

What Is Muscle Soreness? It Isn't Muscle Tears... | Dr. Andy Galpin & Dr. Andrew Huberman

I do have a question about recovery And it's one that I think most people are familiar with themselves which is soreness We think of it as a muscle soreness But I was trained early on in my scientific career to always question the seemingly obvious So a couple of questions about soreness First of all what does soreness really reflect Is it really muscle soreness It feels like it's in the muscles Uh But what other organ systems and tissues and cell types does it involve And then I'm particularly interested in this concept or this experience that many of us including myself had which is delayed onset muscle soreness Why would it be that when we are less in shape or when we perform a movement that is extremely novel to us the soreness seems to arrive after a reasonable delay of maybe even a day you know we're fine the next day But then 48 hours later we are exceedingly sore And as we get more fit or more familiar with the movement the soreness seems to arrive earlier So I realize I just asked you about three questions or more First of all what is muscle soreness at a cellular level which cells which organ systems and so forth What is it mean If we are sore is something I know we'll get into a little bit later And then why the delayed onset muscle soreness It's actually one question So it's totally fine You answered all you asked all three because I'm gonna actually answer number three which will answer number two which will actually answer number one I'd love to tell you that I set it up that way intentionally But uh I'm just happy to hear that where I was unable to be concise you are able to be concise Thank you We are still learning a lot about this area It's actually really difficult to perform these studies Anytime you ask a question about something like pain or soreness you're immediately talking about perception and there is obviously a physical component to that and there's also perception and so teasing those things out is extraordinarily challenging That said there has been a lot of work in this area In fact probably um you may have a show already out on pain or maybe once coming down the road we did an episode on pain uh a while ago but it's definitely time to revisit that literature I also have some amazing colleagues at Stanford who work on pain both from the uh cellular and molecular side but also from the psychological side about how our um understanding of pain and what we believe about pain shapes the experience of pain and pain relief Amazing That's that stuff is incredibly important And I'm and I'm glad

we flagged that and maybe we'll just call that good for now They can come back later for another one of your shows So that being said why does it happen Uh 28 to 48 hours after you exercise Well that actually should give you some clues into what's happening So the traditional dogma of delayed onset muscle soreness is what this is called is that it is a result of quote unquote micro tears in the muscle And so you can sort of think I challenged the muscle Uh there were some small tears in there and I'm feeling the results of that Well in fact that certainly does happen and it can happen That is not what's explaining your muscle soreness And in fact you can be quite sore from exercise and have no measurable amount of muscle damage And so much like anything else when we're in this idea of pain it's not a 1 to 1 explanation There are multiple factors that are probably causing your perception of pain Muscle damage can be one of them It is not the only one And it is probably in my opinion though this is yet to be shown definitively probably not even the leading cause of it And so what's actually happening Well the reason it's taking you 24 to 48 hours is is you can actually uh find various papers uh literature reviews dating back in a number of years now over a decade that show these wonderful curves of an inflammatory and immune response And and we don't need to necessarily go through the entire physiology right now But effectively what's happening is those things have a little bit of a time delay And so some of those steps happen immediately like right when the exercise is there and then some of them are delayed 6 to 24 to 48 hours Um If you know a little bit about this uh physiology it's you have a combination of neutrophils and macrophages and a bunch of things happening And this has a time sequence So what happens is by the time we get to this 28 to 48 hour window now the muscle soreness kicks in which wait a minute if I if this was a result of my muscles being torn and that happened immediately wouldn't that pain start immediately Well the answer is it would And so that that that is your first clue that that's not responsible for it when we look at that immune response and we see that that is actually peaked 24 to 48 hours later And then that's the same time the pain kicked in that's cool you into the problem So we have this immune response happening and inflammation then all of a sudden we start getting fluid accumulation And now there are what are called noor and you're probably very obviously you're very familiar with these and these are your pain receptors What's actually interesting is we don't necessarily know a lot of information about how many pain receptors are in muscle They're not really in the belly In fact this is why I can perform my muscle biopsies and they don't really hurt You

mean in the belly of the muscle correct We do have pressure sensors though And so if you change the volume of the tissue you will respond to that very very quickly So by enhancing swelling in the actual muscle that is immediately putting pressure on those pressure receptors if you will that's the signal So what's probably happening here And I just I just hate to give you another bone but a lot of delayed on some muscle soreness is probably just a neural feedback loop rather than it is actual muscle damage makes a lot of sense There's a lot of interactions between the um types of neurons that control touch sensation and pain sensation and itch sensation In fact a lot of people um kind of collapse itch and pain together You know that's something it's painful and it itches is a familiar thing for people mosquito bites and such Um And then of course there's the classic gate theory of pain uh which uh people will be familiar with And then I'll explain why I'm explaining this Um which is if you you something hurts you know you you bonk your knee or you stub your toe we tend to grab that body part and try and rub it and that rubbing is not a coincidental thing It activates a set of uh touch sensors that are that respond to kind of broad dull touch Um and that actively inhibits through the release of an inhibitory neurotransmitter the fibers that control the pain signal So anytime we we rub a you know like a Charlie horse our leg or we or we stub our toe and we you know we wince and then we grab the toe and we got like squeezing it a little bit that's actually deactivating or partially inactivating the the pain mechanism So the idea that uh a swelling response would then trigger a neural response that that then would recruit the pain receptor response here I'm using broad broad brush um strokes here to explain this um makes very good sense to me Um Now and only now that you've explained how this process works I can actually even add more to that So if you remember how muscles work so we have to have some sort of signal from the nervous system that has to actually go in and tell the muscle to contract Well remember there a few episodes ago we covered uh the physiology here of what's called the motor unit Ok Well what I didn't explain to you are called muscle spindles And we have talked about proprioception in uh an episode of before as well but we never tied this picture together So let me walk you through that really quickly and it's gonna tie this loop in into a nice bow So what happens is um this motor unit is is coming in from what's called an alpha motor unit And that's gonna be innervating your muscle fibers and that's gonna tell the muscle fibers to contract Those are typically spread out throughout the uh all sides of the muscle in interior or exterior all over on the outside though there is another type of muscle called

