MERCOLA
Take Control of Your Health

How to Best Optimize Your Muscular Health

Analysis by Dr. Joseph Mercola ✔ Fact Checked | October 15, 2023

STORY AT-A-GLANCE

- Concentric exercise refers to movements where your muscle is shortened, whereas eccentric movement is when the muscles lengthen. Another way to think about it is moving with or against gravity. During the eccentric part of an exercise, you're resisting the pull of gravity, and during the concentric part you're moving against gravity
- Concentric exercise is preferred if you're trying to improve mitochondrial biogenesis
- Eccentric exercise is typically superior to concentric exercise if you're looking for strength, performance and hypertrophy (muscle enlargement)
- When doing blood flow restriction (BFR) training, concentric exercise tends to be the most effective
- During concentric exercise, the faster you're able to lift something, the less amount of weight you're able to lift. The heavier the weight, the slower the velocity. This relationship is inversed for eccentric exercise, so you're able to lift far heavier weights eccentrically at a faster velocity

This interview features two repeat guests, Georgi Dinkov, a pro-metabolic expert and a student of the late Ray Peat's work, and Tyler LeBaron, Ph.D., an adjunct professor of chemistry, exercise physiology, nutrition, and sports bioenergetics. LeBaron is also the founder of the Molecular Hydrogen Institute and as an elite athlete is more than qualified for this discussion. Peat was a biologist with a specialization in physiology.

A large part of our discussion revolves around the pros and cons of eccentric versus concentric exercise, but toward the end we also delve into important topics like the metabolism of cancer, if and when baking soda can be used to treat cancer, and how molecular hydrogen helps prevent stroke damage.

Admittedly this is a dense scientific discussion on the fine details of the specifics of resistance training as a form of health. I felt it was important to bring it to the public as it is somewhat controversial, but it clearly will only be useful for a small segment of the population.

So, if you aren't interested in resistance training then let me reinforce right at the start, as we do mention it in the interview, but it is buried at the end, that the most important exercise you can do is regular movement throughout the day. If you are a wearing an Oura ring or step counter, you should be shooting for five to seven miles (10,000 to 15,000 steps) per day.

There was a **compelling study published earlier this year** that showed that moderate activity was far more important than vigorous activity at decreasing mortality. Ideally you can do this activity outside during the middle of the day with minimal clothing on so you can also get your daily sun exposure full of UVB, and near IR to optimize your health.

Since this interview has limited practical use for most of us, I am reposting my new summary of why KAATSU is likely the most important resistance training you can do after 40 to 50 years old. I would also encourage you to **read the free article on Substack** as it has all the specific details you need to know about KAATSU. If you are interested in purchasing the KAATSU please use the 10% off link that is in the Substack article.

I believe using KAATSU for the last few years is why I was recently able to win an arm-wrestling contest in June at the Orlando Biohacking event with Dr. Marcos De Andrade, who is nearly half my age and in great shape. I am actually doing a full interview with him as to why I believe I was able to beat him and will post that in a future article.

What Are Concentric and Eccentric Exercises?

Concentric exercise refers to movements where your muscle is shortened, whereas eccentric movement is when the muscles lengthen. During a bicep curl, for example, pulling the weight toward your chest is concentric contraction, and extending your arm back out to lower the weight is eccentric contraction.

Another way to think about it is moving with or against gravity. During the eccentric part of an exercise, you're resisting the pull of gravity, and during the concentric part you're moving against gravity.

Concentric Exercise Improves Mitochondrial Biogenesis

Dinkov is of the opinion that concentric exercise is preferred if you're trying to improve mitochondrial biogenesis, or an increase in the quantity of your mitochondria. He feels that eccentric exercise could impair mitochondrial reproduction and explains:

> *"So, I make [three] main claims here. One is that — at least the studies that I've seen — concentric exercise increases mitochondrial biogenesis, the density and the size of the mitochondria a lot more than eccentric does.*
>
> *The second thing is that concentric exercise has been shown to improve glucose uptake into the cell and reduce lactic acid. Third is that concentric exercise, but not so much eccentric ... increases [and] allows muscle cells to synthesize a lot of these protective steroids.*
>
> *In males, specifically testosterone, and in females, things like dehydroepiandrosterone, which is supposed to be predominantly of adrenal origin. Turns out that it's not, and muscles can produce it as well.*
>
> *While eccentric seems to be mostly good for hypertrophy and maybe in corroboration to that, during eccentric exercise only ... muscles produce predominantly estrogen ...*
>
> *So you can get bulkier on eccentric exercise, but probably not stronger and not as metabolically healthy, if you assume that a good oxidation of glucose and*

production of these anti-catabolic hormones — such as propranolol, progesterone, DHA, testosterone from males and mostly DHA for women — is what we're after. That's really it in a nutshell."

