

The Science of Size

By James Krieger, MS

Usually, big, full muscles and a symmetrically built body are the last reasons an athlete turns to weights; those goals are left for the bodybuilders. How big a muscle *looks* is irrelevant to an athlete's performance, but how big a muscle *is* isn't irrelevant to an athlete's performance. From a physiological perspective, a muscle's size is related to its strength and power abilities, albeit size is only one of many variables. So to maximize your athletic potential you do, indeed, have to consider building muscle size. The problem, however, is how to do that. Obviously you can't go by what you hear in the gym or by purely opinion-based articles, so I set out to review the scientific data on how a human's physiology builds muscle from lifting weights. So get ready to get huge.



**Design your training
program to add
maximum mass**



MUSCLE GROWTH 101

You go into the gym, and you start pumping iron. The increased tension on your muscles from the weights sends a signal to the muscle that it needs to start building new protein. Once you leave the gym, your muscles go quickly to work. Within four hours, your muscles are already starting to build new protein,²⁴ both to increase their size and to repair any damage from training.

Now, your muscles also have some help. You've got two potent anabolic (tissue-building) hormones in your blood. These are growth hormone (gH) and testosterone. These two hormones can bind to receptors in your muscle tissue, further stimulating them to build new protein. In fact, testosterone is the main reason why men have larger muscles than women, since they have about 10 times more of it.¹⁷ Now, gH can cause growth of all sorts of tissues, not just muscle. When it comes to muscle, however, gH can stimulate your muscle cells to produce insulin-like growth factor-I (IGF-I),⁴ an important hormone secreted by your muscle cells that stimulates them to grow.

So why am I talking about hormones? Because a lot of athletes, coaches, and even scientists believe that the way you lift weights can affect how much of these hormones you produce. The next logical conclusion would obviously be to train in a manner that produces the most hormones, resulting in bigger muscles. But it's not quite that simple, as you'll see.

HORMONES OF HUGENESS?

Researchers have found that gH and testosterone will increase during the hour after a weight training session,¹⁹ indicating that there *may* be a link between this hormone surge and muscle growth. However, since this hormone surge lasts less than an hour and since your muscles continue to build new protein for up to 36 hours after training,²⁴ there may *not* be a link. And here's where it gets complicated and interesting.

Let's assume that this brief hormone surge starts your muscles growing. Scientists at the University of Southern Denmark, put 16 untrained males on a 9-week training program to determine if there was a relationship between increased post-workout hormones and strength.¹³ They found that the group that trained both large muscle groups (legs) and small muscle groups (arms) had higher post-exercise hormone levels than the group that trained only arms. The subjects that trained both sets of extremities also had greater increases in



isometric or static strength. Not only that, but their untrained arm got stronger, which didn't happen in the arms-only group.

These results, however, don't necessarily mean that there's a link between the post-exercise hormonal response and changes in muscle strength. While the group that trained both arms and legs had greater increases in isometric strength, they also started out weaker, so you might expect them to have greater increases regardless of whether they had a greater hormone response. Also, 1-rep max curl strength and isokinetic strength (when the joint moves at a constant speed) improved by the same amount in both groups. Finally, the researchers only measured changes in muscle strength, not size, so some of the strength changes might be neurological in nature.

In a different study, researchers put 12 college-aged men on a 12-week, high-volume weight training program.²⁶ Subjects who had larger increases in gH after a workout tended to have larger increases in muscle fiber size. Also, elderly men have lower hormonal responses to exercise than young men^{12, 20} and show smaller changes in muscle size.²⁰ Nevertheless, not all evidence points to a link between the post-workout hormone response and changes in muscle size.²³

SEEKING THE SURGE

Yes, gH and testosterone are tissue-building hormones. But research doesn't entirely support the notion that higher hormone levels in and of themselves will cause your muscles to grow more. However, you can still arrange your training to take advantage of any *possible* growth. [I

If you want to get the best gH response from your training, you should look at sets of 10 to 15 reps with short rests of 1 to 2 minutes between sets.^{16, 19, 22, 39} This type of training also creates more acidic conditions and other fatigue by-products in your muscles, all associated with muscle growth.³⁶ Focus on exercises that work large muscle groups and include many muscle groups (e.g., squats) as opposed to small muscle groups and "isolation" exercises (e.g., leg extensions).¹³ Also, forced reps may increase the gH response to exercise,¹ so include them occasionally. The reason you don't want to do them all the time is that they increase your cortisol levels, and since that hormone breaks down muscle tissue and increases recovery time, too frequent forced reps can be detrimental to your goals.¹

