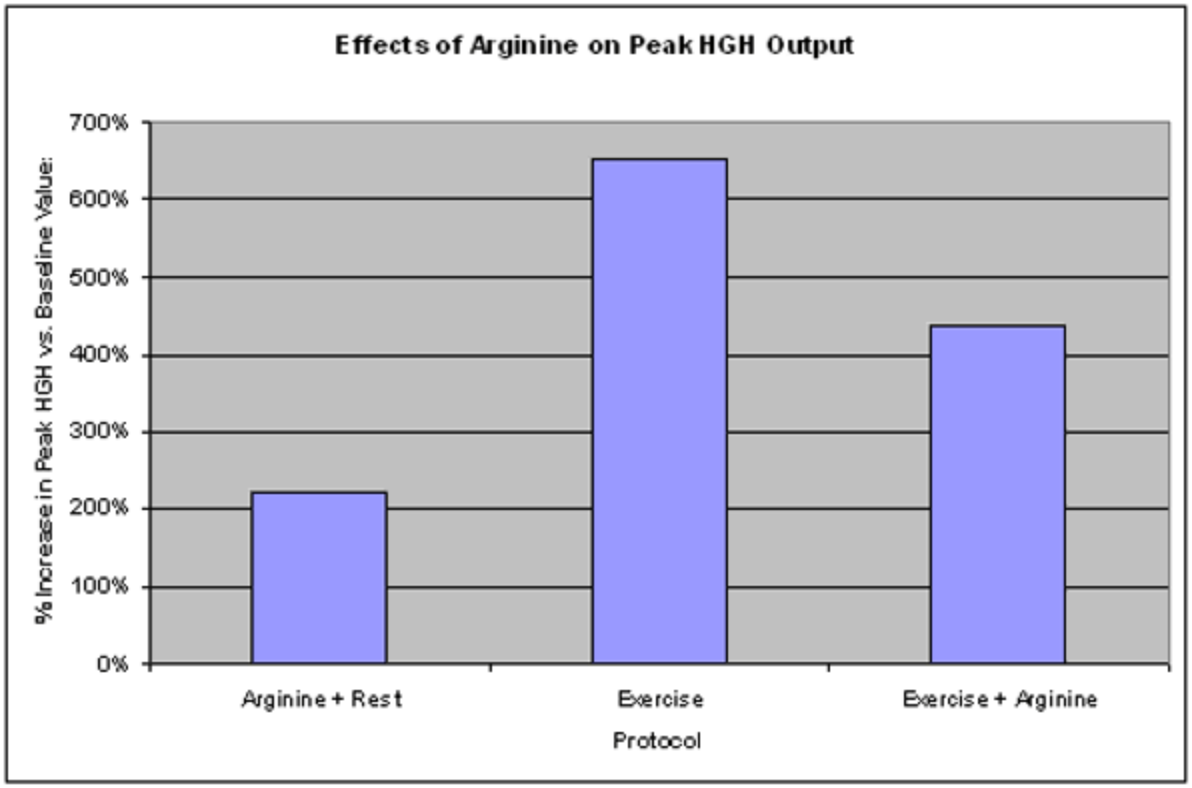

Figure 4 Percent increase in HGH levels vs. baseline after arginine consumption and exercise.[4] All of these increases were significantly greater than baseline measurements.

It should be noted that **some studies have failed to find any benefit of arginine on HGH levels**. This was seen in a study completed by Marcell et al. who gave ~ 4 grams of arginine to both young (mean age-22) and older (mean age- 68.5) participants[14]. In contrast to Collier et al.[13], Marcell et al.[14] failed to find any stimulatory effect for arginine on HGH levels in subjects at rest. Arginine also came up short with respect to enhancing exercising HGH levels. These results were observed in both the older and younger age groups. It should be mentioned that no placebo pill was given in this study. Rather, they just compared HGH levels during and following an exercise only session vs. arginine(4g) + exercise session.

Amino Acid Combinations

L-arginine & L-lysine

Suminski et al. gave 16 men (mean age- 22.4) 1.5 g lysine + 1.5 g arginine under both resting and exercising conditions[15]. At rest, HGH was significantly increased (270%) 60 minutes post ingestion, but no significant differences were found at 30 and 90 minutes. During exercise conditions, **no significant differences were seen between the amino acid and placebo treatments**.

L-arginine, L-ornithine & L-lysine

Fogelholm et al. completed an interesting study in which 11 trained weightlifters (19-35 years of age), took L-arginine, L-ornithine & L-lysine prior to a training session as well as just prior to going to bed[16]. 1 g of each amino acid was taken at both time periods for a total daily dose of 6 grams. After four days of this routine, the researches found that "*supplementation did not affect the physiological variation of serum hGH concentration*."[16]

L-arginine & Aspartate

Abel et al. randomly assigned 30 endurance trained athletes to either a placebo, high supplement (5.7 g arginine and 8.7 g aspartate), or low supplement (2.8 g arginine and 2.2 g aspartate) groups for a duration of 4 weeks[17]. At study's conclusion, **Abel et al. found no differences** in HGH levels between any of the groups.

What does this all mean?

