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Wheelchair Selection and Training Considerations for the
Client with Spinal Cord Injury
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Presenter: Kristen Cezat, PT, DPT, NCS, ATP/SMS
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- [Calista] Well, it is my pleasure to welcome back Dr. Kristen Cezat to PhysicalTherapy.com. Kristen is a board-certified specialist in Neurologic Physical Therapy, a RESNA certified Assistive Technology Professional as well as a Seating and Mobility Specialist. She currently works as a Clinical Specialist at Orlando Health Institute for Advanced Rehabilitation, inpatient rehabilitation where she specializes including direct patient care and program development for patients with spinal cord injury and other traumatic and neurologic diagnosis. She received her doctorate of PT degree from the University of Central Florida, and she guest lectures annually with the University of Central Florida's Physical Therapy program, and is also a clinical faculty for the UCF Orlando Health Neurologic Physical Therapy residency program. She works with a team at Orlando Health who have obtained grants from the Paralyzed Veterans of America and the Craig Neilsen Foundation to serve those living with spinal cord injury in the Central Florida community. She recently received the APTA Spinal Cord Injury Special's Interest Group Award for clinical excellence in spinal cord injury care in 2020. So thank you so much, Kristen, for presenting for us once again today, and at this time I'm going to turn the microphone over to you.

- [Kristen] Awesome. Welcome everybody. I'm so thankful for everyone joining us today. Today's topic is so important and relevant to our clients with spinal cord injury. And really PT Schools and Residency Programs only spend a few hours at best on wheelchair selection in training skills in our programs. So when you think of wheelchairs and spinal cord injury, it truly is an extension of the client's body. So I'm so excited today to get together to discuss wheelchair selection and training considerations for the client with spinal cord injury. So first, just real quick, a few disclosures. I am receiving an honorarium for presenting this course today, but I have no other financial relationships. The learning event does not focus exclusively on any specific product or service. And this course is presented by PhysicalTherapy.com. And

then I have a quick note for myself. There are lots of different pictures that you're going to see throughout this course and if you do see any specific products, they're just example purposes only. I don't endorse any type of product, I have no financial relationships to any products or companies and I really made a strong effort to avoid discussion of any or my own opinions of any specific brands throughout this presentation. So we're going to keep it generic about some of the topics. All right, so learning outcomes. So after the course today, the participants will be able to identify three common postural abnormalities related to spinal cord injury. We're gonna identify at least two types of alternative drive controls for power wheelchairs for clients with spinal cord injury resulting in high level of tetraplegia.

We're gonna identify at least two considerations for determining the type of wheelchair for a client with spinal cord injury that's resulting in low tetraplegia or paraplegia. And then we're going to identify at least two key training interventions or goals for both manual and power chair users. And we're going to identify at least two possible outcome measures that can be utilized to determine the need of a wheelchair or the effectiveness of the intervention selected for wheelchair training. All right, so let's get started. So, I think this is such a powerful statement. "The wheelchair is essential to someone who has experienced paralysis. It acts as an extension of my body and if my chair isn't right, then that's when I feel like I can't do something." I had a really great discussion with a former client of mine with a C6 injury and we were talking about some of the challenges that come when things go wrong with his wheelchair or when his wheelchair doesn't feel just right. And he says he doesn't really think about his paralysis in the moment until he can't do something. And a lot of times that's wheelchair related. And we're gonna talk a lot about that today. 95% of those with a complete spinal cord injury and 67% of those with a motor incomplete or AIS Bs rely on a wheelchair for mobility. You don't have to work in a spinal cord injury-specific center or in a seating clinic to encounter a client with spinal cord injury in need of wheelchair-related services. Every year I get a phone call from a colleague or a friend

who wants to discuss the client that's rolled through their doors when they work in like an outpatient ortho or in home health saying, "This person has come into my clinic and they need a new chair and I'm not sure what to do." So, the services are needed everywhere and especially for those living with spinal cord injury in rural areas, they may not have access to a local seating clinic or spinal cord injury center so they're going to show up in all sorts of places. So it's really important that we are up-to-date with some of the latest technology and some of the concepts specific to spinal cord injury and seating and wheelchairs.

Whether the client has a brand new injury and we all know, when someone's first injured, we're really convincing them that they need this wheelchair. That it's necessary to be able to go home and return back to a meaningful and independent life. Or if it's someone who is injured for 25 years and they're on their fifth chair and they know exactly what they want, these clients are going to need wheelchair services for the rest of their lives. So it's really important, some of the things that we're going to go through today to become more comfortable to be able to serve this population the best that we able to. So the wheelchair. What's the big deal? Chaves et al. examined participant limitations for clients with spinal cord injury in the home, community and transportation.

This was a study done out of the University of Pittsburgh in St. Louis where they looked at 70 participants with spinal injury who were primary wheelchair users. And they were surveyed. All of them were one year or greater post-injury. I find this so like really, really profound that this survey found that wheelchair was perceived as the greatest participation restriction over that of the physical impairment or the environment that the client was in. So take that in for a second. That that's saying that these clients found that having problems with their wheelchair was a far bigger restriction to participating in what they were trying to do than that of their actual physical impairments from their spinal cord injury or the environment that they lived in.

So that's really, really important and that really tells us how essential it is that we are taking into consideration all the different things we're going to talk about today in the wheelchair. So, of course, when we miss the target, nobody loves to talk about this part, but this really is, I mean, every seating therapist's worst nightmare is when things don't quite go right. How often does somebody come into a clinic and they're missing some of the pieces to their chair, their laterals are hanging off, they only have one hip guide now. All these pieces that we have prescribed to them are no longer on the chair or have gone missing or the client just didn't feel that they were essential. Equipment abandonment really is one of those worst case scenarios for a seating therapist or any therapist who's prescribed a chair. So there was a study from Phillips & Zhao's article, "Predictors of Assistive Technology Abandonment," where they surveyed 227 adults with various disabilities.

There were four factors that were found to be related to equipment abandonment. And those were decreased input of the client, ease of obtaining equipment, poor performance of the equipment and a change in the need of the client. So obviously in those living with spinal cord injury, it's not very often that the entire wheelchair is abandoned because it's essential for their mobility. However, it does happen. I had somebody who came into clinic not too long ago and they were on like their third or fourth chair, and they had just recently gotten a new chair and they were so dissatisfied with the fit and the performance of the chair that they ultimately just said, "Forget it," and went back to using their old chair. They went online, they bought pieces that were no longer functioning on the old chair out-of-pocket, and tried to fix things themselves because they were so dissatisfied with the brand new chair that they had gotten. So when we see that, we really need to sit back and evaluate what went wrong. We often see, however, the pieces and the parts of the chair that become abandoned in spinal cord injury. And what does that result in? When the chair isn't right, we end up with a decreased client function or independence of the client. So it's so important to remember that collaborating with the client and the team is the most important part of

what we do. It's hard. We as therapist sometimes think we know what's best or especially the longer you've been doing this you can think, "I've seen this a million times before. This is what I think you need." However, if that specific product or if that recommendation doesn't meet the end user satisfaction, then really what have we done? we need to be looking at what is the patient's goals and preferences specifically, and how does that fit into the big picture of their world? If you think of it as what you're recommending, so say you have a client who has two or three children and they work and we're recommending a chair that by the time they get into it and put all the pieces of the chair together, it's now taken them 30 minutes to position themselves. Is that functional? Is that going to work for the client that's trying to get out of the door with their kids and get to school and work?

So all of those things play into the decisions that we make and why we make them. So really quickly, I do want to talk about the RESNA Wheelchair Service Provision Guide. RESNA is the rehab engineering and assistive technology society of America. They have developed this provision guide really as a standard of practice for wheelchair assessment and provision. It's a framework for anyone who's involved in wheelchairs, from the client to the healthcare team, to the law makers and policy makers, to the insurers and the funders for the equipment that we're recommending, and it's really based off of the ICF model.

So I highlighted in bold the things that really we as the therapist are involved in during this process. So obviously first the referral is made to clinic or it's either comes from the supplier or from the physician. There's many different places that the referral comes from. And then next is the assessment. So the assessment is really where we come in and we look at it based off of the ICF model. We look at body structures and functions, activities, participation in the chair, the environment they're going to be using the chair in. And we really try to understand the client's goals and expectations. After that we're going to look at what equipment now meets the things that we have

assessed. So we've come together with this picture, with the posture and the function and all of those things, now it's time to match up, what is the equipment recommendation and selection for that client? And remember sometimes that does include trial of the equipment. That may or may not take more than one visit depending on what setting you're in. Whether it be home health or outpatient. For those of us in an inpatient rehab, it's we tend to have them for an extended period of time that we're able to try different products. But if you're doing this in another setting, it's okay to say, "We really need to try X, Y, Z and I'd like to see you again one more time." That's okay to do. One of my favorite things about this document and something that taught me a lot is look at what's number four. Funding and procurement is fourth on the list. It's not first, it's not second.

So many people place such an emphasis on the funding. And not that that's not important because it definitely is, but it's not the most important thing. It is something that needs to be considered obviously, but it's not the sole reason we make a decision. It's important that we as clinicians are matching the technology to the client and what would serve them best in their world and allow them the most independence without saying, "Well, this is all the money you have so this is what I'm going to prescribe to you." That's really the opposite way that I think we should be looking at wheelchairs. However, we all know the pressures that are put on us as clinicians sometimes from the companies that we work with and the vendors and things like that, but we don't know what is important to the client. And if something's really, really important, they tend to find a way to get it. There's foundations. Everybody has a GoFundMe these days. There's grants that are available. So just remember funding although necessary isn't the sole reason that we do or do not recommend something to someone if it's appropriate for the person. Next comes the product preparation and putting the chair together. The fitting where we fit the equipment to the client and we train them on how to use the new equipment that they've received with the delivery process. There is a lot that comes with the followup and the maintenance and the repairs that are required for

the wheelchair. Oftentimes as clinicians we kind of glaze over this process because we've done our job, right? We got the chair, they've gotten it, they know how to use it. So it's kinda like, "Good luck. See again the next time you need a chair." However, there are a lot of things that we could be educating our clients on for followup and maintenance and repairs that we're gonna spend a little bit of time talking about today. And then lastly is the outcome measures. Determining how effective was this process and what was the satisfaction level in the function of our client before and after the new wheelchair prescription? So just some things that I think are really important and if you have the chance to read this document, it's awesome. But some things that will kind of break it down into today as well.

Alright, so many considerations, right? We haven't even really gotten started with the important stuff and we already have so many considerations to think about. So these are some questions that just kind of help you point you as the clinician into the right direction. So obviously first and foremost, what is my client's goal? If that goal is not realistic, then we need to sit down and spend some time educating. But it's really important that we are discussing with your client. What are you hoping for in your chair? Are you happy with what you have currently? Are you not happy? What are the things that you wish you could be doing?

Or, is this your first chair, and you really have no idea where to even start? What is your client's level of injury? That's obviously going to play a big role in determining what type of chair and some of the features on it. Looking at if this is your client's first chair or their fifth chair 'cause that again, the needs of the client may change as their injury evolves and their abilities evolve. What are the findings that we're going to talk about from our MAT assessment, 'cause that's going to be a huge factor into the pieces that we're going to put onto our seating system? Looking at the patient's functional mobility status and if that has changed since the last time we've seen them, or if it's the first time that they've received a chair. Some of the comorbidities and the client's weight

and their age are also gonna steer us into a direction of looking at either maybe manual or power and why. What is the client's home environment and what is their support system at home? In a higher level of injury, support system is hugely important because they're going to be reliant on using lots of different things that the caregivers are going to have to set up for them. So what does that support system look like and how skilled, I guess, would be the word? Is the caregiver in the family at completing some of the things that we're going to be asking them to do? And then also, how are we going to move the chair around? Is the client going to be using a wheelchair accessible van, city transportation? Is it a chair that they can break apart and put in the car?

