Optimizing Lower Extremity Strength and Power in the Masters Level Runnert

Recorded October 20th, 2020

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PhysicalTherapy.com Course #3889

- [Calista] Today's title is "Optimizing Lower Extremity Strength and Power and the Masters Level of Runner." It is my pleasure to welcome back to PhysicalTherapy.com. Christopher Johnson. Chris completed his undergraduate studies at the University of Delaware, where he earned a bachelor's of science with distinction while completing a senior thesis and the physical therapy department under Dr. Lynn Snyder Mackler. Chris was a member of the varsity's men's tennis team, a scholar athlete, a team captain and a recipient of High-Tech Award for excellence in athletics and academics. He remained at the University of Delaware to earn his master's degree in PT while completing an orthopedic and sports graduate fellowship under Dr. Michael J. Axe of First State Orthopedics. Chris is currently open and is working at PT to provide unparalleled physical therapy and performance coaching for Multi-Sport Athletes in the Pacific Northwest. He is also the co-founder and CEO of Run Cadence, LLC, which is an iOS app that helps runners apply step rate manipulation to their... and outside of his professional work. Chris races triathlons at the amateur elite level, and he's a five time USAT All American at three time, Kona qualifier, and one of the dominant age group athletes in long course triathlon. Chris is also extremely extensively published in the medical literature and is sought after international public speaker. We are so glad to have you with us today, again, and part of this virtual conference, Chris. And at this time I'm gonna turn the microphone over to you.

- Thank you very much Calista. I just wanna make sure that everything is coming through clear on your end. Okay, fantastic. So I want to just start by thanking everyone for carving out time from their busy schedule. It looks like we have close to 70 people on the call. So thanks for joining, and hopefully I'll make this worth your while. So the title of this talk is "Optimizing Lower Extremity Strength and Power in the Master Level Runner." In terms of disclosures I've received an honorarium for presenting this course in terms of nonfinancial. I have no relevant financial relationships to disclose outside of

what Calista had mentioned regarding the Run Cadence app in terms of content, this learning event does not focus exclusively on any specific product or service. And this course is presented by PhysicalTherapy.com. So the learning outcomes upon completing this course, the attendee will identify at least three primary muscle groups of the lower extremity affected by the aging process. Identify and conduct at least two assessments specific to the calf muscle complex. List at least two major running gait related changes that occur among master level runners. And list at least two primary exercises and rationale for utilizing them with the master level runner. All right, let's get things rolling here.

So welcome again. It's fun to be back in sharing my perspective with PhysicalTherapy.com and it's sort of ironic that I am talking about training or working with a master level runner because I never thought I would find myself here and at the ripe age of 42, I fit the script. This is actually from last actually, yeah, I wish it was last summer. The summer before racing Ironman Canada. And I've learned a lot, not only from just my time in the clinic and coaching athletes, but now as a master endurance athlete.

I feel like I'm that much more in tune into the needs of this demographic. And I think we're all looking for the fountain of youth and a lot of our abilities and skills are unfortunately fleeting, but there are things that we can do to try and delay the normal age related changes. You'll hear me reference Dan John on occasion. He's a brilliant strength coach and human being. He's a Fulbright scholar. And one of my favorite quotes from him is "Don't act your age, but train your age." And our training is definitely going to change over the course of our lifetime. And if it doesn't, we'll probably run into problems. And I think that a lot of Master runners are looking for tips and tricks that ultimately are really more of a trap than anything that will get them into trouble. So what do we see? We're seeing a big rise in terms of participation in endurance sports among master athletes. The picture on the right here is my good

friend and old sparring partner from when I lived in New York city, Stephen Day. And he would have been slated to potentially win his age group in the Hawaii Ironman World Championships this year. 50 to 55. And he didn't start up triathlon until his early forties. And he's currently running a three hour marathon off the bike, it almost 50 years of age. And he is just the epitome of what we strive for as a master runner in Endurance Athlete. So as I mentioned, we've seen endurance participation among master athletes steadily rise in recent decades. If you look to the New York city marathon finishers over 40 has increased approximately 170% between the 1980s and 2000s with the largest increase in runners over 60 with the 3.5 to 4.8 fold increase in participation. And also finishing times and runners over 50 have also improved between 1983 and 1999. And this has been more evident in women. And lastly, average age of the 2015, group of triathletes and Kona, average age was 43.2. And there's probably a number of reasons for this, which we'll touch on. So let's take a step back and just do sort of a quick crash course in running. And I think this is really important to bear in mind. So when we go to discuss some of the exercises and interventions that they'll ultimately prepare the master runner for the performance demands of the sport. So With walking, 60% of the time is spent in stance and 40% in swing.

And we see a reversal of the support characteristics with running. So the main thing to appreciate is that when you're running, you're either in contact with one or none, which makes running apply a metric activity. And even though it's a plyometric activity, it's a low level one, but this is important because we're gonna ultimately need to address that aspect of the running gait. In terms of range of motion at the foot and ankle. I think the first thing that we have to agree on is it's complex and a lot of the research studies that exists are really going off of rude and crude models. So we have to be pretty conservative in our interpretation of those. What we do know is it, the leg has to advance over the foot. And in technical jargon, we refer to this as ankle dorsiflexion. The net ankle mobility and running is gonna be slightly greater than walking 50 versus 30 degrees. And in terms of a full toe flection of the MTP joints, ideally we're looking for

someone to have probably at least 30 to 35 degrees of great toe extension. But I'll be the first to tell you that I know plenty of people who don't have that kind of motion. And it's still able to run at a very high level. Though they do have some minor compensatory changes. When we get to the knee. When we're talking about a close chain, the knee is gonna cycle between 20 to 45 degrees of knee flection. The slower that you run, especially if you have a lower step rate, you're gonna probably get to the higher end of that 45 degrees. And obviously if you're running faster, you're gonna have relatively shorter ground contact times. When we talk about open chain, think of your heel working towards your bottom. We're gonna see anywhere from 90 to 130 degrees. Again, that'll be dictated by running speed with sprinters, basically having their heel hit their bottom. And the knee is also gonna extend to approximately 10 to 20 degrees of full extension at terminal swing.

Sometimes you may have people that are initiating contact with the ground with a fully extended knee. And that's what we often refer to as over-striding. And as I mentioned in sprinting, the absorption is shorter in the knee flex is less Working our way up when we get to the lumbopelvic-Hip region, the hip is gonna cycle through a flection extension of our arch of approximately 40 to 60 degrees in recreational runners. Hip flection range of motion will increase as velocity increases.

And the hip can be flexed up to 65 degrees in swing phase and extend to 11 degrees. But appreciate that hip extension is a coordinated movement. And there's actually a very interesting study that was recently published where they took a group of people who they identified as having tight hip flexors, and they put them on a strict stretching protocol for roughly three to four week period. They showed that they statistically change their hip flexor extensibility, but we saw no changes in their running. All right, so this is something that I personally don't tend to prioritize a lot, and this is sort of a sidebar, but I see too many runners that present to me in consultation. Who've been doing aggressive hip flexor stretching. And if anything, they've just sensitized the

anterior portion of the hip. So again, respect the fact that this is a coordinated movement between the low back pelvis, hip and thigh. In mean trunk flection angles will range from 2.4 to 13 degrees with mean pelvic A-P tilt angle, usually between 15 to 20 of anterior tilt. And also Keeping in mind that anterior pelvic tilt in normal standing as approximately 11 degrees. So when we run, we anticipate a slightly greater degree of anterior pelvic tilt. And this just goes to show this is a still pic or a screenshot of me running at conversation pace. And it's just highlighting the fact that running is a relatively mid range activity. All right. So that's important to know when we go to, when we go to consider exercises that we're gonna use to challenge the runner. And we can go back to the presentation. If we look at energy sources going from walking to running, to sprinting, the main thing that you'll see with these pie graphs is when we're talking about walking, the majority of the energy is gonna come from the foot and ankle. All right. We'll have some contribution from the hip flexors in terms of clearing the leg during swing.

But again, this is a predominantly a foot and ankle based exercise. When we go to running, the big change that you'll see is the shift to the knee. So again, 41% still coming from the foot and ankle with 22% now coming from the knee. And we'll still have some contribution from the hip flexors and extensors. And then as we go from walking to running to sprinting, we still see a contribution from the foot and ankle. We actually see less at the level of the knee and greater energy coming from the hip. So as I always remind people, the faster we run, the more the force is shift upstream. And bear in mind when we're talking about sprinting, we're talking about basically approaching 20 miles per hour. So very few people that are gonna be consulting us are gonna fall into this demographic, but it's just helpful to conceptualize how the strategy shifts as we increase running speed. When we look at contributions to propulsion and support, the main thing is there is a breaking phase in a propulsive phase. And when we talk about the breaking phase, this is gonna take place during the initial 60% of stance. The quad is gonna be the main contributor to both braking and support. This is

particularly gonna be the case with someone who's a rear foot striker. And it's gonna contribute twice a peak breaking acceleration in nearly half of peak vertical support of the body mass center. All right. We'll also have contributions from the glute max, Gmed and ADDuctor magnus, which is often referred to as the extensor Magnus. And together they'll contribute about half of the peak vertical support after initial contact. And then when we get to the propulsive phase, this is gonna be the latter 40% of stance. This is where the soleus and gastric become the main contributors to propulsion and support. And they're gonna provide greater than twice the peak forward acceleration and over half of the peak vertical support of the body mass center. And it's also worth knowing that during the propulsive phase, the quadriceps are continuing to resist forward motion. So obviously when we sort of submit all of this information, the quads and the calves are front and center.