When an effect is seen with amino acids on circulating HGH levels, it appears to occur only under resting, fasted conditions. The important question one has to ask themselves is, "**Do these small transient increases in HGH, induced by amino acids, have any significant effect on body composition or performance?**" Exercise induced HGH secretions were shown to have no effect on myofibrillar protein synthesis (MPS), muscle strength or size in the aforementioned study by West et al.[34]. This lack of effect on MPS occurred despite an 8 fold increase in peak HGH levels[4], which is greater than the peak increase seen with most of the amino acid supplements[18].

Before I go any further evaluating all of this research on amino acids and HGH, there is one **BIG** problem that needs to be mentioned. As pointed out by Chromiak and Antonio, HGH secretions are usually stimulated to a greater degree following an overnight fast[18]. Thus, if you're going to take these HGH secretagogues, one should probably do it on an empty stomach. In the above studies that showed a positive effect of GABA[11] and arginine[13] on HGH, **the amino acids were given following an overnight fast. In addition, individuals in the GABA and arginine trials waited > 90 minutes before having any food after the amino acid ingestion**. When putting this into practice, I feel that it would be very foolish for any exerciser/athlete to follow this type of a fast. After an overnight fast, catabolic forces are at full throttle in your body, destroying your hard earned skeletal muscle[20]. This metabolic state must be reversed and one of the best ways to accomplish this is by eating anabolic foods… one should not prolong it simply to get a little more benefit from an amino acid HGH secretagogue!

Don't get me wrong. **I'm not saying that taking supplements containing amino acids are bad**. In fact some studies have shown a beneficial effect of taking some of the above mentioned amino acids. Elam et al. found that taking 1 gram of both arginine and ornithine in conjunction with a 5 week resistance training program led to significantly greater gains in lean body mass and total strength vs. those taking a placebo[19]. However, I feel these gains are completely independent of HGH. As seen in the studies by West et al., HGH does not appear to increase MPS in young, healthy individuals.

What About taking These Amino Acids as You're Getting Older to Assist HGH?

If I wanted to play the devil's advocate, I could point out that all but 1[14] of the studies showing little to no effect were done on a younger population who normally have high HGH levels. However, research seems to indicate that with increasing age, one is less responsive to a given dose of various HGH secretagogues[21]. A dose of 1.5 g lysine + 1.5 g arginine has been shown to stimulate HGH in young adults (mean age 22.4)[15]. Yet, even when this dose is quadrupled (6 g of each amino acid), HGH levels fail to significantly rise in older adult men (mean age- 69)[22].

Bottom Line

There's strong evidence that exercise induced HGH secretions have no anabolic effect on the contractile fibers (myofibrillar proteins) of muscle tissue in **healthy (ie- not clinically deficient in HGH)** populations. With respect to the current scientific literature on fat loss, the jury is still out on if exercise inducing HGH workouts (aerobic) are more effective than non HGH inducing workouts (aerobic) when kcal expenditure is held constant. If you're going to do high rep, short rest intervals do it to train a certain metabolic system, not spike hormone levels.

Various studies provide evidence that amino acids can act as HGH secretagogues in resting individuals[11][12][13]. However, this finding is not universal amongst all studies[14]. Additionally, when taken prior to a training session, it appears that taking HGH secretagogues will have no effect or actually reduce the exercise induced levels of HGH.

Amino acids are great supplements to use in conjunction to an exercise program due to their ability to **directly stimulate protein synthesis**[23]. I use various amino acid supplements myself. However, the current scientific research just doesn't support their ergogenic effect via a HGH pathway/mechanism. Rather I think they work via a non-HGH pathway/mechanism to enhance muscle size/performance. For this reason, I feel they are wrongfully promoted as "HGH Secretagogues" since their beneficial effect on body composition/performance is likely through a non-HGH pathway.

And with that, Human Growth Hormone-Part I comes to an end, but **stay tuned for Part II of this story when we bring out the big boy… HGH injections!!!**

References

[1] Baum HB, Biller BM, Finkelstein JS, Cannistraro KB, Oppenhein DS, Schoenfeld DA, Michel TH, Wittink H, Klibanski A. Effects of physiologic growth hormone therapy on bone density and body composition in patients with adult-onset growth hormone deficiency. A randomized, placebo-controlled trial. Ann Intern Med. 1996 Dec 1;125(11):883-90.

[2] Kraemer WJ, Ratamess NA. Hormonal responses and adaptations to resistance exercise and training.Sports Med. 2005;35(4):339-61.

[3] West DW, Kujbida GW, Moore DR, Atherton P, Burd NA, Padzik JP, De Lisio M, Tang JE, Parise G, Rennie MJ, Baker SK, Phillips SM. Resistance exercise-induced increases in putative anabolic hormones do not enhance muscle protein synthesis or intracellular signaling in young men. J Physiol. 2009 Nov 1;587(Pt 21):5239-47.

[4] West DW, Burd NA, Tang JE, Moore DR, Staples AW, Holwerda AM, Baker SK, Phillips SM. Elevations in ostensibly anabolic hormones with resistance exercise enhance neither training-induced muscle hypertrophy nor strength of the elbow flexors. . J Appl Physiol. 2010 Jan;108(1):60-7. Epub 2009 Nov 12.

