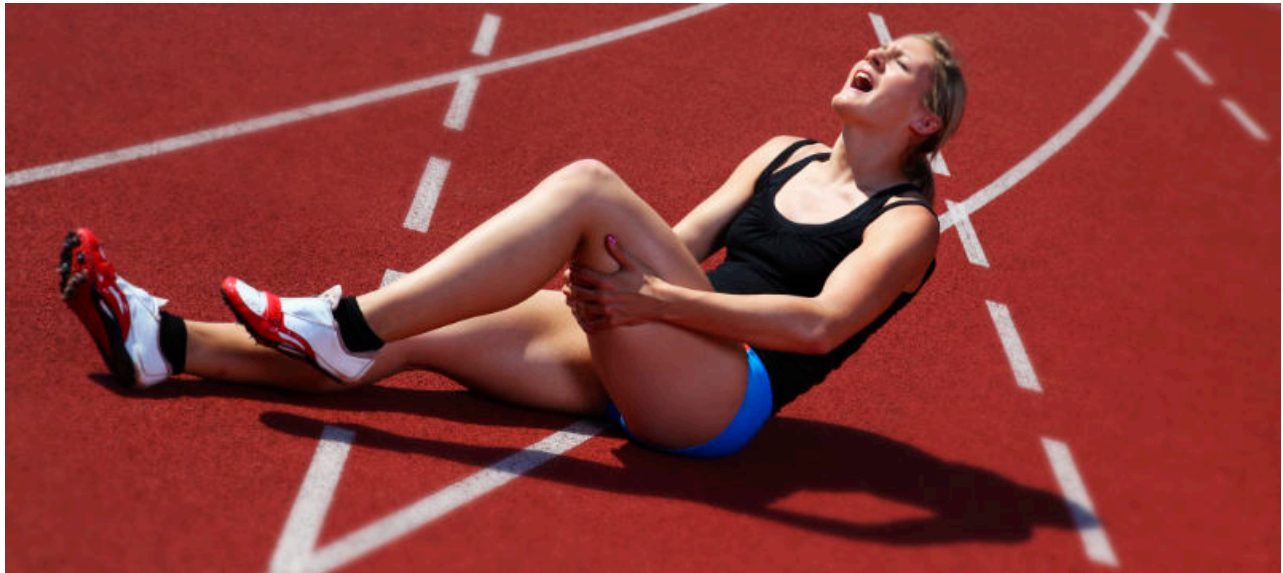


The Complete Guide to Muscle Strains

Muscle strain (pulled muscle) and muscle pain explained and discussed in great detail, plus reviews of every imaginable treatment option, with lots of referencing

Paul Ingraham • Jun 15, 2022 • 160m read



Muscle strains strike most often in the big muscles of the body. But sometimes the pain is not what it seems ...

Muscle strain — a literally ripped muscle — is often extremely difficult to recover from. In 2012, Gene Lawrence, a 74-year-old weightlifter, tore his quads (and *not* while lifting). A doctor told him he'd never do a squat again. But Gene's passion for his sport kept him going. And yet several months later he was on the verge of beating his personal records — a nearly total recovery. ¹

You can recover from nearly anything *if* you are patient and methodical.

But how patient, and what method? What is muscle injury, and how does it heal? What works? What doesn't? And here's a curve ball: *is your muscle even actually physically damaged?* Muscle *strain* and *pain* are usually woven together, and often pain alone is mistaken for injury. And there are some other kinds of injury that can mimic a strain (especially stress fractures in the pelvis).

This is an extremely detailed guide, regularly updated for almost twenty years (seriously). It thoroughly explores the science of injured and hurting muscle.

Major sections... [Diagnosis](#) [Causes](#) [Treatment](#)

Muscle strain and pain myths and misconceptions

Believe it or not (and it does seem a bit ridiculous in 2024) muscle pain is still a subject of scientific mystery and many myths and misconceptions. A torn muscle is arguably among the most medically neglected of all common injuries. ^{2 3} A major recent review couldn't find enough evidence for conclusions about *any* of the most popular treatments ⁴ — for an injury that affects the highest profile athletes in the world, playing sports that involve more resources than small nations. It's a little surprising we're not further along at this point in history.

"We can put a man on the moon, but ... "

And so, although most muscle pain is relatively simple to diagnose and self-treat, an incredible number of people seek treatment for muscle strains that have been *misdiagnosed as something else* ... or they have "something else" that's been misdiagnosed as a muscle strain. Strain, pain, spasm, contracture, scar tissue, tone, tension, and stiffness are all poorly understood and routinely

Strong enough for a pro ...but made for patients. The main text is user-friendly, but oodles of footnotes provide extra info and citations.

I do criticize many common practices and beliefs. If you disagree, let me know — I can

confused. They are not only surprisingly complex topics scientifically, but clinicians are not generally aware of the research that has been done. Certainly family doctors are not competent to assess and treat musculoskeletal problems, including muscle strains. ⁵

take it, and I've made many changes over the years based on quality feedback.

The world obviously needs more and better information about muscle pain.

So what is a muscle strain exactly?