Those types of things. Does the client drive or does their family drive them? So all different reasons why we would possibly choose one chair over another. All right, so let's look a little bit of the effects of spinal cord injury on posture. So what is ideal sitting posture? What does that look like? And that's really different to different people. Are you sitting right now with ideal sitting posture at your chair? Are you able to sit like this for 10 minutes or 30 minutes the whole presentation? Can you sit that way for eight hours?

Because it's really hard. I mean, we all end up in that kind of posterior pelvic tilt, slumped positioning. So think of our clients with paralysis. It's even harder for them. We have intact muscles that are working and we're still not sitting up straight. So it's really important to think of what is ideal sitting posture and what does that look like to our clients? The wheelchair's role is to fill in the gaps and best facilitate the functional posture for those weakened or paralyzed or even hypertonic muscles that we often see as a result of spinal cord injury. What is the goal of the seating system? Is it to achieve that ideal posture? Is it to just get into a neutral position to be able to function? Do we have significant abnormalities and now we're just trying to slow the progression down and create a functional environment that they can interact in? There's a lot of different

considerations and ideal sitting posture is going to be very different depending on what your MAT assessment looks like. And then lastly, stability versus mobility, right? So those are two different concepts that both need to be addressed in the wheelchair. And it's a very fine line. I can make somebody very, very stable in their chair and we can put all kinds of positioning belts and straps and things to help maintain posture, but is that functional? Can they use their upper extremities the way they need to? Are they able to reach for things? We don't want stability to be at the cost of hindering their mobility. So it is a fine balance. What does when the client is moving around? So it's one thing to look at their stability while they're sitting still, but what does the client look like when they're moving around? Does the mobility aspect of the wheelchair now start to affect what their stability looks like in the chair?

So it really is a concept that makes wheelchair seating so difficult because the functioning of the wheelchair is really a dynamic process. Whether it be sitting at a desk or moving or carrying things or shopping. There's so many different needs that this wheelchair has to fill. So looking at stability versus mobility and finding that right, exact point that works best for the client can be challenging sometimes. All right, so why do some of these postural changes occur following spinal cord injury? So obviously after spinal cord injury, one of the biggest things is the paralysis that results. So now we've got musculature that is no longer innervated, so that can result in multiple different muscle tones, whether it be hypertonicity and spasticity that causes movement in the chair throughout the day to causing them to come out of the positions that we would like them to stay in, or whether it's hypotonicity in which case there is no spasticity and we're really looking at decreased stability from just the paralysis of the muscle itself. Having poor fitting equipment. So sitting in a chair that doesn't fit properly is going to result in postural changes over time. So whether it be too wide or too deep or not deep enough, if the arm rests aren't adjusted right or the leg rests aren't quite right, all of that is going to result in postural changes. So it's important that we are looking, even if it's in very, very basic equipment that we're just

sitting in an acute care hospital, it's so important that we're looking and using low-tech options if that's all we have available: Towel rolls, different things like that to try to make sure that the equipment isn't the reason that we are seeing curvatures of the spine or things like that. And then also poor fitting is just one aspect, but what about poor positioning in the equipment? So obviously whether it be then the nurses if you're in an inpatient or acute care who are positioning the patient or the patient's family or the client themselves, if they're not paying attention to the positioning in the equipment we prescribed, we're going to start to see postural changes over time. If somebody has strength asymmetries, we often too see changes over time. If somebody's constantly using their stronger upper extremity following tetraplegia, it's not uncommon that we may see some rotational things to the trunk because they're constantly reaching with that side, strengthened symmetries in the legs.

All different types of things, but having really imbalanced strength from one side to another can result in postural changes. And then lastly, it's not often that somebody with a spinal cord injury, that's the only injury that he incurs from the trauma or that they have received. We see a lot of these clients are in car accidents and motorcycle accidents and sports injuries and all types of things that result in other injuries besides the spinal cord injury itself. So if we have broken bones or pelvic or any type of injury that now has also occurred on top of the paralysis, we can see contractures form very easily with limited range of motion or if there's pain felt from the patient, obviously when we have pain, what do we try to do? Right? If you have pain just for example through the pelvis, we try to get off of that area. So you may start to see some postural changes from pain that occurs, whether it be from the original injury itself or prolonged use of the wheelchair. But those are just a few examples of some reasons that we'll start to see changes over time. So some of the postural abnormalities that we're going to talk about today that we see following spinal cord injury are listed here. So these are some pretty common ones: Posterior pelvic tilt and pelvic obliquity. We're going to talk a little bit about pelvic and spinal rotations and spinal kyphosis, curvatures, windswept

deformity which is one of the not quite as common in spinal cord injury, but we still do see it. And then just that splayed sitting posture. So let's break these down a little bit. All right, so posterior pelvic tilt. That's when the pelvis rolls backwards when someone is sitting in their chair and the effect of that posterior pelvic tilt leads to other things like thoracic kyphosis and rounded shoulders. Posterior pelvic tilt is really common in spinal cord injury. Often as a result of paralysis, clients are seeking stability, right? So sitting upright, we don't feel balanced nor do we have the muscle control to do that so the pelvis rolls backwards which increases their surface area and makes the client feel more stable. So even if we have a really good supportive back rest and things like that, a lot of times we'll still see the client kind of seek that posterior pelvic tilt because they feel more stable in that position 'cause there's more and more contact. But what are the ramifications of this? So we can see in the...

This is a picture of a pressure mapping system here, and somebody who is significantly posterior pelvic-tilted, and where do we see all the pressure? Right through that sacrum and coccyx area. So it's important that we pay attention to what are the ramifications of the postural changes that are occurring on things like pressure. So shifting from the ischial tuberosities to the sacrum is a result of posterior pelvic tilt. Also looking at the mechanics of propulsion. What is posterior pelvic doing to the shoulders while we are now trying to propel the chair?

So it's going to lead to very decreased mechanics. So we can see the curvature of the person sitting in this chair and how rounded we are and what is that going to do when we're pushing a chair all day long. So, next we're going to look at pelvic obliquity, which is another one that's very common following spinal cord injury that we see. Pelvic obliquity is when the pelvis tilts to one side or it's a lateral pelvic tilt, either one where we see weights through one ischial tuberosity more than the other. When the pelvis has an obliquity to it, we often see that in combination with a spinal curvature 'cause the trunk is going to follow where the pelvis is going. And it's important to

remember that we need to document the pelvic obliquity based on the side that is lower. So just for an example, in this picture of the pressure map here, we can see that the right ischial tuberosity is taking more pressure than the left, so that would result in a right pelvic obliquity. And that's important for when we get to our documentation and we start asking funding and procurement of resources to pay for a specialized cushion. We need to make sure that we're documenting correctly why they need that cushion and it's based on what type of pelvic obliquity they have or posterior pelvic tilt or something along those lines. Next we're going to go to pelvic and spinal rotation. So this is when one side of the pelvis and the trunk rotates forward and the other rotates backwards. Sometimes we see this just as a result of pain and the client trying to find a comfortable position, but sitting in this position prolonged is going to result in more pain. So it also results in just decreased pelvic stability, decreased function. So it's important also that we document our rotations for our pelvis and our spine properly. So the pelvis is rotated to the left if the left ASIS is further back, or you can describe exactly what you see.

The right ASIS is forward to the left ASIS. So again, when we're looking at a specialized back or cushion as a result, we want to describe clearly what we're seeing in our posture to those that we're asking to pay for the equipment. So spinal kyphosis. We discussed that that goes hand in hand with the posterior pelvic tilt. That's when the upper trunk is curved forward and it often relates to the posterior pelvic tilt. It has the same effects that we would see in the posterior pelvic tilt on posture. Sometimes we see this in our older population. Just degenerative changes over time and that's their pre-morbid posture or sometimes we see this as a result of just gravity pushing down on the paralyzed muscles themselves. So spinal kyphosis is another common one that we have to address through our seating system. Looking at a spinal curvature or scoliosis. The spinal curvature is when we're looking at it curving from one side or the other. We want to document that or name that based on the convex side of the curvature. And oftentimes it's important that we put our hands on the client's back, we

lift their shirt, we want to see what the spine is doing. And I want to feel the rib cage, I want to feel what is going on in the back. It's easy sometimes to put your hands on and feel which side is protruding more. And again, this can be effect. This can be a premorbid thing that they've had their entire lives or this could be an effective again, gravity pushing down on the paralyzed. Especially we see it a lot in really long trunk clients. The trunk's going to collapse one way or another if there's nothing, if there's no muscular tone supporting that. So oftentimes without a good seating system around them, you're going to see that posture that's going to cause them to collapse one way or another. Hypertonicity can also cause that curvature one direction or another, or again, we talked a little bit about the asymmetry of strength if we're constantly using one side all the time. We're relying on a single upper extremity, then we start to see some changes to the spine.

One thing that's purely preventable is having uneven arm rest. Sometimes we see that a lot and just like we just get the client up for the first time and maybe nobody has addressed the arm rest height, but those are simple things that can be fixed pretty easily, but equipment not supporting properly can also result in curvatures because they need that support to maintain the spine straight. All right, a windswept deformity is when we're looking at both hips turning in the same direction. We want to describe this in our documentation as to which hip is externally rotated and which hip is internally rotated. And we often name it for the direction that the legs are swept to. And this obviously has a significant effect on function and stability because we know where the pelvis and the legs go can significantly alter the trunk stability and function. So this can be a tricky one sometimes to position depending on how severe it is to be able to function and the client face the environment in a forward direction. And lastly, we're going to look at splayed sitting posture. So splayed sitting posture is another really common one we see in paralysis. And this is when the hips are abducted away from midline or externally rotated out to the side. There's a lot contributing factors to this and a lot of times it has to do with the seat depth being too short and not supporting

the femurs properly or the leg rest being too short and so same thing that result in the femurs not being supported properly, but what can end up happening is we again, prolonged sitting in this position, we start to lose range of motion and we can become stuck in this position. So it's really important that we address why is the client sitting with that kind of externally rotated, abducted, lower extremity positioning. So lastly, we'll look at the MAT assessment. I'm going to say this over and over. We could spend hours just talking about the MAT assessment itself, but the MAT assessment is our opportunity as clinicians to assess our client's posture in various positions and to be able to assess balance and posture and to be able to document the things that we're finding. So it's really important that we start our MAT assessment in supine, and that we start our MAT assessment with the pelvis. Remember the pelvis is our building block or foundation to everything above and below. So we start with the pelvis to look to see what kind of posture we have going on.

So, when we start in supine, we're looking at each part of the body: Posture, trunk, lower extremities, upper extremities, head, neck, feet to be able to see... One of our main objectives of a MAT assessment is, is the posture that we're seeing fixed or now we're trying to move to the terminology of, is it not reducible? Meaning it is stuck in that position. It's been that way for a long time and we're not gonna change that. Or, is it flexible? And again, we're trying to change that terminology to reducible. So you may see either, or, in which case is the posture that we're seeing easily able to be moved out of the posture into a more neutral position? That's going to really determine some of the features of our seating system. If we're looking at a fixed or a not reducible abnormality in the seating system, we have to accommodate it for it. We want to do certain things to maybe slow the progression of that postural abnormality, but we're not going to necessarily change it. So we need to accommodate for that in whatever we're selecting, whether it be the back rest or the cushion or various things like that. If it is reducible or flexible, we are looking to fix the problems. So we want to try to use our seating system to correct that abnormality before it does become fixed. So just

some different directions that your mind would go in based on what you're seeing in your MAT assessment. Once we've done everything in supine, we're going to go ahead and seat them up. So we want to seat them up at the edge of the mat or the bed or whatever setting that you're in, and this sometimes requires two people depending on the client how high level of an injury they are. But now I want to look at, what I just saw in supine, is that going to change when I seat them up? What are the effects of gravity? What are the effects of spasticity? There's a lot of different things that can affect what their supine to sitting posture looks like. And then we also want to look at them in the seating system if they have one already or if you're just putting them in one for the first time, we want to look at their posture now in the seating system itself. So the MAT assessment is really, I consider that my chance to get organized, right? That's my way as a clinician to put all of my thoughts into one place and document that for starting to look at the selection of what we're going to do on the client's chair.