The hamstrings tib ant and iliopsoas will also accelerate the mass center downward at the end of stance. So basically when we're running, which is more of a steady state activity, the lower limbs are gonna behave like Springs with no net change in average mechanical energy. And if we're accelerating, which would be the case in safe sprinting, the lower limbs are gonna function more like motors, doing positive work to generate power, to increase kinetic energy. And this is an image that which really was kind enough to let me reproduce.

And this is based off of the study by Dorn and colleagues. And this is just a really great way to conceptualize the different tissues and muscle groups that we're calling on during the running gait. And what's interesting is it, this is in pretty stark contrast to what we see in the lay press. So again, we're seeing this range because this is a function of running speed. So if we work top down, so the glute max gets a lot of attention. It's only putting out 1.5 times body weight for us, the glute made 2.6 to 3.5 times body weight force. The hamstring is 2.1 to nine times body weight force. The nine is really gonna be kicked in when we're talking about sprinting, the quads four to

six times body weight force, the guads 2.5 to 3, and then the solely is 6.5 to 8. Again, just reminding you that, where are we gonna concentrate our efforts? Well, they should largely start to mirror what we're seeing with this slide. So again, when we talk about less than 7 meters per second, that's 15.7 miles per hour. The plantar flexors will contribute most significantly to vertical support forces and increases in stride length. Once we're right around 7 meters per second, the contract out conditions for these muscles will deteriorate because of increased shortening velocities. And then once we get above 15.7 miles per hour, the strategy will shift from increasing stride length, which becomes a game diminishing returns to increasing stride frequency. And this is achieved by the synergistic actions of the ipsi and contralateral hip musculature. And these are just some other tables that I adapted from that article.

And again, what you'll see going from slower to faster running, we're gonna see shorter ground contact times, and we'll also see an increase in the stride frequency per second. Again, looking at peak forces developed by the muscles expresses a percent of body weight. So is we go, if you look at the top row as we go from 742 minute per mile to 510, to 349 to 3 minute per mile. What you'll see with the iliopsoas complex back to the point I made earlier is the faster you run, the more the force is shift upstream. So obviously we're gonna see the greatest contribution.

Once we get to those faster speeds. Again, we don't see a ton with the glute max. You'll see it increase as a function of speed, but nowhere near the iliopsoas complex. And we'll also see the hamstrings start to take on greater importance with faster running speeds. The quads are pretty steady if we look at the vastus lateralis and the gastroc again, is playing a role, but the obvious muscle that we're zooming in on here is the soleus. So you can see going from 742 up to 3 minute per mile pace, it's really working pretty hard. It actually starts to work a little bit less hard because of the shortening velocities of sprinting, which start to get away from the optimal force velocity relationship of this muscle group. Then when we look at peak muscle

contributions to the vertical ground reaction force, again, we see this theme of the soleus and the quads playing an important role. So I just put those in really for your reference. And this is also why we see the faster you run the forces start to shift upstream, which is why oftentimes when runners pull up lame, who are sprinting, they're gonna be reaching towards their high hamstring because of the demands of sprinting. So moving on to the workhorse of running. So basically the major takeaway from the door and it all study is the solely is a big player.

And we often refer to it as a workhorse or the powerhouse of distance running. So that's gonna be a big focal point. And this is something that becomes that much more front and center. When we start talking about the master runner, just considering the aging process. This is a table that was adapted from Kim Herbert-Loser manuscript from 2009. And I'm not gonna spend too much time on origin insertion. The thing that I want you to appreciate though, is when we look at the physiological cross-sectional areas, the surae as well as it, the different portions of the gastroc.

You can see that the soleus relative to the medial gastric and lateral gastrocs, it's a 6 to 2 to 1 ratio. Okay. So the solely physiological cross-sectional areas about three times that of the medial gastroc and almost eight times that of the lateral gastrocs. And also just note that the medial gastric is roughly 2.5 times that of the lateral gastroc. What we'll also see in terms of fiber type size and distribution, is the soleus is approximately 30% larger than the medial and lateral gastroc and it's composed primarily of type one fibers, which makes sense given its role with running. So what's the role of the plantar flexors? Well, the muscle tendon unit design of the plantar flexors is gonna tendon and elastic strain energy over muscular work. And this is really for the sake of improved mechanical efficiency of locomotion. The majority of the muscle tendon unit length change is composed of tendon stretch and recoil. And this applies to the medial truck in the soleus. And this is essentially gonna allow us to generate force more economically by optimizing the contractile conditions of skeletal muscle in terms of

force, length, and force velocity relationship. All right, bad news first. What we know is that upwards of 80% of runners are likely to sustain a running related injury over the course of the year. And one of the things I always joke with in terms of the runners that I work with is the 80% rule. And I want them to just bear this in mind, because a lot of the times people don't handle their training intensity distribution, as well as it could. So the 80% rule is 80% of runners run at 80% intensity, 80% of the time, which is why upwards of 80% get injured. The other thing that doesn't bode very well for us is one of the greatest predictors of future injury is a previous injury. So anytime we're working with a master level runner in particular, you can pretty much bet on the fact that they will have some remarkable past medical history whether that's an ankle sprain or something going on in the lower leg, but we want to really make sure that we collect a detailed history because we're gonna have a better lens into potential impairments that may be worth addressing.

When we look at the frequency and sex distribution of the top 10 injuries in runners, we end up seeing a lot of the usual players. So patellofemoral pain, iliotibial pains, syndrome, plantar fascia, apathy, meniscal injuries, medial tibial, stress syndrome, patellar, tendinopathy, Achilles tendinopathy. All right. So when we look at what the common denominator is among these different diagnoses or presentations, what we're gonna see is a lot of issues tend to hit the knee in distal. All right. So again, we're gonna really zoom in on this region of the body in working with master runners. So what's a typical injury profile. I see a lot of high school runners and collegiate runners and then a lot of master runners. So with the younger runners, we tend to see more knee and lower leg injuries in the form of iliotibial band syndrome and medial tibial stress syndrome. The latter of which is probably the main thing that I'm seeing with a lot of high schoolers. With master runners, we start to see more muscle in tendonous injuries. So we will see some stuff upstream above the level of the knee at the hamstrings. But we tend to see a lot of issues affecting the plantar flexors and the Achilles tendon. And this is expected in runners who exhibit lower leg stiffness during

running. The other thing that we've started to really establish is among master runners we don't tend to see a lot of osteoarthritis. So there's something that is likely chondro protective in terms of running at the level of the knee. And there've been some great studies in recent years, highlighting this. In terms of injury rates, master runners, 49% reported a running related injury in the previous year, compared with younger runners, master runners, more likely to experience multiple injuries in previous years versus younger runners. So let's start to take a closer look at the Achilles tendon. It's the most common running related injury among master runners with the prevalence of tricep surgery and Achilles tendon injuries increasing significantly after the mid twenties in highest in the fourth and fifth decades. What we've started to learn through the literature is high plantar flexor capacity and function seems to be protective against Achilles tendinopathy.

So if you have greater eccentric plantar flexion strength, and greater propulsive forces during running, you actually have a reduced risk of developing an Achilles tendinopathy. On the flip side of the coin, reduced plantar flexion strength in a running pattern that involves posteriorly shifting the center of pressure under the foot. Actually increases the risk of Achilles tendinopathy, even though it's reducing the demand on the Achilles. So one of the themes that you'll start to appreciate over the course of this talk is this concept of stiffness.

All right, so there was a 20% reduction in Achilles tendon stiffness is observed in individuals presenting with an Achilles tendinopathy. And this is similar to the 17.1% less Achilles tendon stiffness noted in older versus young, healthy individuals. A less stiff Achilles tendon will experience greater tendon strain when transmitting plantar flexion muscle forces. So what happens as we age? So, as I mentioned, the plantar flexors are the powerhouse of distance running, especially the soleus. So as we age, we start to see declines in muscle mass, cross-sectional area, maximal and rate of force production, tendon stiffness, as well as a rate of collagen synthesis. Highlighting

the importance of the plantar flexors during running concentric ankle power during running is strongly associated with stride length in the peak propulsive ground reaction force. And we also have to start considering the influence of sarcopenia. And this is a very complex topic that we're far from understanding, but in general, the things that I would want someone to know about sarcopenia is that there's a reduction in muscle mass and function with aging. A gradual decline in the muscle fiber number that begins around 50. Early sarcopenia is characterized by a decrease in the size of the muscle.

And you're gonna have a replacement of muscle fibers with fat changes in muscle metabolism, oxidative stress, and degeneration of the neuromuscular junction. It seems to predominantly affect type II fibers, whereas a type I are less affected. And runners will exhibits a slower decline and speed and strength with aging relative to more sedentary people. The good thing is we know that resistance train can be somewhat effective in preventing and treating sarcopenia. All right, so and it's most likely operating or acting on the level of the neuromuscular system. And you're gonna have increased hormone concentrations and rate of protein synthesis. This is what I want you to really start to appreciate here.

So in terms of running gait changes, when we look at the temporolspatial parameters, you're gonna see a 4% to 6% higher stride frequency. All right. So if we're losing these propulsive abilities, we're gonna try to offset that in some way. And the way that we're gonna generally do that is to increase our cadence. And if you watch any masters level runner, especially during a race, they almost take on this appearance of like they're shuffling. All right. And also remember that step rate is inversely related to step length. All right. So is step rate goes up, you're gonna have a shorter step length. It's predicted that a 13% reduction in step length will occur between the ages of 20 and 60 with upwards of a 20% reduction step length by the age of 80. And what you also see is these will be a lot of the changes that we see with tinkering with cadence. If you're working with runners and you have any appreciation for step rate manipulation or

cadence manipulation. We'll start to see a very similar pattern here. So with decreased step length, you're gonna have a more flexed knee at initial contact, and there's gonna be a reduced excursion of the ankle, knee, and hip with less vertical oscillation of the center of mass. And again, related to the reduction running speed and step lengths, we'll see decreased peak propulsive and vertical ground reaction forces in the master runner. This is a big one that will definitely impact how we approach what we're trying to accomplish in working with the master runner. So in terms of ankle power, so think push-off concentric ankle power during running can decrease almost 50% between the ages of 20 and 80. And this is not offset with greater contributions from the hip and knee in this diminished ankle power is gonna also be observed during walking and in older adults. So again, this just highlights the fact that with aging, that you're gonna have the calf muscle complex being preferentially affected without any offset from other regions of the lower extremity.

