John Ball: Quantifying Climbing Efficiency

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[00:00:00] [Conference Rewind logo on left. Video on right of speaker.]

Kathy Brennan: Hi, I'm Kathy Brennan, Director of Educational Products and Services with the International Society of Arboriculture. I'm very happy to bring to you today our Conference Rewind video series. Today's presentation is quantifying climbing efficiency with Dr. John Ball.

So this presentation was originally given at the ISA 2020 Virtual Conference and therefore, of course, the viewpoints and information given are those of the presenter. If you're interested in learning a little bit about the history of climbing systems, as well as some of the latest research on climbing efficiency, then I'm sure you'll enjoy this presentation. Now sit back, relax and enjoy.

[Video goes to full screen and shows PowerPoint slides.]

John Ball: [00:00:44] Hello and welcome to the ISA virtual conference. My name is John Ball. I'm a professor at South Dakota State University in Brookings, South Dakota. And I'm here today to talk to you about climbing performance. I also want to add that Tim Walsh with Davey [00:01:00] is very much a part of this research and will be expanding it for his PhD program over the next year or two. So we're going to have even more data on about another 18 months, I hope.

What are we going to talk about today? Well, we're going to start with looking at the progression of climbing systems over the last decades. And then how do we measure human performance? So when we're looking at climbing systems, how do we evaluate one to the other?

And then what have we learned so far with the data we've collected on the various climbing systems, in terms of efficiency, human performance, and then finally at the end, I'll spend a few moments talking about climbing safety.

I would like to start out with, with our agricultural operation incidences. I do spend a lot of time working on this. And as a reminder, according to OSHA, Occupational Safety and Health [00:02:00] Administration in the United States. In the US we have about 13 fatalities per 100,000 workers in the general category grounds and tree workers. I should also mention that if we pool every worker under United States together, we have a fatality rate of about four per 100,000. Just in this general category of landscapers and tree workers, we have about three times of fatalities of the all industry average. If we just separate out tree workers and Michigan's OSHA did this recently, we have about 48 fatalities per 100,000. So really doing tree work is more than 10 times the risk. At least the fatalities that occur to the all industry average.

If we look at where those injuries occur, notice that falls to lower levels are about [00:03:00] 34% of our fatal injuries in the United States, looking at data over the last 15 or so years. If we look at the non-fatal injuries and by this category, I mean, injuries that resulted in inpatient hospitalization for at least a day, amputation or loss of eye, that falls to lower levels and climbers really are the category where we have the most non-fatal injuries.

Alot of this may be due to fatigue. You know, you're on a, doing a job, you're up there, you're getting tired…How much does that affect your thinking or your strength? So that's a real key part of the research that we're doing.

Climbing's had it start a long time ago. Had it start Europe, of course. But when we take a look

at climbing, how have our systems changed [00:04:00] over the decades? In the beginning, we did a lot of free climbing and free climbing even occurred as you can see in these pictures up until the 1950s and even the sixties.

And I remember free climbing a little bit into the seventies, even though it certainly wasn't advised. I think it's interesting you go back to the early literature was they looked at it as trying to convince people to use a rope.

And where did we start? We really started here with a buck strap and I've kept mine. That's an old leather buck strap. It's 50 years old and I certainly wouldn't use it today. I'm glad I survived using it back then, but our climbing systems have changed quite a bit. We started using a climbing line. Now these became a little bit more common in the 1930s and they certainly were in use during the 1970s. And from then since we've always used a climbing [00:05:00] line.

But have you ever seen anyone climb like this? Now, what I want you to notice is that's a manila rope and going hand over hand over the rope. Believe it or not, that was a technique that was utilized once. In fact, if you go to the February 1983 issue of *Journal of Arboriculture*, you'll find on the cover this picture.

And this is a student at a university I will not mention that was instructing their students in climbing a tree. Just as that picture that I just showed you illustrates, that he has his saddle on, but you'll notice the d-rings are hanging down because he's pulling himself handover hands over that rope.