A muscle “strain” is any physical trauma to muscle caused by force applied along the length of the muscle (tensile force). That force can be applied by contraction of the muscle itself (active strain), or imposed on it by a stretch (passive strain), but there’s no practical difference between those scenarios. There are other kinds of muscle injuries, and a surprising amount of confusion, even among professionals, about exactly what a “strain” means. ⁶

A strain is also often called a “pulled muscle” or “muscle tear.” The word “pulled” is an odd misnomer, a synonym for spasm in many languages. ⁸

That's no sprain! Note that there is no such thing as a muscle “sprain” with-a-p, just a muscle strain with-a-t. (Only ligaments can be sprained.) ⁷

Although you might have problems that make you *vulnerable* to a muscle strain, the *direct* cause of every muscle strain is *traumatic ripping of the muscle tissue* — arg! — usually at the point where the muscle meets its tendon. Muscle will tear under the force of your own muscular contraction, or excessive stretch.

The more muscle fibres are torn, the worse the strain. In the case of a serious strain, the entire muscle may completely rupture — literally ripped in half! Triple arg! (Total ruptures are serious injuries, much worse than partial ruptures.)

Obviously a muscle can also be bruised, crushed, or lacerated, but those are quite different and much more obvious traumas: the “contact” muscle injuries. This tutorial is mainly about *non-contact strains*, the kinds of strains that happen without colliding with anything or anyone. (“Why are you hitting yourself?”) There’s not much medical mystery involved in being gouged by a hockey skate. We also won’t discuss full *muscle ruptures* in much detail, because they are *so* extreme that they are easy to diagnose — even doctors can do it! 😊

It's important to determine whether or not you actually *have* a muscle strain, or some *other* kind of muscle injury... because tearing is not the only invisible way to hurt a muscle. Physical injury does not have tidy borders. Surprisingly, there's actually a major grey area between muscle that's clearly physically damaged and much more subtle and cryptic kinds of muscle injury. That grey area is interesting, and it is this document's *raison d'être*.

DIAGNOSIS

How do you know that you've got a muscle strain?

Many people mistakenly think they have a torn muscle, because there are some common problems that *feel* like a muscle strain. These other problems can be seen as a different *type* or *degree* of muscle injury, and in fact they have even been *formally classified* that way. ⁹ But such classifications are usually controversial the moment they are published, and other experts describe these more subtle muscle problems as just “muscle pain” without injury... because we clearly don't understand *exactly* what's wrong with the muscle (just its effect, pain).

True structural muscle strains — defined by visible fibre disruption — are actually surprisingly rare, compared to other causes of muscle pain. Funny thing about this tutorial: most people who find this document, like most people who think they have strained a muscle, have actually *not* done any such thing — or (just as common) they strained a muscle *once upon a time*, but the strain healed long ago and has since become an entirely different problem.

This could be you!

Some of the things that get confused with muscle strains are (and these will all be covered in more detail below):

- **Muscle cramps** and spasms (charlie horses) are whole muscle contractions, ranging from uncomfortable to those howling, awful attacks that usually afflict the calves and feet.

Most people who think they have strained a muscle have actually **not** done any such thing.

- **Nasty muscle knots**, technically known as trigger points, are small patches of localized muscle spasm and involve no actual damage to the muscle.
- **Delayed onset muscle soreness**, a.k.a. DOMS, is that savage muscle soreness we all get after an unfamiliar workout ... but it always (really) fades after about three days, guaranteed.
- **Low back pain** is a complex phenomenon which routinely gets attributed to muscle strain, when in fact it is rarely caused by muscle strain. Just about the only time low back pain is ever caused by muscle strain is when you have a sudden, severe onset of pain while trying to move a piano down some stairs ... or something like that. (If you have low back pain, stop reading this article right now and head on over to [The Complete Guide to Low Back Pain](#).)
- Other musculoskeletal injuries, of course: anatomical structures adjacent to muscles, especially tendons and ligaments.

True muscle strain checklist


Here's a checklist of the signs and symptoms of a *true* pulled muscle. *If* you can say, "Yeah, that's me," to all of these, then congratulations: you probably have an actual, certifiable, card-carrying Muscle Strain® — that is, structural muscle damage.

- ☐ Did it hit you suddenly during strong stretching or a moment of athletic intensity? Were you lifting something way too dangd heavy and/or awkward? In other words, did you have an "oh, shit" moment?
- ☐ Is the injury fairly recent? A few weeks old at the most? If it's been a long time, it's probably not a muscle strain any more — certainly not an acute one!
- ☐ Do you have just one muscle (or muscle group) that's both weak and painful to use?
- ☐ Is there a spot in the muscle that's especially sensitive?
- ☐ Is the skin flushed and hot? Does it look puffy? Is the area raised? Injured muscle fibers swell up to about *five times* their normal size! **10**
- ☐ Does the muscle seem deformed? In addition to overall swelling, more sharply defined bumps or depressions can form. If the muscle fibres tear enough, the muscle will be significantly thinned, causing a depression, and adjacent muscle may bunch up.

If you "woke up with it," or the pain came on slowly over several days, or if it's six months old, or if the pain isn't consistently in one particular place ... then we'll be talking about other possibilities. If your real problem is actually a painful "muscle knot," for

instance, you might want to take your knots for a nice massage — but massage is mostly pointless for a strain.



[Brittany goes to the Misogynist](#)  [0:13](#)

The “oh shit” moment: the most essential sign of muscle strain

Muscle strain cannot occur without an “oh shit” moment. In other words, it hits suddenly: you know that something nasty has happened, immediately and with perfect clarity. You feel *wounded*. In physical therapy, this is what we call a history of “sudden onset.” **11**

If your pain didn’t start suddenly (or very nearly so), *it ain’t a muscle strain*. Muscle strains are traumatic by nature, almost always occurring during intense athletic activity. The victim says a bad word, perhaps several of them in the case of a grade II injury. In the case of a grade III, there is generally screaming and falling down and probably turning a bit green.