While we know how to get the best gH response to training, it's not really clear how to get the best testosterone response to weight training. One study suggested that heavier weights (3-rep max to 6-rep max) produce a better testosterone response than 70% of the same weight for the same



number of reps.³² However, most studies show no difference in the testosterone response with training schemes ranging from sets of 4 with 90% 1-rep max to sets of 15 with 60% 1-rep max.^{16, 19, 22, 37} One study showed no testosterone response to exercise, regardless of whether sets of 5, 10, or 15 were performed.³⁹

CYCLING SUCCESS

Now you know how to get a gH surge from training, while it appears that testosterone will respond as long as you hit the gym and work hard. But does this mean you should always train with sets of 10 to 15 and short rest periods? No. First, training this way frequently might lead to overtraining because high volume coupled with short rest periods can cause greater anxiety and fatigue than other types of training⁴¹ and this isn't easy to recover from.²⁸ Second, training consistently with short rests can compromise the amount of weight that you can use and thereby decrease strength gains.³⁵ Decreasing the amount of weight you use may also decrease muscle fiber recruitment,²⁵ which can be counterproductive because if you want to be as big as possible, you



need to make sure all your fibers are working hard.

So how do you get the best of all possible worlds? Through cycling. Cycle your training between stints of moderate-to-high volume and moderate intensity (sets of 10- to 15-rep max with 1 to 2 minutes' rest) and stints of moderate volume and higher intensity (sets of 5- to 8-rep max with 2 to 3 minutes' rest). This way, you can get the gH-stimulating advantages that moderate weights and short rests provide, plus the fiber recruitment and strength-building advantages that heavier weights and longer rest periods provide. Here's some research support: Tennis players who cycled their training between 4- to 6-rep max, 8- to 10-rep max, and 12- to 15-rep max gained more lean body mass than players who trained consistently at 8- to 10-rep max for 9 months.²¹ What's also critical to your athletic success is that cycling results in better strength gains than noncycled training,³³ and there's a strong relationship between strength and size.³

Another approach would be to mix different training intensities within the same workout. In

fact, doing a single set at a low-to-moderate intensity (around 50% 1-rep max) after multiple sets of high intensity (around 90% 1-rep max) can increase the gH response over doing high-intensity alone.¹⁰ The key is not to let your intensity get too high and your volume (total repetitions, or sets x reps) too low. In one study, when subjects' training volume decreased to 3 x 3 (only 9 total reps) in core exercises and 3 x 6 (only 18 total reps) in assistance exercises, the subjects stopped gaining lean muscle.³ Even when a single set of 10 reps in the core exercises was added, it didn't help. In another study, subjects who did 5 sets at 90% 1-rep max for 8 weeks gained less muscle size than

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subjects who did 9 sets at 40 to 80% 1-rep max.⁶ So, when training for size, don't let your intensity get above 85 to 90% 1-rep max, or 4- to 5-rep max, too often.

FREQUENCY FOR MASS

A common trend among a lot of mass-seeking athletes is to train each muscle group once per week, with a lot of sets. However, this may not be the best approach. Here's why: protein synthesis in muscle is increased within four hours after training and returns to normal after about 36 hours.²⁴ This means that your muscles are building new tissue within hours after training and are done within a couple of days. Waiting a whole week to train them again doesn't make sense.

In one study, recreational lifters were assigned to one of two groups.²⁷ One group did 3 sets to failure per exercise once per week; the other group did 1 set to failure per exercise three times per week. Thus, both groups did the exact same

program and number of sets per week. The group that trained three times per week had larger increases in strength and muscle size than the group that trained once per week.

Matthew Rhea, a PhD student at Arizona State University and his colleagues have also published research indicating that frequent training may be the most useful. They did a meta-analysis (a "study of studies") of 140 weight training studies, combining all the data to get an idea of what the best training frequency is.³⁴ They found that three times per week was best for people with less than a year of training experience and twice per week was best for experienced subjects. While they only looked at strength and not muscle size, there's a relationship between the two, and given the other evidence in favor of frequent training, there seems little doubt that training each muscle two or three times per week is the best way to add maximum mass.