So with regards to stiffness, master runners, also exhibit less leg and ankle stiffness relative to younger peers. And while young runners maintain leg stiffness across a variety of endurance per speed. Leg stiffness in the master runner will tend to decrease his running speed increases.

This decreased ankle power door during running may be a protective adaptation to operate within the reduced capacity of the plantar flexor muscle tendon unit to decrease the risk of injury. If you look at any well-trained master runner. So if you watch my friend Steven Day, who I put up at the beginning of the presentation, he likely has comparable leg stiffness versus younger runners. But again, he's well-trained, and he's prioritized resistance training over the course of the past several years. So what are the key findings here? What you're gonna see with the master runners, decreased calf muscle volume, decreased tendon stiffness of the Achilles, decreased ankle power and propulsive force, decreased leg stiffness, decreased knee and ankle excursion. And this should say increased stride frequency and increased risk of Achilles tendon, calf

strains, sorry for the glitch there. So it's also important to just know what running modes will increase plantar flection demand. Not only when someone is ready to go out and perhaps layer in some hills, but also how to avoid someone incurring an unnecessary injury. I have a lot of friends that say, "I can't wait to go on vacation and run "on the beach along the water." And that's something that you likely want to discourage a master runner from. The same thing goes, if you're working with a master runner who is in a part of the world where the weather's not great and they have to run inside on a treadmill, we know through Rich Willie and his team's work, that that's gonna place a greater demand on the ankle plantar flexors. So again, soft surfaces, inclines, speed work, and running on a treadmill.

And we also need to be aware of any antibiotics that someone's been put on, just because we know that they can retard collagen synthesis. So if you ever have someone and I just, I've worked with a couple of athletes in consultation, recent weeks who were on an antibiotic, and you just wanna make sure that they're not on one of the fluoroquinolones. So what's the good news. The good news is a lot of these changes that I just covered while we can't prevent them, just because they're part of a normal age-related process. We can do things to slow down that process and to really make sure that a lot of these runners who have a remarkable past medical history involving the lower extremities, especially the lower leg that we completely rehab them to the best of our ability.

All right. I just got off the phone with an athlete over the weekend who wants to do an Ironman in the upcoming weeks. And he ended up sustaining a calf strain and he, upon being questioned saying, "Hey, what do you feel like you're ready to start running?" He said, "Yeah." Because the pain is gone. And this is a very common theme is with a lot of folks. We're all human here. Once the pain subsides or resolves, if people think that healing has taken place and any potential impairments are no longer it play, and that's something we need to really go in and test and make sure we know what we're dealing

with. So what are the physical performance tests that we're gonna look at? And this is really getting into the crux of this presentation. So we can look at a single leg calf raise. We should look at pogo jumps to get a lens into reactive strength, as well as energy storage and release. We can look at single leg hopping in terms of how we express power in the lower extremity. And we could look at a single leg broad jump. And lastly, We want to look at the meaningful task, which is running. All right. Some apps or equipment that I tend to use when I'm working with runners. I'll use the calf raise app from Kim Herbert-Loser. I will use the My Jump 2 app. The first one is free, the My Jump 2, I think is 999. If you have a dynamometer by all means, use it, especially if we're gonna try and get some raw numbers on solely strength. And then you can look at the Runmatic app in terms of helping to demystify someone is running in terms of certain biomechanical factors.

All right. And I Just threw these in, I mean, we could spend the whole lecture talking about each of those apps in isolation. But this is just a slide that I screenshot a couple of the images in terms of results. So the top three images across the top are from the calf raise app. And basically what it'll give you is an objective measure of the height of each calf raise. And then you can also take a look at the power and then compare the left versus right, in terms of work. If we go to the lower left, this is just a screenshot of the Runmatic app in terms of biomechanical factors.

So it gives you contact times, flight times, step rate or frequency, vertical oscillation, relative max force expressed as a percent of body weight and leg stiffness. All right. So in terms of contact time, just to put this out there now, is we ideally want to see a ground contact time of less than 250 milliseconds or 0.25 seconds. So again, this is a really nice way using a simple app to just go in and get some hard data. And then the My Jump 2 app, this is just looking at me doing some pogo jumps. So it gives me the mean height, and then it shows you to the extent any fatigue is setting in over the course of a series of pogo jumps in place. So we'll go through these systematically. I'd

say the most common assessment that clinicians are doing and working with patients, especially runners is they're doing the calf raise test. And this is a commonly used screening tool to assess a tricep surae muscle tendon unit and lower limb function. And it basically just involves single leg calf raises. So that's the primary outcome, but we wanna be a little bit more on top of how we're conducting this in terms of standardization. In making sure that we know when to pull the plug and saying the test is over because I've seen a lot of clinicians who are misinterpreting the results where they may say, "Hey, this person got 20 reps."

And if I were to go in and assess them, I may have stopped the test at five because they weren't hitting peak amplitude, or they lost the rhythm of the calf raise. All right. This is a table that just gives you some considerations or taking a little bit more in depth, look at the calf raise test in terms of how we may be able to bias it slightly, depending on the tissues that we're looking to assess. So, but again, most of the time we're looking at this is sort of a strength endurance test. And to be honest with you, I don't put a lot of faith in this test just because I expect people to be able to do at least 20 plus reps. But it's not really approaching the forces that we're gonna get into with running.

Do I think it's an okay test in terms of a starting point? Yeah, for sure. Especially if someone has a history of an Achilles tendon rupture or an Achilles tendon repair, but it's not really broaching the forces that we're dealing with in terms of the running gait. There's always a lot of discussion about soleus versus gastroc. So it's important to appreciate that the soleus is gonna produce similar force irrespective of the knee position. The gastroc is gonna generate less force with the knee in large degrees of flection. So what we see is once you start approaching 60 degrees of knee flection, we start to see that gastro being taken out of the equation. And if you really want to have confidence that it's not doing much in the way of contributing to a calf raise test, you would want that person at 90, but ideally a 100 degrees of knee flection. All right. And

this makes sense when you see the seated Soliz machine at the gym. The gastroc will account for between 3.7 and 11% of identified deficits in runners, dealing with an Achilles tendinopathy that's Seth O'Neill's research, but the soleus may be responsible for the remaining 23.2 to 36.1% of the difference. So again, we see the importance of the solely shining through here. And as my friend, Brad Beer likes to say below the knee is key in working with runners. So if you could play the video here. So this is in a way that if I were going to do a single leg calf raise, based on what's been published in the literature, this is how I would set someone up. All right. So you're going single leg, I'm on a bumper plate in this case.

So I'm trying to basically start someone in roughly 20 degrees of ankle dorsa flection, and then have them work up to peak height or amplitude. You can basically, if you have someone in front of a wall, you can have fingertip contact just to make sure they're keeping their trunk and torso square. In this case, I'm just using a simple fingertip contact, but I'm not using my arm to add to the calf raise assessment.

And we can go to the next video And in this one, this would be how you would do this test. If someone has say an insertional Achilles tendinopathy, because we know that if you go pass the plane, or if you go in any degree of dorsa flection, that it may sensitize the situation. Now I'll also do this to a metronome it 30 beats per minute, because I wanna get at that rhythmicity. All right. So that would be another criteria that if someone can't maintain the rhythm of the assessment, that I would stop the test. All right. If we could go to the next video. Bear with us one second. So this is a way that I typically test it, assuming that the person's not dealing with an insertional Achilles tendinopathy. So I'm basically putting the non-involved or the non dorsa leg on a platform, which essentially will take that leg out of the equation. It's not gonna be able to do much in terms of contributing to the calf raise. But I also don't want to turn this into a balancing act. All right. The goal is to really assess the calf muscle complex or the muscle tendon unit. So this way I'm cycling someone through the ranges that

they're going to encounter during the running gait, which is roughly 20 degrees of dorsa flection to 10 degrees of plantar flection. And if this is too easy for someone, you could also have them start holding a dumbbell or an external load in the same arm as a stance leg. And I usually would say 10% of body weight would be a reasonable starting point. Now you also have to respect the fact that with some master runners, that they may have limited first MTP extension or Hallux Limitus. So that's just something you need to factor in in the event that they have a tough time getting to a certain amplitude that you would otherwise expect. And we can go to the next slide. All right, and again, based on the work of Lunsford and Perry you'll see, 25 is a number that's often that's often thrown out and you'll be surprised how tough of a time people have doing this.

These are the normative values that Kim Herbert-Loser developed and this is nice because she essentially stratified things as a function of decade. So the main thing is though, is that even up to 70 years old, we should expect people to get close to 20 calf raises. So again, screenshot this committed to memory and this is something that, if you're gonna use that calf raise test, that these are the values of the targets that we're looking for. Now, this is a dynamometer.

