

Work and Power Progression in HIT and HST

Part 3 of Physics and Training with Weights

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Introduction

In Parts 1 and 2 of the series, entitled “Physics and Training with Weights,” techniques for analyzing the work and power you perform in your training were demonstrated [1-2]. In the following sections, we’re going to use those techniques to analyze the progression of work and power in High Intensity Training (HIT) and Hypertrophy-Specific Training™ (HST).

After reading Part 1 [1], you may have been thinking: Why should I care about work? So long as the weights are heavy, I’m progressing, right? The answer to the second question is easy. You’ll progress (i.e., experience muscle growth) with heavy weights as long as your muscles aren’t conditioned to the weights [3]. As mentioned in [1], perceived effort and work are not the same thing. Just because a weight feels heavy doesn’t necessarily mean that your muscles will grow. Once your muscles have adapted, and thus become conditioned to the weight, no further muscle growth will occur until the weight is increased.

In answer to the first question, the reason we care about work is because it’s a good measure of the level of tension we place on our muscles and the amount of time that we apply this tension. Recall that the expression for the work in our training is

$$W = fR, \quad (1)$$

where W is the work performed, f is a fraction of your 1RM weight, and R is the number of repetitions performed. One way to look at Eq. (1) is to note that f is the intensity of the tension that we expose our muscles to, and R is a measure of the duration of the exposure, also referred to as “time under tension.” Put another way, the higher the number of reps R that you perform, greater is the time under tension experienced by your muscles. Similarly, the higher the fraction f of your 1RM weight that you use, greater is the intensity of the tension placed on your muscles. Generally, we’d like both f and R to increase, but since they affect one another (e.g., f limits R), we must be careful about the way we attempt to progress the work we perform in our training.

The weights represented by the values of f depend on your performance capability for each exercise that you use. These weight values are not constant, but rather change over time. For instance, as your performance improves (e.g., you can lift more weight, perform more reps, or both), the weights represented by f will increase. Moreover, your values of f generally will differ from those of other lifters depending on how you train. For instance,

if you have been training with high repetitions, your values of f will differ somewhat from those of a lifter who trains primarily with low repetitions. Because of the relative nature of these fractional values, we’ll use the generalized fractional values listed in Table A [4-6].

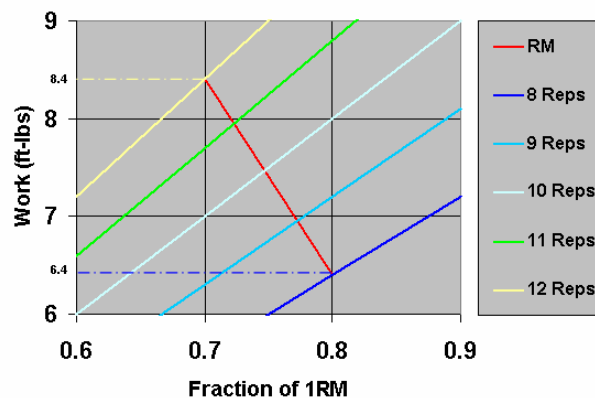
Reps (R)	Load (f)	Reps (R)	Load (f)
1	1.000	9	0.775
2	0.950	10	0.750
3	0.925	11	0.725
4	0.900	12	0.700
5	0.875	13	0.675
6	0.850	14	0.650
7	0.825	15	0.625
8	0.800		

Table A: Generalized Fractional Values of 1RM

Work Performed in HIT

With HIT, you generally use weights ranging between 70-80% of your 1RM weight for each exercise, and every set is taken to momentary muscular failure [7]. One popular way to perform HIT is to start with your 8RM weight and then work until that weight becomes your 12RM weight. At that point, you add enough weight to make the load your 8RM weight and then work to make this newer, heavier weight become your 12RM weight. The work performed during this type of training is illustrated in the following graph.

Normalized Work vs. Load



This Work versus Load graph is similar to the graph presented in Part 1 [1], but the graph above is tailored for

our analysis of HIT. As you can see, the graph has a vertical set of values, a horizontal set of values, and several colored lines. The vertical values are the normalized work performed per linear foot that the weights move [1]. The horizontal values are the fractional values f of your 1RM weight. Fractional values less than 0.6 are omitted here because we're concerned with the weights ranging between 70-80% of your 1RM weight.

Each of the colored lines illustrates the relationship between the load lifted and the work performed during a set having a particular number of reps R . A legend on the right-hand side of the graph identifies the number of reps associated with each line. For example, take a look at the dark-blue line at the bottom of the graph. According to the legend, the dark-blue line represents 8 repetitions. The next line up in the graph is associated with 9 reps, and the next line above that is associated with 10 reps, and so on.