Now, if you go to that issue and to the next several issues, you'll find a lot of letters to the editor. And there was one in the following issue that said, “I find it inexcusable for you to use this cover picture on the [00:06:00] February, 1983 journal” and the following issue, the author and the and the photographer mentioned that “we allow students to climb either as body thrust or hand to hand. Your words of excusable are a little strong.”

Now that really started at conversation. But the point of this too, is that notice even in 1983, our climbing systems were relatively simple. Body thrust or hand to hand were both fairly common systems. And we routinely would free climb to the tie-in point.

I can remember this, you trailed your rope all the way up the tree until you got to the height that you wanted to be. You tried to find a central appoint as you could, and only then did you tie in and then being tied in you'd work the tree down.

That's my harness, my saddle from back then [00:07:00] and 1983, I believe. And it's one of the originals. If you'll notice that this was a buckle that you pull the strap through, they discontinued those because too many people wouldn't go through and add that extra loop. And they went to buckles to help reduce having the chance of having the saddle come off you.

We still were using manila ropes back there at the end of the seventies. And that, and that's typically how I would, I was taught to tie on. What you used were two half hitches, tied off on a taunt line hitch, a figure eight, not as a stopper, not because anyone that remembers a taut line knows that it would roll as you are working. And fairly soon you'd find that figure eight, not pulling almost up against the knot. And then for those that wonder, well, what's that other figure eight knot. That was the knot to where to cut your line [00:08:00] if we had to do an aerial rescue.

Well, we're not using manila ropes anymore. We certainly gone to a lot better materials and we've gone to a lot better techniques. Let's go over them. Now, of course, SRTs stationary rope technique, as it's now called has really become a very common way to climb and work tree. And there's a lot of advantages into the system, but what about efficiency?

And I hear this a lot. Well, what is the more efficient method? The first thing is Shygo would always tell us is you have to define on your terms. And what are we actually measuring when we talk about efficiency and that's what I'll start out with here now.

We're going to use real climbers, not these. And I got this photograph from Tom Dunlap, where we're [00:09:00] going to put all our little mechanical people through various climbing techniques and do that.

No, instead we're going to work with people on these techniques. And rock climbers have studied efficiency for a long time. A lot of our literature really comes from them. We're really just starting to look at efficiencies for climbing systems for arborists, and as a rock climber, I kind of appreciate the work that has been done, looking at rock climbing. I'm glad to see that we can actually take some of that work and their methods and apply them to arboriculture.

Let's borrow some of the methods that they have. Well, we started out practicing in the gym, using some of their tools and techniques, working with the sports medicine department here at South Dakota State University. And we set them up in the gym and practiced to refine our measuring techniques.

Let's [00:10:00] go through the systems that we use to measure climbing efficiency. First of all, we're looking at VO_2 . V stands for volume and O_2 stands for oxygen. And this is a measure of an individual's capacity to transport and utilize oxygen during exercise. It's a measure of aerobic fitness. And aerobic fitness is important for rock climbing and it's certainly important for tree climbing.

The VO_2 is really the rate of oxygen consumption. It's the rate used by the body, by the way, it's not the amount inhaled. Really not talking about the huffing and puffing air as you're going up the tree. And I do want to point out that aerobic fitness is only one component in measuring efficiency.

But it's an important one. Everybody here is an arborist as well aware of these [00:11:00] formulas, photosynthesis, that process of converting water and carbon dioxide into sugar with light energy. And then of course there's respiration which we don't talk about as much, but that's the release of that energy captured in photosynthesis for cellular activity.

Well, you're not undergoing photosynthesis, but you all are undergoing respiration. When we look at human respiration here, we're essentially taking sugars and oxygen, and then giving off carbon dioxide, water, and producing ATP. ATP is really what transforms us into mechanical energy. If you want to think of it, think of it as ATP is diesel going into the tank, right? That's what really provides the energy to allow you to do your work.