And yet ...

Rupture: not as obvious as you'd think!

Complete hamstring avulsions — that is, complete ruptures of muscles where they attach to bones — are not necessarily obvious. They aren't all as painful initially as they sound (not a strong “oh shit” sign). And according to O’Laughlin *et al.*, they “can be difficult to diagnose due to swelling and patient guarding, which may mask a visibly palpable defect and lead to delays in diagnosis.” ¹² Yikes!

In that case study, the only diagnosis was “hamstring pain” for several days, before the avulsion was finally confirmed by MRI, and surgically repaired on day 13. It's not hard to imagine cases where the diagnosis would have taken much longer — too long.

So how *would* you know? Many of the *other* signs discussed here would be relatively obvious, especially substantial weakness. If the muscle is actually detached, obviously there will be a loss of strength. With some muscles, the loss is total or close to it. ¹³ In the case of the hamstrings, there are other “strings” that can take over — which is another reason why a hamstring rupture is surprisingly hard to diagnose. The strength loss would be dramatic, probably about one third (because there are three hamstrings: the semitendinosus, semimembranosus, and biceps femoris), but it's interesting how non-obvious that is. ¹⁴ But anyone with a hamstring rupture is going to have a significant performance problem.

Cramp versus strain example: Multi-muscle cramping catastrophe on a hot summer night

Back in the late 2000s I was enjoying my athletic peak and just barely managing not to embarrass myself with younger and more talented athletes. One hot summer night I was running low on electrolytes: too much sweating, not enough salt intake. (Actually, that's a surprising myth. ¹⁵) I was playing “goaltie” (say it like *goal-tea*) a variant of ultimate: a hard-running Frisbee sport with the same intensity and speed as soccer, but with more jumping.

Both calves spasmed on a jump, bringing me down hard. That was nasty, but it was just the start: as soon as I hit the ground, both sets of hamstrings went off as well, and all that was more than enough to make for a good cramping story ... but then my *abdominals* joined the fray, and that gave me an anecdote I'll be sharing for the rest of my life.

The cramping all hurt, a lot, but I was too surprised and *busy* to focus on the pain. If you've ever had a strong spasm, you know that there's a powerful instinct and need to

elongate the muscles. Stretching is your only hope of relief. But I had a puzzle to solve: just *try* to stretch the backs of your legs and your abdominal muscles at the same time. It's an anatomical impossibility.

I jackknifed back and forth so violently that the other players wondered if I was having a seizure, but I was simply on my impossible mission to stretch both sides of my body. If I stretched my legs, the abdominals would bunch up; if I stretched my abdominals, then leg muscles tried to kill me! After about three tries each way, I realized it couldn't be done and that my only hope was compromise: to find the least awful position somewhere between the extremes. It meant that neither muscle group would really be stretched at all — but neither would be allowed to fully contract either. I gasped “cramps! lots of cramps!” so everyone knew I wasn't actually having a seizure ... and then waited it out.

Without the power of stretch, the cramps took a long time to fade. It was a long time to endure extremely powerful contractions.

A spasm is capable of injuring muscle. In this case, I was wrenching back and forth, my own muscles in a tug-of-war with each other. These were perfect conditions for injury. Something had to give, and it did — I had mild strains of all the affected muscles, resulting in not just days of soreness but severe soreness for weeks, and a vulnerability to reinjury that was still a problem a full year later.

The *spasm* here was the strong involuntary contraction of the muscles. The *strain* was the injury caused by the forces on the muscles.

Location, location, location

Another way of knowing you've got a muscle strain is by the location. Muscle strains are much more common in some muscles than others. Every “groin pull” is a muscle strain of one or more of your hip adductors, for instance.

You can strain virtually any muscle in your body, but the commonly strained muscles are:

- the hamstrings
- the rectus femoris (the smallest of the quadriceps group, on top of the thigh)
- gastrocnemius (the muscle that gives the calf its shape)
- the lumbar paraspinals (thick columns of muscle on either side of the lumbar spine)
- the biceps

The pattern here is *big muscles*, which we tend to use for explosive or intense effort. However, a strain is possible in any muscle.

Even more specifically ...

Strains often occur where muscles meet tendons, the *myotendinous junction*. Tendon is the shiny white “bio rope” that connects muscles to bones (in contrast to the bone-to-bone connections of *ligaments*). Tendons blend smoothly into muscles, like fingers of two types laced together, but at a cellular level. When a muscle contracts, the greatest strain naturally occurs *where it pulls*, which is of course where the tendon is. All the force converges on the tendon, but it’s not going to give. (In many cases, even bone will give way before tendon does!) Tendon has an extraordinary tensile strength, much greater than steel cable. Instead, the muscle tissue tends to fail close to where it becomes more tendon-y.

It can be hard to tell where this zone of likelihood is. For instance, in the hamstrings, the tendons are quite long and complex, and blend into the muscle along a considerable span. So you can have a myotendinous strain there that is basically right in the middle, between thigh and knee.

The hurtin’ and the weak

You can feel confident that you probably have a muscle strain when the contraction of one specific muscle feels both *weak* and *painful*. This is because strength is inhibited by more than just pain: the ability of the muscle to contract has been physically disrupted.