[5] Hartman JW, Tang JE, Wilkinson SB, Tarnopolsky MA, Lawrence RL, Fullerton AV, Phillips SM. Consumption of fat-free fluid milk after resistance exercise promotes greater lean mass accretion than does consumption of soy or carbohydrate in young, novice, male weightlifters. Am J Clin Nutr. 2007 Aug;86(2):373-81.

[6] Moller N, Jorgensen JO. Effects of growth hormone on glucose, lipid, and protein metabolism in human subjects. Endocr Rev. 2009 Apr;30(2):152-77. Epub 2009 Feb 24.

[7] Irving BA, Davis CK, Brock DW, Weltman JY, Swift D, Barrett EJ, Gaesser GA, Weltman A. Effect of exercise training intensity on abdominal visceral fat and body composition. Med Sci Sports Exerc. 2008 Nov;40(11):1863-72.

[8] Irving BA, Weltman JY, Patrie JT, Davis CK, Brock DW, Swift D, Barrett EJ, Gaesser GA, Weltman A. Effects of exercise training intensity on nocturnal growth hormone secretion in obese adults with the metabolic syndrome. J Clin Endocrinol Metab. 2009 Jun;94(6):1979-86. Epub 2009 Mar 24.

[9] Cavagnini F, Benetti G, Invitti C, Ramella G, Pinto M, Lazza M, Dubini A, Marelli A, Müller EE. Effect of gamma-aminobutyric acid on growth hormone and prolactin secretion in man: influence of pimozide and domperidone. J Clin Endocrinol Metab. 1980 Oct;51(4):789-92.

[10] SW Tech Staff. GABA. IronMagazine.com. 2003. Accessed February 20, 2010 from: http://www.ironmagazine.com/review20.html.

[11] Powers ME, Yarrow JF, McCoy SC, Borst SE. Growth hormone isoform responses to GABA ingestion at rest and after exercise. Med Sci Sports Exerc. 2008 Jan;40(1):104-10.

[12] Collier SR, Casey DP, Kanaley JA. Growth hormone responses to varying doses of oral arginine. Growth Horm IGF Res. 2005 Apr;15(2):136-9. Epub 2005 Jan 26.

[13] Collier S, Collins E, Kanaley JA. Oral arginine attenuates the growth hormone response to resistance exercise. J Appl Physiol 2006; 101:848–852.

[14] Marcell TJ, Taaffe DR, Hawkins SA, Tarpenning KM, Pyka G, Kohlmeier L, Wiswell RA, Marcus R. Oral arginine does not stimulate basal or augment exercise-induced GH secretion in either young or old adults. J Gerontol A Biol Sci Med Sci. 1999 Aug;54(8):M395-9.

[15] Suminski RR, Robertson RJ, Goss FL, Arslanian S, Kang J, DaSilva S, Utter AC, Metz KF. Acute effect of amino acid ingestion and resistance exercise on plasma growth hormone concentration in young men. Int J Sport Nutr. 1997 Mar;7(1):48-60.

[16] Fogelholm GM, Näveri HK, Kiilavuori KT, Härkönen MH. Low-dose amino acid supplementation: no effects on serum human growth hormone and insulin in male weightlifters. Int J Sport Nutr. 1993 Sep;3(3):290-7.

[17] Abel T, Knechtle B, Perret C, Eser P, von Arx P, Knecht H. Influence of chronic supplementation of arginine aspartate in endurance athletes on performance and substrate metabolism – a randomized, double-blind, placebo-controlled study. Int J Sports Med. 2005 Jun;26(5):344-9.

[18] Chromiak JA, Antonio J. Use of amino acids as growth hormone-releasing agents by athletes. Nutrition. 2002 Jul-Aug;18(7-8):657-61.

[19] Elam RP, Hardin DH, Sutton RA, Hagen L. Effects of arginine and ornithine on strength, lean body mass and urinary hydroxyproline in adult males. J Sports Med Phys Fitness. 1989;29(1):52-6.

[20] Meek SE, Persson M, Ford GC, Nair KS. Differential regulation of amino acid exchange and protein dynamics across splanchnic and skeletal muscle beds by insulin in healthy human subjects. Diabetes. 1998 Dec;47(12):1824-35.

[21] Tanaka, KS, Inoue J, Shiraki J, et al. Age-related decreases in plasma growth hormone: response to growth hormone-releasing hormone, arginine, and L-dopa in obesity. Metabolism 1991;40:1257.

[22] Corpas E, Blackman MR, Roberson R, Schofield D, Harman SM. Oral argininelysine does not increase growth hormone or insulin-like growth factor-I in old men. J Gerontol 1993;48:M128.

[23] Drummond MJ, Rasmussen BB. Leucine-enriched nutrients and the regulation of mammalian target of rapamycin signaling and human skeletal muscle protein synthesis. Curr Opin Clin Nutr Metab Care. 2008 May;11(3):222-6.

Cover Photo for ebook taken by Zaldylmg and obtained on 9-11-2010 from:
http://www.flickr.com/photos/8499561@N02/2756332192/

Growth Hormone- Part II: Does it enhance physical performance?