All right, so let's break this down a little bit into level of injury and wheelchair selection based on that. So we're going to look at level of spinal cord injury based on high tetraplegia. So high injuries, C1 to C4, and we're going to look at that from a standpoint of power wheelchairs and alternative drive controls. Then we're going to look at low tetraplegia and power or manual chairs, 'cause oftentimes those clients, we have to make kind of a decision in which direction we're going to go in. And then looking at paraplegia. So the injuries that are at T1 and below. And for today's purposes, we're really gonna talk about manual chairs in that part. Obviously paraplegia can result in needing a power chair as well, but for today's focus we're going to really highlight use of manual chair. All right, so let's break down the power wheelchair just a little bit. So in a power wheelchair, the foundation of the chair, we're looking at the propulsion system and the seating system. So the propulsion system is the actual base of the chair. That's where it's either a front, mid or rear. And we'll break those down in just a second. We're looking at that's where the motors are housed, the batteries, the suspension, the electronics of the chair. So those are all of the things that

I always say make the chair move if that makes sense. The seating system itself is what we now put on top of the propulsion system. So that's going to be our back rest, our cushion, our arm rest, leg rests, the positioning aids and supports and things like that. So it's important that we look at each aspect of the power chair 'cause we need to justify obviously what we're going to be selecting. But first and foremost we're going to start with deciding on like the propulsion system first. So real quick, just a couple pictures of just some basic power chairs. Deciding on what type of drive configuration and the location of the drive control are going to be our first choices. So when I get a client with a C1 to C4 injury, I'm going to decide first, what is the best type of drive configuration for them? Is it going to be a front, a mid or a rear? And we're gonna break that down. How are they going to drive, right?

So we're going to look at a lot of different options for location of the drive control and breaking that down into what's called proportional or non-proportional drive controls. What are the power features that we're going to put on that chair from tilt, recline, leg rests, seat elevation, there's anterior tilt, we have power standing chairs or so many different options in technology. We'll go over that a little bit more later on in the section. And then all of the pieces that go onto the seating system. So the head rest, the back rest, the trunk supports, arm rest, leg rests.

Those types of things and why would we need those in this high level of injury that we're going to talk. So, going into front wheel drive, I'm a pros and cons kind of girl. I'm a advantages and disadvantages and I really like to sit down and go over that with my clients because there's never a, this is the perfect option, right? There's always good and bad of anything that we select when it comes to a chair. There's always an advantage and a disadvantage. So in a front wheel drive chair, this is when the propulsion wheel is located in front of the wheelchair base and the casters are in the rear. So if you look at this chair here as an example, we have the major drive wheel here and then we have the caster in the back. This chair specifically does have a

teeny-tiny little caster in the front that may or may not be present on the front wheel drive and that's actually based on how fast the chair goes. So at once if a chair goes a certain speed, that has to be there for stability. However, this is the general thing that you're looking at. So how do I know the difference between front, mid and rear? I look at where is this big wheel. And here it's in front of the base. So some of the pros of having a front wheel drive chair is that the chair is very stable, it has a tight turning radius especially in regards to 90 degree turns. So I always tell people like if you have a home environment and they have long hallways and their bedroom's at the end of the hallway, a front wheel drive can really handle that 90 degree turn very efficiently. So that's definitely a pro of this type of chair. Of all of the types of chairs, it is one of the most efficient in like in outdoor environment, an outdoor terrain or over uneven obstacles.

And one of the major reasons of that is because this drive wheel here is the major thing that's going to be pushing the chair up and over an obstacle. So because the big wheel is located in the front, it can push itself up and over obstacles easier than if say this was in the front. We'll talk about that in just a moment. One of the cons of a front wheel drive is when traveling really fast, the chair itself may fishtail or sometimes I get clients who having the wheel in front of their head, 'cause think of where they're going to be sitting with their head in this chair. Having the wheel in front of their head isn't as intuitive for them because the whole feel of the chair just takes some getting used to. So that could be another con when someone's learning how to use a front wheel drive chair in the beginning. Going into a mid wheel drive chair, in a mid wheel we've got the propulsion wheels located in the middle of the chair. So if we're looking at these two chairs here, which one is the mid wheel? it's going to be this one. So this be a front wheel 'cause the major drive wheel is in the front and this one is a mid because the wheel's in the middle of the base. We also have a set of casters in the front and in the rear of the chair. So on this type of chair, that would be how you would identify what is a mid wheel. You'll see the casters in the front and the back with the drive wheel in the

middle. So some of the pros are that again it's stable. It has a very tight turning radius in a circle which creates a good indoor mobility. So this of all the chairs makes a very nice, tight turning radius so that in really small apartments or settings like that can be more conducive than some of the other drive configurations. And then also it's intuitive to drive. So for the client, the wheel is directly under where their head and their inner ear is. So when they turn, they feel much more like they're on top of what's turning the same way you do as when you're walking before your injury. So for some folks it's much more intuitive. So when I put somebody in a front wheel and they're like, "Gosh, I just can't get the hang of this." Mid wheel obviously would be my next choice. Some of the cons are that it's not quite as effective when negotiating uneven terrain outdoors. Part of that is because, we talked about in the front wheel, the major drive wheel's in the front of the chair to push it up and over, but here we've got the small wheel first. So if we encounter a bigger uneven dip in the terrain or whatever the case may be, this is what is going up and over it versus this.

So it makes it for things like larger uneven surfaces, it doesn't go over quite as well as a front wheel. The other thing too is this has six wheels that are on the ground versus four. And so sometimes what I'll see is if clients are like on really like sloped or uneven like laterally slope things, they can get one wheel that ends up off the ground and it kind of makes them spin out a little bit. So can a mid wheel drive chair go over grass and you can go to the park, all of those things? Absolutely, but it just may not go over uneven obstacles the same as a front wheel drive. Any of these power chairs can go over things like grass, mulch, different outdoor environments, but what we really want to avoid and that we talked to our clients about is no sand, because think of how heavy this chair is. It's going to sink right down and spin out. Avoiding mud, things like that. But absolutely they could go to the park with their kids and things like that in a power chair. And then lastly is a rear wheel drive. Now these you don't see quite as often anymore just because of the large turning radius that's involved. So a rear wheel drive is when we see the propulsion wheels located in the rear of the chair and the caster

wheels are in the front. So in this particular example, you can see here the wheels are behind the user's head and pelvis, and then you have the little caster wheels in the front of the chair. So some of the pros of that are that it's stable and it can do really well in high outdoor speeds. So some of our clients who are in rear wheel drives, right? And have been injured for 20 years, they love that rear wheel drive and they don't want to come out of it.

So I will say I tend to only seat rear wheels in folks who are already using them just because they don't do very well in tight spaces. And a lot of the clients and folks that I work with have small home environments and apartments and things like that. So just different things to consider. So looking at the client with C1 to C4 injuries, the first thing we need to really look at is the client has a very limited area that we can now drive the chair with. So we're not going to be able to use a standard joystick at the hand, because think of our high level injuries, the only muscles that we're going to have to use are going to be the muscles of the neck and the head. The breathing muscles are going to be affected in our high levels of injuries, so we're often ventilator dependent for our injury C1 to C3. When we start getting to C4, we start seeing a lot more folks that are off of the ventilator.

Can occur in C3, but it takes a very long time to do so. So a lot of times C4 is when we start to see free off the ventilator. So some of the things that we really need to think specifically in this level of injury are what is the client's cognitive capacity? And that's meant in a way that if we hit our head, I'm sorry, if we break our neck, right? In a high level, oftentimes it's associated with some sort of trauma. Whether it be concussion or documented brain injury, whatever the case may be, but how has that affected our cognitive capabilities because this is going to require some ability to remember in sequence and things like that? What is the endurance of the control site that we're going to look at and what is the access to that site in different spatial orientation? So it's one thing to look at them up, right? But then what does it look like when they tilt or

recline? What is the accuracy? Obviously that's one of the most important things. And then another consideration that we don't really think about immediately, but is really important is what type of technology is the client gonna interface with? In our high levels of injury, obviously we aren't going to be using our hands and our arms to be able to interface with our phone and our computer and our tablet and things like that, but the nice thing about technology these days is most of the chairs are equipped with Bluetooth. So we are able to help our clients to interact with different technology. So based on the type of device that we choose, which we're going to go over in a moment, it may be more efficient for one device versus another for that particular client and that may sway their decision to choosing one. So let's real quick break it down into proportional and non-proportional drive. So alternative drive control means it's not a joystick. It's not a standard joystick.

So anytime we talk alternative drive controls, you're thinking anything other than the standard joystick placed at the hand. So when we look at a proportional drive control, we're looking at a control that can speed and direction is mere directly to the force and the direction that is applied to the input device. So that is a joystick. So in many joystick at the chin, our chin control would be considered a proportional drive control. It's a much more efficient way of driving because it responds immediately to how hard I push it and with whatever direction I push it. It has a 360 degree arc of movement because a joystick can go in any direction. It's not just forward, backwards, left and right. However, when we move to a non-proportional drive control, that's when we're looking at something that commands by turning on and off a switch and the speed is predetermined. So it requires more time and memory and sequencing because it's not quite as intuitive as a joystick. So examples of that would be switches, scanners. The things we use most often in spinal cord injury tend to be the sip-and-puffs and the head arrays. And then we'll talk a little bit about proximity switches as well. But in a head array or sip-and-puff, I am directing that in a forward, backwards, left, or right position and I'm doing that with a predetermined speed based on what we've

programmed in the chair. So it's not, think of the difference. Proportional is your joystick concept, non-proportional is going to be switches that are turning on and off. So let's look at the head array. So the head array is exactly like it sounds. It's set up in the head rest and it's a series of commands for steering via the pads of the wheelchair head rest and they are going to drive in the corresponding direction of what is set up. So if they want to turn left, they're going to hit the left aspect of the head rest. If they want to turn right, if they want to go forward or backwards, it's usually a one tap on the back of the head rest or two depending on how it's programmed, but we're looking at all of the driving is done via the head rest itself. We do have some options in our head array to either use mechanical switches which require physical contact. So I physically have to touch that pad to activate the switch to go in that direction or we can use electronic switches which are proximity sensors.

And I can locate that, let's say the left and right side of the head, and they don't physically have to touch the pad. Once we get to a certain proximity, it will activate the sensor and then the switch would be turned on. So for those with very limited strength and abilities, or I use that a lot in my clients that are brand new and in a cervical collar and we're unable to do a lot of head motion, we can use the proximity sensors and get them driving pretty efficiently. We can combine that with a head array and a sip-and-puff combo. So where there're pads located on the left and the right side, just for an example for the turning left and right, but they use the straw to be able to command forward and backwards. So again, just another option as to what you can set up for your client. Again, back to the advantages and disadvantages 'cause there's always some for everything that we look at. So some of the advantages are that with a head array, the device itself doesn't sit directly in the user's face, which can be aesthetically pleasing. I had a 19 year old client not too long ago and he was just, oh, cracked me off. He was hilarious, but one of the first things he said when I pulled out a chin controller is he's like, "Ah, that's not going in my face." Like, "This is my moneymaker, this is how I get girls," and he just made me laugh so hard. So right away

any device that was going in his face was out for him because he absolutely didn't want to hear it. So we ended up going with the head array because there was just nothing sitting in his face. So he felt like he could be seen more than the device could be seen. A lot of times it's pretty intuitive to drive when it comes to training purposes, but there are some disadvantages. It does require positioning. Proper positioning of the client in the wheelchair. So, we spend however long in our session, our seating session to get everything set up and then they're driving beautifully, right? And then the next day their family gets them in the chair and all of a sudden they're coming to me and they're like, "Kristen, I need you to come adjust the head rest. Something's wrong. It's not fitting right." While the head rest hasn't moved, the client themselves isn't positioned properly so that's why they're having a hard time contacting the things that they need to.