Strength/pain combinations are diagnostically informative, and a good physical therapist is always looking for such combinations when assessing your case. A “weak and painful” contraction test tends to indicate muscle strain. “Strong and painful” means something else. “Weak and painless” something else again.

The strong-but-painful category of possibilities is large and diverse, but dominated by tendinitis, which is sometimes mistaken for a muscle strain. But tendinitis will not cause significant *weakness*. The pain might make you hesitant to pull on the tendon, but the muscle can still do it: so the contraction will be strong-but-ouchy.

Painless-but-weak is an even bigger diagnostic category, and I’ve included it here mainly to say what it does *not* indicate, rather than what it *does* indicate. ¹⁶ Strains are mostly *not*

painless, and a completely painless strain is probably impossible. Therefore, if your muscle contraction is painless, you probably don't have a strain. (Note that if you have really *any* pain at all, that doesn't quite count as painless in the "weak and painless" combo.)

There is an exception (because of course there is): some strains cause so much "inhibition" — neurological shutdown of contraction — that you are simply unable to *use* the muscle enough to be painful. The inhibition is actually preventing you from hurting yourself. This is most likely to occur with more severe strains, but people are quirky; I haven't seen any clear examples in practice that I can recall, but I bet they exist.

Ligament sprains, for a contrasting example, do not cause weakness *or* pain with muscle contraction alone, because ligaments just hold joints together and muscle contraction mostly does not directly pull on them — it just moves the joint they are attached to, which might hurt a little. So if you just clench your muscles in place, without moving (isometric contraction), and nothing hurts (much) ... that could be a ligament sprain: strong and largely painless contraction.

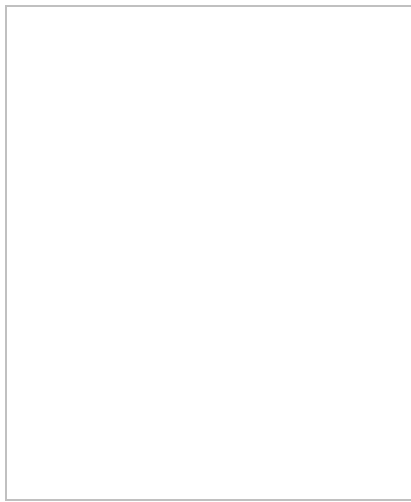
This is more about guidelines than rules: contraction of a strained muscle *probably* isn't weak and totally painless, and *probably* isn't strong and painful. Muscles strains *mainly* make muscle contractions weak and painful, but there are undoubtedly a few exceptions, as there are with anything in medicine.

Could you have a *muscle spasm* instead of a strain?

You sure could! Spasms, cramps and "charlie horses" can both *seem* like a muscle strain *and* they can also actually cause one...

END OF FREE INTRODUCTION

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Further Reading

What's new in this tutorial?

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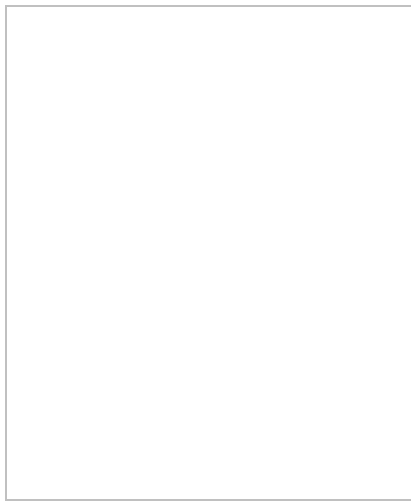
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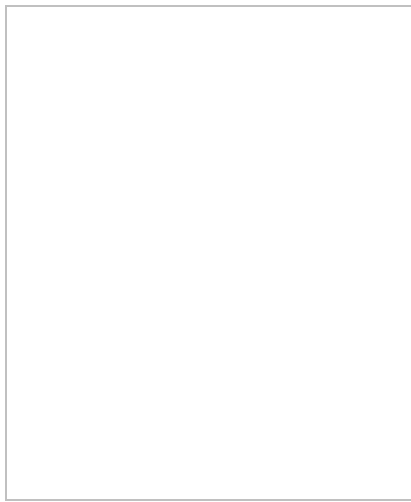
How can you trust *this* information?

I apply a MythBusters approach to health care (without explosives): I have fun questioning everything. I don't claim to have The Answer for muscle strain and pain. When I don't know, I admit it. I read scientific journals, I explain the science behind key points (there are more than 110 footnotes here, drawn from a huge bibliography), and I *always* link to my sources.

For instance, there's good evidence that educational tutorials are actually effective medicine for pain.  Good information is good medicine!

So all the science and all the options for muscle strain treatment are here. If you've been struggling with pulled muscle injury, I think this tutorial will feel like a "good find" to you!

As with all the tutorials on PainScience.com, I've worked hard to provide you with the best information available *anywhere* — not just better researched and referenced, but also regularly updated, and presented in a clear, friendly style that's just like coming to my office and having a nice long conversation about it, where all your questions get answered. But at a fraction of the cost.



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Muscle Strain Causes

This is the free introduction to the causes (etiology) section of the tutorial. In the full version, there are a half dozen chapters reviewing every aspect of the origins of muscle strains.

Assuming you have a muscle strain — and not trigger points or DOMS or a spasm or a small purple monster stabbing you in the back — then it's time to discuss how it happened.