Quick Hit Summary

HGH injections are a hot topic in both the athletic and anti-aging communities. However, there is little scientific evidence to support the notion that HGH alone will provide much benefit for either group. Currently there is no evidence that HGH alone will increase strength, vertical jump, or aerobic capacity (VO2) in trained or untrained athletes. However, it does appear to increase anaerobic capacity in recreational strength athletes. These effects appear to be amplified when co-administered with testosterone. A similar lack of effect with HGH alone has been seen in older individuals. HGH does appear to have a strong anabolic effect on collagen, the main protein in connective tissue (tendons, cartilage, ligaments). Increased fat loss has also been observed in those receiving HGH. Adverse affects were reported in all the studies that examined HGH administration. Most common side effects were joint pain, edema, and carpel tunnel.

HGH Injections

In the first part of this ebook, we observed a lack of evidence supporting the use of popular amino acids purported to stimulate HGH secretion. Furthermore, it was noted that exercise induced HGH secretions failed to enhance myofibrillar protein synthesis (**MPS**) (the proteins which are responsible for generating force in the muscle during muscular contraction), muscle strength, and/or muscle size. I know what you're thinking right now… The studies reviewed in Part I examined the effects of *exercise induced* or HGH secretagogues on increases in HGH. Individuals who take *HGH injections* to increase muscle size and strength often take supraphysiological doses far larger than those induced by these methods. Furthermore, HGH injections clearly benefit individuals clinically deficient in the hormone[1] So, the question still exists, "Do HGH injections benefit physical performance"?

Growth Hormone Secretion Rate Per 24 hours:

Prepubertal boys: ~ 30 micrograms/kg/24 hours
Late Puberty: ~ 60 micrograms/kg/24 hours
Young Adults: ~ 20 micrograms/kg/24 hours in young adults

Source[18]

The Effects of Human Growth Hormone Injections on Muscle Hypertrophy and Strength

Untrained Individuals

Conversion Chart:

1000µg HGH = 1 mg rHGH = 3 IU HGH

Source[17]

Yarasheski et al. studied the effects of HGH injections on changes in strength and body composition amongst 16 previously untrained men (mean age- 27 years) following a 12 week resistance training program[2]. Each participant was randomly assigned to either a placebo or the experimental group which received 40 µg rHGH/kg/day. For reference, this would be 8.4 IU/day for a 154 lb (70kg) individual. Prior to initiating the 12 week training program, no significant differences were present between groups with respect to body composition (total body weight, fat mass, fat free mass). At study's end, it was found that **HGH injections did not significantly increase muscle strength gains (9 common exercises tested including shoulder, bench and leg presses) or size** between the 2 groups. This happened despite significantly increasing circulating HGH (6x) and IGF-1 (4x) levels vs. placebo treatment (**See below for explanation of IGF-1**).

Both groups experienced similar gains in total body weight[2]. Although not quite statistically significant (p= 0.056) the HGH group tended to experience losses in fat mass. Those receiving HGH did experience significantly greater gains in fat free mass (which includes lean muscle tissue, connective tissue, body fluid, etc) vs. placebo. However, as pointed out by Yarasheski et al., no significant differences in muscle protein synthesis were found between groups. Furthermore, greater water retention was found in those given HGH. Thus, the research team concluded that chronic HGH injections do not augment muscle gains commonly observed following a 12 week resistance training program. Finally, it should be noted that the study originally included 18 individuals. However, 2 of the individuals receiving HGH had to drop out due to symptoms of carpel tunnel.

Insulin-like growth factor (IGF-1) is another hormone produced by the body that has anabolic effects on muscle tissue[3]. As seen in **Figure 1 (page 18)**, HGH stimulates the release of IGF-1, which is then believed to stimulate growth of muscle tissue. Few published studies have examined the effects of administering only IGF-1 on muscle growth. A study completed by Friedlander et al. indicated that receiving IGF-1 had no benefit on body composition or muscle strength in postmenopausal women[4].