We're going to measure VO_2 with a couple of [00:12:00] techniques, and I'm going to show you one we've utilized in the past that we're changing now to more modern systems, but this is technique that actually you can wear. It's used for for rock climbing and we modified its use for tree climbing to take a look at oxygen consumption among climbers using different climbing systems. The system goes over the shoulders, the holders are there. The holders the harness doesn't weight very much. And what we end up doing is placing that cup over your nose. Now, initially, when you put that on, you think you're not going to be able to breathe, but we use this on treadmills, we use it for runners, we use it for a lot of various athletes. And after a few moments, surprisingly, you can get used to the system and realize it does not interfere with your breathing at all. What it allows us to [00:13:00] do is measure your oxygen consumption.

There's the entire setup now with electronics they're improving dramatically, so we're going to a newer system, which is an analyzer that just fits over your mouth and your nose there and still using a small piece like that. But, we're able to get rid of all these various lines that are attached and it's wifi right to the computer. It's making it a little easier to work your way

through a tree when you're wearing the newer systems.

But even with the old system it's not bad, we can fold those cords underneath her. They're not your way and the sensors go on those pockets. As you're climbing it, doesn't interfere with your climbing as you're working your way up the tree. Now at rest, your VO_2 oxygen consumption essentially is about [00:14:00] 3.4 milliliters per kilogram per minute. I realized that is kind of, well, it's hard to put up a basis to it. But if you just remember that number at rest, as you're sitting there watching your computer, when you're looking at your oxygen consumption, it's about 3.4 between three and four, mostly close to three, mill milliliters of oxygen per kilogram of your weight, per minute.

What we also have to do to make this work. We have to weigh all the people and get their height. We get all the, all the basic measurements of the participants. And then we also get all that baseline data that we need. Not only are we going to measure their oxygen consumption, but we're also going to measure their heart rate.

And that heart rate can be wifi-ed as well because oxygen consumption is dependent on the heart to pump out the blood because that's the way we move [00:15:00] oxygen in your body. This is one of the systems that we're using. It's fairly small and easy to do. It's also wifi-ed and you don't even notice it as it's being worn, as you're climbing through the tree.

Heart rate for most of our participants is at about 65 beats per minute. Now, for the average adult, it varies somewhere between 60 and 100. But arborists or athletes, there's no way to get around it, particularly climbers, you have to be in good shape. You're going to be typically at the low end of that. And some of you may be even lower than that, that are runners in that may have a heart rate that is at 60 or even in the fifties. Generally speaking, there is a linear relationship between your oxygen consumption and your heart rate. In other words, as your oxygen consumption increases, as your breathing heavier, moving more oxygen through your system, right? That your [00:16:00] heart rate's going to go up. And that's true as well with climbing. However, one of the things that we'll point out here today, is that it's not even. That the relationship is not quite the same as it is for other activities.

We're going to get the person geared up, put everything together.

Again, we can wifi this. Everything is coming right into the computer and we're able to evaluate in real time, two of these: their oxygen consumption and their heart rate. So we're getting both pieces of data continuously as their ascending the tree, and for our practice here, that's what we're looking at. Is merely ascending because obviously that's where you're going to have a lot of oxygen demand as you're working your way up into the tree.

And what techniques are we going to use just for the small trial here? Well, [00:17:00] let's start out and take a look at the *Tree Climber's Companion*. And in there he talks about the basic climbing techniques. Now, a lot of you may be watching us say, I don't body thrust. I get that. I understand. Surprisingly, there's still quite a few people that still do this, so it was worth considering. And for those that may not be familiar with climbing body thrust. It's where are your place your feet high on the tree trunk, thrust your hips forward while pulling down on the rope. It's a pretty energy intensive way of working up the tree. Those you remember doing this back in the seventies, I wore out the inseams of all my jeans could be are continually pulling your legs up trying to pull yourself up to the next branch. And obviously this would be part of a moveable rope technique.