The red line illustrates the relationship between your RM weights and the level of work you can perform. Notice the location where the red line intersects the dark-blue line. That intersection tells us that you can perform a maximum of 8 reps with 0.8 of your 1RM weight. Moreover, the blue horizontal, dashed line tells us that when you perform the 8 reps with 0.8 of your 1RM weight, you'll perform 6.4 ft-lbs of normalized work per foot that the weights move.

Now, notice the location where the red line intersects the yellow line that represents 12 reps. This intersection tells us that you can perform a maximum of 12 reps with about 70% of your 1RM weight, and that when you do so you'll perform 8.4 ft-lbs of work. Note that the yellow, horizontal dashed line represents 8.4 ft-lbs of work. Table 1 summarizes the performance data associated with the red line in the graph.

Reps (R)	Load (f)	Work/Set (ft-lbs)	Power/Rep (ft-lbs/s)
8	0.8	6.4	0.267
9	0.775	6.975	0.258
10	0.75	7.5	0.250
11	0.725	7.975	0.242
12	0.7	8.4	0.233

Table 1: Normalized Work and Power in HIT

When you train with the version of HIT described above, you're always working along the red line in the graph. That is, you start with a weight that you can perform 8 reps with and then attempt to work up along the red line until you can perform 12 reps with that weight. But look at what happens to the load you're using; it drops from 0.8 to 0.7 of your 1RM weight. This tells us that while you're striving to increase the work you can do by performing more reps, your muscles are becoming conditioned to the load and you're becoming stronger. In essence, what was once 80% of your 1RM weight is now 70% of your 1RM weight simply because your 1RM weight has increased. This is a good thing if strength is

your goal. On the other hand, if you want muscle size, then becoming conditioned to the load is not such a good thing, after all.

The red line in the graph above actually says more about strength than growing muscle. The muscles will adapt so long as the weight being lifted exceeds the current level of conditioning of the muscles. Taking sets to failure, however, places a high level of stress on the nervous system, which then requires recovery time. Since the nervous system recovers more slowly than the muscles [8], further adaptation of the muscles must wait for the nervous system to catch up. As the nervous system becomes conditioned to failure training, strength will improve. Unfortunately, since the nervous system takes longer to recover than do the muscles [8], the frequency with which the muscles are loaded must be lowered to accommodate the recovery of the nervous system. As a result of this delay, the muscles have enough time to become conditioned to the loads, and growth will begin to plateau even though strength improves.

You'll notice that Table I also includes power values. Let's take a look at the power you perform when training with the version of HIT presented above. To do this, we must consider how long each repetition takes to perform. Suppose you lift the weight upwards for 1.0 second, and then lower the weight for 2.0 seconds. Each repetition takes a total of 3.0 seconds to perform. Although your rep-speed will slow as you approach momentary muscular failure, we won't bother taking that into consideration here. Since we know the rep-cadence and the load you're using, we can determine the power by using [2]

$$P = \frac{f}{t}, \quad (2)$$

where f is the load expressed as a fractional value of your 1RM weight, and t is the time taken to complete one repetition. Using the loads listed in Table 1 and the 3.0-second time interval in Eq. (2) leads to the normalized power values listed in Table 1.

Upon examining the power values in Table 1, you'll notice that they decrease as the number of reps increases. This suggests that as you become stronger, and thus are able to perform more reps, the power that you perform actually drops. Notice that the power drops even though the level of work you perform increases. The drop in power is an unfortunate consequence of training to failure, as will become clearer below.

So how can we tweak our HIT routine so that the work and power you perform are progressing? The easiest way, if not the only way to make your work progressive is to add more sets. That is, once you're able to add more weight to the bar, you'll have to perform more sets if you want your work to increase beyond what you were doing before adding the weight. One way to handle this is once you add weight to make the load your 8RM weight, be sure to perform a second set. Doing this ensures that

you're performing more work than you did with your previous 12RM weight. The following table illustrates the effect of doing extra sets on the level of work performed.