A strain really is a *rip*. Muscle is made up of fibres, bound together in “fractal sausage wrappings.” If enough force is applied to them, those fibres and wrappings tear just like anything if you pull on it hard enough. There are three kinds of situations where muscle tends to tear:

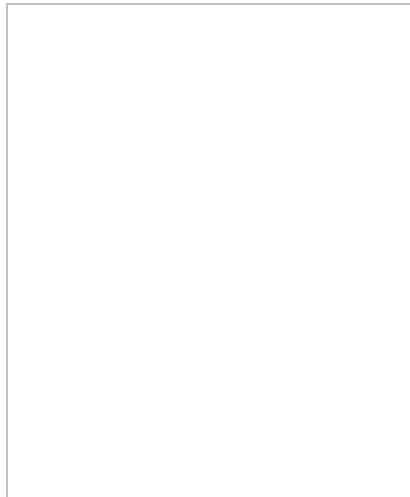
1. by stretching it too far yourself
2. by being forced into a stretch too quickly or too far
3. by contracting hard against strong resistance

The third scenario is the most common in sports. Such strains usually happen at moments when the muscle would normally elongate to allow a movement, but is *also* contracting to control or limit elongation. Sometimes the muscle just isn't strong enough to hold up under these opposing forces, or perhaps the opposing forces are slightly unbalanced and/or at odds with momentum — and something has to give.

This “contracting while lengthening” strangeness is called an “eccentric” contraction in physio-speak. You could tear your biceps by exerting yourself too intensely to resist the

descent of the barbell, for instance. Most such muscle tears occur during *fast* eccentric contractions. They are common in sprinters, for instance.

Technically, the muscle is doing what it is “supposed” to do. Eccentric contractions are a normal part of the action, and sometimes the forces involved are simply too great. Another view, however, is that injury occurs only when the muscle action is *poorly coordinated*.



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Muscle Strain Treatment

This is the free introduction to the treatment section of the tutorial. In the full version, there are two dozen chapters reviewing every popular treatment option and consideration.

You can do a few things that *may* improve recovery time and completeness, or at least reduce pain along the way. I will also explain some of the basics of self-treating your trigger points, because they often complicate muscle strain healing.

But it's important to bear in mind that there are essentially *no* proven treatments for muscle strain — that is, nothing that definitely speeds healing along, makes it more complete, or eliminates complications. A large 2017 scientific review by Ramos *et al.* concluded that “the evidence of the effectiveness of these modalities in muscle injuries is not fully established due to the little scientific research on the topic.” They were referring to cryotherapy, laser therapy, therapeutic ultrasound, therapeutic exercise, and manual therapy, and I will get further into most of these.

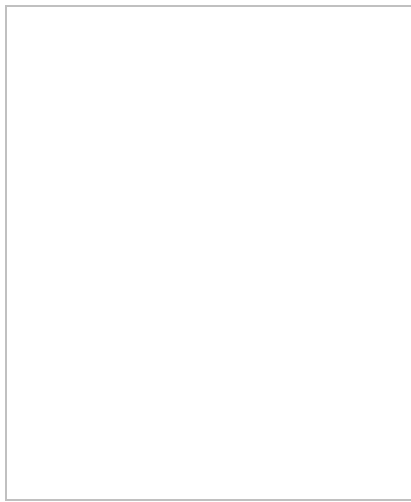
The absence of evidence doesn't mean that *nothing* works — just that none of the options have really been studied well enough to actually know. Speculation is unavoidable. In many ways, this book is not about “what works,” but about how to *make educated guesses* about what things are the most worth trying: the safest, the cheapest, the most practical and plausible. Here's a quick summary of all the options, roughly in order of most promising to least:

- prevention of re-injury is always the top priority, and the trick is actually understanding the risk factors
- a progressive rehab plan — disciplined baby steps back to normal function — is important for more serious strains
- pain-free range of motion exercises are very valuable in the early stages of rehab: stimulus without stress
- warmups: more thorough, and including warmups for workouts that wouldn't normally need one
- strength training as rehab progresses, especially “eccentric” training (loading while lengthening)
- endurance training throughout
- general self-massage around the strain, and trigger point therapy in some cases
- icing can be useful for fresh strains in the back
- contrast therapy (hot and then cold) has some potential to stimulate tissue without stressing it, and may be helpful
- cramp prevention (which is mostly about avoiding extremes of exertion and overheating, not about staying hydrated or electrolytes)
- stretching is a mixed bag: it probably has no preventative value, but some treatment value, maybe
- the drug suramin may aid healing
- platelet-rich plasma is not promising, but some people may consider it worth the risk
- pain killers may be useful occasionally, but mostly should be avoided, especially
- muscle “flossing” (compression) isn't very promising, but cheap and low risk, an option if you're scraping the bottom of the worth-a-shot barrel

And there are some treatment approaches that I am so skeptical of that I recommend avoiding:

- cold laser therapy
- electrical muscle stimulation (EMS)
- the pursuit of “muscle balance” specifically (just get stronger generally, don't worry about “balance”)

Continue reading much, much more...



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APPENDICES

Reader feedback ... good *and* bad

Testimonials on health care websites reek of quackery, so publishing them has always made me a bit queasy. But my testimonials are mostly about the *quality of the information* I'm selling, and I hope that makes all the difference. So here are some highlights from the kind words I've received over the years ... plus some of the common criticisms I receive, at the end. These are all genuine testimonials, mostly received by email. In many cases I withhold or change names and identifying details.