So really good education to the family or the caregiver or the nursing team, whatever setting you're in is important because positioning is going to make or break their use of the device. When we recline the wheelchair back rest, it can cause the client to slide down a little bit and lose contact with the head array resulting in needing of repositioning. And then I definitely steer away from a head array if my client has significant spasticity or if they're really on uneven terrain in their environment around their house. Limited sidewalks, whatever the case may be, but they have very uneven terrain and it causes a lot of jostling of the head that can be difficult even with optimal positioning of the chair of the setup.

That if they have spasticity and they're unintentionally hitting that head array, obviously that can result in dire consequences. I have had one client who was really adamant about wanting to use a head array that did have spasticity. I was concerned about and we were able to do like a boom switch that came to her shoulder that she was able to tap when spasticity would start and it would get her out of the drive mode. But for all intensive purposes, really when there's significant spasticity, head array is kind of going

to the back of your choice list. Next we're going to look at a chin control. So a chin control is another type of alternative drive that is located at the head to be able to drive when we don't have upper extremity strength. We are using a small alternative joystick called like a mini-joystick or something along those lines that's located at the chin and is used to operate the wheelchair. So the wheelchair itself is the joystick can be positioned in really two different options. One there's like a neck collar that comes down and rests on the client's chest that has a little bloom that sits the joystick in front of the client's chin, or it can be placed on the chair itself where there's a bar that comes off of the chair and then it's positioned in front of the client's face. I mean, in front of the client's chin to be able to use. There's different reasons why you choose one or the other. I tend to like the neck collar for a lot of clients if we can go that way because for those who aren't in their chair all day, it's nice because even if they're not in their chair and they're in their bed, you can still take the neck collar and put it on and they can interface with their electronics and their devices even when they're not in their powered wheelchair.

So they can use that mini-joystick to control their phone and things like that. So for some of my younger clients who are obviously technology is everything and we are on our phone all the time, that was maybe one reason that swayed me towards one decision or another. Some of the advantages of the chin control is that the joystick usually remains at the client's chin regardless of the position. So if they tilt, recline, it stays there. It's proportional. So it's a lot more efficient. Even when you are driving with your chin, it's just a pretty efficient way of driving. So you're not having to remember, tapping this twice, doing that three times. The proportional drive it's the same as when you drive with your hand. And some prefer it when it comes to interfacing with other technologies. So this is a whole other lecture in itself, but when it comes to using your wheelchair to control your phone or your tablet, when we're using proportional control, it's much easier to use that device most often, because you're able to move the mouse on the screen in the same way that you would with like a normal mouse versus in

non-proportional you're using it kind of like a scanner to go through the different options. Some of the disadvantages to using a chin control are that the control does sit in front of the client's face. So that may be a deterrent to some users. If they have a really significant amount of facial hair, sometimes that can interfere with the accuracy. And I've had some guys over the years who were like, "Nope, you're not shaving my beard." So that is if it does interfere with accuracy, then that may deter you from using that alternative drive control. And it does still require some adjustments throughout the day from the caregivers. So that in itself is also another consideration to think about. Alright. And the last alternative drive that we're going to talk about in our high level injuries is the sip-and-puff.

So we are now looking at using a straw device that's located in front the user's mouth, and the user provides a series of commands via different forces to sequence sips and puffs to be able to manage the chair. When we talk about sips and puffs, we're really looking at that as positive and negative pressure. So if you think of who are we using a sip-and-puff chair with, it's a higher level of injury in which case the diaphragm is affected and our breathing is affected. So we aren't probably going to have the respiratory capacity to be giving huge puffs and sips and things like that. So positive when you think of it more as a positive pressure and a negative pressure, that can help you to kind of make sense of what you're looking for the user to do.

Now, when somebody is very impaired with respiratory compromise, it can still be fatiguing in our really high levels of injury, but it doesn't require, again, it's not requiring a hard like and exhale for them to be able to drive it. You can set it really quite sensitive to not require a lot of respiratory control, but they still have to be able to differentiate between a sip and puff, one sip, two sips, a hard puff, a soft puff. So there does have to be some element of control to those commands. Some of the advantages of using this type of device is that it does move with the person through all the changes of position. It's easy for the caregiver to adjust the position of the straw. Usually it's on a

flexible-type boom that's attached to the chair so it can be moved throughout the day without any tools. And then it is cost effective of all of the types of alternative drive controls. Some of the disadvantages again is that it sits in front of the user's face. Communicating while you're using a sip-and-puff is limited until you're able to use a latch device. We're gonna talk about that in a minute. So if your mouth is having to create a seal and a pressure, obviously that's going to limit your ability to communicate while you're managing the chair. Multiple breath commands can cause respiratory fatigue depending on how impaired that is. And it does require some level of maintenance for hygiene. The straws need to be replaced because there a certain amount of saliva gets in there.

Things like that. So that can be a disadvantage to some people, but it's not hard to do. The new thing about the sip-and-puff is that you can practice those sip and puff commands. When you set up a sip-and-puff device, there is a screen that you go to that allows you to program how hard and soft you want the different inputs to be. So you could take them to that screen and they can practice throughout the day, their sips and their puffs and various things without physically having to move the chair. Some of my colleagues that are speech therapists have really enjoyed that part of the chair to be able to do training on their own without having to actually drive the chair anywhere. So how do you decide?

We've got three different options here. How do we decide on what we're looking do with someone when it's a brand new injury? And really I discuss the options with my client. I get their input first 'cause again, you're going to get the people who are gonna say absolutely that no way. I don't want to use that. So we talked about my gentlemen who didn't want something in his face. So that really helped me to kind of go in the direction of what he aesthetically was looking for. I recently had a client that had a progressive non-traumatic spinal cord injury and he had severe spasticity and contractures resulting from his injury. So initially my mind went to a sip-and-puff and

after weeks and weeks of training, he spent two weeks using that with lots and lots of practice and we just weren't making progress. So we ended up switching to a chin control and right away he was like, "Oh, this is the device for me." So sometimes it is an element of trial and error based on the accuracy and the endurance of the client using that device. Okay, so let's go into advancing alternative drive control training. So when we have a non-proportional control, so which ones are those again? Those are our head array and our sip-and-puff devices. We can look at advancing from what we call a momentary control to a latch drive. So momentary control means that I have... Now the only way I can activate that switch is when I'm physically giving a sip or a puff or when I'm physically touching the head rest, where latch control is a preset time. So I can indefinitely use that command until I switch it again or I can set it say for 10 seconds.

So with a latch drive, I can give a puff command, have the chair drive, it stays driving for 10 seconds without me having to continuously provide that command and then after say 10 seconds, I'm just using that as an example, it gives us some kind of notification. Usually it's a low beep to let the user know either provide another cue to let me keep going or the chair is going to stop. Or you can set it as an indefinite latch where that chair is going to keep going until the user gives it another stop. So for people who are doing like college campuses and they're going really long distances, sometimes an indefinite latch device can be very helpful to only having to command when I need to stop something or change something and not have to constantly maintain that pressure. So just something to think about. So as a clinician, a latch drive control training can be a little nerve wracking because that chair is going to keep going regardless if your client is unable to stop the chair. So if unless, I'm sorry. Let me rephrase that. Unless the client gives the command, that chair is going to keep going. So if the client gets distracted or if the client isn't paying attention, those kinds of things, it can be a little nerve wracking for the clinician. So one of the things I like to do is if you look right here, this is an alternative drive screen. Underneath each side here,

you have a little plug that you can put a switch in. And one turns the chair on and off, and one turns the chair from driving to modes. So I'll put a switch in, which is just a button that is on a cord so that way I can control the chair as well. So if it's going way out of control or something's not what I want, I just hit the button and it'll either turn the chair off or switch them to positioning and stop the chair. So that way I still have some element of control over what's happening because I am a control freak and I want to make sure, I mean, we all want to make sure our client's safe, but that gives you like a little bit of control back. Okay. So some of the power position features that someone with high tetraplegia is going to need are going to be power tilt for pressure relief, postural control with fatigue over time. If the head and neck start to fatigue, it allows them to change positions.

To manage complications like orthostatic hypotension where the blood pressure drops or to manage autonomic dysreflexia. If we need to sit up quickly from a laying down position, power tilt is pretty essential in high levels of injury. Power recline also contributes to pressure relief when used in combination with the power tilt. We'll talk about that later. Power recline is really helpful in intermittent cathing when we need to recline the client back to be able to access what we need to do to cath. To complete EDLs in the chair. If we need to change clothes or pants or something, and we don't want to have to get out of the chair, recline can help us to do that. Power elevating leg rests also is another really common one that we see in our high injuries that is medically necessary for things like edema management, orthostatic management.

Again, when our blood pressure drops to be able to bring our legs up over our heart to help return the blood back where we want it to go. And then lastly, power seat elevation. So power seat elevation is something that is not funded by insurances often. That does not mean it's never. I do get it covered sometimes, but power seat elevation is not always covered by insurance, but it's something that is so important to our client with spinal cord injury in many, many instances. Some of the justifications that I use for

power seat elevation are for transfers downhill and the safety aspect of that. In high level of injuries, we're looking at the client's caregiver assisting them with transfers, but obviously the lower level of injuries we're looking at them being able to do it more independently. Being able to access safety features like light switches. I mean, go around in your environment and look at where light switches are they're high. So for some of our clients with very weak shoulders, being able to get up higher is really important for safety devices. Being to hit elevator switches, eye to eye communication. So we're not having to hyper-extend our neck all day to look at our loved ones. Being able to access countertops. Visibility in parking lots is so important. My gosh, people who are sitting lower are hard to be seen from a car level, but raising yourself up while you're going through the parking lot makes it much safer to be seen by those who are driving and same thing when you're crossing streets.

So even if it's not covered, I still, if it's appropriate for my client, I always ask for that when it comes to writing my element and in ordering a chair, I explain that to my patient that this likely will not be covered, but if you find it important, I find it important. Here's why and it's something that you're going to use in your day-to-day world to make your real life more independent. Even if funding sources say no, we have other options. We can look at there's foundations, there's grants. We talked a little bit about that. There's GoFundMe's, there's different options that you can do that if the client is willing to pay out-of-pocket and that's important enough to them. I don't want to say, "No, I'm not going to do seat elevation 'cause your insurance is never going to cover that." Make the insurance say no and then fight some more. We write... I can't think the word I'm looking for. Justifications a second and a third time if needed if that's what it takes to fight and tell the funders and the policymakers that no, this is an important thing even though you're saying no. So just a few things to consider. And then lastly is, so we've talked a lot about driving in high level injuries, but how do they go from driving their chair to now positioning and being able to do their own pressure reliefs? So we have a few different options as a clinician. One is a switch. A switch is that

there's several different types. You have toggles, buttons. We don't use levers that often in spinal cord injury, but they do exist. You have proximity switches that can be placed somewhere that the client can move their body to be able to hit that switch to then change the screen from drive to now positioning. Switches in high level injuries are most often placed at either the head or somewhere around the head or at the upper trap. If we have elevation of the shoulder, we can put it right at the top of the shoulder and they can elevate up and hit it. But that allows them to switch between their driving and their positioning. Another option you have that some clients prefer rather than a switch is using what's called a timed out to position. So again, that's a predetermined time that if the input device does not receive any type of activation, the screen will automatically switch to positioning.