Reps (<i>R</i>)	Load (<i>f</i>)	Total Reps/Bout	Work (ft-lbs)
8	0.8	8	6.4
9	0.775	9	6.975
10	0.75	10	7.5
11	0.725	11	7.975
12	0.7	12	8.4
Add more weight to make the load your 8RM weight.			
8 + 4	0.8	12	9.6
9 + 4	0.775	13	10.1
10 + 5	0.75	15	11.3
11 + 5	0.725	16	11.6
12 + 6	0.7	18	12.6

As you can see, adding an additional set with as little as half the number of reps is enough to maintain the progression in the level of work you perform as you increase the weights. Continuing, once you add weight again, later on down the road, you'll have to perform 3 sets with that weight to keep your work progressing. You can continue with this volume progression process until you're ready for a layoff. Then, once you're recovered, you can start the whole process over again. Of course, this is only one way to make HIT more progressive, as far as work is concerned.

Although we can make sure your work is progressing in the HIT protocol, there doesn't appear to be any way to do the same with the power you perform. The only way to increase the power you perform is by either lifting greater loads or reducing the amount of time it takes to lift the same loads. Both approaches are hindered by fatigue and training to momentary muscular failure. When you're trying to lift your 8RM weight for more than 8 reps, you must wait for your strength to improve before you can do so. But once your strength has improved, the load is a lower fraction of your 1RM weight, and thus the power you perform with the load drops a bit. On the other hand, you can try to increase your rep-speed as you increase the load. In theory this should work, but the reality is that fatigue and momentary muscular failure will slow your rep-speed, preventing you from decreasing the time spent lifting the load. Either way, the power you perform will drop during this type of training. The only way to avoid this problem appears to be to start out with submaximal loads and work up to your RM weights (i.e., avoid failure), but doing so is a direct violation of the tenets of HIT-style training [7].

Overview of HST

Setting up HST is a bit more complex than HIT, so let's spend some time getting a brief overview of how HST training is arranged.

An HST cycle is typically an eight-week, mass-building macrocycle which is comprised of at least three mesocycles. Each mesocycle provides a repetition range which specifies a number of repetitions that you'll perform with each exercise. The recommended repetition ranges are a 15-rep range, a 10-rep range, and a 5-rep range. These rep-ranges are generally referred to as the 15s, 10s, and 5s, respectively. The purpose of the rep-ranges is to guide you in choosing effective weights that increase throughout your HST cycle.

A fourth mesocycle may include negatives (i.e., eccentric repetitions), or a continuation of the 5s, or even the addition of drop sets. Strategic Deconditioning (SD) can be considered to be a fifth, or final mesocycle wherein you leave the weights alone for a period of between 9-16 days [8]. The following table summarizes the primary mesocycles in an HST cycle.

One HST Cycle	
Weeks 1-2	15s
Weeks 3-4	10s
Weeks 5-6	5s
Weeks 7-8	More 5s, Negatives, or Drops
Weeks 9-10	Strategic Deconditioning

Each mesocycle includes at least six individual workouts. The weights you use should become progressively heavier as you work through each mesocycle.

To get started, you'll need to find your 15RM, 10RM, and 5RM weights for each of the exercises you select for your training. Once you know these weights for all of your selected exercises, you can enter them into your workout log. Your 15RM weights are the weights you'll use on the last workout day of the 15s (i.e., the 15RM mesocycle). Your 10RM weights are the weights you'll use on the last workout day of the 10s, and your 5RM weights are the weights you'll use on the last workout day of the 5s.

Next, you must subtract weight from your 15RM, 10RM, and 5RM to determine the weights you'll use as you work up to your RMs. Before you can do this, however, you must determine a decrement weight for each exercise. The decrement weight is the amount of weight you subtract from your RM weights for each workout day preceding the workout day on which you use your RM weights. The decrement weight typically is about 5% of your 5RM weight. For example, if your 5RM weight for a particular exercise is 160 lbs, then your decrement weight for this exercise is $(0.05)(160 \text{ lbs}) = 8 \text{ lbs}$.

Once you know the decrement weight for each of your exercises, you're ready to determine the weights you'll use

throughout the cycle. To do this, you work backwards from the RM weight, subtracting the decrement weight from the weight for each workout day to determine the weight for the preceding workout day. For example, suppose your 15RM for a particular exercise is 120 lbs and that your decrement weight is 8 lbs. The weights you'll use during the 15s are thus 80, 88, 96, 104, 112, and 120 lbs.

The procedure for determining the weights for the 10s and 5s is identical to that discussed above for the 15s. After having performed this procedure, you'll have all the weights you need for this particular exercise for your entire HST cycle. It should be noted, however, that you'll have different 15RM, 10RM, and 5RM weights for each exercise, and thus the decrement weight for each exercise will be different. Consequently, you must perform the procedure discussed above for each exercise you intend to use in your cycle.

Work Performed in HST

Now that you know how to set up your own HST cycle, let's see how the level of work performed progresses throughout an HST cycle. In order to do this, we'll have to determine the fractional values *f* that you'll use throughout the cycle.