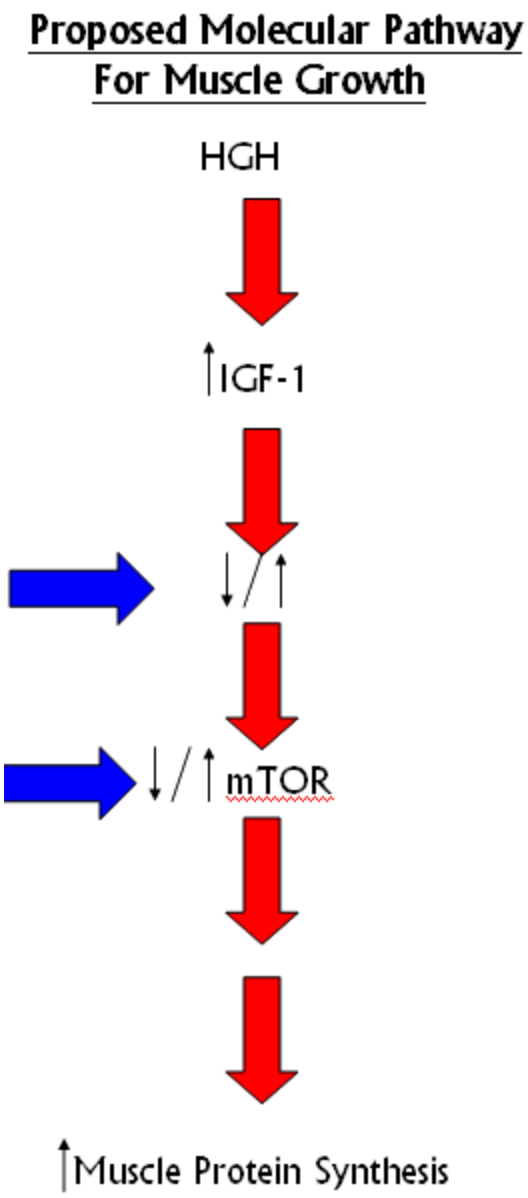

Figure 1. The hypothesized hormone pathway leading to increased muscle protein synthesis. Please note that this is an EXTREMELY over-simplified look at the process. Note the blue arrows coming in from the side. These represent other factors that are capable of increasing or decreasing the activity of this pathway.

Similar to HGH, current literature does not support the use of exogenous (of external origin) IGF-1 in already healthy individuals[3]. A more in-depth look at IGF-1 is beyond the scope of this article.

Trained Individuals

Deyssig et al. studied the effects of HGH injections in 18 male, lean, power trained athletes (mean age-23.4; 10% body fat)[6]. Over the course of a 6 week period, individuals received a placebo or 30 µg rHGH/kg/day. Despite significantly increasing circulating HGH and IGF-1 levels over this time period, HGH injections did not significantly alter gains in muscle strength, total body weight and fat mass. With respect to adverse effects, a case of carpel tunnel like symptoms developed in one participant using HGH. In closing, Deyssig et al. stated.

> "We conclude that the anabolic, lipolytic effect of GH therapy in adults depends on the degree of fat mass and GH deficiency. In highly trained power athletes with low fat mass there were no effects of GH treatment on strength and body composition"[6]

HGH + Testosterone

Recently, Meinhardt et al. studied the effects of giving HGH, testosterone or the combination of the two on multiple measures of athletic performance and body composition[16]. Over the course of 8 weeks, 96 recreational athletes (>12 months of resistance training experience; mean age – 27.9 years) were assigned to the following groups:

Men (66 athletes)

- Testosterone (250 mg/wk)
- HGH (2 mg/day = ~30 µg/kg/d for a 70-kg person)
- Testosterone (250 mg/wk) + HGH (2 mg/day)
- Placebo

Women (33 athletes):

- HGH (2 mg/day)
- Placebo

Along with body composition, the researchers wanted to examine the effects of this supplementation protocol on VO2, vertical jump, anaerobic capacity (Wingate bike test), and isometric dead lift strength test (bar position not mentioned)[16]. **At the end of the 8 weeks, all performance variables were the same between groups except the Wingate test**. Compared to those taking the placebo, Men and women who received HGH experienced a 3.9% increase in anaerobic capacity. This increase in performance jumped to 8.3% in men who received both

HGH and testosterone. With respect to body composition, HGH decreased fat mass and increased water retention. **Body cell mass**, an indicator of muscle tissue, was assessed pre and post trial in all groups. Those taking HGH alone did not experience any gains in body cell mass. Although not statistically significant (p=0.06), those receiving testosterone tended to increase body cell mass by 3.1% (vs. placebo). However **a synergistic effect was found between testosterone + HGH; individuals taking both substances significantly increased their body cell mass by 5.8% (vs. placebo)**.

Six weeks after the final round of injections, Meinhardt et al. reassessed all performance variables to see if there would be any lasting effect. During this 2nd round of testing, all performance measurements were the same, regardless of if you received the placebo or HGH/testosterone treatment. As with the aforementioned studies, swelling and joint pain were common side effects in those receiving HGH.

Meta-Analysis

In a large meta-analysis, Liu et al reviewed all evidence to date (2008) that examined the effects of HGH injections on athletic performance or body composition changes in active, physically fit populations[7]. When combining the results of all 27 studies reviewed, it was found that lean body mass increased and there was a tendency for body fat to decrease. However, **performance measurements such as muscular strength and aerobic capacity (VO2max) were not altered**. Similar to Yarasheski et al[2], Liu et al concluded that **gains in lean body mass could be attributed to fluid retention** rather than increases in contractile muscle proteins[7]. For reference, the 27 studies included 440 participants with the following characteristics: lean (BMI-24), young (mean age- 27 years), physically fit and received a mean dose of 36 µg HGH/kg/day.

Does HGH Affect Protein Synthesis at All?

The question as to if HGH injections have anabolic effects in non-clinical populations may have finally been put to rest by Doessing et al[8]. In their study, 10 healthy, untrained men (mean age- 30 years) received HGH shots for 14 consecutive days (33 µg rHGH/kg/days 1-7; 50 µg rHGH/kg/days 8-14) after which they completed unilateral (single leg) leg extensions. 5 months later, the process was repeated except those who received HGH previously now received a placebo. Despite increasing circulating HGH levels by ~850% and insulin like growth factor (IGF-1) by ~320%, the rate of MPS was not significantly altered while receiving HGH injections vs. placebo treatment. Although MPS did not increase, HGH injections did increase collagen protein syntheses. For those unfamiliar with **collagen**, this protein serves as "guy wires" in the connective tissue of the musculoskeletal system. It's found in tendons, bone, ligaments, muscles and cartilage. In contrast to myofibrillar proteins, collagen does not have any contractile properties. Rather it provides structural/connective support. In this study, the **HGH injections increased collagen synthesis 1.3-fold in tendon tissue and 6-fold in muscle tissue**. This led the authors of the study to conclude that:

> "… rather than causing muscle fibre growth, GH/IGF-I appear to stimulate the supporting connective tissue that would help force transmission from the contracting muscle fibres to the bone."[8]

Simply put, HGH does not appear to *directly* increase the size or strength of muscle tissue. It may *indirectly* increase muscular force capabilities (via strengthening support tissue), but to my knowledge, this has yet to be shown in exercise based research.