So say they're in their drive position or their driving mode and now they have not hit a command in let's just say again, I'm gonna throw out 10 seconds, in 10 seconds it will automatically switch them to the positioning screen. This is a safety feature in the aspect of not accidentally driving the chair when you don't mean to, but also it can be a way that rather than a switch, they can now switch over to their pressure relief or their recliner or whatever they're looking to do to be able to access both types. All right. Just a few other real quick in high tetraplegia, positioning is really important. Here we are focusing on stability because the level of paralysis is so high and we aren't using our arms and legs functionally.

It is important that we are stabilizing the trunk and that can be done through chest straps, lateral trunk supports, pelvic straps, guides of the lower extremities, because if their trunk is moving around and their pelvis is moving around, they are not going to maintain access and control of their alternative drive device that they're using to drive their chair. So very important that they are stable in all environments: Indoors, outdoors, or transportation. Any environment that the client is in. And then also upper extremity positioning is a little bit more involved in our high injuries than it is in other

levels because of the level of paralysis. We are looking at complete paralysis of the upper extremities. So we need to do things such as arm troughs that fully support the elbow and the forearm and not allowing it to fall off laterally or posteriorly off the arm rest. If we don't choose an arm trough, then we need to look at doing a planar arm rest, but something that has buildups around it. So having elbow blocks on the back of the arm rest so when they're in tilt that the elbow doesn't fall off posteriorly and result in the arm hanging and injury to the shoulder. Having lateral and medial arm pads on the sides of the forearms to be able to build that up so their arm doesn't fall off in either direction. And then also looking at like palm and hand supports and various straps maybe at the hand to maintain the wrist in a neutral position and maintain the hand elevated. So that way they're not getting swelling or edema of the hand and fingers. All right, so the last thing we're going to talk about for high tetraplegia is there are a few other little details that again, we're not really necessarily having to think about in any other levels of injury.

So when someone's using an alternative drive control, their caregivers are not going to be able to drive that chair when they're not in it. So you can't. You don't wanna use someone's sip-and-puff. That's not... There's no hygiene to that and in the time of COVID, obviously we are not doing that. That's gross. So we need to have some type of control that the caregiver can access. That when they're not in the chair, they are able to move the chair out of the way or position it for transfers or whatever the case may be. So an attendant control is something that goes on the back of the chair, and is a small joystick that the caregiver can use to move the chair. If your client is using a ventilator, obviously we need some way to attach that ventilator to the wheelchair. So with the ventilator tray of some type. If your client is using an augmentative communication device, there are mounts that can allow that to be placed onto the wheelchair in the same that a phone or a tablet can be mounted to the wheelchair. Those things often, again, aren't covered by insurance, but are very, very helpful in once the client's in their chair, all their technology is there with them. So they can be

fully independent. And then they do have different types of hydration systems out there that somebody who's unable to use their arms can access hydration without having to rely on a caregiver. All right, so next we're going to talk about seating the client with a C5 to C8 spinal cord injury. So we talked a lot about all the features of a power chair. So one of the major things we have to look at in these levels is are we going to do manual or are we going to do power for this client? And we need to look at all of the different things that we've discussed already. What is their independence? A, can they push a manual chair? What does that look like? Can they do pressure relief and positioning in that chair? How do they transfer in and out of what we're looking at? Skin integrity. Do they have a history of sores?

Do they have a history of shoulder pain? How fatiguing is this to them? What is their endurance? Can they do it for an hour or can they do it for eight hours? That makes a huge difference. And then transportation is really a conversation that is important to have when we're deciding between power and manual, because a power chair doesn't fold up and go into the car. So we need to talk about what other options there are in your local area to be able to transport a power chair. We also want to look at any other comorbidities that the client may have if they have severe orthostatic hypotension or frequent ED.

Different things like that that may also require a change of position or things that could possibly be utilized on a power chair. There is no one answer. Motivation plays a huge role in what decision your client is looking at and what we're looking at to assist our clients between power and manual. Unfortunately insurance only covers one. So we're not looking at being able to fund both options, but in some of our C6 and C7 folks, it's really a lot of people choose to have a power chair and then maybe purchase a manual chair out-of-pocket. So that way they have both for different situations. I've had clients, I had a gentleman who was a C6 injury who independently he needed a power chair but he was young. And when he socially went out with his friends, he wanted to be

able to be in a manual chair to be able to get in and out of a car with them. And his friends helped him in the manual chair while he was in it, but he wanted to have both. So, we're looking at funding through obviously what is going to make the client most independent. And then we do have some options such as power assist options that are a manual wheelchair frame, but that use some type of power to help assist the propulsion. So there are designs where the power assist is a battery pack that is within the wheels themselves or a separate little power device that goes on the back of the chair and attaches to the axle of the manual wheelchair frame. There's lots of different types and there's new types coming out every day as technology evolves. But again, there's pros and cons to those.

The battery packs in the wheels can make the wheels heavier and can your client then load and unload that manual chair independently if they're driving and things like that? But sometimes that can be the ticket between the two for a client that could make them more independent in their manual chair. So for a C5 spinal cord injury, we've got some innervation of the shoulder, right? So we have some abduction, flexion and rotation. It's often still very weak. The shoulder girdle is innervated and it allows for pushing, but is it stable? Should we be pushing is always the big question. We need to consider a lot of different things:

What is the client's age, their motivation, the environment they're in, transportation, or all the same things we just talked about is very important, but one of the key factors in a C5 injury is that the serratus anterior is only minimally innervated. So our scapular stability is not good in this level of injury and as a result the scapula doesn't adhere to the trunk and it results in winging which can play a huge effect on propulsion and what the safety of that would look like to the shoulder joint. So I highly recommend use of power wheelchair in a C5 injury. There are folks who've had their injury for a very long time in our C5 injuries and using manual chairs, but nowadays with the length of stay that we have with people in inpatient in acute hospitals, and even how much time we

get with them in outpatient which is so limited compared to what it used to be 30 years ago, seating a client with a C5 injury in a manual chair really is just not recommended these days. However, we can move from all those alternative options we talked about to now using a standard joystick on the arm rest like you traditionally would think of in a power wheelchair. For somebody who has a very weak C5 innervation, we still may need to make some adaptations by using switches to be able to turn on and off the chair or to be able to switch from drive to their power positioning. In some of the weaker innervation at C5, oftentimes they can push that joystick and they can control the joystick from the shoulder, but that's only sitting upright. When it comes to tilting and reclining in different spatial orientations, we can have a really hard time getting out of those positions when we have a very weak shoulder to push against gravity.

So sometimes what has been successful for my practice is using switches that the client can hit and hold to help them to come out of the position via the switch. Whether it be at the head or the arm itself. But if the client is unable to get out of a tilt position with their upper extremity and that's the only thing that's limiting them from being independent with a standard joystick, there are ways around that. With our C5 injuries we may be requiring still some additional upper extremity positioning aids, especially in the beginning until we get stronger as our injury evolves, but we may still need arm troughs and the elbow blocks and inner, outer pads too in different orientations when we tilt to support that upper extremity.

Or to support the upper extremity when we're driving, we may need various joystick handles. You think of a normal just little joystick topper. There's about 14 or 15 different types of joystick toppers out there. So sometimes using like the field goal joysticks or things that are more supportive to the hand that require less accuracy can help them to be more accurate when they're driving and then looking at the trunk stability while they're using that arm to drive. So making sure that their trunk has the appropriate lateral trunk supports if necessary or chest straps or harnesses to make sure that in a

variety of environments they're safe with the trunk as they're going into higher speeds. So we know some of our clients with C5 injuries can push a manual chair short distances, but that doesn't mean that they're functional. So sometimes they get clinicians who are like, "Oh, my client can push down the hall. I'm so excited." And that is awesome, but it's not functional in their real world. And a lot of times the answer is no. Is that functional on carpet? Is that functional on sidewalks that are sloped or ramped and things like that? So just knowing just because we can push a chair doesn't mean it's good for our shoulders and it doesn't mean that it's going to be effective or safe to do so all day long. When we move to C6 injuries, we start to have better innervation of the rotator cuff. We get the wrist extension, improved scapular stability, we start to get some horizontal abduction with better pec innervation, some shoulder depression. So different things that can make pushing more effective and make the shoulder and the scapula more stable while doing so. With the C7s, we know we start to get elbow extension and triceps, and we have full serratus innervation at this level.

So we're looking at a much more stable scapula, and it's not till we get to C8 that we start to see some finger function. So again, here with these C6 to C8 levels of injury, we're looking at really deciding power versus manual because a manual wheelchair can be an appropriate choice for some of these clients, but does require stability of the pelvis and trunk. We may need a more supportive back rest if we're going manual, we may need some type of adaptive hand rims where we have projections or a texture to the rim or the shape of the rim is different to accommodate for not having grasp or finger function. So next we're going to look at ultra lightweight wheelchairs as we move into our talking about our lower paraplegic level injuries. So we're going to break down our ultra lightweight manual wheelchairs into rigid and folding frames. So looking at a rigid frame chair, a rigid frame has several advantages. For someone who's in a chair full-time, it allows us to be able to have a more durable frame. Because there's less moving parts, the durability of the frame tends to last longer. The efficiency of the propulsion is better, because again there's less moving parts. So the less moving parts

we have, the more we lose that forward translation of energy into all the little pieces that move on the chair. It can be very advantageous for wheelchair breakdown for getting in and out of the car and bringing the frame of the chair over our body into the passenger seat for those who drive independently. And sometimes the folding frame can be less weight. But there are some disadvantages to a folding frame. If your client is a very low level of injury and is working towards standing and does stand pivots or maybe short distance gait, having a foot plate rigid right in the way can be difficult or make it a little bit more difficult to stand. So sometimes folks with low-level injuries don't like the fixed foot plate aspect of a rigid frame chair. So here's just examples. There are so many things we're gonna talk about here in just a second on the design of a rigid frame, but the way that we know a chair is rigid is by underneath the frame of the chair there is no traditional cross like we see in a folding. So you have a one axle here that makes the chair rigid in its design.

So that would be the way that you would know looking at a chair if it's a rigid or a folding frame. Some of the folding frame advantages if we're looking at an ultra lightweight folding frame would be that the leg rest do move out of the way. So for somebody who has preservation of motor function in their legs and who can extend their knees out and move the leg rest out of the way with no problem, some folks who are going to be standing do prefer to have their feet on the floor directly underneath them and that may steer you in that direction. But some of the disadvantages are that the leg rest do require moving. So if you have a client who has no motor function in their legs, if every time you get in and out of that chair, you have to now take your paralyzed limb, move it, lift it, swing away a leg rest with the other hand. I mean, that can be cumbersome and tiring and just requires increased time. And then again, you have more moving parts in a folding frame chair. So for somebody who's really active, a folding frame, you're looking at less durability over time. So a folding frame, we know again, this is a folding frame based on the X that you see underneath. So you've got the joint right here that allows the chair to collapse inward, but that aspect of it is what

can cause you to lose a little bit of the propulsion energy into that moving part. So, just something to think about. All right, so let's talk about seating the client with paraplegia. So for a T1 to T6 injuries, we need to really think, I mean, we have a very high level of paralysis of the trunk, so we need to think about appropriate pelvis and trunk stability and we need to consider what is our front and rear seat to floor height is going to be by having a little bit of dumping the chair which is what we call having a difference between the front and the rear angle. I'm sorry, the front and the rear height of the chair. We can achieve some more stability by doing so, but then they also have to be able to get out of that dump to do their transfer appropriately. We may want to consider push handles on the chair.