Let's assume that each mesocycle (e.g., 15s, 10s, 5s) comprises six workout days. Also, suppose the decrement weight is 5% of your 5RM weight. According to Table A, your 5RM weight is 0.875 of your 1RM weight. Thus, the fractional value corresponding to your decrement weight is $(0.05)(0.875) = 0.04375$. This tells us that the decrement weight is 0.04375 of your 1RM weight. In order to determine the daily fractional values you'll use in HST, we must subtract 0.04375 from the fractional values representing your RM weights, and this must be done for each workout day in the cycle. For example, according to Table A your 15RM weight is 0.625 of your 1RM weight. This is the weight you'll use on the final workout day of the 15s. On the preceding workout day, you'll use $(0.625 - 0.04375) = 0.58125$ of your 1RM weight; and on the workout day before that, you'll use $(0.58125 - 0.04375) = 0.5375$ of your 1RM weight, and so on. Carrying out this procedure for each day in the HST cycle leads to the values in Table B [9].

Workout Day	<i>f</i> (15s)	<i>f</i> (10s)	<i>f</i> (5s)
1	0.40625	0.53125	0.65625
2	0.45	0.575	0.7
3	0.49375	0.61875	0.74375
4	0.5375	0.6625	0.7875
5	0.58125	0.70625	0.83125
6	0.625	0.75	0.875

Table B: Fractional Values of 1RM in HST

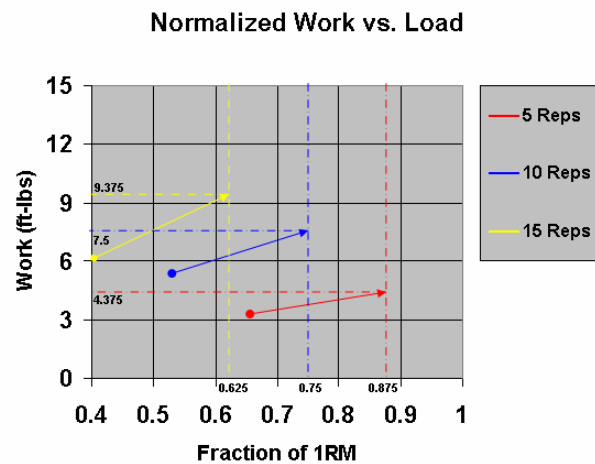
These values are daily fractions of your 1RM weight; they express the weights you'll use on each workout day of your cycle. As you can see, the general trend is an increase in weight throughout the cycle. With the fractional values in Table B now in hand, we can determine the level of work performed throughout the entire HST cycle.

Consider a basic HST cycle wherein one set is performed for each exercise throughout the cycle. During the 15s one set of 15 reps is performed for each exercise; during the 10s, one set of 10 reps is performed for each exercise; and during the 5s, one set of 5 reps is performed for each exercise. Therefore, the total volume for each exercise in the 15s, 10s, and 5s is 15, 10, and 5 reps, respectively. Using Eq. (1) and the fractional values listed in Table B leads directly to the work values listed in Table 2 [9].

Workout Day	Work 15s (ft-lbs)	Work 10s (ft-lbs)	Work 5s (ft-lbs)
1	6.09	5.31	3.28
2	6.75	5.75	3.50
3	7.41	6.19	3.72
4	8.06	6.63	3.94
5	8.72	7.06	4.16
6	9.38	7.50	4.38

Table 2: Normalized Work in HST

Each of the work values in Table 2 gives the work performed during one set, throughout the cycle. Moreover, as mentioned above, since the work is normalized, the work values listed in Table 2 are valid for all individuals regardless of variation in individual capabilities [1-2]. Following is a Work versus Load graph which illustrates the values in Table 2.



Clearly, in the basic HST cycle the work performed drops from one mesocycle to the next, and thus the total time under tension also drops. This happens even though the load on the bar increases throughout the cycle. Consequently, the work performed in the 5s is far less than the work performed in the 10s, and the work performed in

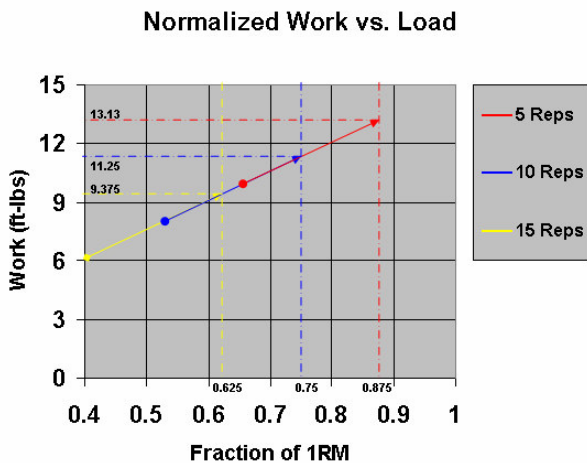
the 10s is less than the work performed in the 15s. Many lifters prefer to keep their time under tension constant, or even increasing, throughout their HST cycles by adding sets when the rep-ranges decrease. The objective of this is nothing more than to expose the muscles to tension for as long as possible without overtraining or becoming injured.