a muscle spindle Now these are noncontractile So they don't have that Actinomyosin and they don't produce force they are responsive they are proprioceptive So what that means is they sense stretch And this is why for example if you were to um stretch a hamstring stretch any muscle group it doesn't really matter or muscle its innate response is to fire back to close that distance And this is what keeps you from say if you're leaning to the right Um You can imagine that the example we give is if you're if you're standing on 1 ft and you start swaying to the right All right let's say you're standing on your right foot and this makes this easier for folks and you start swaying to the right like you're gonna fall on your right ear will hit the ground The inside of your right calf muscle will start being stretched the outside will start being compressed right So they stretch on the inside of the right calf muscle will sense that stretch and it will respond by contracting that pulls you back to the middle and stops you from falling That's proprioception and muscle spindles and stretch and tell you to contract the way that they work is through gamma motor neurons And so these are sensory things So what's happening is unlike when you tell your muscle to contract it goes alpha to the muscle contract these muscle spindles work so that it is oh I've been stretched send signal back to some central point typically in the spinal cord And we don't actually want to go all the way up to the brain We've got a time delay This is why these are subconscious autonomic right versus somatic So the gamma is gonna go back to the central location and then come back to the alpha motor neurons and tell it to contract So you have this wonderful mechanism of sensing stretch going back Well one theory that's been put forward regarding muscle damage is that the pressure is actually being applied to those nerve endings of the muscle spindles And that's actually responsible for the pain signal that's going back and coming up to your brain And you're registering that as pain rather than it is actually in the the contractile units So the muscle fibers that that's a very intriguing idea uh because it would suggest that stretching muscles in order to alleviate soreness might be the exact incorrect thing to do Now I'm not saying that's for sure for certain I'm just building off the mechanistic logic that we've laid out here really that you've laid out here there is the more effective principle based on exactly that which is this is generally why low level movement is effective at reducing acute soreness because that's low level contraction of the muscles and you're gonna stretch and get tissue out and you get fluid out Wow you're literally pumping it out of the the cell Yes And in our previous episode where we were talking about programming we keep using the wii

but let's be fair here where you were educating us including me um in the audience about different structures for programming exercise for specific adaptations et cetera the month week year scales et cetera We had a brief um discussion about the fact that if one trains legs very hard with resistance training you know some heavy squatting or dead lifting it or and there's some soreness that oftentimes doing some quote unquote lighter cardio or um some uh low impact work the next day or or any number of different things that involve um not high intensity uh contractions of the muscles But that do require contractions of the muscles that it can alleviate soreness more quickly than if one were to simply lie around and you know watch Netflix or something Yeah that's exactly right The um to go back just a little bit as well the if that's really the case um the question is like where is this inflammatory signal coming from And while there's much to be learned there uh there is a little bit of information right now that suggests it's potentially coming from free radicals released from the mitochondria Again that may or may not hold up as more research comes I'm not sure But if you remember back to our uh conversation on endurance so we talked about the electron transport chain and a role with metabolism And regardless of whether or not you're getting energy from glycolysis or carbohydrates remember they have to be finished through aerobic metabolism So even if you're lifting weights and you're using carbs for your fuel you have got to finish that metabolism by running it into the mitochondria and performing oxygen metabolism as a result of that that electron transport chain runs So theoretically if free radicals which is um which are hyper reactive oxygen species basically they're oxygen molecules that are missing electrons so that they react to a lot of things Um they're the opposite of antioxidants By the way this is you know the oxygen modules with extra protons So they can balance the charge if those leak out that in and of itself is going to be a massive inflammatory signal and that's probably what signals the cause of these neutrophils and macrophages and kicks off this entire cascade again I believe we need more research there Uh I need to look into it Maybe it's more definitive than I that I know Um but that's probably what's happening potentially what's happening rather that causes that cascade in signal also Um what you have is this combination of well if that's the case why am I not getting tremendous amount of muscle damage when I do more aerobic based exercise Well because you don't have the mechanical tension pulling on the fibers that's actually causing damage to the cell wall that allows these free radicals to escape the mitochondria and the cell wall So that's the best we can postulate at this moment as to why those

things are happening and then why again low level exercise tends to enhance uh even things like percussion Um So using either instruments that put a low level of vibration in your leg or like pneumatic boots So you massage all these things are generally probably helping because they're moving that stuff out edema most specifically So pressure comes off of those nerve endings in the muscle spindles and allows you to stop receiving that signal of pain Despite the fact that you didn't actually regenerate tissue at all yet