A lot of times in our higher injuries, C6, C7, C8, T1, it's really helpful to be able to hook on to that handle to then reach outside of the base of support or reach down to the floor to pick something up. So having push handles can be a source of stability for somebody with a very high level of spinal cord injury. When we move down to our T7 to T12 injuries, we're obviously progressively gaining more trunk control. So we may be able to lower our trunk support at that point. For our L1 to L5 injuries, we're really looking at, how does our clients perform any type of gait? Do they perform any type of standing? Do they use any type of leg braces that may be needed in order to accomplish their transfers?

In which case we may look at a folding frame or we can do a rigid frame that has a foot plate that is designed to flip up out of the way in order to put the feet on the floor in order to do a stand pivot or whatever the short distance gait maybe that the client does. So again, just depending on how much motor function is preserved is going to help us to decide some of the design aspects of the chair itself. So we're going to talk about some of the different things we look at in a manual chair. And I'm actually gonna go back to the picture here real quick as we talk about it. So the first thing that we're going to look at is the axle positioning. So the axle positioning is where does the wheel

sit in relative aspect to the frame? And that can be moved. So we'll talk a little bit in a second about moving the axle, but axial positioning adjustments is one of the most important things to the feel of the chair. So we'll talk about that in just a minute. We need to look at the seat with the seat depth and the seat height of how high do you sit from the floor. And usually that's based off of the client's measurements themselves, but again, we can have a difference in seat height in the front. We can have more seat height and less seat height in the back to create that kind of dumped effect that we often see in clients with spinal cord injury. We need to next look at what type of back rest and how high is that back rest going to be? And really that depends on how much trunk control the client has and how active is your client and different aspects like that. So there's not a one set rule to how this looks, but we usually say, if you're using your upper extremities to propel, then we want to make sure that we have the scapular free to be able to move.

So we want our back rest to be positioned below the scapula and not interfere with propulsion in any way. And then obviously the lower the injury, the lower the back rest can become. For the cushion, we're going to spend a couple minutes talking about that. So we're going to skip right over, but obviously cushion is a huge aspect as to what we're doing in our seating system. The hanger angle is the front end of the chair here is how much of an angle do we have of this part of the chair dropping down into the foot plates?

So the hanger angle a lot of times we're going to see it at like 80 degrees, 85 degrees, or very, very tucked under, which would be a 90 degree angle. And that's just dependent on really client stability and range of motion and things like that. We have different options for tapering the seat width as well as tapering the front angle of our chair. So we can taper the seat width, in which case say you have a 15 inch wide client, we are doing a back seat with a 15 inches, but a front seat width of let's just say for example, 13 and a half inches. So we now have a seat frame taper of an inch and a

half to be able to really tuck those legs in or we can taper the front end of the chair. In which case you can see here, this for an example, there's not any taper in this chair to where these two here, you can see how the frame bends in to create some type of taper to the lower extremities. So that again is just different options. We can look at many different types of wheel aspects. We're looking at the size of the wheel based on the client's arm length. We're looking at the types of rims that they have based on their hand function. We need to look at the different types of spokes. They're standard spokes. If you think about it, it's like a bike tire. You can have standard spokes or you can have carbon fiber which is an upgrade, but you can have carbon fiber aspects to the spokes that make them more durable, but a little bit lighter weight when it comes to loading. Wheel camber is when we look at, how much is this wheel angled in this direction? So if there's no camber, the wheel's going to be perfectly straight up to the chair. Usually in spinal cord injury we do a little bit of camber. I think these would be like two to three degrees.

Oh, I see I can't see my pointer. Sorry guys. For the camber right here on the wheel, so zero camber would be the wheel being straight up and down, but a little bit of camber here, two to three degrees allows that lateral stability of the chair. So if you think of sports chairs, right? They have a lot of camber in them. You see the wheel and it's going in this direction, but in a real world functional environment, that isn't going to fit through many doors. So we want enough camber to be stable, but not so much camber that we kick the wheel out so far that they don't fit through doors. A very quick little caveat. When you are measuring the overall width of the chair, 'cause what do we need to know, right? We need to know, is this chair going to fit through a door in the client's house? You always want to measure at the bottom of the chair from rim to rim because the bottom is going to be wider than the top when we have camber to our wheel. So don't forget that whenever you're measuring if your client's just like, "Oh, how wide is this chair going to be when I go home?" Kind of concept. The caster size is the wheel in the front. So the caster sizes come in in various, from three, four or five

inches depending on the environment they're going to be in. The smaller the caster, the quicker the turns, but the harder it is to go over uneven surfaces. So if they're really an active outdoor user, you may want to consider a slightly bigger, wider caster versus if they are like never outside doing anything and they are an indoor person. So those may be the decisions that you make with your client. Whether or not they have arm rests. A lot of manual chair users don't use arm rest as they become more experienced, but obviously you can see there's many different types of armrests that come in different sizes and some swing away, some remove, some flip back. That's really just a preference, but each one comes with their own weight of the chair. Pushing handles, brakes. All of these, you may have pushed to lock, you have scissor brakes. You have different options of brakes depending on your client's hand function or preference. Anti-tippers.

A lot of times as the client becomes more advanced, they get rid of those. And then looking at the material of the wheelchair. The material that the chairs are made of nowadays are much, much higher than they used to be. And a lot of times you see like a high strength aluminum, but they do make carbon frame chairs that are lighter and more durable, but are an upgrade. So if you're trying to do something along those lines, you really have to have justification for things like significant spasticity and vibration dampening and things like that. But what type of material do you want the frame to be made out of? All right, let's go back to where we were. Okay, so for the seat height for your client who is going to be using a manual chair, we want to look at positioning the axle so that way when their hand is at the top of the rim, their elbow is bent between 100 and 120 degrees. If the angle is more, so if they have their hand on the top of the rim and their elbows bent like 130, 140 degrees, or if they're vice versa, they have to reach farther down for the rim because they're sitting higher and now their arm is extended straight. That's going to affect the integrity of their push and their shoulder and elbow mechanics. So we're really looking for that elbow flexion to be between 100 and 120 when they're positioned at the top of the rim. And then also if the

users' arm is rested at their side, we would like their middle fingertip to be in line with the axle to be able to be positioned with the axle. If it's way below or way above, that also tells us that we're either sitting too low or too high. And then we want to make sure that we adjust the axle as far forward as the patient remains stable. So the whole point of getting one of these ultra lightweight wheelchairs, one of the major features of it is to have the adjustable axle to be able to change where the axle sits under the user's arm. The rule of thumb, if the axle's farther back, the chair's very, very stable, but it's a heavier, or it feels harder to push because you have more rolling resistance versus if you move the axle forward, there's less resistance because there's less contact of the chair to the ground, but the chair can be tipper in which case we need to make sure that our client has the ability to do advanced skills.

So some of the common complaints that you do hear with manual chairs is that my chair does feel heavy. So I really dig deep in this with my clients. Does it feel heavy when you're pushing it or does it feel heavy when you're loading it in the car? Because those are two different things. If the chair feels heavy when we're pushing it, a lot of times we need to adjust the axle more forward. Not so much that we compromise our stability, but again, we're decreasing that rolling resistance and the chair is going to feel much easier to push.

And then we also do want to look at what components are on the chair 'cause the more stuff on the chair, the heavier the chair is. And then the other thing you hear a lot is my chair feels very big. And we're looking at is that the rim? I'm sorry. Is that the width of the chair? I mean, obviously we have to match the width to their hips. So say you have somebody with wider hips who is in a 20, 21 or 22 inch wide chair, we need to do everything we can to reduce the overall footprint of that chair to fit through doors and in different environments. So the rims where the rims connect to the tire, you may want to look at considering short tabs 'cause that will bring the rims in closer to the tire and decrease the width of the chair. Maybe look at adjusting the camber. Some chairs

come with adjustable camber tubes which can also adjust where the wheel sits in relationship to the hips. So different things that you can look at to decrease the overall width without having to adjust based on the hip width itself. We can consider if there's necessary if we need seat taper. Where again, we talked about the back is a different seat within the front. If it's the depth of the chair, you may want to consider frame bends in the chair itself. So there's some that without getting too complex have a more like ergonomic design to them where the frame bends in different places to help for folks who are very, very long, like six, four all legs. That kind of stuff can help reduce the overall footprint without compromising femur stability. And then are they feeling like their footplate is too big? In that case we're looking at what is the hanger angle and the taper angle to determine if we can reduce that down at all. So it's just some different things to look at.

So real fast we're gonna run through some of the seating system considerations before we get into the interventions. So the basic guideline for seating the pelvis. The pelvis is going to be positioned with the cushion. That provides stability, pressure relief over the boney prominences and provides a firm base for stability. If you have a sling base to your wheelchair, you may want to consider some type of like firm base under. What we call an apple boards under a cushion. If you're chair over time starts to sling out a lot, that will affect the stability of your cushion. We need to look at the seat depth. Is it too long?

That's going to result in a posterior pelvic tilt. Is it too short? That will cause that splayed sitting posture. So making sure that we're basing that appropriately off of the client's measurements. So let's get a little bit into the cushions. And we're only going to talk briefly. And my gosh, we could talk about cushions in a six-hour lecture easily. So, there's lots and lots of different cushion selections out there. We have air, foam, gel, fluid, hybrid versions, orthotic style that offload the boney prominences, you have custom molds. So when selecting a cushion it's important that we individualize that

cushion to the user. So I am not a fan of, I mean, we all have products that we kind of get used to and know and feel comfortable with, but I am a big fan of, I don't like to say like this is the only cushion I use. Like if that's the case, we really need to reevaluate what we're looking at, because we should always be individualizing this to the client. There's a lots of considerations besides pressure relief and positioning which are the top two that we look at. But what is their current skin integrity or have they ever had a wound of any kind? What is the maintenance required? I work in our outpatient or so, I'm sorry. In our outpatient seating clinics sometimes and when I get to see clients who are on cushions that require a lot of maintenance and they're not maintaining the cushion the way they should be, there are severe consequences to that. So if the cushion requires a lot of maintenance, the client needs to be willing and understand how to do that and be trained to do that properly. With the cleanliness, if there's incontinence or we have like hyper-hydrate where we have a lot of sweating, what is the cleanliness?

How easily can that be cleaned? What's the durability of the cushion? And what is the weight of the cushion? 'Cause all of those things are going to steer us in different paths. So just a few examples. This would be a hybrid with air, a hybrid with fluid or gel. This is just a basic foam cushion. This is an all-air cushion. There's so many different options out there that are available to us. So specific to pressure injuries, pressure injuries are another really scary thing that we all think about when it comes to clients with spinal cord injury and seating, but there's so many different factors that play into why a pressure injury occurs.

So Marin et al. did a study that looked at the risk factors for pressure injuries and spinal cord injury. And they found that some of the most common risks included the mobility, skin quality which is really important, spinal level characteristics, independence in pressure management, and a history of a pressure injury. So skin quality, there's a lot of factors that play into that: Age, hydration, nutrition, medications. I've seen people

who've gone the whole life of their injury without ever having a wound and now have a hospitalization that results in changes of medications and significant other things, and now they come out and end up with a wound because the skin integrity, the skin quality has changed. This was another really interesting read. I'm gonna pronounce this wrong. Catania, Michaels, and Morgan investigated a retrospective case study over four years looking at pressure injury incidents in upper motor neuron injuries and lower motor neuron injuries. And I found this really interesting. Lower motor neuron injuries based on their research found that lower motor neuron injuries were more likely to present with, or have a history of a pressure injury. And I did a little thinking of just my own practice and my own clients and I was really looking back and I said, "Gosh, I have had over the years thinking I could recall quite a few folks that have had L1, L2, L3 injuries that ended up with wounds." That really kind of blew my mind in the aspect of, we tend to think the more the lower your injury, the more you can move, the easier it is to prevent skin breakdown.