What About HGH Injections for Acting as "The Fountain of Youth"?

Does HGH stem off the physical decline seen with normal, healthy aging? That appears to be the popular question amongst the aging baby boomer population. Many anecdotal stories indicate that HGH can greatly enhance personal well-being and physical function as you age. Current scientific research to support these anecdotal stories is inconclusive and highly debated. In a recent review of the literature (completed in 2007), Liu et al. examined the effects of HGH injections in elderly individuals without any known health problems (ie- free of cancer, heart disease, diabetes, osteoporosis, etc)[9]. Their meta-analysis included results of 21 studies, consisting of 220 older, overweight individuals (mean age- 69 years; 33% women; BMI-28). Although great variation existed, the mean duration of each study was 27 weeks and average starting dose was 14 µg rHGH/kg/days. On one hand, results indicated that **receiving HGH injections (vs. placebo treatment) ≥ 26 significantly increased lean body mass (3.6 lbs; attributed to gains in water vs. actual muscle tissue) and decreased fat mass (5.1 lbs)**. On the other hand, those treated with HGH experienced significantly more "adverse events" such as carpel tunnel, edema, and arthralgias (joint pain). No significant differences were seen in bone density or blood lipid levels between groups.

Unfortunately, as noted be Liu et al., there was not enough information presented on physical function variables (ie- grip strength, 30 second sit-to-stand muscular endurance test, etc) and well-being measurements (mood profile, etc) to statistically analyze all of the purported benefits associated with HGH. However, in the small number of studies that did examine performance gains, **HGH + exercise did not appear to increase muscular strength in trained[10] or untrained[11][12] older individuals vs. exercise alone**. Thus, looking only at the scientific data available to them, they concluded.

> "Although GH has been widely publicized as an antiaging therapy and initial studies suggested that it might be clinically beneficial and safe in the healthy elderly, we find little evidence to support these claims. The scant clinical experience of GH in the healthy elderly suggests that although GH may minimally alter body composition, it does not improve other clinically relevant outcomes. Substantial evidence suggests that GH use in the healthy elderly is associated with high rates of adverse events. On the basis of available evidence, GH cannot be recommended for use among the healthy elderly."[9]

HGH + Testosterone

Although HGH alone does not appear beneficial, Sattler et al. demonstrated that **HGH + testosterone** was more beneficial than testosterone alone[13]. Their study involved 122 older, slightly overweight, men (mean age- 70.8 years; BMI- 27.4) with testosterone and IGF-1 levels "typical" for their age group. Over the course of 4 months, individuals were randomly assigned to receive various low dose testosterone and /or HGH combinations (Please see **Table 1, page 22**).

Table 1 Daily testosterone and HGH doses. Doses were chosen to reflect normal physiological level of these hormones vs. supra-physiological levels seen in other studies.

Group	Testosterone Dose	HGH Dose
Group A	5 mg/d (5g of a 1% testosterone transdermal Gel)	0 µg rHGH/kg/day (placebo)
Group B	5 mg/d	3 µg rHGH/kg/day
Group C	5 mg/d	5 µg rHGH/kg/day
Group D	10 mg/d (5g of a 1% testosterone transdermal Gel)	0 µg rHGH/kg/day (placebo)
Group E	10 mg/d	3 µg rHGH/kg/day
Group F	10 mg/d	5 µg rHGH/kg/day

After 4 months, it was found that increasingly greater hormone doses enhanced changes in body composition this seemed to be augmented with testosterone co-administration[13]. **Individuals who received HGH + testosterone experienced significant increases in total body strength** (based off composite scores obtained on leg press, leg flexion/extension, lat pulls & chest press) . With respect to cardiometabolic risk factors, insulin resistance, total and LDL cholesterol remained unchanged during the 4 month trial. Additionally, HDL cholesterol increased whereas triglyceride levels decreased. Outside of a small increase in fasting blood glucose, the only significant cardiometabolic risk factor negatively affected was blood pressure (systolic and diastolic blood pressure increased by 12 mmHG and 8mmHG).

Other Possible Benefits of HGH

From an orthopedic standpoint, HGH injections may be useful to those who have muscle-tendon, ligament, bone fractures or cartilage injuries. As seen in the study by Doessing et al., HGH does significantly increase collagen protein synthesis[5]. Studies completed by Raschke et al.[14] and Van der Lely et al.[15] provide some support to this possible use for HGH injections. However, more research is needed in this area before a definitive conclusion can be drawn.