All right. And we all know that just telling some of they have a four out of five or five out of five is probably reductionist. So if we are gonna go to in and truly test the soleus this is what you would want to use and these are roughly $800. The ones that are handheld are just probably not robust enough. So this is something that people can reach out if they have any questions. But this is a one that that I recently ordered to start testing solely as strength, but appreciate that we still don't have any hard data benchmarks. Seth O'Neil has thrown out two times body weight force as a target if we're rehabbing someone falling in Achilles tendinopathy. But the main thing is we just wanna get them tolerant of to have a certain amount of strength, but really for them to be tolerant of the running that they're doing, especially in the way of energy storage and release. So if we

could play this video. So these are pogo jumps. And this is something that I would, again, I would use the My Jump 2 app, when I'm looking at this and essentially what you do is you freeze frame or indicate where takeoff is and where landing is. And this is really getting at the ballistic or plyometric nature of running aside from the fact that it is double leg. But we would want to do double leg before we get someone, a single leg hopping. Now with pogo jumps, I am generally doing these at 150 beats per minute. Blaze Williams has a running readiness scale and he throws out 160. I wouldn't be wed to any specific number, understand that the lower, that beat frequency is the more challenging it's gonna be because you're gonna have to have longer flight time. So when you're doing Pogo jumps, the things that you wanna be on the lookout for is you don't want the heels hitting the ground.

All right, because you're gonna be in contact for too long. You also want to really minimize knee flection excursion. So you're really biasing the load towards the calf muscle complex in the Achilles tendon. All right. And I'll usually look at this for 30 seconds and I'll capture 15 Pogo jumps with the app. If we could go to the next slide. And then this is just looking at a single leg hop for distance. Where we're essentially trying to look at the role of the lower leg in conjunction with the kinetic chain. So again, with this, I'm just looking at a side to side assessment and I'll use the My Jump 2 app. Again, to look at distance. And I don't expect it to be perfectly symmetrical. I would like to ideally see less than a 10% side to side difference though. If we could go to the next video. And I would also look at single leg hopping. I didn't put that video in here to avoid redundancy. So back to Dan John, a couple quotes that I love that I think would just really be helpful or resonate with you. 80% of training should be spent practicing the sport. All right, so with a lot of the master runners that we work with, I think they're always concerned that this is gonna start to interfere with their training, or they don't have enough time. So we'll approach it from the prisoner's dilemma standpoint, which is basically if you have two to three sessions of say, 15 to 20 minutes a week, what are you going to do? And you'll really sort of consolidate your resistance training. 20% of

training should be spent in the weight room, improving strength should help an athlete, improving technique should help an athlete, improving both strength and technique should really help an athlete. You only move forward by vigilantly and aggressively sorting out your weaknesses and your gaps and bring them up to some standard. Being enamored by the visual similarity of an exercise to a sport or life task will prevent you from doing some very productive exercises. And one of my favorite quotes from him is concentrate on doing fewer things better. And hopefully that's a theme that resonates throughout the next portion of the talk. So the thing that we're ultimately addressing, and this is taken from Joe Cook and Sean Docking's editorial and BJSM is this concept of capacity.

All right, so a tissue is at full capacity when one's able to perform functional movements at the volume and frequency require without exacerbating symptoms or causing injury. Oftentimes when we're working with a master runner is they've lost capacity and they may be operating on the right side of the fence, but all it takes is a poor night's sleep and overzealous training session. And then they tip the scales and start to get pushed back injury, sensitization of certain tissues. So when we go to restore capacity, we're gonna try and build it in a considered gradual manner by progressing the intensity and complexity of movement specific for that tissue and region.

And as the saying goes, it was with a lot of endurance athletes, especially master runners who can be quite stubborn is 'You can lead a horse to water, but you can't make it drink.' All right, so I tell people, I say, "Hey, look, this is what I would be doing" or "This is what I do as a master runner "and triathlete in hopes of them getting "in hopes of getting some buy-in." But the reality is most runners aren't gonna do a much beyond run. All right, especially if you have sort of other barriers to resistance training. So a lot of the times I'll end up taking weights, cinder blocks, kettlebells to the track or to a training session because otherwise I know nothing is getting done. And this isn't

just the case with recreational runners. There's a study back in 2007 that showed that half of runners competing in the 2008 US Olympic marathon trials did absolutely zero strength training. And I do think that right now, strength training is a resistance training is very sexy. But there's still a lot of that we don't know. And I've seen resistance training get a lot of athletes into trouble, just as much as it's probably helped others. So what are the resistance training adaptations that we anticipate increased muscle mass, improve tendon qualities, greater strength, greater power, perhaps increase range of motion. You'll hear people say strengthen the lengthen, delayed muscle fatigue and improved activation or recruit. So as we start to talk about resistance training. It's important to just touch on some key definitions of muscle performance. So strength is a big thing that we focus on. So strength is a greatest force a muscle can generate in one effort against a maximal load.

So if anyone's ever participated in a research study on say an isokinetic dynamometer, say of the quadriceps, you be doing a max kick, max isometric kick at between 60 and 90 degrees of knee flection, just 'cause that's the optimal length tension relationship. Endurance, the ability of a muscle to sustain the same forest during a series of submaximal efforts, power is the amount of work of bustle generates within a given time. Plyometrics, think ballistic short ground contact times stretch shortening cycle. And then reactive strength, which has a lot of salience to running which has the ability to change quickly from an eccentric to a concentric muscle action.

Some other terms, as far as resistance training goes isometrics, they've gotten a lot of attention in recent years, thanks to a lot of research from Ebony Rio and colleagues. And people have looked at isometrics for pain amelioration, especially in the context of patellar tendinopathy. But unfortunately some of their true benefits have been overshadowed. Isometrics understand you can produce more force isometrically relative to a concentric-contraction. So they can actually be very helpful in terms of improving muscle morphology as well as tendon structure and function provided that

we're working at appropriate contraction intensities of greater than 70%. We see a mixed response in terms of the Achilles. Seth O'Neil is a first to show that and that's been supported by some followup research. So again, if someone's dealing with an active or reactive Achilles tendinopathy. Isometrics may help they've helped me in the past, but don't treat them as a rite of passage. A lot of the focus in working with this demographic is gonna be on HSR, heavy, slow resistance, so slow velocity of movements that are gonna improve muscle activation through enhanced recruitment of the motor neuron pool. So the classic set and rep scheme of say three to four sets of six to eight reps, two to three times per week is gonna do master runners a lot of good. It's gonna have a beneficial effect on muscle qualities, tendon stiffness, and running performance. So when you're doing these, it's like two to three seconds on the lowering phase, two to three seconds on the concentric phase. And also realize that bone as well as tendon becomes mechanically insensitive or death after 40 to 50 contraction. So we shouldn't be giving someone say four sets of 15 reps. If we're trying to really address someone who has a hip past medical history, remarkable for an Achilles tendinopathy for example.

Explosive resistance training thing, more of Olympic lifts. I don't tend to prioritize this a lot. I mean, you have to spend years trying to master that if that's a goal, but the lighter is loads being moved more rapidly to enhance firing frequent rate of force development. Plyometrics, we will talk about. And this is sort of, once someone establishes a reasonable level of strength, we're gonna use plyometrics to help them better express it. While again, bearing in mind that running is applying metric activity, but you're really looking at plyometric training to transfer max strength to power and rate of force development. And this isn't gonna have any change in terms of the architecture of the plantar flexors, but it can lend to improve the Achilles tendon stiffness. So people are always concerned. They're gonna put on more mass with resistance training or doing resistance training in conjunction with their typical endurance training. But what we actually see is we see improved running economy,

delayed fatigue, improved anaerobic capacity, improved rate of force development, as well as enhanced maximum speed. What are the mechanisms by which resistance training improves endurance training, altered muscle fiber type recruitment pattern. So we'll see increased maximum strength of the type one fibers, which is great because most endurance runners are gonna be relying on their type one fibers. We'll see an increased proportion of type two A, fibers and reduced portion of type two X fibers increase maximum force and or increase rate of force development, improve musculotendinous stiffness and improved inter and intra-muscular coordination. There's a lot of theoretical concepts that are put out in terms of how you sequence this stuff.

And I would say evolve them that there is some credence to block periodization, which is basically focusing on initially strengthened endurance. So perhaps this is more just building up your capacity, focusing on tissue tolerance, then moving to basic strength and then max strength in power. And there's some interesting research that shows that we should really be focusing on max strength until someone can really hit 1.6 times body weight force or at 1.6 times body weight in terms of a squat. All right, you have to give some leeway because that was not done in master athletes. But again, the point being is it, you can't get someone strong enough.

All right. So think of strength as a vehicle to better expressing power and rate of force development. In terms of exercises, it we're going to select, we have to take a step back and just look at the loads that we have to consider with running. So the cumulative loads, that's gonna be accomplished through running and consistency of training. It's the latter two here that we're gonna focus on from a resistance training perspective. So the strength training will get at the peak force and then some of the plyometric and reactive strength stuff that we're doing is really gonna get at the energy storage and release. We can try to mimic running. It's not critical I'll tell you what, I mean, doing a seated soleus raise. Doesn't look a lot like running, but does wonder if

we're trying to target the soleus. Primarily, we're gonna be looking at closed kinetic chain exercises with the leg extensor bias, and we wanna challenge the runner to be upright. And if possible, multi-joint though isolated exercises are oftentimes very helpful. If someone has a history of a patellar tendinopathy, I am going to have them on a knee extension Nautilus machine. If they are coming off of, say again, an Achilles tendinopathy, I would have them in a smith machine. I would have them on a seated soleus machine. So always think isolation to integration. In terms of mode, free weights are gonna challenge control and coordination a little bit more. There's a famous quote that go something along the lines of, "Resistance training is essentially coordination training underload," right? And as I mentioned, don't be afraid of machines. Often times, and this is something that I was even guilty of. I would say earlier on in my career is I would do a lot more unilateral training almost to the exclusion of double legwork. So understand first and foremost, with bilateral training that it's gonna be safer. And one of the important aspects to appreciate and working with master runners and triathletes is they start getting into their sixth, seventh, eighth, decade is safety is a critical factor.