Following that, and actually seemed rather modern at the time into the eighties [00:18:00] was what we called a modified body thrust, which is still utilized quite a bit. And this was, whereas Jensen describes it. "The climber rocks back and forth and forms a lock on the rope, stands up on the foot lock and advances the hitch."

Those you remember looking at the videos back in the nineties on tree climbing. A lot of them discuss this technique. And as I say, I still see a lot of arborists utilizing it today.

Well, then we also have some stationary rope techniques rather than a moveable rope technique. This used to be referred to as a single rope, but obviously we're only using one rope. A better description of it is as a stationary rope technique. In other words, you're moving on the rope, the rope is not moving. One of the other ones that showed up in the [00:19:00] actually in the eighties and nineties was what we call called the secured foot lock. Now foot locking was used before that, but it wasn't secured.

You literally just climbed the line until you got up the first branch. And this was a technique we used for getting up to the white pines out East, but secure foot lock obviously provided that extra level of protection. That's what we have been utilizing. And if you go back to the videos done on tree climbing back in the nineties, you'll see this technique showing, and this is where as Jepson describes it. The climber grabs both ropes, and by that he means both ends, with the hand below the friction hitch, raises the leg, foot locks the rope, stands up to advance the prospect loop, or any other loop that you're using.

And then now of course, there's a multitude of SRT systems that are being utilized. A lot of different mechanical advices as [00:20:00] well that are being used. We have a lot of systems in which to evaluate, but for today, we're only looking at one to compare it to the other three. And obviously this is where the climber incorporates two attachment points on a single rope. Now they're all single ropes by which the climber transfer alternates weight transfer. And I'm sure a lot of people that are watching this, SRT a technique like such as this, is one that you're utilizing for most of your work.

Well, let's start out and measure this. Well, first of all, again, at rest, we're going to take a couple of our participants, their heart rate of about 57. Again, some of them have a lower heart rate than 60.

Again, they're fairly good athletes as well. And the average VO_2 at rest of about 35, 3.5 milligrams per kilogram, per minute. Now their VO_2 max. In other words, [00:21:00] what's the maximum oxygen consumption that they can have is about 48 milliliters per kilograms for a minute. Now, by the way, that is not hereditary. You don't have a max that you are born with and that's as good as you're going to get. Now certainly there's variations and capabilities of all people, their baseline, but nevertheless, with training, you can increase that. Cyclists, for example, competitive cyclists, which really depend on aerobic fitness. Many of those, their VO_2 max is 80, almost twice as high because cycling is a very much an aerobic sport as well as running.

But you start at rest and look what happens the minute you start going up that rope. Your heart rate, which was somewhere in the high fifties or low sixties [00:22:00] is now pushed to 166. Your VO_2 consumption. Which might've been at 3.2 to 3.5 has spiked to 41. Now remember your max for a lot of these was about 48. When the really working to go up that line they're exerting a tremendous amount of energy. And every climber here that does this, understands this.

Let's look at the four systems. And again, this was just a brief trial here. Body thrust, the modified body thrust, the secured foot lock, and then just a SRT technique without going over all the mechanical devices. And a fairly small pool of people four; and the same four tried all four techniques.

What I want you to notice is on these ascents. Take a [00:23:00] look, the one that required the most oxygen consumption, no surprise, was the body thrust and really the modified body thrust at 29 to 25. And again, you might say, well, on your last slide, you show it going up to 41 and that's correct. But if we take a look at the long climb, continuous climb, this is what it

would average out at.

And then take a look at the heart rate. For body thrust 183 as a spike, 168 and 160 down there for the SRT technique. If we looked at efficiency, in other words, the climbing system, by how efficient it was, and really what we wanted to look at was oxygen consumption. What technique resulted in the lowest oxygen consumption and the lowest heart rate. Clearly here SRT is the system. [00:24:00]

And I also want to point out that every time the arms were working above the heart, the heart rate spiked, again those weren't continual heart rates, they would spike at that. And what we find with climbing and this was found also with rock climbing. That there's a disproportional increase in heart rate. The VO_2, in other words, climbing is not as much of an aerobic sport as cycling is for example, but nevertheless, we are going to push our heart rates quite a bit. And one way to push your heart rate is get your hands above your heart, above your head and pull. That is where your heart is really working.