LeBaron comments:

"You did clarify one point ... regarding the concentric versus eccentric in terms of the mitochondrial biogenesis that, yes, I would agree with. There's a lot of data that would show that eccentric exercises — eccentric running, eccentric cycling — simply don't have as much oxygen consumption. The O2 cost is a lot lower.

Also, during that eccentric exercise, you're damaging the contractile proteins, you're breaking down the architecture of the sarcomeres. So, yes, in those regards it doesn't seem that there would be any stimulus — at least not near as much compared to concentric exercise — for mitochondria biogenesis, for oxygen uptake, ATP demands and everything. Eccentric exercises don't require that.

I also agree with your statement regarding the hypertrophy aspect. I was telling Dr. Mercola that eccentric exercise is really key for hypertrophy and strength. Now, I would say then, what are the superiorities ... of the eccentric exercise?"

Benefits of Eccentric Exercise

According to LeBaron, in many studies, including meta-analyses and systemic reviews, eccentric exercise ends up being superior to concentric exercise in terms of strength, performance and hypertrophy (muscle enlargement). He explains:

"First off, if the eccentric exercise damages the muscular architecture, that damage to the muscle cells is one of the potent stimuli for anabolism

(increasing muscle growth) and for muscle protein synthesis. It's not the only one, of course. Metabolic waste and many other stimuli are also important, but eccentric exercise damaging the actual muscle fibers and is a potent stimulus.

In some of these studies, when they did just a concentric exercise without the eccentric portion, there was hardly any benefit in terms of increased strength and or increased hypertrophy, versus a group that did only eccentric and not the concentric portion.

So essentially, they're doing half the amount of reps because they're doing [only] the concentric portion. That's halfway. The other group is only doing the lowering phase, right? So, essentially doing half the amount, they were able to improve just as much, if not often more in different parameters in terms of strength and hypertrophy.

The other part that was interesting is, doing that eccentric portion of the exercise seems to increase muscle hypertrophy longitudinally. Basically, you're putting sarcomere, the functional unit of the muscle in series, and that could have some benefits. You have maybe more muscle growth at the distal lens of the muscle.

That could explain even some differences between why, say, power lifters who are lifting extremely heavy weight often do eccentric loading, their muscles, and the way they look is different than a bodybuilder where they're trying to train their muscles to look a certain way versus for absolute strength.

So going back to what we agree with, yes, mitochondrial biogenesis, all the oxygen utilization, that makes much more sense for a concentric exercise. But I would still say in terms of muscle strength and hypertrophy, the eccentric exercise is very important."

Concentric Movement May Be More Effective With BFR

Another interesting caveat highlighted by LeBaron is a study showing that when doing blood flow restriction (BFR) training, concentric exercise was the most effective.

This makes sense, LeBaron says, "because when you do an eccentric exercise with blood flow restriction, you're not lifting very much weight." Since the weight is so light, you're not breaking down your muscle much, so the primary stimulus in that case is metabolic waste.

With BFR, you get a lot more metabolic waste when doing concentric movements, because during eccentric movement you're not creating as much metabolic energy since it's less demanding metabolically. "So, with BFR, concentric is probably more important than the eccentric phase, but not with standard resistance training," LeBaron says.

Summary of Concentric Versus Eccentric Benefits

Dinkov comments:

> *"So ... we can say that eccentric exercise is like a hormetic response, because you are damaging the muscle periodically and then you have an over-response by the growth, while the concentric exercise is mostly stimulating oxygen consumption and oxidation of glucose.*
>
> *I have a counter example, because you said that powerlifters do a lot of eccentric. I'm originally from Bulgaria and one of the few sports that we used to be known for ... was Olympic power lifting.*
>
> *They never do eccentric exercise. They're doing snatches. They're doing a push and then drop. They never ever do, in the actual training portion, eccentric exercise. They don't run either. They lift the weight once and they drop it.*
>
> *And studies on that have shown that is probably the highest muscle contraction force per square inch that has been measured so far. How do you explain that? Or would you agree that concentric is better for strength, while eccentric is better for hypertrophy?"*