You do not want to put these people, say doing a step up with a barbell on their back, stepping up to a platform because if they lose their balance, have to dump the weight. You get into more serious safety issues. So bilateral training is gonna be safer. You're going to have a greater platform to produce force because you have a wider base of support. And this is going to allow you to really improve the strength, power characteristics. Unilateral exercises, obviously decreased stability. They're gonna limit the safe prescription of heavier loads or performance especially in the context of fatigue. But they should be used to supplement the primary bilateral lifts. And obviously they have greater salience to running. So what are our goals with resistance training? So again, we have to consider the primary tissues that we're calling on with running, which are bones, tendons, and muscles. All right. And as I mentioned before, we have to deal with the peak loads, accumulated loads in energy storage and release.

The thing that is not discussed enough because there are limitations from a research standpoint is a rhythm timing in smoothness. And what we tend to see, whether it's working with, I have two young kids as well as older parents and what you see is this lack of smoothness. Now, kids are, through exposure and just moving will start to enjoy greater smoothness as they develop, but this is what we lose and people don't challenge this enough, which is where a metronome comes into play. Not only from an assessment standpoint, but also when you're doing certain exercises. So you sync up to the rhythm. So our goals are first and foremost to optimize calf muscle complex strength, especially in terms of the soleus.

We want to train ankle dominant, reactive strength. We want to augment quad and lateral hip strength. And we want to challenge single leg postural stability and lumbopelvic hip coordination. A couple other things to bear in mind in terms of max strength training. We're trying to get into meaningful loads. I think clinicians oftentimes are gun shy in terms of working up to heavier loads. Now you can't start here, but this is sort of giving you an idea of where we're looking to go. Rx if we're really focusing on strengths should be in the one to six range, doing three to five sets while providing adequate rest of three to five minutes.

And you'll hear this number thrown out quite a bit with resistance training two to three times per week. And I would say, a lot of the times set people are for success if you get them going twice a week. Great. In terms of targeting tendons, knowing that these are often afflicted by the aging process. Again, we come back to high intensity or contraction intensity 85 to 90% of an MVC applied in five sets of four reps with a contraction and relaxation duration of three seconds each with an inner set rest of two minutes. If you could play this video. So I used to always shy away from working my calves until I started taking a deep dive in the literature and what you'll notice with this particular exercise. And again, this is tricky if you don't have access to a gym is you have that knee flexed roughly 90 to a hundred degrees. And I'm working specifically in

the ranges and I'm likely to encounter during the running gait. So I'm not way up on my tip toes and with, thanks to social media and a lot of the videos that people are posting. You'll see a lot of folks touting solely as strength, but when you see them training, the exercise in the video train the calf muscle complex and soleus, they're all the way up on their tiptoes and from a length tension relationship. That's not something that is particularly helpful in terms of targeting that muscle. If we could go back to presentation, Assuming most of us will not have access to a soleus machine. The way that I'm typically doing this. And again, I would position myself with my forefoot on a bumper plate. So I'm roughly at 20 degrees of ankle dorsiflexion. And I would just grab a dumbbell that it's roughly 10 to 15% of body weight in the same arm as a stance leg.

And if you could go ahead and play the video. And you're just having the performer focus on moving in a vertical direction towards the ceiling or sky. And again, just to remind folks to do this on a small platform, and we can go back to the presentation. So those would be two great exercises. If the focus is on building max strength of the plantar flexors. Now we would also want to get folks into doing some squat variation. This may start off as air squats. If someone doesn't have a background with any resistance training, we may take them through a tissue conditioning process where we have them do say three, four or five sets of air squats until they hit an eight out of 10 on the rating of perceived exertion scale.

In this case, I'm just showing a goblet squat or a front loaded squat with a cinder block, which is 35 pounds. And again, I would start people bilateral with the goal of perhaps working up into a rear foot elevated split squat. In working with master runners, I do like the rear foot elevated split squat is opposed to a standard split squat with the hind leg on the floor because they start to really put a lot of load into first MTP extension. And that's assuming they have it. You could also take that hind foot and position it against a wall or a door. And that way it just gives you a chance to augment

their balance or stability. If you could play this video. So with this exercise, if you talked to most strength coaches what they'll say is when you're at the bottom of this range, that your spine angle should mirror the shin angle of the front leg. Alright. And while that's not a bad cue to give, and we absolutely want that knee advancing forward. And I'm, even okay if it goes up past the plane of the toes. I know that that'll be a never ending debate or argument, but if we could go to the next video. If we're working with runners and we know that the quad is playing such an important role, especially during the first 60% of stance. Well, we want to bias the rear foot elevated split squat to the knee and the quad.

So the biggest difference that you'll see between these two videos is in this one maintaining a relatively more upright trunk. And that's also a common denominator among the best runners in the world where they have a little bit more of an upright trunk. assuming that they're on level ground. A lot of times people queue this forward, lean into me. That's reductionist. You find your angle of lean dynamically, but if you're going to program a rear foot elevated split squat, you want the person with a relatively more upright trunk. All right. And now usually have people hold dumbbells in their hands until they get to a weight that they can no longer handle. I'm gonna just play this video for folks to see.

And you may start someone again, going two to three seconds on the lowering phase two to three seconds on the up phase. In time you could have that progress or advanced by going two to three seconds on the way down. And then one second really quick on the way up alright? If we could go back to the presentation. And another exercise that I find myself prioritizing more and more is a Farmer's March. And this is something that there's not a ton of research on. Stuart McGill and his team published a paper on strong men. And essentially what he showed us is that this does a lot to challenge the trunk musculature, but the lateral hip in particular. All right. The reason I love the Farmer's March is it's challenging the runner to get upright as well as onto one

leg. And if you get into trouble with the weight, all you do is drop it, no harm, no foul, okay. As opposed to perhaps being under a barbell with heavy load, that can be potentially become a safety issue. So this is also does wonders in terms of grip strength, which we know is associated with mortality. So if we could go ahead and play this. So there's a lot of details to this exercise. So I'm going into a high knee position, but when I'm going to lower, I'm making it a point to contact with either a flat foot or my forefoot before gently kissing my heel to the ground. And the reason that's helpful is because we're starting to train someone to adopt a slightly shorter step length. If someone's working with younger runners, this is very helpful to safeguard against overstriding. But as we know with the research with master runners, a lot of times they're already going to adopt a shorter stride to offset the loss of plantar flexion strength. But with this exercise, they may still want to initiate contact with the heel. So I just train them to enqueue them to contact with the forefoot and gently kissed the heel to the ground. And you can go as slow or as fast. I do this to a metronome a lot of the times at 30 beats per minute.

And we can go back to the presentation. I'm pretty simple when it comes to getting into rating of perceived exertion. Well, when it gets in the exercise parameters. So I make it a point to send this anytime, giving someone a home program or developing a resistance training program. I'll use what's called an autoregulatory approach, which we'll get into in the upcoming slides. But I do a lot with rating of perceived exertion, as well as reps in reserve which is RIR. I think you have to put this in front of people. All right. So that way you're talking apples to apples because a lot of times what someone may think of as a six may be very different from the reality of their situation someone who has a more elaborate background with resistance training. So, I've competed in sport throughout my life. And I've spent a lot of time in a weight room. I'm gonna put a little bit more faith in that person's RPE versus someone who is green to resistance training. So again, try and figure out what bucket this person is falling into. And also to anchor it, if I'm working with someone for the first time and say, they're master runner

who has very limited experience with strength training. I may say, "Hey, I want you to pick a light, "medium and heavy load." And I'll have them do repetitions to failure. And if they pick a heavy load and they're suddenly doing 15 reps, well, you know that you need to add more load because that's not really accurate. So there's a disconnect with their perceived versus their actual abilities, alright? Something that doesn't get discussed enough that was published back in the 1970s in the "Physical Therapy Journal" by Night is the DAPRE, which is Daily Adjustable, Progressive Resistance Exercise. And this is a method to just ensure that people are working at the right intensities. If the goal is say to improve someone's strength. So again, just gives you a very objective means of increasing resistance. I love it because I'm a physical therapist, as well as a coach.

I can apply this to both the rehab and the performance domains. And the key to the DAPRE is the payoff is really on the third and fourth set where the performance trying to complete as many reps as possible. And we'll go into this in more detail momentarily. So essentially you're using the number of reps performed during the third set and fourth set to determine the amount of weight that's either gonna be added or removed from the next set and session, with the goal being, you're trying to get that athlete to exercise closer to their optimal capacity during each training or rehab session.

So this is basically, this is a slightly adapted version of the DAPRE. So if you look at the table up top, you'll see obviously first column is sets. Now it depends on what rep max routine we wanna take. With someone who has some experience in the weight room I may focus on a six rep max routine with someone who has relatively less experience, I may focus on a 10 rep max routine versus someone who has considerable extensive experience. I may focus on a three rep max routine. I would say for most of the master runners that I'm working with the focus would be more on that six rep max routine provided they have some experience in the weight room. So the way that you would do

this, if we just walk through a hypothetical situation is say, we're gonna have someone front squat. All right. So you could have them basically walk for 10 minutes, ride the bike, do whatever their typical warmup routine is. So the first set you would say, hey, let's have you basically grab the barbell, or we'd say, grab a 50 weight and we're just gonna have you do 10 reps. All right. So again, you're just getting them go on with the exercise on the second set, you would have them do six reps, it say 75 pounds. And then on the third set, you would have them do reps to failure with the target weight of a six rep max and based on how many reps they do, then you would adjust for the fourth set. So this is essentially an open system that becomes self-correcting, which is the beauty of it. All right.

And some days you may feel like you have a little bit more going into the weight room. Other days, maybe you're tired, maybe, you're dealing with some residual soreness from a track session earlier in the week. So If someone hits right around six reps, if we go down to the scale below or the table below, Say, if they only got zero to two reps on that third set, well, you probably need to pull some of the weight off. So you're trying to get them to a six rep set on the fourth set. If they fall in that five to seven range, you're leaving the weight as is if they're getting eight to 12, 13 plus reps, we need to add on more weight because we're trying to create a greater stimulus. So think of this, it's a very objective way that is an open system that will reflect the athletes ability and readiness going into that workout.