And this has been found in numerous studies that due to the upper body pull, the arms working above the heart, that's where you're maximizing the heart [00:25:00] rate. These old techniques and here's a body thrust. I believe this picture is probably about 12 years old. And this was a company and you can see as he's doing his, raising his legs, getting his legs as high as he can.

And then what he's going to do is pull with those arms. And by putting your arms above your head and pulling, working in your arms, takes a tremendous amount of energy. Any system where you can reduce that arm pole, particularly the arm pull above the head is going to be more efficient and efficiency by measuring really energy consumption here; oxygen and the heart rate push to move that oxygen through the body.

Again, take a look at heart rate of 57, the VO_2 at rest a 3.5. And as I mentioned, or VO_2, which we can measure as well was about [00:26:00] 48. I mean, they're, they're fairly good athletes and that is the maximum potential for using oxygen to make ATP now. What they found in rock climbing, again is you can perform at about 60% of your VO_2 max. In other words, you can push yourself that high, but you can't hold it.

And for tree climbing, that's critical because your job just climbing the tree. When you get up on the tree, you've got to work the tree. Just exerting yourself to the maximum level that you can to get up there is not efficient. You want to keep a technique that's about 60% of your VO_2 max. And if you do that throughout the day, you can actually work the day with those techniques.

And as I mentioned before, your VO_2, max varies among workers. I mean, one of the things that's nice to do is actually measure it. A [00:27:00] climber has a base. In other words, we know what you're capable of doing right now.

Now, as I mentioned, this can be improved with training. Any aerobic activity is going to prove this running, spinning, cycling is going to do that. And a lot of people don't think of those as activities that climbers would do to improve their efficiency or performance. And as I mentioned, it's not all your performance, but nevertheless, improving your aerobic fitness is a big help and those activities can do it.

And we take a look, people that are sitting a lot, which is unfortunetly most people, their VO_2 max is going to be less than 20, 29 or 28. In fact, it would no surprise to anyone here. That's where most of your customers are. The people look up in the tree and say, well, I would do that if I had a rope. No, you probably couldn't because quite honestly, they don't even have the aerobic fitness [00:28:00] to actually be able to move up a rope, let alone the strength.

Moderates between 30 and 44. High, we're getting into athletes is greater than 45. When we take a look at a lot of arborists and we haven't measured as many as we planned, you're really looking at somewhere in the forties to even the low fifties, if there are also runners besides, and as you can see here.

26 is about 60% for this group. Using the secured foot block and obviously SRT systems is really the way to do so. You do not fatigue yourself during the entire day of work.

Thought you'd be interested in this too. If we look at the climbing event, the belayed speed climb, where you're climbing that predetermined route from the ground to about 18 meters. I looked at the [00:29:00] times over the past several. And they generally range. And I say generally range, from about 23 to 50 seconds for this climb.

And those, I may not be familiar with it, essentially. You are being belayed and you're climbing. You can pull on the line, you can also use the branches and you're actually going up the tree almost as though we rock climb, though, with rock climbing, we're not using line at all. It's merely there for fall protection.

And for rock climbing. If you're climbing at the rate of about nine to 12 meters permitted, excuse me, you're often at your VO_2 max. Now, again with climbing, it's not running, it's not a sprint. You're not always operated high speed. You can rest or go gradually up the tree there, but that blade speed climb is actually where you're going to be closest to really maximizing your oxygen consumption because you're [00:30:00] just pulling yourself branch to branch, to branch using a line up about 18 meters. And so that's equivalent to rock climbing in a gym, for example where you're just trying to go up there as quickly as you can.