But I do think one of the biggest considerations that this made me really think of is in our upper motor neuron injuries, we tend to have a lot more spasticity which does, there's constant contraction. So the muscle, the makeup of the tissues may be different than somebody who has a lower motor neuron injury in which there's never contractions and we end up with a lot of atrophy. What does that do to the pelvis? And there's hopefully a lot more studies coming out like this because I found this really, really interesting. Alright, so preventing pressure injury isn't just passive. So obviously there's pressure relief techniques that we're teaching our patients. So in a power chair, we're looking at power tilt, recline and elevating leg rests. The residence position paper on the application of tilt/recline, and elevating leg rests says that tilt of 15 to 30 degrees and reclining of 100 to 120 degrees provided the best pressure relief for our clients. But we've got to remember that the folks that are new injuries they may not be paying attention to all these details. So it's really important that we're going over a lot of training in the specifics of what does that mean? What does that look like? And how

long do we hold it? So we want to be holding our pressure reliefs, the research supports for three minutes. It says that three minutes is better than one to allow the tissue perfusion and all the other theories that they have to being able to prevent skin breakdown. And we want to be doing those pressure release every 15 to 30 minutes. In a manual wheelchair we're looking at being able to do our pressure release by doing forward leaning to be able to un-weight the ischials, lateral leaning to un-weight the ischials and obviously we can press up in the chair. However, to do a press up every 15 to 30 minutes can require a lot of shoulder stress, especially if you're holding it for the amount of time that is recommended. So a lot of times we talk about those change of positions of forward and lateral leaning. Lung et al. looked at a peak pressure gradient in the direction.

So the difference between peak pressure gradients and the direction of the pressure gradients in various power and tilt/recline angles. They found that the tilt affected the direction of the pressure and the recline effected the magnitude of the pressure. So I thought that was pretty interesting. So again, remembering that tilt and recline together is what we really recommend for our pressure relief. For pressure mapping we are looking at using a sensor that provides input on a screen that allows us to be able to assist in decision making for the cushion. But I always tell people that is not the sole reason that we ever decide on a cushion. Pressure mapping is just one component.

And honestly I like to use it more of an education tool for my clients to visually have feedback because pressure mapping is static most of the time. So it's not considering dynamic movements and propulsion and all these other things. So it is an amazing tool and if you have access to it. I use mine all the time, but if you don't have access to it, no, it's not the only reason that we make decisions for cushions. So just remember that to yourself that it's not the sole decision making aspect. So when it comes to the trunk, we need to decide for seating, are we going to do a rigid or a sling? And oftentimes we're doing some type of rigid for postural changes and abnormalities. How high

should the back be? As the trunk control improves the back rest can be lower. For poor trunk control, obviously we need it to be higher, but we want it to be lower than the spine of the scapula and the inferior angle of the scapula if they're using their upper extremities to push. If they have fair trunk control, we're moving down below lower into the back. And then if we have very good trunk control, we're an active user, a hands-free sitter, we can really start going to the lower ribs themselves. But there's not a one rule fits each person. It's very individualized to the client themselves. Looking at the lower extremities, we really want to pay attention to the leg rests and how they're positioned. If they're too long, they contributes to posterior pelvic tilt, sliding forward. The ankles can be supinated as a result 'cause they don't quite contact the leg rest and be in plantar flexion.

I've seen folks whose leg rests are too long and they end up with wounds along the outside of their foot. Like along the feet metatarsal because it is not appropriately. The weight distribution through the foot isn't good. If the leg rests are too short, it's going to create too much pressure through the ischial tuberosities. We get the external rotation and abduction of the hips, and we can get increased pressure of the calves through the frame if it's a manual chair that they're using. We talked a lot about tetraplegia arm rest, but making sure that the arm rest height is appropriate. If it's too low, we're going to get subluxation of the shoulder, the arms are going to fall off the arm rest, we're going to end up with pain, and the trunk is going to often lean one way or another based on which arm they're using usually to drive if they're not supported properly through the arms.

Too high results in shoulder elevation, which is just going to increase their overall pain through the shoulders and neck. Remember that height of the arm rest does play into pressure relief as well. So it's important that if their arms aren't positioned, that's more weight. If they're not supported, that's more weight going through the pelvis. So make sure that someone's arm rests are appropriate for them. And then for paraplegia in the

arm rest, we're really looking at stability of the clients without interfering in their mobility. We want to look at the weight of the arm rest, but again, a lot of clients end up not using them over the years when they get more comfortable. So as if that's not enough, we've got a few more considerations when it comes to deciding on the chair. Can your client ambulate? This is a big decision making and often very, very challenging for our clinicians to decide, "Well, my patient can walk a little bit or they can do some walking, how do I know if they need a wheelchair? Is a wheelchair necessary?" And there's lots of things that we want to be looking at in their gait to determine that. So the first is their gait speed. How fast and efficient is their gait? And is that working within their world to accomplish all the things they need in a timely fashion? What is their energy expenditure? How much assistance? Do they need any help or are they fully independent? If they're fully independent with ambulation, then obviously we're not considering a chair, but if we can walk and still require assistance to do so, we're not independent at that point. Same thing I always look at, what is the safety during ambulation?

'Cause if my client has fallen 10 times in the last three months, that's not a safe way of getting around. They may be able to do it, but should they be? Or should they be doing that as their main mode of transportation? Or should they only be doing it when family is besides them? So again, do they have a history of falls? What's their age? How much are they? There's a difference between somebody who's 18 and somebody who's 75, especially if falls are involved and what are the ramifications of that? Are there any co-morbidities? And then using our outcome measures. So the outcome measures for gait are really important. It can help in our justification for the chair and the major ones that we use in spinal cord injury are a 10 Meter Walk Test or Timed Up and Go, Six Minute Walk Test to be able to help us to determine what type of chair is needed or if a chair is needed at all. Next to seating the bariatric client. So obviously we all know that in the United States our sizes tend to fluctuate greatly, and we're getting some of our clients seating the client with wider hips is becoming a much more

common thing. So to be able to seat a bariatric client, we need to consider what is the weight limit of the frame itself because they all have a weight limit usually between 265 and 300 depending on the brand pounds. And then what is the stability of that frame? What is the overall width required which is based off of the client's hips? And then what's maybe limitations? When we start getting into hip width that are like 24 inches, things like that, it really limits the products that are available to our clients and may affect some of the choices that have to be made. What is the transfer technique? So when we're using a manual chair with a bariatric client, sometimes going around the wheel or over the wheel or in front of the wheel can be very, very tricky and that may really affect their safety and skin integrity with the transfer technique. So that's something that we want to consider.

One thing that can be very helpful is doing an aftermarket back rest that we can set. So if we have a lot of posterior tissue in the pelvis that if we sit up against a back rest, the posterior tissue doesn't allow the support to the lumbar spine, having that aftermarket back rest that we can position a little higher to accommodate for the posterior tissue can still provide back support while not limiting their ability to position their hips if that makes sense. Having a cantilever arm rest, which is an arm rest that flips up without any type of post, especially in our power chairs can allow those that have maybe wider hips to be able to allow that tissue display out the side some without having pressure or anything from the arm rests themselves.

And then same with the foot plates. If we have a wider hip width, then a lot of times we may need some kind of thigh guide or something to help to position to prevent that splayed posture for the footplates. And we may want to avoid like a center mount or we may need to position the legs appropriately if we are using a center mount that tucks their legs in more. So just some different thoughts to have. And then lastly looking at aging in a wheelchair. So it is very difficult over the life of someone's spinal cord injury to be able to find those details that occur with age, that result in needs of

change for the chair. So shoulder pain is one of the big ones. Those who are using manual chairs over time, there's a high rate and a high incidence of shoulder pain. So that may result in us having to change from manual to power. Looking at skin integrity, has there been weight loss or gain over the years? What's the bone density? The gradual loss of strength that can occur as we age and flexibility and all of those things that may then result in changes to the chair itself. So looking at the aging and the life of the time that the person has been in the chair. So looking at letters of medical necessity. I really tried to keep this brief, because again, this can be a whole another lecture, but we all have a love/hate relationship with the LMN, right? So we need to document the evaluation of the client's systems: Neurologic, orthopedic. All the different systems.

Their postural assessment, their level of function. It's easy to assume that my client is paralyzed or my client has tetraplegia or paraplegia, but we can't assume that our funding source is going to approve something just because of that. We have to state the obvious. State that your client can't stand or ambulate with any assistive device. State that your client is unable to use a lesser cost manual chair because they can't propel a manual wheelchair, because if you're doing power, they're unable to use a scooter because...

So those things have to be stated clearly for the funding source or you're going to get a denial just based off of that. And then I also like to always say that my client is willing to use the recommended complex rehab technology that I have recommended and they can do so safely. That's very important to funding sources. We obviously need to do a detailed justification of functional ADLs, mobility, positioning, management of their secondary effects of their spinal cord injury, and we need to have a clinical and medical justification for every aspect of the chair that we are recommending. In addition to the LMN, we're also going to need a few things that change over time. So you want to make sure you're up-to-date with the CMS guidelines and your Local and National

Coverage, but we need a physician signature in a concurrence of the prescribing equipment that you have recommended, a statement of financial independence of the PT or OT from the vendor, there needs to be a face-to-face evaluation of the physician and a prescription from the physician. You can write the best letter in the world, but if you don't have all those things in place, then the chair itself can be denied. All right, so let's get into some of the wheelchair interventions. So, prioritizing wheelchair skills can be very difficult with the magnitude of the things that we have to accomplish for somebody who's had a spinal cord injury. Obviously it's a life-changing event. There's many things that we're trying to do to prepare this person to face life following their spinal cord injury. But, Best et al. found that basic wheelchair skills were addressed but advanced wheelchair skills were rare. And only an average of one to four hours were performed with clients.

And I understand it. There's so much to do in so little time, and we have decreased length of stays in inpatient and outpatient, we have limited number of visits. Wheelchair skills can sometimes take a back seat to other goals that we have for the client, but it's really important that as clinicians, we are focusing on the wheelchair, especially if that's their primary form of mobility because that is the key to independence not just in their home environment, but in their community as well. That can be done in a lot of different ways. Many clinics use one-on-one session, some do group setting, some do pure mentor-assisted training clinics. There's so many different ways that we can address this, but making sure that we are looking at the advanced skills that we're going to talk about. When it comes to wheelchair skills, some of the basic indoor things or household things are: Positioning the chair for transfers, transferring to and from the chair, using the power positioning that we've recommended for all the ADLs and cathing and things that they're going to need to do. Can they do that independently? Positioning and going up a ramp, being able to open and close the door if that is appropriate for the client based on their level of injury, picking up an object from the floor and carrying an object while propelling. So when we're talking about opening and

closing doors, it really we need to practice doors that open outward and doors that open inward. And a lot of times we talk about using the frame of the door to help pull the client through the doorframe. When we're carrying an object while propelling we're looking at, are we carrying it with one hand? Is it something that is like a coffee that requires one hand in which we're alternating propelling cup? Or is it something that like we just cooked in the kitchen and now we're bringing that to the table? In which case we need to do a lot of education on having like a lap tray or something that protects the skin. If we're putting hot things on our lap, we don't want to be doing that. So again, educating the client on how do we carry objects while we're propelling or managing our chair.