And you could apply this to the knee extensors. You can apply this to work in the shoulder. It works very well for a lot of the compound lifts of push pull hinge, squat carry. So put it to use. This is another autoregulatory training approach that I'll often use. You could spend literally a year trying to demystify this, but what we're looking at is just rating of perceived exertion and we're tinkering with these different variables. So rating of perceived exertion repetitions as well as external load. So don't get too hung up. You can let the top table model around, But if we look at the bottom table in terms

of the goal and specific examples. I mentioned if someone doesn't have a lot of background with resistance training and you want to introduce a squat, well, you may have them just do air squats to begin with or a whole set if you really want to regress it. But if we stick with the theme of an air squat, you may say, "Hey, let's have you do 15 reps "equal work to rest. And I want you to do sets until you hit an RPE of eight." All right. And that would be more just tissue conditioning or protection with the goal of getting them to go up to working with some external load. So if we start to basically get a little bit more into volume where we're to work on capacity with that person, We may say, hey, let's have you do five sets of 225 pounds. If we have someone who's pretty strong with a back squat, and you may say, hey, I want you to do reps until you hit an RPE of eight, which is very hard, which means that you have maybe two reps in the tank, all right, versus pure strength focus, which would be four sets of three reps, longer rest period. And you're saying, hey, I want you to do sets. You're gonna do three reps per set.

And I want you to work up to a three rep max. And that's where something like the DAPRE would start to dovetail nicely. So don't try and make sense of this in five minutes. I continue to come back to this and look at it. And I continue to refine my thoughts on this approach, but it's definitely something worth taking a deeper dive on. And this is another just flow chart that Scott was kind enough to let me use for this presentation. And I think that back to the point, we're all in a pandemic right now. Our energy probably fluctuates a little bit more than it otherwise would. So when you have a master runner or triathlete, go into the weight room, you want to just have the ask, what's their general soreness in energy, and you can just sort of follow this flow chart because some days, if people are really tired and they find themselves at the gym, well, maybe that's a day where I put it in quotes. They should just be touching the weights where they're probably gonna do more harm than good if they try and have some breakout sessions. You're trying to use these autoregulatory approaches to just mirror the athletes' present state. All right. And you... Again I put this in there just so you have

it on file. So you can follow it. If someone has high soreness and low energy, well, you probably want to give them an easy day where they're going in. They're only doing one to two sets of a lower RPE, leaving more reps in the tank. If they have moderate, if you combine their soreness and energy scores and they're moderate, well, maybe you can have them do some meaningful work. Versus if someone comes in very little soreness, high energy, they'd had a good night's sleep. They feel properly, maybe it's a weekend. Then you would want to push a little bit more.

Okay. So, and then have them reassess after they do the first set. Sometimes people may start feeling a little bit better. They just need to get out of their office and maybe they start gaining a little bit of momentum. So again, this is just always reflecting their current state and readiness. So let's get into plyometrics, a lot of clinicians and coaches will shy away from plyometrics when they're working with master runners, for the fear that they're gonna perhaps cause more injury, whether that's a calf muscle strain, or if that's an Achilles tendon rupture. All right. So we need to be very calculated in how we're layering in plyometrics.

And we also want to first make sure that someone has developed this rock solid foundation of strength, because that's only going to allow them to better express their force through an energy storage and release activity. When we talk about Plyos, there are slow versus fast stretch, shortening cycle activities. All right, if we think of a fast stretch shortening cycle, that would be a Pogo jump. If you think of some of the NFL football players in the combine, if they're doing something like a broad jump, that would be a slower stretch shortening cycle. So fast stretch, shortening cycles. This is gonna have more salients to running characterized by short ground contact times. So, less than 250 milliseconds. Small displacements of the hips, knees, and ankles, and think of reactive strength. So what would be some examples, Pogo jumps, as much as it's a great assessment. It's also a great drill. So the springy reactive jumps, making sure that someone's not allowing their heel to contact the ground in their minimizing

knee flection excursion. What we see with rear foot strikers is roughly 200 milliseconds in terms of ground contact time. And we see that actually a little bit less with mid foot to four foot strikers. So this would be a great drill if we're starting to look at some single leg stuff. And these are in no particular order, we'll talk through each of them, if you could play this video. And you're just trying to tell the performer, hey, imagine you're on hot coals, not taking them through a gnarly excursion of movement. And it also requires a little bit of coordination in terms of where they're placing their foot. If we could go back to the presentation. So where I like to start people is Pogo jumps in place. So I know we've covered a lot of different numbers here but I'll usually start somewhere around 150 to 160 beats per minute, and just set up a metronome and you have them do it to the beat and people auto in train or auto sync to it. Once someone has demonstrated good forum with Pogo jumps.

And I should also mention that these are things that you're gonna want to do at the beginning of a session when you're not in a fatigued state, because you're trying to have that reactivity with short ground contact times, but once someone has demonstrated good form, then I would progress them to doing Pogo jumps forward. All right. Go ahead and play the video. Nothing fancy. And I'm not gonna have someone do these, especially when we're first getting started for more than perhaps 15 to 20 contacts. So when I first go to introduce this, I may say, hey, let's have you do two passes rest 1.5 times, work duration no more. But no more than two passes. I may get someone up to a hundred contacts so long as they're tolerant of them, but you have to be calculated with your exercise parameters when you're going to incorporate these. And you would also want to be mindful. You wouldn't want to have someone coming off of a really challenging hilly run or track session, and then do these on the same day or the following day, just because you want to afford them a little bit more of a recovery period. And that's the greatest challenge is when you're working with a master runner from whether late stage rehab or performance standpoint, it's how you're managing their training intensity distribution and how you're interfacing these workouts. So they

are complimentary to the run training and not leaving the athlete under recovered. If we could go back to the presentation. And you can start working in some diagonals for variability sake. So this is basically a Pogo jump and I'm just using the line and I'm hopping in a diagonal matter as I progress forward. If we could go ahead and play that video. And back to the presentation. And then I will get into some single leg hopping. I would generally suggest doing this in place first, and then you could work towards anterior or forward single leg hopping as well as some medial lateral hopping. I'm sure everyone appreciates, no reason to watch the video here but, with someone who's a trail runner, I live in the Northwest. I would incorporate more medial lateral hopping or lateral hopping with that specific master runner versus someone who may be spending more time purely on the roads, right?

But either way, I think as long as someone has your confidence, they have the tissue tolerance that you can work these and, in certain folks, you may actually really need to regress things where if they don't have any background with jump training or plyometric training, or you may have to first just start with drop lands, and then maybe just doing some counter movement jumps in place. Right, but the goal is to get someone to a series of repetitive contacts focusing on short ground contact time.

Another critical aspect of working with master runners is as much as we are doing all of the resistance training that we need to go out and have them express this force. If you live in a place like the Northwest, that's not a remote problem, same thing for a city like Pittsburgh or San Francisco. So you ultimately want them to take the benefits that they've reaped from the resistance training in terms of bolstering their capacity, and then put them out onto a relatively more hilly runs, which will start to shift the forces around the lower extremity. You also need to be again, calculated in terms of how these runs are interfacing with the resistance training sessions. So if we look at uphill running, the thing to appreciate is uphill running will lead to greater activity in the quads, the hip flexors, as well as the plantar flexors, right? And if you're working with a

master runner from a rehab sense, it would probably be important to discourage them from doing too much hill training. So if you have them in the late stages of a rehab program and you're getting them back to a return to run, you would want to start them on level ground, and work up their return to running program in terms of walk, rest, or walk run before you start putting them out onto a relatively more hilly route. And when you do have them start to incorporate some hills, take them from level ground to rolling terrain, and then you could start putting them on perhaps some relatively more aggressive hills. But when you start to introduce more advanced hill work, you want to keep their effort low in the sense that you wouldn't want to introduce more speed while you're introducing hills for the first time, because that's probably what's gonna get them into trouble.

We'll also see increased hip power generation and compared to level and downhill running decreased impact, but increased energy costs. I work with a lot of female master runners who invariably seem to present with proximal hamstring tendinopathy, and it's probably stemming from a training habit really going out and exceeding their tissue capacity where they're on some relatively more challenging hills or inclines. And they are getting into compressive forces at the level of the proximal hamstring. And they just simply don't have the tissue capacity.

With downhill running. And one other point about uphill running. You're also gonna put someone in that optimal length tension relationship for the calf muscle complex, which think of 20 degrees of dorsiflexion to roughly 10 degrees of plantar flexion. If you watch anyone run up a hill, it's gonna throw them roughly in that range. So it's very specific to challenging the calf muscle complex. With downhill running, we'll see increased hip power absorption during the breaking phase, increased knee power absorption, increased patella, femoral stress, decreased ankle power generation. Compared to level and downhill running you'll have increased impacts. And as far as the energy costs go there'll be decreased of the grades less than 20% and increased if the grade

is greater than 20%. As a sidebar, folks who are dealing with patellofemoral pain, iliotibial band syndrome even proximal hamstring, tendinopathy, downhill running can definitely sensitize things. The same would go with a patellar tendinopathy. So what would a progression look like? So if we're working with someone who has limited experience phase one, we just want to start to basically address or improve their work capacity and make sure their tissues become tolerant of the loads that we're calling on. So we're gonna increase strength and endurance. What are the exercises? Starting off with the seated and standing calf raises. We could do something like a goblet squat band resisted lateral toe taps to challenge the lateral hip. We may start with relatively lower contraction intensity. So if we go off of the RPE scale, we may start them at around a six.