LeBaron replies:

> *"I would say that they're both true, but it's not totally a paradox. It's because now we're talking about elite levels. And this goes into terms of specificity. In general, all in all, eccentric exercise is going to make you stronger and it's going to grow your muscles more.*
>
> *But when you start getting to that elite level, now you start talking about sports specificity. And if you're going to do really, really well at eccentric exercise, you're going to get really, really good at eccentric exercise — not necessarily maximal concentric, voluntary concentric action.*
>
> *And so, when you take elite level athletes or people who are extremely well resistance-trained, and you have one group do 100% concentric, partial repetitions and isometric static holds, and another group that does just the eccentric portion, well then, at the end of the study ... you're going to find that the group that did the isometric is going to perform the best in isometric and not as well in the eccentric or concentric.*
>
> *And the group that does the concentric performs the best in concentric, but not as well in isometric or eccentric. And the group that does eccentric is going to perform the best in eccentric, but not as well in the other two groups. And they're both going to see these improvements ...*
>
> *I would still say that the eccentric group will probably see the least decrease in the other two, but still not as good as just the concentric. But again, this is the elite level."*

Eccentric Exercise Boosts Results for Nonathletes

LeBaron points out that the No. 1 recommendation he gives people who can't do a pullup is to simply hold yourself over the bar and lower yourself down slowly. Doing this will allow you to perform a complete pullup much faster than if you were to train by trying to pull yourself up or doing jumping pullups.

The reason this works is because the eccentric exercise reduces neural inhibition while increasing muscle activation of the agonist muscles, which helps to activate those muscle fibers. You're also engaging more Type 2 muscle fibers. But again, this is primarily true for untrained individuals, not elite-level athletes. Dinkov comments:

> *"So maybe in summary, we can say that eccentric exercise will allow you to apply lower amount of force for longer [period of time] ... while concentric will create ability to apply much higher peak force ... but for much shorter times*."

Force Velocity

LeBaron also points out that there is a force velocity relationship with our muscle fibers. If you were to create a graph to illustrate this relationship, on the Y axis you'd have the strength of contraction, and on the X axis you'd have velocity.

During concentric exercise, the faster you're able to lift something, the less amount of weight you're able to lift. There's a curved, linear, inverse relationship where the heavier the weight, the slower the velocity.

> *"For strength training, it's often good to work along this entire curve,"* LeBaron says. *"So sometimes you're lifting at a lower weight, but you're keeping that velocity along that curve so you can continue feeding your Type 2 muscle fibers and getting the recruitment of all fiber type distributions*."

This relationship is inversed for eccentric exercise.

> *"With the eccentric exercise, as the speed of contraction increases, the amount of weight that can be maneuvered also increases. So, you're able to lift an enormous amount of weight eccentrically at a faster velocity,"* LeBaron says.

Remedies for Delayed Onset Muscle Soreness

On a side note, according to LeBaron, delayed onset muscle soreness (DOMS) can largely be prevented by focusing on eccentric exercises. "We get what's called the

repeated bout effect, where doing a heavy day of eccentric exercise and then the very next day doing another set, it doesn't really break down the muscular architecture even more," he says.

In other words, there's a protective effect. It could also help prevent injuries, and increase tendon strength, muscle motor neuron connection and muscle fibers. Of course, pro-metabolic interventions can also be used to address DOMS, including:

- Methylene blue
- Niacinamide
- Vitamin B1 (thiamine) — Taken one hour before exercise, 100 to 150 milligrams of vitamin B1 will inhibit lactic acid buildup
- Red and/or near-infrared light therapy, done as soon as possible after the precipitating event

Benefits of Lactate

That said, lactic acid isn't necessarily a bad thing. It has certain benefits. LeBaron explains:

> *"It's important that we recognize that lactic acid is never actually formed in the body, and almost all textbooks even get that wrong. Generally, they say that the lactic acid molecule is produced and then as soon as it shuttled out of the cell, it converts to lactate and the hydrogen ion.*
>
> *But that's actually not even true itself. That lactic acid is never formed, only lactate. That pyruvate is the end of glycolysis. You take pyruvate and you add onto that two hydrogens and two electrons. And so, the formation of lactate actually increases the pH of the body.*
>
> *I just want to talk a little bit about the benefits of lactate ... First off, if you were to take pyruvate and lactate dehydrogenase and put it in water to pH of 7 and make the reaction go forward, you'd actually see the pH of the water rise*

because, again, you are acquiring a hydrogen ion from the solution, so the pH rises.