But again, look at that heart rate, that heart rate really gets pushed when we're climbing. And one reason is that you're putting your arms above your heart. That's going to increase it. Another though rather minor is anxiety. The fact that you're doing an activity that, which you could fall as climbers, we're all pretty accustomed to that environment anxiety actually is a fairly small percent of it. Really it's all about the legs. Use the legs as much as you can, not the arms, just like rock climbing. One of the things I teach in my rock climbing class, and this is our setup [00:31:00] Devil's Tower is lift with your legs, hold with your hands. And that's fairly common.

I like this quote out of the REI internal or rock climbing, “feet are the foundation of climbing, lots of beginners, try to pull themselves up on the wall and quickly tire out. Think about climbing a ladder. You don't pull yourself up, you step up and use your arms and hands for balance. It's the same with climbing.”

And we really consider that more with tree climbing. Now with tree climbing, we tend to climb the line more than we do the tree these days. As much as you can use your leg muscles, rather than your arm muscles, it's far more effective.

As we say, when you pull, you can actually see it, pulling that heart rate goes up. And then when you're resting, that heart rate goes down. And why that disproportional heart rate rise to oxygen consumption. I've already mentioned it's getting in the [00:32:00] hands above the heart, but one of the things we don't realize, it's also the gripping with the forearms. Now we get that with rock climbing as you can see here, as he's working his way up, that you're gripping. Think of that grip strength as well.

And if you really look at it, it's that rhythmic where you're gripping and releasing you're gripping and releasing, are gripping and releasing, that also raises your heart rate. And if Charlie's watching this and he always comes to TCI and off, and I say he is very big on grip strength.

If you ever shake hands with him, you'll know grip strength. Charlie's comment, which is absolutely true is that people don't have quite the strength that they used to, and we need to do more, to get a better, better strength on it. And again, we're going to be measuring this as well. Having done quite a bit of it yet, but once again, having good arm strength, grip strength [00:33:00] actually is going to help.What we have found is that you fatigue slower, no surprise, with the better strength that you have.

What do we know so far? Well, climbers are made not born, and I think that's good. That a lot of times you look at it and say, Oh yeah, that they're going to be a climber. I can't. No, you can be, anyone can be. Within reason. What do we know about good climbers? And we're taking this from rock climbing, because this is an ongoing study. Utilize this, but again, tactical route decisions. Good climbers, know how to read a tree. They know how they're going to get up in the tree. They know how they're going to work the tree. They know how they're going to come down. They've got it figured out. That's going to provide efficiency.

Good grip and they can rest their hands ever watched rock climbers will drop the hand down and shake it. Okay. Getting that blood flow going again. Something we need to do more when we're [00:34:00] tree climbing. Take care of that grip. Obviously have a high VO_2 max and upper arm strength is still important, but should not be over-utilized.

Where do we use the most energy? I thought you might find this interesting. And a reminder at rest, you're using about three to 3.5. We ran through a couple of other exercises just for fun, and we'll take one of the students here. And that was her rate. And by the way, she's also an excellent rock climber certainly has the aerobic fitness you need. And let's run her through a lot of other activities and measure them as we go. Ascending is where you're going to use the most energy and that's not a surprise to anyone here. And it doesn't matter what technique you're going to use. That requires a lot of energy to get ascend a tree, but it's not much less when you're actually moving through the [00:35:00] tree and working through the canopy. That does drop a bit, but not as much as you might think.

And of course, descending. Yes. Your activity drops quite a bit there, but nevertheless, it's still a way above rest.

Operator chainsaw. Yeah. Look at that. About 20 to 22, and there's other studies that have shown the same thing with chainsaws. It's more energy than you might think, but if you really want to burn yourself out, drag brush. Dragging and chipping brush, which you're going to do on a longer time period than climbing perhaps is incredibly energy intensive. And anyone who does drag brush understands that.

Well, what about flying in an Aerial lift. Okay. They got to put a cup holder in those buckets because you know what, if you look at three or that being what's, you're burning just as you're [00:36:00] sitting here today, you're only doubling that when you're flying the arial lift, that's the job you want.