For outdoor skills we're going to be looking at uneven terrain: Going over grass, asphalt, the ramps, thresholds, going up and down a step. If there's a cross slope or a cambered sidewalk, how do we push or negotiate that? How do we push a shopping cart in the grocery store or a stroller if we're a parent? Again, propelling while holding a drink if you're out for coffee with a friend, how to break apart the manual chair 'cause both the folding and the rigid frames will break apart to put it in the car for transportation, and then managing if you have a power chair, how are we going to get that on and off city transportation or in and out of the van if that's what we are using to transport the chair?

Those are all skills we need to practice. For power wheelchair skills, we're looking at drive control in all directions. So accuracy with forwards, backwards, turning. All of those different things. Utilization of all of the power seat functions. Can they do them efficiently and independently? Can they access their switches independently? We need to spend time training the caregivers, especially in our high level tetraplegias, we clients with tetraplegia, we need to make sure that the caregiver understands how to move the chair, manage the chair, set up the chair. If they're dependent for the transfers that the family needs to understand or the caregiver needs to understand all

of the pieces that we've recommended and how they operate, because they're going to be the ones assisting the client with it. The client needs to know how to charge the wheelchair. It's often right underneath the joystick. How to disengage the batteries if they run out of battery. How does the chair get pushed if necessary? And there's usually like switches somewhere down by the tires themselves. And then again, access to their technology and being able to access their phone and all of those types of things. So lots and lots of things. Being able to access the elevator buttons from their power chair. There's so many different skills that are outside just driving down the hallway of your outpatient clinic or driving down the hallway of your acute care inpatient to think about. For manual propulsion technique, the PVA Consortium for Spinal Cord Medicine has a document called the preser... A clinical practice guideline. The preservation of upper limb function following spinal cord injury. And it recommends when we are pushing a manual wheelchair, we want long smooth strokes, and we want to recovery phase during the stroke that happens where the hand is below the rim.

That's going to help with the shoulder mechanics and overuse injuries. Symonds et al. looked at real time feedback and training for propulsion technique and they found that there was an improved push arc and a decrease rate of propulsion. I'm sorry. A decreased rate of having to push the chair when there was real time feedback, whether that be visual or auditory, or they had haptic where they had somewhere if something vibrated if the technique wasn't correctly. So there's all different types of ways of doing it, but correcting it in the moment so they're not continuing to push with poor technique. So here's an example. Let me get my little cursor. Being able to push through the arc with a nice long push to the top of the rim, release and then having that arm relax and come down. So this is the motion we're looking at, but how often do we get our clients who just contact the rim just from like 12 o'clock to three o'clock, right? We just slide our hands back and forth. So it takes a lot of cueing for folks to be able to grasp the concept of how to properly push the manual chair. One thing I remind my clients is that we didn't get you this really nice, light, awesome chair for you to push it

10,000 times a day. The whole point of this chair is to be able to push it less often, and the way you do that is by having a good push every time you do it. So that sometimes helps them to visualize. And we set goals of, "You're going to make it from this point to down the hall in less than six pushes. Go." Because again, we need them to start to understand what the propulsion technique looks like and how important that is to the longevity of their shoulders. We're going to get into the wheelie for just a second. So the wheelie is really important for pre-curb or pre-step training. So a few tips for success. I'm a big believer in you can't teach what you can't do. So get in the chair and practice safely with a colleague, but starting on something with high friction like a carpet.

Something that reduce that, sorry. Increases the resistance to the rolling can make it a little easier for someone who's learning. In this picture here I have blocks to the front and the back of the wheel. So all the person has to do in the beginning is learn how to move the frame on the axle without having to worry about the wheel moving on them. So that's like a phase one of wheelie training. Cues we want to give our client are to keep their hands positioned at the top of the wheel. Let me go to the next page. We want to keep their hands positioned at the top of the wheel because the farther forward or the farther backwards their hands get, the more difficult it is to maintain.

We want to also encourage our clients to have light hand adjustments. So it's really hard to make these little tiny hand adjustments, but people tend to. I call it the white knuckle. If I can see your white knuckles then that means you're grabbing for dear life and your adjustments are gonna be far too drastic. So we want very light handheld assist on this as we're starting to learn. As the clinician we need to keep them safe. So you can see here if there's push handles, you can obviously use those, but here I have a gait belt wrapped around the axle that I'm using and then I also have a hand right in front. A gait belt here, a hand right in front so that way we don't go forward or backwards. Once we've mastered the actual wheelie itself, then we talk about flicking

the wheelie themselves independently, moving forward and backwards in a wheelie position, turning in a wheelie and setting goals for that in our plan of care. So my client will be able to maintain static wheelie position for 30 seconds with standby assist in order to prepare for curb management to enter, exit their home. So different things like that, but it is really important that we are implementing that into our plan of care. Once we've mastered the wheelie, we start talking about charging a curb. And charging a curb is done when we are going at the curb with speed. Depends on the height of the curb, but it again can be a little intimidating for the client when you're first learning. But what we're really looking at is the client needs to be able to time their wheelie. And we usually say it's right when their eyes are looking down at their knees and see the step. That's when it's time to flip the wheelies. So that way we can get the casters in the air and then once the casters are in the air and the wheel contacts the curb, the client needs to position their head and trunk appropriately so that way they don't tip backwards.

So we need to tuck our chin or lean our trunk forward a little bit to be able to get up and over that curb. As the clinician, we are guarding again with our gait belt, but we also want to have that hand in the front to prevent our client from coming out of the chair forward if they don't hit the curb at the right time. So when we look at stairs, stairs are dependent really on the person's environment. So some people have to do stairs to go home safely, other people very rarely encounter them. So it depends on how often are they going to do it. There are two-person techniques for the client in the chair, there's one-person technique. Is that safe? Are there rails? What does the stair design look like? Does the client need to get out of the chair and bump up on their bottom? All of these things are really important. I like to say when we start stair training have a pelvic belt that's in place so that way your client is keeping their pelvis into the chair. And just remember, communication during training is key. So just for an example here. Here's a rail. The client needs to have a very good trunk understanding and good balance and be like mini-assist to be able to talk about doing stairs with one person.

And again keeping them guarded safely throughout. If the client is not at that level then it is an automatic. You need to have two people if stairs are recommended to do at home in teaching the family and the client how to do that. Going up the stairs we tend to go backwards. Going down the stairs, you can go forward or backwards. It depends on the setup of the stairs and again, the control of the client in the chair and their ability to do wheelies and if there's railings present or not. So next we're going to look at the maintenance required of a wheelchair. So Toro et al. found that 63% of full-time wheelchair users with spinal cord injury surveyed at least one repair required. 27% of those surveyed had some type of adverse results or effect from the repair that was needed.

In manual wheelchairs, that's often the wheels and the casters. In 40% of wheelchair users from that survey were performing their wheelchair maintenance at home themselves. In power wheelchairs it's the electronics and the power controls that are most often needed adjustments and 14% of clients were doing those repairs at home. So it's really hard to put this into our plan of care, but this is something that needs to be addressed. Hogaboom et al. found that those who were surveyed experienced immediate consequences.

Those who experienced immediate consequences from their maintenance and repair had a higher self-perceived health status and pain score. They had a higher chance of re-hospitalization, a higher chance of pressure injuries. So should we be doing a better job as clinicians? In the University of Pittsburgh, actually if you have time to go in and look has done a lot of really great things on maintenance programs in maintaining your wheelchair for your client. So it is something that we should be including. What needs to be done weekly, monthly, yearly in order to maintain your wheelchair appropriately. So again, things to consider. All right, and lastly we're gonna look at wheelchair prescription and intervention. How did we do, right? We're assessing that through our outcome measures. So I will just say, in the world of wheelchairs, we're a little bit

behind. I think the rest of physical therapy and our outcome measures and the research that has been done on that. But I included in here a few different options. So some of the self-report measures that are available and there are many more than this. These are just a few that I found that are easy to administer in clinic. The functional mobility assessment is a 10 question survey that provides, it looks at activities before and after receiving their new chair and satisfaction with the process. It gives you a one to six score from completely disagrees to completely agrees. And again, it's a good way to provide feedback or to provide concrete evidence at what we did with this new chair, made a difference. The Quebec User Evaluation of Satisfaction with Assistive Technology or QUEST looks at many, many different things. It's a 12 items to assess the satisfaction of a specific assistive technology. It's recommended for home health or outpatient settings and it looks at weight, dimensions, adjustability of the device, safety, durability. All different types of things. It also includes looking at service and delivery and repairs and professionalism, and some other things that I think are really important to our process of how our clients get their chair. So that's another one that could be used in clinic.

The Wheelchair Users Shoulder Pain Index, WUSPI. This line is a 15 items scale. It's functionally related, it assesses shoulder pain from no pain to the worst pain ever. This one does have a MDC associated with it, which is 5.1 for chronic wheelchair users. So again, if somebody is having pain and now you've done these interventions to address that or you've done this new chair to address that, I'm doing a shoulder, a WUSPI before and after could be very beneficial to show, yes, this MDC, we achieved the MDC and that was because of the intervention that we provided. The WOM, the Wheelchair Outcome Measure is another one that it takes approximately 15 minutes. It's easy to administer the activities that the client... I like this one because it really you're finding out from the client, what activities do they want to be doing in the home, the community? And it rates their comfort or skin breakdown before and after their new wheelchair. There's a lot of different things that it assesses, but it really is goal-focused

on the client. And that's really important because everybody's goals in their wheelchair is different. So it's nice to have something that addresses the specific goals of the client themselves. And this one also has an MDC that's associated with it with a score of two. It's free but they do ask that you go to their website to register if you're using the assessment. And then the Functioning Everyday with a Wheelchair, the FEW is a 10 question function-based questionnaire that looks at functional mobility, ADLs, IADLs, and it looks again at stability, durability, comfort. All these different aspects. And they do have a clinic version. Now a lot of these self-report measures are really applicable to the home health and outpatient setting because the client really needs to have been in the chair, using it for a little while. And then lastly we have our activity-based outcome measures.

And two of those are the Wheelchair Skills Test. The Wheelchair Skills Test is awesome because they have a whole... If you go look at their website, they have videos and very good descriptions of exactly how to administer this test and what that looks like. And they have a manual version and a power version. There's 32 items on the power version and 28 items I believe on the manual version. And then they also have caregiver aspects into caregiver training for the wheelchair skills. And then there's also a questionnaire that is associated with it which can be a great tool to help you to develop your plan of care 'cause it asks a client the same thing.

Very specific goal-oriented things that can help you. Like what is your ability, confidence, and frequency that you perform these specific skills? So you can go to their website to see home, I'm sorry. To see videos and very specifics on how to administer that outcome measure. And then lastly is the Wheelchair Propulsion Test. And this is like the 10 meter for the wheelchair world. And this looks at 10 meters and the client propels the chair and it looks at propulsion speed, the number of propulsion cycles as well as do they have a recovery phase? And what are the limbs? Are they using their arms or their legs if they're foot propulsion? And this can be really helpful in

somebody when you're trying to decide between manual and power. You can do the Wheelchair Propulsion Test to determine the effectiveness of the propulsion and be able to give a little more objectivity to that. So I really appreciate you all joining me. I'm sorry, I went just a few minutes over. I could talk about wheelchairs and spinal cord injury all day long. So I really appreciate you guys hanging in there with me. If you have any questions, I see that we had a couple throughout the course, so I can go over those, but I'll hand it over to Calista real quick just for any closing things before I answer any of those questions.

- [Calista] All right. Well, thank you so much, Kristen for sharing your expertise today. And before we close out the course, we will address those questions post time here. But again, thank you everyone for coming. And this is the completion of the course.