It's fine if you're going slightly lower, when you're going through this particular phase, and we're going to just say, hey, let's have you do three sets with a manageable load to failure. Next we would start to focus a little bit more on general strength. Goal is gonna be to increase muscle strength and start to address tendon stiffness. We'll continue with the seated and standing calf raises, maybe starting to incorporate some external load. We would start to get into rear foot elevated split squats.

We could throw some farmers' marches in there. If you wanted to do something in the way of a hip dominant exercise, you could throw in an RDL or trap bar deadlift, and you may start to introduce some drop lands from the smaller platform or height. Three to four sets of six to eight reps, and then maybe four by four for the drop lands. All right. So not getting crazy here. Phase three, you would start to get into more power and plyometric. With the goal of increased power output and reactive strength. Exercises, you're gonna start to really focus on heavier loads. You could do traditional front squat or rear foot elevated split squat. We could start to get into some Pogo jumps going from bilateral to unilateral and getting into, since we're getting into heavier loads three to four sets of relatively fewer reps. So three to five reps, and with Pogo

jumps, two to three sets of 20 to 25 reps. This is a table that I adapted from a recent article by Baxter and colleagues that essentially they looked at a bunch of exercises that are routinely given by clinicians as well as coaches. And they came up with this loading index, which pulled together the peak loading, the loading impulse force over time, as well as the loading rate. And it just helps you to conceptualize how challenging some of these exercises are. And this is particularly relevant, if you're working with someone who is perhaps coming off of an Achilles tendon rupture, or a calf muscle complex strain and going from least challenging to most challenging, you'll see tier one low level and also bear in mind that they were doing these exercises from the ground. They weren't over in edge. So they weren't starting in that 20 degrees of dorsiflexion. In naturally you would start to see greater forces as we start to get into some of the stretch shortening cycles or hopping type drills.

So I just put this in, so you have it on file. And this brings us to a sample case study. So I work with a lot of athletes from a performance coaching standpoint who have finished with physical therapy and this would be laying out. And this is very simple. I didn't want to get too complicated. But this is how I would lay out a sample week. So usually on Monday, if we go to the 19th here, I usually give people a relatively lighter day on Monday.

So I would have them warm up with the 10 minute fitness walk, which is essentially brisk walk with the arms pumping in a manner that you would see the arms working in terms of running. I would give them one simple marching drill as a warmup, and then we would get into farmers' marches for one minute passes on 90 seconds rest. If this is a 150 pound individual, I may have them, if they have gym access holding 45 pound barbell plates or 20 kilogram kettlebells in each arm. You'd be surprised with a lot of the males that I work with. My goal for their farmers marches to get them up to half body weight in each hand with the women I work with as well as people have grip strength issues, I may go with a way to invest to get more axial load so I can go

relatively lighter if grip strength is a problem. So again, simple neuromotor control marching warmup to the farmer's March. Then I would get into a goblet squat, and I would have had to have figured out how to anchor this. So I may have someone take the type approach or I may just have them say, "Hey, let's have you do three "to four sets working up to an eight out of 10." And if they're in that, let's say five to 15 rep range. I know they're probably doing some meaningful work, but the goal is to get them down into lower reps. I always say if someone can do more than 15 reps, it's probably not an adequate stimulus. If the goal is indeed strength or strength endurance. And if it's less than five that, it's probably a little bit too much for most endurance athletes, unless they have more extensive background in the weight room. And then I would finish off with a single leg calf raise where they're doing three sets, holding a weight in the same arm as a working leg, while focusing on that 20 degrees of dorsiflexion position to 10 degrees of plantar flex action. Tuesday, I'll take them into just a 40 minute conversation. Pace run with a slight negative split, meaning you run the second half slightly faster than the first.

And I also want to mention before any run, I always have athletes, I don't care if there are Olympic caliber athletes or there's someone who is doing a couch to 5K program. I always have them start their run with the 10 minute walking warmup. And I have them finished with a five minute walking, warm down. Just to ritualize the training session, allow them to unplug from the day. But the other thing is if we acknowledge the fact that a lot of these master runners and triathletes have a past medical history, that's remarkable for a lower limb tendinopathy. What we know is that tendons warm up. So let's give them the time or for them the time to warm up. I've helped a lot of people troubleshoot and overcome recalcitrant lower limb tendinopathies in one of the major principles. It probably got them on the other side of it was simply avoiding opening the door and taking off for run where they're just going out, they're allowing their body to warm up. We're getting blood flow to the tissues that we're gonna be calling on, and then they bleed into their run. All right. I like having people once they tolerate running

every other day to throw some back-to-back days. And so Tuesday, Wednesday would be an example of that. So on Wednesday, I'll have them do a 45 minute conversation, pace run, and maybe finish with some strides. So, where I tell people I want them running long and loose strides can be anywhere from say 15 to 30 seconds on one minute job recovery. And I would do those on level ground, especially when I'm first introducing. Thursday, we would have another strength training session. You don't need to be mix things up every time you give someone a resistance training session. A lot of the times it's just taking the same exercises and starting to just progressively nudge the person. So we're getting a snapshot in the one week here. In terms of how this would look the following week, I may just add five pounds to their major lifts. So may add five pounds of the goblet squat.

I may add 5 pounds to the Farmer's March. All right, so things don't need to be really fancy. And I would argue if the fancier they are probably the less focused they are. I tend to give people a lighter day on Fridays, in this case you'll see I have a 35 minute run at conversation pace. And that's just because a lot of times at the end of the week, people are a little bit more gassed and then I may give them relatively two more challenging runs on the weekend. And ideally I'm promoting 24 hours of rest between workouts.

So if I give someone a strength training session, say on Thursday, I would say, ideally afford 24 hours between your Thursday and Friday session. You also know that I don't have this 50 minute run on rolling terrain coming right after the strength training session, because I'm trying to mitigate threat and avoid exceeding tissue capacity. So I wouldn't want to give someone a more challenging resistance training program, especially if we start layering in plyometrics. And then follow that up with a 50 minute run on rolling terrain, which is gonna further challenge the calf muscle complex. So we could spend an eternity talking about different athletes and specific contexts, but this just goes to show, we're keeping it simple. You're seeing two days of resistance

training and you're seeing in this case five days of running, I would say most of the time with the master runners that I'm working with they need to be running at least three days a week. Ideally, probably four. If they're not, if they're running less than three, one to two times a week or six to seven, you're probably flirting with fire a little bit. So with all that said, I wanna leave some time. I'm sure folks have questions and I appreciate you spending time with me this morning, and hopefully that helps you better conceptualize how to approach working with a master runner to some extent across the rehab to performance spectrum. But like I said the most important thing is to just assume that these folks have sub-clinical pathology and there is incomplete rehab at play. And as a physical therapist, I say the most important thing that we can do is to rehab someone to the fullest or to the best of our abilities because human nature is such that second someone no longer is experiencing or dealing with pain. They just assume that everything is healed and they're good to go. And they go out on a training session and boom re-injured or sensitize their situation. Is it okay to start answering some questions here?

All right. So the first question that we have is does a gait deviation of decreased stride length in increased cadence with aging also apply to master trail runners. I'm not aware of any literature that has specifically looked at that. I would say that if you have a master trail runner who is spending more time on terrain, where they're dealing with more inclines, I would say they're probably likely to stave off that process or that pattern. But right now I'm not aware of any particular studies that have addressed that specific research question. Let's see. The second question, masters level runners who present with a history remarkable or an Achilles tendinopathy likely have reduced tendon stiffness in a portion of their tendon. Let me just go down a little bit here. There we go. Master's level runners who present with history remarkable for an Achilles tendinopathy likely have reduced tendon stiffness and a portion of their tendency to mechanically dead or silent, increased tendon stiffness, normal tendon mobility and strength. No. Oh, this is just pertaining to one of the questions. So what you have with

masters level runners they'll have reduced tendon stiffness. And when someone has tendon pathic tissue from everything that we know right now is that that portion of the tendon is mechanically dead or silent. All right. So this gets back to the whole hole in the donut concept that you'll hear a lot of the researchers talk about in addressing tendinopathies. There's still plenty of tendon to load. So if someone has an MRI and they see this tendinopathic portion of the tendon, which may get red as a partial tear, which you have to be prepared to have that conversation, because it's just tendinopathic tissue. What we know is that that's not coming back and we shouldn't be trying to do interventions like PRP or other interventions.

If the goal is to try and normalize that. What we wanna do is strengthen the tendon, make sure we're doing some focal loading, and then try to just optimize the kinetic chain in that individual. Cool, let's see the next question. Inability to see your presentation on the screen for the last 10 minutes. Not sure if it's just me. I would just reach out to the folks at physical therapy and see if that was a problem. Apologies for that. Let's see, for those of us with old eyes, which exercise in the chart had the greatest Achilles tendon load.

Single leg forward hopping is what had the greatest Achilles tendon load. Dusty runner's optimal stride frequency is X% above their preferred. What is this? I didn't hear you say this. Apologies for that. I should've touched on that. So a runner's optimal stride frequency is generally 3% above their preferred. All right. Most of the time, if we're trying to do cadence retraining or we're doing gait retraining and we're trying to address reducing the magnitude of load. Usually it's five to 10% above one's preferred stride, frequency or cadence. So I apologize for that. Our apologies for that. Next question is what do you think of jump ropes? I think they're great, I have one upstairs. It just was shipped yesterday. Less is more to me though. So I think that what we can do is rather than if you're working with a master runner first and foremost, we have to make sure that these people, especially, as they get older and aged, you don't give

them something to get tripped up on. So when I'm doing Pogo jumps, and I think it's fine. I mean, if someone, if you're not concerned about that by all means. But I think that the easiest thing to do is just start someone on from level ground and have them do Pogo jumps and do it to a metronome. I threw out the value of 150 to 160 beats per minute. So focus there with some of the higher level runners, and this wouldn't be the case so much with master runners, but if I'm working with, I have a couple of Olympic caliber runners, I may get them down to a hundred beats per minute. So it's just really explosive Pogo jumps. So hopefully that answers your question. In regards to running cadence, I didn't hear any talk of it except that cadence increased with age. What is optimal cadence in regards to the question? What percent above that cadence is preferred? So we partially answered that question. So in regards to running cadence, you'll hear Jack Daniels throw out the number 180 steps per minute, but that was based off of Olympic caliber runners during the Los Angeles or during the 1984 Olympics.