Well, as I mentioned, let's take a look at some of the challenges that we have utilizing SRT here. Let's talk a minute here on safety. Well, first of all, our techniques have changed quite a bit. We've now got the small throw bags that we can fling way up into the tree. And if we can't, we can actually use a big shot and get them farther.

That's a big change from the old throw bags we used to use those throw pouch. And as I mentioned back in the seventies and even a little bit into the eighties, it was fairly common to free climb to the top of the tree, using three points of contact, tie in, and then work the tree coming down. We were taught, always take your line and make sure it goes around the [00:37:00] trunk over a branch union as a stop. And that was the technique that we did because you were standing literally right there. And in fact, it was a requirement in the United States until 1994 in our Z standards, that the climbing line be positioned over a branch union

and around a trunk as this illustration shows from an earlier publication.

And obviously if you do that, that's a fairly safe connection. It's not going to fail or a very low probability of failure. But nowadays we're often isolating it with a canopy anchor for doing SRT. And the canopy anchors are great. There's less force on that tie end point, right?
There's less bounce in the line, but you've got to isolate the line and obviously it's harder to retrieve. And as Kane has pointed out a number of his excellent articles here and *Arborist* [00:38:00] *News* that you better make sure you've got it anchored just right. The farther out that is the greater dynamic amplification, that sway frequency. You want to stay at, or within a foot of that union too often, we're shooting a line way up there can barely see where it is. And we're too far out on the branch should be there.

And I've seen these fail and Tim did as well. We were both out at this climbing competition as they were setting up someone put a line up there put their weight on it and it snapped. And by the way, it's snapped when he'd already started climbing. And fortunately he wasn't hurt.

And we have that in our Z that US safety standard that when climbing a rope, you're supposed to begin by inspecting the anchor point. And then if suitable, subject to a weight, approximately twice the weight of the climber before climbing commences [00:39:00], but really does that work?

And it was Brian Kane's written a number of articles in this in *Arborist News*. And I have Tim and I have one or two as well. And what we found is that two people don't pull with a force attention equal to their own weight. You can't pull with your own weight if you're still standing on the ground. Right. If we have two people standing on the ground and pole, they're not pulling with their own weight and their weight may not be that of the climber. In fact, if you're staying on the ground, it's about 60%. So if we have two 280 pound people, they're going to pull with a force of about 220 pounds.

The climber can exert about one to 1.5 times their weight. So 180 pound person is actually pulling with a weight greater than their weight. And in fact, if you look at this two people, polling can exert less force on that rope on that anchor point [00:40:00] than one person climbing it. And that one person it's oscillating, they're loading, loading back, loading back.

And so this was one reason we do get time point failures now. You can use a bazell anchor rather than the canopy anchor. And these are obviously easier to retrieve and we can use them as rescue and unfortunately, there's going to be greater force of that tie in point, that primary suspension point. And there's going to be more bounced because you've got more line built into the system, but that ability to retrieve is so valuable. And this is what we practiced at the tree care industry associations, aerial rescue a symposium last year, that is handy and being able to retrieve an injured worker.

But a climber here is going to exert about two to three times their own weight. Okay. 180 pound person, 360 to 540 pounds. [00:41:00] And you don't want to sway at all.

Well, what you can do of course is try to get that bazell anchor as far out as you can. You want to increase that angle. We found that in that what was called the single rope technique, which is now the stationary rope technique, of course, that the farther, the angle out, the less force on that primary suspension point, your top anchor and more force on your bazell anchor.

It's not a major change, but it does help. So, what we take a look at is trying to get your bazell anchor tied off on another tree. Because you can see your bazell anchor, but that anchor up above, or top anchor, or primary suspension point, which may not, you may not have seen it because you're climbing up to it.

So we want to reduce the amount of force on that. However, I would like to mention that even

though it's a great system [00:42:00] to moving the weight more, transferring that more to your bezell anchor the more you angle out. The more obstacles between you and what you're climbing. And we did have an unfortunate incident in the industry in the United States where someone drove down a road in which they had that Bazell anchor tied off. And top of the truck actually caught the rope, pulled the climber out of the tree and unfortunately killed her.