Just to let you know your style and thoughts are so much more on target than anything I have ever read. I'm an engineer, runner, father of eight, kids that are doctors, and I find that so little is properly discussed or backed up with evidence and decent reasoning. I may not agree with everything, but I've

come to trust that you are diligent and earnest and know your subject matter as well as anyone.

~ Greg Lennon

The internet is a dicey place to spend money ... so many scams. I wanted to let you know how appreciative I am of your eBook on muscle strains. When I got to the stop sign, I had to reflect and realized that the style and quality of what you had written was worth a gamble. Well, paying the twenty bucks and learning what I wanted to learn — and more — was worth every penny. I am now rehabbing my level 1 calf strain with full confidence and feel very well informed moving ahead. Good luck and keep writing — we need all the help we can get out here!

~ Craig Adkins, tennis player and professional skiing cameraman, Portland, Oregon

I read your article on muscle strains, and I was very impressed. You seem to really know your stuff. I wish there was one of you in every state!

~ Robin

I found this article when I was researching how to heal my pulled muscle. I love the mobilization exercises at the end — great for a 'desk jockey' like me!

~ Juanita Vannay

One more noteworthy endorsement, with regards to this whole website and all of my books, submitted by a London physician specializing in chronic pain, medical education, and patient-advocacy (that's a link to his excellent blog):

I'm writing to congratulate and thank you for your impressive ongoing review of musculoskeletal research. I teach a course, Medicine in Society, at St. Leonards Hospital in Hoxton. I originally stumbled across your website whilst looking for information about pain for my medical students, and have recommended your tutorials to them. Your work deserves special mention for its transparency, evidence base, clear presentation, educational content, regular documented updates, and lack of any commercial promotional material.

~ Dr. Jonathon Tomlinson, MBBS, DRCOG, MRCGP, MA,
The Lawson Practice, London

What about criticism and complaints?

Oh, I get those too! I do not host public comments on PainScience.com for many reasons, but emailed constructive criticism, factual corrections, requests, and suggestions are all very welcome. I have made many important changes to this tutorial inspired directly by critical, informed reader feedback.

But you can't make everyone happy! Some people demand their money back (and get it). I have about a 1% refund rate (far better than average in retail/e-commerce). The complaints of my most dissatisfied customers have strong themes:

- **Too negative in general.** Some people just can't stomach all the debunking. Such customers often think that I dismiss "everything" ... which I disagree with.
- **Too negative *specifically*.** Some are offended by my criticisms of a treatment option that they personally use and like. Or sell!
- **Too advanced.** Although I work hard to "dumb" the material down, quite a few people still just find it too dense and dorky.
- **Too simple.** Some people think they already know everything about the topic. Maybe they do, and maybe they don't. I always wish I could give these readers a pop quiz. 😊
In my experience, all truly knowledgeable people get that way by embracing every new perspective and source of information.

Acknowledgements

Thanks to every reader, client, and book customer for your curiosity, your faith, and your feedback and suggestions, and your stories most of all — without you, all of this would be impossible and pointless.

Writers go on and on about how grateful they are for the support they had while writing *one measly book*, but this website is actually a much bigger project than a book.

PainScience.com was originally created in my so-called "spare time" with a lot of assistance from family and friends (see the origin story). Thanks to my wife for countless indulgences large and small; to my parents for (possibly blind) faith in me, and much copyediting; and to friends and technical mentors Mike, Dirk, Aaron, and Erin for endless useful chats, repeatedly saving my ass, plus actually building many of the nifty features of this website.

Special thanks to some professionals and experts who have been particularly inspiring and/or directly supportive: Dr. Rob Tarzwell, Dr. Steven Novella, Dr. David Gorski, Sam

Homola, DC, Dr. Mark Crislip, Scott Gavura, Dr. Harriet Hall, Dr. Stephen Barrett, Dr. Greg Lehman, Dr. Jason Silvernail, Todd Hargrove, Nick Ng, Alice Sanvito, Dr. Chris Moyer, Lars Avemarie, PT, Dr. Brian James, Bodhi Haraldsson, Diane Jacobs, Adam Meakins, Sol Orwell, Laura Allen, James Fell, Dr. Ravensara Travillian, Dr. Neil O'Connell, Dr. Tony Ingram, Dr. Jim Eubanks, Kira Stoops, Dr. Bronnie Thompson, Dr. James Coyne, Alex Hutchinson, Dr. David Colquhoun, Bas Asselbergs ... and almost certainly a dozen more I am embarrassed to have neglected.

I work “alone,” but not really, thanks to all these people.

I have some relationship with everyone named above, but there are also many experts who have influenced me that I am not privileged to know personally. Some of the most notable are: Drs. Lorimer Moseley, David Butler, Gordon Waddell, Robert Sapolsky, Brad Schoenfeld, Edzard Ernst, Jan Dommerholt, Simon Singh, Ben Goldacre, Atul Gawande, and Nikolai Boguduk.