So understand that you also have to appreciate the role of leg length. So if someone has really long legs, they're not going to have the same cadence. It's gonna be relatively lower. Now, there has been some work done in high school athletes by Lace Lukey, and they talk about step rate as a function of knee versus shin pain. And in that manuscript, the value of 174 comes up. My main concern with canes is if someone is able to run, but they're dealing with some pushback or maybe they get to the fifth or six mile, and then they start to get some pushback. I ultimately would just bump their gains up five to 10% just because there's a whole slew of benefits that have been documented. I would say generally, if I see someone who is below 170 and they're especially complaining of knee pain, say patellofemoral pain, ITB syndrome, that's someone who I'm gonna bump up five to 10%. I'm more concerned with people who are in the, like the one 60s or you know, perhaps low one 70s, but really at those lower step rates, I would say 150 to 170 because that's a simple lever that if we pull it's gonna accomplish a whole slew of things and it's also something that's easy. Chris

Brahma did a really great paper in the American journal of sports medicine, just showing that one session of gait retraining not only improved lower extremity function, but these people also maintain their kinematic and kinetic differences at four weeks as well as three months. And all they did was basically bring someone in, they had them trained to a metronome for five minutes while they're running on the treadmill at a new step rate. And then they pulled the metronome away and only gave feedback if they felt like someone fell out of that range. And then they told them to go home. And for the first two weeks run with the metronome and then just go to the GPS watch that they were provided as a part of being involved with the research study.

And most of these folks just ditch the metronome when they went to their own running. And they just started looking at the GPS watch to monitor their step rate. But I love that study because it's so simple, and this is how things pan out in the clinic. Most of us are not gonna be able to work with someone for eight sessions. So it's just sort of a rude and crude way of bringing about meaningful change. Let's see. For initial introduction of plyometrics to patients, would it be appropriate to start with a Trx Trainer or just start smaller amplitude movements and decrease reliance on upper extremity support?

Yeah, I'm cool with that. Whatever allows them to focus on short ground contact times with the performer being relatively upright. These should be relatively easy to perform, but if you feel like that augments someone's confidence or safety yeah, by all means do it. Do you see issues with footwear contributing to injury? What should we look for? I never enjoy talking about shoes because I feel like there's such a distraction. With that said, I do think that you have to anticipate some aberrant or awkward contacts, especially if you are working with someone who's doing plyometrics early on. So you want to give them a shoe that may be a little bit more forgiving. I would say that you also want to monitor for defects and no one talks about this to the extent that they happen. So, most shoe companies will admit to maybe a six to 10% incidents of

defective shoes. So I want to just make sure that when someone goes to get a shoe that it's also, it's not defective. And then I want to really prioritize what feels comfortable things that I would discourage in terms of footwear people who are in Hokas these big rock or bottom or cushy shoes. If you think of weightlifting shoes, they're these firm platforms that we have people on. And that's because we want to give them as much, we want to give them the most stable base to produce force from. I would just say something that's comfortable that has good torsional stiffness. If you grab the shoe from the heel and the forefoot and you try and twist it that's great. I mean, I do a lot of lifting in vans. There's a couple pairs of ultras that I like that are good that have... Like I lived in the Altra Solstice. I don't have a relationship with that company. But again, you want something with a little bit more of a firm platform, and if you're talking about plyometrics, I would give someone a little bit more cushioning under their forefoot. A lot of master athletes will, their metatarsal will start to drop and it may be a little bit more comfortable for them.

Let's see. What does the Achilles tendon load over ground versus treadmill running? I mentioned briefly in the early part of the talk that the Achilles tendon load is gonna be greater with treadmill running because you have a slightly higher step rate, which is going to engender a slightly flatter foot placement. So you're gonna start to shift the load more towards the calf muscle complex, and that was Rich Willy and his team's work. We didn't see much of a difference in the way of the knee, but at the Achilles we did. Does increase tendon stiffness cause master runners to have hip knee and ankle joint pain? I don't think we know the answer to that. What we know is that when we're giving a master runner heavy, slow resistance, what we see is tendon stiffness. We lose tendon stiffness as we age. So what we're trying to really target is tendon stiffness in Young's modulus. All right. I Would say that, you know perhaps there's a case to be made that with folks who don't have adequate tendon stiffness, that they may be setting themselves up for trouble in terms of injuries to the calf muscle complex in Achilles tendon. How Many days or week should we stretch these athletes? I do zero

stretching. Wherever you allocate your time and energy, we have to allocate, we have to basically relinquish it elsewhere. So there's no convincing research that shows that we should be doing any form of stretching with these people. When people ask me about stretching, I say, look, I don't want you stretching if you have a lower limb tendinopathy, especially because a lot of the stretches that people do, we take them in the compressive forces, which runs the risk of sensitizing, those tissues and regions. So if there's anything we should be focusing on, it's getting these athletes to part with their stretching and they're stretching because they may have the sensation of tightness or stiffness, but the stretch is not really doing anything to address that. So focus on the resistance training with heavy, slow resistance, and then getting into some reactive strength and energy storage and release.

What type of drills or postures do you suggest to help runners train to increase cadence? I would have them practice. Well, if they're running to increase cadence. I've spent a lot of time around some very high level cyclists over the course of my career. And these cyclists can maintain such a broad range of pedaling Cadence and without even really knowing it.

So now, if someone... if you're trying to challenge them to perhaps do a drill outside of running that focuses on cadence, I would have them do marching to a metronome where you get them, maybe you start them a little bit slower, but getting them off to 120, 135, 150 beats per minute. But most of the time, if we're trying to address cadence, we're doing that in real time with running. All right. So both 5% and 10% are options for the quiz question as is the 3% you previously mentioned for optimal stride. Can you clarify? I need to go back and look at that question. Obviously that's come up quite a bit. So if we're trying to reduce the magnitude of loading at the lower extremity, 5% to 10% is a sweet spot. We know that if you go above 10%, it occurs at a metabolic cost. And we also, I talk a lot about the five 20 rule when I teach this meaning a 5% increase in step rate while keeping running velocity constant can lead to

upwards of a 20% reduction in shock at the level of the knee. So I need to go back and clarify that. So people aren't failing the exam over that question. My apologies. Someone just said, thank you, great presentation. Yeah, I really hope, hopefully folks have a refined understanding or approach. Now that you've seen this presentation into some of the moving parts and really how this pans out clinically. I can't emphasize enough that if we're gonna really focus on one thing with this population of athletes or this demographic it's to make sure that you've fully understand or ascertain their past medical history, that you're collecting some objective data because we have these apps that make it so simple, even if you're doing tele-health.

And you really focus on getting people up to meaningful loads with the heavy, slow resistance. The athletes that work with me, their jaws drop up. And when we start getting into the exercises that I tell them are important, and once they start to trust me, they go on to do great things. And they started having performance gains, even as they're getting older. Some of these folks in the 50, 60, 70s. So in the exercises don't need to be complicated, think back to something that Dan John said, "Push, pull hinge, squat, carry." Whatever you're not doing is the weakness in your program. Yeah, and this goes far and wide beyond just running.

But obviously I think that hopefully it's salience to working with runners. If stretching is harmful to tendon muscles, if stretching is harmful to the tendon slash muscles for runners, what exercise as can use to help make the tendon muscle more flexible to prevent micro tears? I would say that what we're gonna do to prevent micro tears is to make sure that the muscle tendon unit has adequate capacity. And what we don't want is less stiffness or greater. We're not trying to promote flexibility. And I would say with micro tears I think that we're getting away from that model. That's a collagen disruption model, and I would encourage you to read 'Joe Cooke and Sean Docking's' work on the continuum model of tendon pathology. But stretchy people like to stretch. All right, are you... I was always amazed when I lived in New York city 'cause I worked with a lot

of performing artists and dancers. And it always blew my mind that people who loves stretching, they always told me they felt so tight where these people who could almost draw their knee towards their nose, and most of the best runners in the world actually lack flexibility. And there's a study where they essentially gave a group of runners, a sitting, or they gave a group of people sit and reach test. And the people who did worse on that sit and reach test were more efficient with running. So hopefully and I think a lot of other runners stretch because they see other runners stretching and they're not doing the strength work that they probably should.

Let's see. Thanks for some of the kind words, video, graph. Someone just said, thanks, great presentation, videos, graphs, and specific examples. Very helpful, I love the question regarding your thoughts on stretches and footwear. Yeah, and I won't claim to have any of the answers. But as I always say less is more and concentrate on doing fewer things better. And if you gave most of these people, some form of a squat and a calf raise and a loaded carry, you would see some great things happening. Let me just answer one of Calista's questions. So a runner is optimal stride frequency is 3% above their preferred. All right. So that's from, Izzy more talks about this in one of her manuscripts, but yeah, that answer is 3%. If we're talking about gait retraining and we're trying to use canes to reduce the magnitude of each individual load, that's a 5% to 10% range that we see. All right. So hopefully, that answers people's questions. Let me see if there's anything else coming in. Oh, someone's saying go blue hens. Yeah. The least fierce mascot out there. All right.

- [Calista] All right. Well, thank you so much, Chris, a wonderful course today. Great videos and great interaction here by the group present for this course. Hope to see you guys in the classroom the rest of the week. And thanks again, Chris.

- Thank you. And thanks to everyone for carving out the time to hang with us this morning.