Bottom Line

Strong evidence exists indicating that HGH administration does not increase muscle strength or size in healthy populations. Rather, it appears to increase collagen (the main protein in connective tissue such as bones, tendons, ligament, and cartilage) and may be useful to those coming off injuries.

HGH injections have been shown to significantly decrease fat mass and increase lean body mass. However, improvements in lean body tissue are likely the result of increased water retention and non contractile tissues vs. actual gains in muscle mass.

Current, peer reviewed, scientific research does not support the "anti-aging" use of HGH in older populations. Although positive changes in body composition are observed, these benefits do not appear to increase strength or aerobic capacity. Resistance training has been shown to be just as effective as HGH + resistance training protocols with respect to increasing strength. Finally, HGH does not appear beneficial when taken alone. On the other hand, one recent study indicated HGH + testosterone does increase lean body mass and increase total body strength. Long term studies must still be carried out to further define potential quality of life/health benefits HGH + testosterone combinations may have in older adults.

References

[1] Rennie MJ. Claims for the anabolic effects of growth hormone: a case of the emperor's new clothes? Br J Sports Med. 2003 Apr;37(2):100-5.

[2] Yarasheski KE, Campbell JA, Smith K, et al. Effect of growth hormone and resistance exercise on muscle growth in young men. Am J Physiol 1992;262:E261–7.

[3] Velloso CP.Regulation of muscle mass by growth hormone and IGF-I. Br J Pharmacol. 2008 Jun;154(3):557-68.

[4] Friedlander AL, Butterfield GE, Moynihan S, Grillo J, Pollack M, Holloway L, et al. One year of insulin-like growth factor I treatment does not affect bone density, body composition, or psychological measures in postmenopausal women. J Clin Endocrinol Metab. 2001;86:1496–1503.

[5] Jacquemin V, Butler-Browne GS, Furling D, Mouly V. IL-13 mediates the recruitment of reserve cells for fusion during IGF-1-induced hypertrophy of human myotubes. J Cell Sci. 2007;120:670–681.

[6] Deyssig R, Frisch H, Blum WF, et al. Effect of growth hormone treatment on hormonal parameters, body composition and strength in athletes. Acta Endocrinol (Copenh) 1993;128:313–18.

[7] Liu H, Bravata DM, Olkin I, Friedlander A, Liu V, Roberts B, Bendavid E, Saynina O, Salpeter SR, Garber AM, Hoffman AR. Systematic review: the effects of growth hormone on athletic performance. Ann Intern Med. 2008 May 20;148(10):747-58. Epub 2008 Mar 17.

[8] Doessing S, Heinemeier KM, Holm L, Mackey AL, Schjerling P, Rennie MJ, Smith K, Reitelseder S, Kappelgaard AM, Rasmussen MH, Flyvbjerg A & Kjaer M (2010). Growth hormone stimulates the collagen synthesis in human tendon and skeletal muscle without affecting myofibrillar protein synthesis. J Physiol 588, 341–351.

[9] Liu H, Bravata DM, Olkin I, Nayak S, Roberts B, Garber AM, Hoffman AR. Systematic review: the safety and efficacy of growth hormone in the healthy elderly. Ann Intern Med. 2007 Jan 16;146(2):104-15.

[10] Taaffe DR, Pruitt L, Reim J, Hintz RL, Butterfield G, Hoffman AR, Marcus R. Effect of recombinant human growth hormone on the muscle strength response to resistance exercise in elderly men. J Clin Endocrinol Metab. 1994 Nov;79(5):1361-6.

[11] Yarasheski KE, Zachwieja JJ, Campbell JA, Bier DM. Effect of growth hormone and resistance exercise on muscle growth and strength in older men. Am J Physiol. 1995 Feb;268(2 Pt 1):E268-76.

[12] Hennessey JV, Chromiak JA, DellaVentura S, Reinert SE, Puhl J, Kiel DP, et al. Growth hormone administration and exercise effects on muscle fiber type and diameter in moderately frail older people. J Am Geriatr Soc. 2001;49:852–858.

[13] Sattler FR, Castaneda-Sceppa C, Binder EF, Schroeder ET, Wang Y, Bhasin S, Kawakubo M, Stewart Y, Yarasheski KE, Ulloor J, Colletti P, Roubenoff R, Azen SP. Testosterone and growth hormone improve body composition and muscle performance in older men. J Clin Endocrinol Metab. 2009 Jun;94(6):1991-2001. Epub 2009 Mar 17.

[14] Raschke M, Rasmussen MH, Govender S, Segal D, Suntum M & Christiansen JS (2007). Effects of growth hormone in patients with tibial fracture: a randomised, double-blind, placebo-controlled clinical trial. Eur J Endocrinol 156, 341–351.

[15] Van der Lely AJ, Lamberts SW, Jauch KW, Swierstra BA, Hertlein H, Danielle De Vries D, Birkett MA, Bates PC, Blum WF, Attanasio AF. Use of human GH in elderly patients with accidental hip fracture. Eur J Endocrinol. 2000 Nov;143(5):585-92.

[16] Meinhardt U, Nelson AE, Hansen JL, Birzniece V, Clifford D, Leung KC, Graham K, Ho KK. The effects of growth hormone on body composition and physical performance in recreational athletes: a randomized trial. Ann Intern Med. 2010 May 4;152(9):568-77.