Further Reading

Here are several additional articles of interest:

- **The Complete Guide to Low Back Pain** — An extremely detailed guide to the myths, controversies, and treatment options for low back pain
- **The Role of Eccentric Contractions in Rehab** — A weird bit of muscle physiology, and what it has to do with recovery from injury
- **Does Epsom Salt Work?** — The science and mythology of Epsom salt bathing for recovery from muscle pain, soreness, or injury
- **The Complete Guide to Neck Pain & Cricks** — An extremely detailed guide to chronic neck pain and the disturbing sensation of a “crick”
- **A Deep Dive into Delayed-Onset Muscle Soreness** — The biology & treatment of “muscle fever,” the deep muscle soreness that surges 24-48 hours after an unfamiliar workout intensity

And here are the articles recommended for those of you who may have muscle knots, as opposed to a muscle strain:

- **The Complete Guide to Trigger Points & Myofascial Pain** — An extremely detailed guide to the unfinished science of muscle pain, with reviews of every theory and treatment option

- **Micro Muscles and the Dance of the Sarcomeres** — A mental picture of muscle knot physiology helps to explain four familiar features of muscle pain
- **Quite a Stretch** — Stretching science has shown that this extremely popular form of exercise has almost no measurable benefits
- **Basic Self-Massage Tips for Myofascial Trigger Points** — Learn how to massage your own trigger points (muscle knots)

What's new in this tutorial?

Regular updates are a key feature of PainScience.com tutorials. As new science and information becomes available, I upgrade them, and the most recent version is always automatically available to customers. Unlike regular books, and even e-books (which can be obsolete by the time they are published, and can go years between editions) this document is updated at least once every three months and often much more. I also *log* updates, making it easy for readers to see what's changed. This tutorial has gotten 60 major and minor updates since I started logging carefully in late 2009 (plus countless minor tweaks and touch-ups).

2022 — More information: Added an additional reason for imaging: some “strains” turn out to be stress fractures. [Updated section: Diagnostic imaging.]

2022 — Science update: Cited Guan, a good review of all inter-limb asymmetry evidence. [Updated section: Can you prevent strains and re-injury by upgrading your “muscle balance”?]

2022 — Minor update: Added neuropathy as a risk factor for strain. [Updated section: Vulnerability and risk factors.]

2022 — Added sub-topic: Discussed the potential value of neural mobilization in strain rehab. [Updated section: What about stretching? Can it treat strains, or prevent re-injury?]

2021 — Upgraded: Added much more information about magnesium: cramping, supplementation, and dietary sources. Also beefed up the warning about excessive hydration and its effect on electrolytes (hyponatremia). [Updated section: Prevention: will water and electrolytes make a difference? Magnesium?]

2021 — More information: Added information about the role of magnesium. [Updated section: Epsom salt baths: don't bother.]

2021 — Upgraded: More and clearer information. A new citation to some basic spasm science. [Updated section: Could you have a *muscle spasm* instead of a strain?]

2021 — Correction: I misinterpreted a study of the relationship between range of motion and recovery time. While the general principle was sound — greater ROM loss correlates strongly

with recovery time) — my more specific “rule of thumb” based on it was a bit wonky. So I fixed that. [Updated section: Timing tips: when is it safe to use a torn muscle again?]

2021 — More info: More detailed information and advice about training for “muscle balance” between the quads and hamstrings. [Updated section: Can you prevent strains and re-injury by upgrading your “muscle balance”?]

2020 — New chapter: No notes. Just a new chapter. [Updated section: Heed the signs! Painful “niggles” are a loud-and-clear sign of an increased risk of injury.]

2020 — Major upgrade: Added a bunch of new information about conventional risk factors. [Updated section: Vulnerability and risk factors.]

2020 — Improvements: Science updates, updated side effect information, and just generally more detail. [Updated section: You and “vitamin I”: anti-inflammatory meds, especially Voltaren® Gel.]

2020 — Major revision: Information about spasms and cramps is now more detailed and nuanced. Some significant modernization was needed. [Updated section: Could you have a *muscle spasm* instead of a strain?]

2020 — Upgrade: Clarification what different combinations of strength and pain might mean. [Updated section: The hurtin’ and the weak.]

2020 — Upgraded: Major improvements and clarifications, inspired by some good scholarly debate about the classification of muscle injuries. A formal classification of some muscle injuries as “functional” is an interesting and useful way to introduce the subtopic of trigger points, and to put it in the context of a book about *structural* muscle injury. [Updated section: Could you have muscle “knots” instead of a muscle strain?]

2020 — Science update: Added a good new citation about the definition/classification of strain, clarified the unclear nature of “strain,” and introduced the idea of other *kinds* of muscle injury. [Updated section: So what is a muscle strain exactly?]

2020 — Science update: Added a citation about the safety of BFR training (it’s not entirely safe, turns out). [Updated section: Compression band training (AKA muscle “flossing”, AKA blood flow restriction training).]

2020 — Science update: Added some information about the potential harms of platelet-rich plasma injection. [Updated section: Regenerative medicine? Platelet-rich plasma.]

Archived updates — All updates, including 36 older updates, are [listed on another page.](#) □

2009 — Publication.