Well closing here. What about some other injuries? And again, I'm taking this from the review that Tim Walsh, Shane Vosburg, and I did and was published this year in *Arboriculture & Urban Forestry*, that if we look at all of fatalities, these 20% of our fatalities are art decliners. Now, remember I mentioned it was in the thirties, so we had aerial lift operators in that and 31% are to climbers.

Why are they? Well, 3% of all our fatal incidences are your [00:43:00] tie in point. Failing a lot of these, not all of them, but a lot of these are SRT techniques and they're just having too much force on that top anchor. And that's also about 7% of our severe non-fatal injuries.
And I might mention that many times they have tested it. Now we don't know exactly how many. We don't have data that fine, but there often is the comment in the incident report. Well, we tested it and then they climbed it. And in some cases they climb about a third, the way up before that anchor fails. And again, it's that oscillation that force, that force, that force, as you're continuing to work your way up on that line.

Repositioning or changing systems, and again, if we take a look overall of all our fatal incidents and all our severe, 4% and 6% is a fairly large number for a single activity. And these are consistent by consistent. I mean, we've had [00:44:00] these ever since we've been using climbing lines that in that moment, when you're switching systems or that you decide I'm not going to use a lanyard, it's only going to take a second. It's all it's taken for you to lose your balance and fall.

We also have more, you've cut your own line. Most of these with chainsaws, but Brian Cain also has an excellent article. It shows a rope under tension can be cut very easily with a handsaw, even. So again, having that two points where you have a climbing line and a lanyard around the tree, when you're operating a saw is requirement, and a darn good idea.

And then we also get them, unfortunately, contact with electrical conductors. Either indirect you drop a branch, which touches the wire or the climber actually touches the wire.

And then finally cut by a chainsaw. Chainsaws are [00:45:00] not many of our fatal incidences, but there are a large number of severe nonfatal. And almost all of these occurred to climbers. And that, and as a reminder, in the United States, ANSI Z 133 safety requirements for our agricultural operations, we do have in there that have a chainsaw shall be operated with two hands at all time, one hand on each handle with a thumbs wrapped around the handles.

There is a sub-part to that, and the part can never violate the part, but it's often confused. And what it says in there is that you should always operate the chainsaw with your left hand around the forward handle and your right hand, around the rear handle, unless it's not practical. And employer demonstrates a Grazer head is opposed by operating chain saw that way.

What that means is that the employer's option, you can reverse hands. It does not mean you can one hand a chainsaw. In the United States, according to our safety [00:46:00] standards. There is no exception that allows you to operate a chainsaw one handed, on the ground, in the tree, in the aerial lift, period. And when we take a look at our series incidences quite often, they're to the left arm, why the left arm? Because someone was operating a chainsaw in the tree with just the right arm.

Because of that too. In some countries you are required to carry a first aid kit with you when you climb. Not a requirement in the United States, but it's a darn good idea. And I know a lot of

people do carry them. Again, since the major risk you run is a chainsaw incident. You do need to have something for chainsaws. And for me, it's one of these tactical tourniquets. I merely mentioned it here today that does require training to utilize one, but they are becoming far more common and first aid kits. And I certainly recommend them for climbers. Because that is the way to actually stop a [00:47:00] blood flow that is caused by a chain saw a cut. That's going to allow you to survive until someone gets you down or you've managed to get yourself down.

And then finally, when you have to carry a chainsaw, a handsaw locked all the time in the United States, essentially when your feet leave the ground, make sure you have a hand saw with you as well.

With that, I thank you for the opportunity to present here today. If you have any questions, I can reach it at any time. We do have a chat box too, and I will be checking that during the conference to make sure I've answered your questions as well. And I may get Tim involved in here as well. I hope you enjoy the conference and I thank you for your attendance.