SET SCIENCE

So you know the weights, the rest intervals, and the frequency...what about the number of sets? Well, performing multiple sets per muscle group results in greater gH and testosterone responses than single sets.^{7, 11, 29} However, there's a point of diminishing returns. One study found 4 sets per muscle group created a greater gH response than 2 sets, but 6 sets didn't produce a larger response



SCIENCE LINGO

- "Rep max" stands for repetition maximum. A 5-rep max weight is a weight you can do for 5 reps but not 6.
- Depending upon your training experience and the muscle group, 10- to 15-rep max translates to 50 to 80% 1-rep max.¹⁵ And 5- to 8-rep max translates to 80% to 90% 1-rep max.

than 4 sets.³⁹ These data tie in nicely with the meta-analysis by Rhea and his colleagues.³⁴ They found that 4 sets produced the best strength gains, and gains didn't get any better with more sets. Another meta-analysis by Rhea, presented at last year's National Strength and Conditioning Association conference, found that 8 sets per muscle group, twice a week, resulted in the best

Multiple sets per muscle group result in greater growth hormone and testosterone responses than single sets.

strength gains in collegiate and professional athletes.³¹ Thus, top-level athletes may need more sets than beginners or intermediate athletes.

While 4 to 8 sets may not seem like much, keep in mind that you're training each muscle group 2 to 3 times a week, which adds up to 8 to 16 sets per week. This isn't much different from what a lot of people do, except they'll do 8 to 16 sets in one session and wait a week before training a muscle group again, which is the critical difference. Also, don't go overboard on the number of sets. While more sets create greater gH responses, they also create greater cortisol responses.^{11, 29, 39} In fact, a high cortisol response after an exercise session may result in less muscle growth.⁴⁰ So stay around the recommendations in this article and you shouldn't have any problems.

NEGATIVE ON THE NEGATIVES

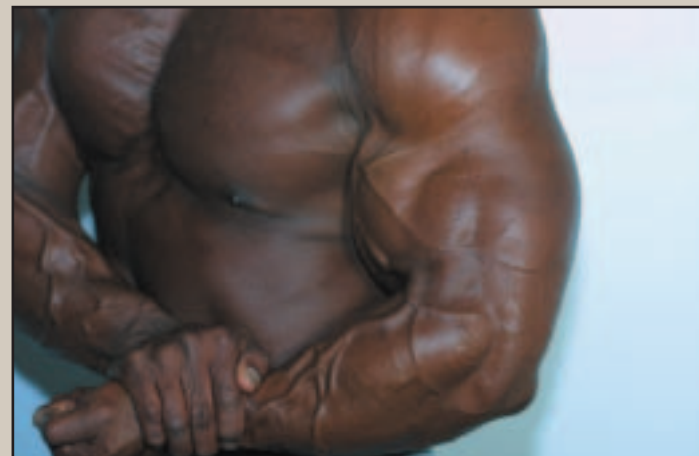
A lot of athletes and coaches believe that the negative portion of a lift is the most important, as this is what causes muscle damage. They believe muscle damage is necessary for muscle growth. In fact, some people believe that negative-only training might be the best way to get increases in muscle size. Recent science says otherwise.


The negative, or eccentric, portion of a lift is definitely important; some research indicates that you need it if you want to see your fast-twitch muscle fibers get bigger.¹⁴ However, this doesn't mean it's *more* important than the positive, or concentric, portion of the lift. In fact, concentric-only lifting creates greater anabolic hormone responses than eccentric-only lifting, and the greater muscle damage from eccentric-only training doesn't result in greater muscle growth than the minimal muscle damage caused by concentric-only training.^{8, 18} In fact, eccentric-only training may cause so much muscle damage that it can interfere with strength gains for several weeks.⁹ So the idea that you need to do a lot of damage to your muscles to get them bigger isn't true: doing heavy negatives won't give you more size.

AN ENORMOUS ENDING

I realize that this is a lot of evidence to digest. So let me summarize the main points. If you stick to them, people will soon be saying, "Yes, Your Hugeness..."

- Cycle your training between moderate-to-high-volume, short-rest training (sets of 10 to 15 with 1 to 2 minutes' rest) and moderate-volume, higher intensity training (sets of 5 to 8 with 2 to 3 minutes' rest)
- Start with 4 sets per muscle group per training session and make adjustments from there based on how you respond. If you're an advanced athlete, you may need up to 8 sets per muscle group per training session.



- Train each muscle group 2 to 3 times per week.
- If you're using a split-routine, combine larger muscle groups with smaller muscle groups
- Perform large muscle group exercises first.³⁸
- Perform multiple exercises per muscle group.²
- Don't worry about speed of movement. Size gains aren't any different with explosive movements vs. slow and controlled movements.⁴² But avoid superslow (4 seconds for the positive, up to 10 seconds on the negative) because that's been shown to be an inferior way to train.⁵
- Don't train to failure or use forced reps consistently.³⁰
- Avoid heavy negatives. 



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