Notes

1. Bret "The Glute Guy" Contreras tells his story, and some other tales of extreme recovery, and extracts some lessons from them. See [You'll Never Squat Again](#).
2. Simons D. [Foreword of The Trigger Point Therapy Workbook](#). 1st ed. New Harbinger Publications; 2001. "Muscle is an orphan organ. No medical speciality claims it. As a consequence, no medical specialty is concerned with promoting funded research into the muscular causes of pain."
3. You can get a rough measure of how well-studied a subject is by doing a search for it on [PubMed](#), a large database of citations to medical research. Searching for muscle strain is a bit tricky, because "muscle strain" is mentioned in lots of papers that aren't really *about* muscle strain. But if you cleverly search for the terms "muscle strain" only in titles, you will get, as of 4/14/07, only 61 search results, even less than iliotibial band syndrome (another under-studied condition). Compare that to, say, 3000 for [frozen shoulder](#), or 5900 for carpal tunnel syndrome.
4. Ramos GA, Arliani GG, Astur DC, *et al.* [Rehabilitation of hamstring muscle injuries: a literature review](#). Rev Bras Ortop. 2017;52(1):11–16. [PubMed 28194375](#) [PainSci Bibliography 52750](#)
5. Most doctors lack the skills and knowledge needed to care for common aches, pains, and injury problems, especially the chronic cases, which they tend to underestimate the complexity of. This has been shown by many studies, like [Stockard *et al.*](#), who found that 82% of medical graduates "failed to demonstrate basic competency in musculoskeletal medicine." It's just not their thing, and people with puzzling or stubborn pain should take their family doctor's advice with a large grain of salt, and even lower their expectations of specialists (who tend to be *too* specialized). See [The Medical Blind Spot for Aches, Pains & Injuries: Most physicians are unqualified to care for many common pain and injury problems, especially the more stubborn and tricky ones](#).
6. Mueller-Wohlfahrt HW, Haensel L, Mithoefer K, *et al.* [Terminology and classification of muscle injuries in sport: the Munich consensus statement](#). Br J Sports Med. 2013 Apr;47(6):342–50. [PubMed 23080315](#) [PainSci Bibliography 52361](#)

In a 2013 survey of professionals, "responses demonstrated a marked variability in the definitions for hypertonus, muscle hardening, muscle strain, muscle tear, bundle/fascicle tear and laceration, with the most obvious inconsistencies for the term muscle strain. Relatively consistent responses were obtained for pulled muscle (Layman's term) and laceration."

7. *Strain* and *sprain* are confusingly similar words for quite different things. They both refer to tearing, but of different tissues. A torn *ligament* is always called a *sprain*. A torn *muscle* is always called a *strain*.

8. [Thesaurus.com](#):

c.1400, from Old French *spasme*, from Latin *spasmodus* "a spasm," from Greek *spasmos* "a spasm, convulsion," from *span* "draw up, tear away, contract violently, pull." Figurative sense of "a sudden convulsion" (of emotion, politics, etc.) is attested from 1817.

9. [Mueller-Wohlfahrt 2013, *op. cit.*](#)

Mueller-Wohlfahrt *et al.* classify muscle injuries into two broad categories, functional and structural. The structural injuries are the obvious traumatic injuries that this volume is mainly about: partial and total tears and avulsions, injuries you can easily see with a microscope if not with the naked eye.

The functional injuries are divided into "overexertion-related" and "neuromuscular muscle disorders," which are defined by their *lack* of clear physical damage. This category is *messy* but *interesting*. The overexertion

category includes a bunch of muscle issues of unclear nature. The neuromuscular disorders refers mainly to muscle that is being irritated by spinal cord lesions.

10. Rozen, I and Dudkiewicz, I. "Wound Ballistics and Tissue Damage." Chapter in: A. Lerner and M. Soudry (eds.), *Armed Conflict Injuries to the Extremities*, 21 DOI: 10.1007/978-3-642-16155-1_2, Springer-Verlag Berlin Heidelberg 2011.
11. Mild strains can come on relatively slowly. I have experienced at least two "slow" muscle tears of my left quadriceps while playing ultimate (a hard-running Frisbee sport). I recall in each case that there was definitely a moment of injury — but it was kind of a long, drawn-out moment. I stumbled a little. There was some pain, but not enough to stop me at first. As I kept running, though, it became clear that I was going to be benched. I had torn a few fibres, perhaps, and I was tearing more as I ran — a slow rip, a few more fibres with every step. The sense of impending doom was very strong! So, in this case, the onset was not exactly a "sudden" attack of serious pain, but it was still a perfectly clear, well-defined, can't-miss-it kind of event.
12. O'Laughlin SJ, Flynn TW, Westrick RB, Ross MD. Diagnosis and expedited surgical intervention of a complete hamstring avulsion in a military combatives athlete: a case report. Int J Sports Phys Ther. 2014 May;9(3):371–6. PubMed 24944856 [PainSci Bibliography 53845](#)
13. Example: if you rupture your Achilles tendon, you lose nearly all of your ankle plantarflexion strength. The only muscles pulling on the back of the heel are the gastrocnemius and soleus, which make up almost all the bulk of the calf, and all that strength is funnelled into the Achilles tendon.
14. Imagine you're a tough athlete, like the guy in the cited case study, a mixed martial arts fighter! How do you feel if you lose about one third of the strength in your hamstrings? You know *something's* wrong, for sure ... but you're *tough*, so you probably don't make all that much of it. "Doc, I hurt something and I don't think I'd want to fight right now, but I can still walk around fine." You don't need anywhere close to full strength most of the time ... so being 30-40% short is really not that big a deal.
15. Was it really the electrolytes? No. That's what I thought at the time, but a nice myth-busting 2011 experiment comparing crampy runners with their uncramped comrades showed clearly that dehydration was *not* the culprit. Fun science. See Schwellnus et al. This will be discussed a bunch more in the water and electrolytes chapter of this book.
16. Weakness has many possible causes — too many to just start listing them as candidates without more information about the case to narrow it down. But in a patient who otherwise suspects a muscle injury, isolated weakness of a movement is most likely to be caused by a neuropathy — an impinged nerve somewhere. That's where the clinical suspicion would be most likely to point.

There are 100 more footnotes in the full version of the book. I really like footnotes, and I try to have fun with them.

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