That's critical because it is the production of lactate that retards acidosis. Two reasons, one, because it's [an] increase in intracellular pH from the production of formation of lactate from pyruvate. And then two, when it does go into the cell — it goes through the cell into the blood — it has to go through a transporter, this model carboxylate transporter, which requires another cation or a hydrogen ion in order to transport out.

So basically, for every lactate molecule that gets excreted into the blood, you are losing two hydrogen ions. And so the pH of the cells is able to maintain that higher pH a lot more effectively. And of course, the blood is full of bicarbonates and hemoglobin, and in many, buffering molecules in protein. So, it can easily handle that for the most part.

But the other big thing is that production of lactate causes regeneration of NAD+, so that the glycolysis can continue. That's the No. 1 reason why we start producing lactate in the first place ... So, you're always able to regenerate that NAD+. That's key.

And, this lactate is a neuromodulatory hormone that has so many benefits. It stimulates muscle protein synthesis, for example. It correlates with acid production and metabolic waste ... which we know [stimulates] protein synthesis.

Lactate is a preferred energy source of the brain as well. It has very therapeutic effects in the brain ... increasing BDNF, brain-derived neurotrophic factor. So, I love lactate. I think it's great. The mitochondria can also uptake lactate. Mitochondrial lactate transporter can uptake and oxidize lactate as well."

Myostatin in Eccentric Versus Concentric Exercise

According to Dinkov, several studies have shown that when you're doing eccentric exercise, the amount of myostatin in the muscles initially decreases. Myostatin is a myokine (a cytokine produced in muscle) that inhibits muscle growth, so if you inhibit myostatin, you gain more muscle growth.

Eventually, however, myostatin levels return to baseline and in some cases even increases, which, according to one study, helps explain why long distance runners are never hypertrophic, meaning they're typically very lean and don't have bulky muscles.

> *"You see that effect even in shorter durations, such as high level high competitive rowing,"* Dinkov says. *"The heavyweights of the sport, in the first and second year look like bodybuilders, but after that, when they adapt, they start to look lean. One of the studies said that this is basically a result of the adaptive increase in myostatin, if you do chronic eccentric exercise, predominantly."*

LeBaron comments:

> *"Endurance runners are doing a lot of eccentric running, basically they're hitting the ground. It's a lot of muscle damage to their legs, yet they're not huge. The muscles are very, very small ... I agree with you that I think that with the myostatin, that is certainly what is happening initially.*
>
> *Myostatin levels decrease and then it goes back to baseline and increase even further, which makes sense, because the eccentric exercise is a potent stimulator of hypertrophy. And so, the higher the hypertrophy, the higher the myostatin levels are going to be.*
>
> *But that's just one of the reasons. Some of those other reasons is, you're still not doing your typical Type 2 muscle fiber recruitment. You're running for hours at a time, and that's not going to be the same stimulus. In fact, you're activating AMPK, PGC-1alpha and the peroxisome proliferator-activated receptors, your PPAR gamma areas."*

Basically, you're emulating fasting, and that’s not going to increase your muscle size. Interestingly, BFR inhibits myostatin, which is part of why it’s so effective for building muscle mass, despite the low weights.

Cancer Misconception Reviewed

Next, we transition to a discussion about cancer and the influence of pH. As noted by both LeBaron and Dinkov, many believe that cancer cells are acidic and can't survive in an alkaline environment, but that’s incorrect. It’s a misconception that goes back to a false attribution to Dr. Otto Warburg.

Warburg never said that cancer can't survive in an oxygen-rich or alkaline environment, and, in fact, his research shows the opposite is true. Acidic pH will kill cancer cells, whereas alkalization can induce cancer progression and metastasis.

The core thesis of pro-metabolic therapy for cancer is that mitochondria are dysfunctional because of excessive fatty acid oxidation. For most people consuming more than 30% dietary fat limits your ability to oxidize glucose in the mitochondria and your metabolism shifts to glycolysis which increases lactate.