[17] MARTINDALE - The Complete Drug Reference. Growth Hormone. Copyright 2009 Pharmaceutical Press.

[18] Email from Dr. Ross Hauser who obtained information from: Textbook of Endocrinology volume 1, third edition edited by Leslie J. Degroot, publisher W. B. Saunders Company Philadelphia, 1995, page 306 and 307

Cover Photo for ebook taken by Zaldylmg and obtained on 9-11-2010 from: http://www.flickr.com/photos/8499561@N02/2756332192/

Testimonial Support for Sean Casey

From his peers…

"Not only is Sean a great nutritionist, but he's an excellent strength coach. I've coached athletes with him on multiple occasions. The most impressive attributes I've seen in him is his integrity, work ethic, ability to work with athletes and desire to be the best coach possible."

- *Luke Richesson. Head NFL Strength Coach for Jacksonville Jaguars.*

"Sean Casey is one of the great up and coming minds in the human performance field. Between his diverse academic background, training experiences and thirst for knowledge, Sean elevates himself above the pack. His writings are extremely well researched yet easy to understand; a great resource for both the competitive and recreational athlete."

- *Dr. Jamie Cooper, PhD, Assistant Professor and Instructor for graduate courses in Nutrition, Exercise, and Sport at Texas Tech University. Marathon and Triathlon Competitor.*

"Whenever I need to bounce nutrition/supplement ideas off someone, I always turn to Sean Casey. I know that anything Sean tells me is backed by multiple scientific studies. It's a true pleasure working with him."

- *Anita Nall-Richesson. Director of Nutrition - Jacksonville Jaguars. 3 time Olympic Medalist. Former world record holder in 200 Breaststroke. Creator of PhenomaNALL Nutrition.*

"Sean was a positive influence on our student-athletes and the Strength and Conditioning Department at UW-Madison. He is a bright, innovative thinker and always looking for ways to improve the performance of the clients he works with, regardless of their starting skill level."

- *Scott Hettenbach. MS- Exercise Science & Sport Administration, Assistant Director of Strength and Conditioning at University of Wisconsin- Madison. Head Strength Coach for Badger Men's Basketball team.*

"This web site was created by Sean Casey, an individual who has dedicated himself to improving your knowledge of exercise science. His commitment to offering up-to-date information to his clients and non clients alike comes as no surprise to me. Having known Sean for over ten years, I can vouch for his personal character and work ethic in everything he does. As you begin to read his articles on nutrition and training you will find a well thought out, research based analysis of each topic. His opinions are supported by scientific research, not anecdotal evidence. I recommend his articles to any individual wanting to learn about the science of exercise for the first time or someone trying to update their knowledge."

- *Chris Rotzenberg, MS Human Performance, Collegiate Cross Country/Track and Field Coach*

From his clients…

"I had the fortunate opportunity to work with Sean Casey at the Athlete's Performance Institute. While coaching, Sean demonstrated a strong work ethic and a desire for perfection. Sean's knowledge of multiple training methods helped prepare me for that season. His greatest concern was making his athletes better each day. Sean Casey is a rising star in the fitness industry."

- *Brady Quinn. NFL Quarterback - Denver Broncos.*

"A few years ago I contacted the University of Wisconsin-Madison for nutrition and weight loss info for both myself and the high school wrestling team that I coach. I was informed that Sean Casey was the guy I wanted and I quickly saw why... Sean explained to us how the food we ate affected our performance on the wrestling mat. With Sean's help, my wrestling team and I stopped dwelling over weight loss and began to concentrate on how to properly fuel our systems. The emphasis of Sean's dietary program was not centered around food restriction; rather it was focused on incorporating healthier food choices to help us attain our specific weights. Additionally, he taught us how to read food labels when evaluating our food options.

Throughout my lifetime, I have tried many different ways to lose weight and have always failed. To date, I am please to say that I personally have lost weight and our wrestlers have much less to worry about during the season. I truly doubt that we would have learned everything we did and feel so good about reaching our goals without Sean's help. Sean is the utmost professional with a great understanding of his clients needs. I am thrilled to be able to say that I worked with him."

Sincerely yours,

Matthew Poster. High School Wrestling Coach. Owner / Lead Motivator of Get Fit Staying Fit

---

"I first knew Sean Casey from the excellent articles he posted on the internet. He clearly knew what he was talking about, both with regard to training and to nutrition. His research was always sound and the fact that he always quoted his sources, further increased my esteem. When I needed advice on my nutrition, Sean was the obvious choice. Still, I had some doubts if even he could help me. I am a middle-aged, competing weightlifter from Europe, who suffers from a digestive disorder; Not exactly your typical college aged athlete."

"Sean exceeded my expectations. He studied my training schedule, food intake, medications and came up with a dietary program that exactly fitted my needs. He taught me the principles of what to eat and when; my meals now fuel my workouts and my supplements no longer conflict with my medications. To make things easier, Sean even took the trouble to convert everything to metrics for me. Since I've started to work with Sean, I am fitter and stronger than I ever was and haven't gained any weight despite eating more food."

"I am very lucky to have worked with Sean. If you're serious about your performance, I can recommend no one better."

- Alexandra Faber. 2011 World Masters Level Olympic Weightlifter.