Let's stabilize our time under tension by adding multiple sets to the 10s and the 5s. One very common approach is to keep the total volume constant throughout the cycle. To do this, let's perform one set for each exercise during the 15s, a first set of 10 reps followed by a second set of 5 reps for each exercise in the 10s, and three sets for each exercise during the 5s. This gives us a total volume of 15 reps for each exercise throughout the entire HST cycle. Using this volume and the fractional values in Table B in Eq. (1) leads to the work values listed in Table 3 [9].

Workout Day	Work 15s (ft-lbs)	Work 10s (ft-lbs)	Work 5s (ft-lbs)
1	6.09	8.00	9.84
2	6.75	8.63	10.5
3	7.41	9.29	11.2
4	8.06	9.94	11.8
5	8.72	10.6	12.5
6	9.38	11.3	13.1

Table 3: Normalized Work Performed in HST Cycle

As you can see, by keeping the total volume constant, the total work performed increases throughout the cycle. This occurs simply because the load on the bar increases as the cycle progresses. The data in Table 3 are illustrated in the following graph.



The example above demonstrates that the combination of volume and the load on the bar has a profound effect on the total work performed in HST. Even though the load on the bar increases as the cycle progresses, the work performed can decrease if you don't include additional repetitions in the 10s and 5s. Clearly then, the productivity of your training may be compromised if you don't carefully plan the progression of your training volume.

Now, let's take a look at the power you'll perform during your HST cycle. As before, we shall suppose that you spend roughly 1.0 second during the concentric portion of each rep, and about 2.0 seconds during the eccentric portion of each rep. This yields a rep-cadence of about 3.0 seconds. Using this rep-cadence and the loads in Table B in Eq. (2) gives the power values listed in Table 4.

Workout Day	Power 15s (ft-lbs/s)	Power 10s (ft-lbs/s)	Power 5s (ft-lbs/s)
1	0.135	0.177	0.219
2	0.150	0.192	0.233
3	0.165	0.206	0.248
4	0.179	0.221	0.263
5	0.194	0.235	0.277
6	0.208	0.250	0.292

Table 4: Normalized Power Performed in HST Cycle

The power values in Table 4 clearly are increasing throughout the cycle. It appears, therefore, that if you maintain a constant rep-speed for all exercises throughout your HST cycle, the power you perform will generally increase, all on its own. This increase occurs regardless of whether or not you perform additional sets in the 10s and 5s. Remember that although performing additional sets does increase the level of work you perform, and thus the time under tension experienced by your muscles, it doesn't do the same for the amount of power you perform [2].

Closing Thoughts

Work is useful for characterizing the effectiveness of your training because it provides a measure of the tension you apply to your muscles and the amount of time you apply this tension during your training. Power is a measure of the efficiency with which you apply tension to your muscles, and thus is a great way to characterize your training performance.

Everyone intuitively knows that load, time under tension, and power should generally increase in our training, but problems abound when these parameters change relative to one another. To make matters worse, analyzing training volume alone doesn't illuminate the relationship between load, time under tension, and our training efficiency. For instance, we saw how lifting heavy weights for more reps in HIT training seems like a good, progressive way to train. Looking at volume alone, who would suspect that your work and power are actually plummeting with this type of training? We also saw that considering the work and power you perform helps you fix potential pitfalls in your training, thus enabling you to tailor your training according to your expectations.

An interesting thing to recall is that when we applied the work and power analysis to HST, we found that work drops as your training progresses, but your power output automatically increases. The techniques presented herein

made it straightforward to see precisely where to add more reps so that your work would also increase in HST. When we analyzed HIT we were able to make the work you perform increase, but we couldn't do the same for your power output. This suggests that momentary muscular failure is a performance barrier which prevents us from increasing our power output.

Regardless of the type of training you like best, taking a look at the work and power you'll perform in various training regimes clearly enables you to make informed choices among the many routines currently available.

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