The shift in the percentage of cells involved in glycolysis can contribute to the development of the cancer, and then eventual spread or metastasis. Dinkov points out that the cancer drug acetazolamide kills cancer by preventing the breakdown of carbon dioxide, which acidifies the cancer cell and induced apoptosis (cell death). This drug has been found to work on many types of cancer and is now in human trials.

Bicarbonate Can Be Helpful in Some Cases

A nondrug therapy that will also acidify your cells would be to take 1 teaspoon of bicarbonate a few times a day. Now, you’re probably thinking, wait a minute, bicarbonate is alkaline and increases pH, and to kill cancer we want to lower the pH. How do we reconcile this? LeBaron explains:

> *"We want to lower the pH of the cancer cell ... to induce apoptosis. But the cancer cells are putting out a lot of acid ... first interstitially, but very quickly [also] in the extracellular space. By taking bicarbonate, your body can regulate and buffer that extra acid load a lot more effectively."*

Basically, by retaining the acid within the cell, the pH of the cell is lowered. That said, not all cancers respond well to this.

> *"There are some studies where bicarbonate actually has the opposite effect because maybe you're inducing alkalosis,"* LeBaron warns. *"When you have alkalosis, it's making that gradient not as favorable because the pH of the cancer cell is already really high, and then the pH of the blood is high.*
>
> *And so, it's going to be contraindicated. I'm just saying if somebody has cancer, it's not the best idea in every case to go get some extra bicarbonate. That may not be what you want to do."*

According to Dinkov, elevated lactate in the blood could be an indication that bicarbonate might be warranted. Many cancer patients have extremely low bicarbonate levels, so testing your bicarbonate level is also a good idea. You can also test your pH. Together, these tests can give you an indication of whether bicarbonate is a good idea for you specifically.

For more in-depth discussion about this and other cancer-related issues — including the risks of a chronic high-fat diet, which causes reductive stress, reverse electron transport and more free radicals — please listen to the interview.

Molecular Hydrogen Helps Prevent Stroke Damage

We also delve into some of the benefits of molecular hydrogen, which is one of LeBaron's specialty since he is the founder of the Molecular Hydrogen Institute.

> *"Because I do research on hydrogen gas, I wanted to mention why hydrogen gas is so interesting ... specifically in the realm of ischemia and reperfusion.*

Ischemia [is] ... anytime there's a stop in blood flow ... where you don't have oxygen present, so you have a hypoxic environment. That's going to cause some free radical damage, because you get a mismatch between oxygen availability and the electron flow ...

But most of the damage comes from the reperfusion side, where now the heart starts beating again [in the case of a heart attack] and you clear the blockage, and so the oxygen-rich blood is able to travel through those tissues. Well, now you're waking up the mitochondria and they're trying to get active again, and you end up producing a lot of free radicals and oxidative damage.

The first study that really showed us therapeutic effect of hydrogen gas was in Nature Medicine, published in 2007. It was a stroke model, and they found 2% hydrogen gas completely prevented the brain damage ...

Hydrogen gas does a couple things, but it's a pretreatment to improve the oxygen handling capacity of the mitochondria. And, in fact, some data indicates that molecular hydrogen somehow acts as an electron transport chain rectifier. This is extremely fascinating, because we talk about how the electron transport chain is so important.

We want forward electron transport so we can get ATP production, and we can get a little bit of free radicals that we can handle. Sometimes we can get a little bit of reverse electron transport chain, a little bit more free radicals, just for some hormetic effects. We don't want to go too far out of that homeostatic range, and hydrogen gas is able to modulate this entire process as a rectifier.

It does so because in some cases it's going to act as an electron sync and sometimes as an electron donor, to get things to go where it needs to be. If you look at the redox potential of the different complexes — complex 1, 2, 3 and 4 — and then you look at the redox potential of hydrogen gas at physiological pH, it's right in line with where you would want it to be so that it can participate as a rectifier of the electron transport chain."

More Information

For more details on the topics summarized here, be sure to listen to the entire interview. Also check out Dinkov's blog at www.haidut.me or **follow him on Twitter**. He also has hundreds of videos on **YouTube** on a plethora of topics. A major sampling of Ray Peat's work is also available for free on these two sites: **wiki.chadnet.org/Ray-Peat** and **RayPeat.com**.

If you want to take a deep dive into the science and application of molecular hydrogen, check out LeBaron's **courses, available at molecularhydrogeninstitute.org**. The institute offers four levels of certification, plus an apprentice course, but you don't have to be a health professional to take them.