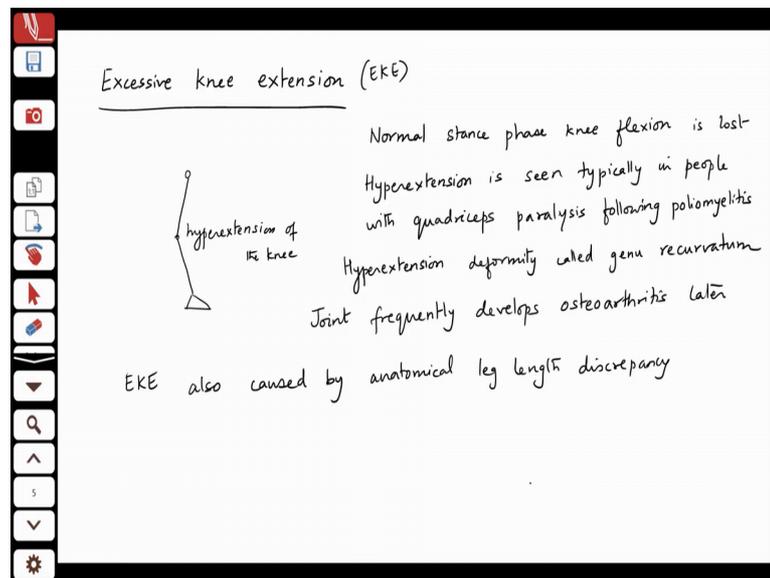


Mechanics of Human Movement
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Lecture - 45
Pathological Gait Part III

So, we have looked at some instances of pathological gait, today we will look at a few more. We saw that for functional leg length discrepancy, there are four different ways a person could adapt to that and still walk. So, today we will look at a few more cases of pathological gait and how it affects a person's ability to walk.

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So, excessive knee extension is one such instance, where do you think this would matter? If a person has extension beyond you know has excessive knee extension either because of especially following poliomyelitis, because they are used to you know pressing their thigh, walking with anterior trunk bending, after a while their knee if you look at it from the sagittal plane it starts looking like this ok.

So, this is hyper extension of the knee because they are constantly it becomes a deformity hyperextension deformity of the knee, because to stabilize the knee they keep extending the thigh say with their hands or by anterior trunk bending or by both. And those; so that results in a secondary deformity happening where the knee is always in a hyper extended position when its load bearing ok. For most of us 0 degrees is your full

extension right you do not have, but because of the deformity now it becomes hyper extended.

Where do you think this could have an impact in the gait cycle? Where does? If you remember during the loading response phase, the knee undergoes a slight flexion ok. Now if the knee is hyper extended like that in load bearing, then that slight flexion is lost which usually is responsible for the, it which has a shock absorbing effect. So, that is lost in this case and also what happens is, this condition keeps getting worse because now the load line always passes anterior to the knee. So, this condition is actually getting worsened as the person walks.

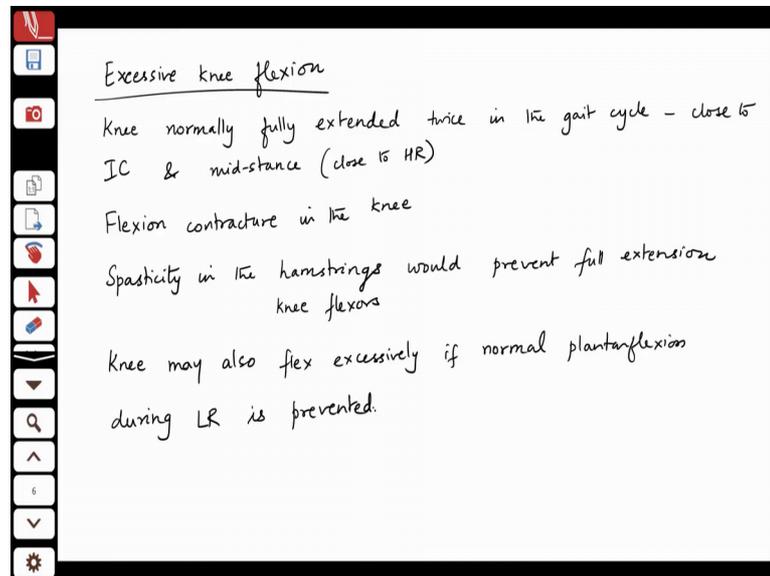
So, in this case normal stands phase knee flexion, because you have to knee flexion at two stages. One is in the stands phase for the shock absorption during loading response and of course, the other knee flexion happens in swing that may still not be affected by this hyperextension, but the normal stands place a phase knee extension knee flexion is lost. And this kind of hyperextension is seen typically in people who have quadriceps paralysis following poliomyelitis.

So, this kind of a hyperextension deformity is called genu recurvatum. And it also is a problem because with continued hyperextension loading like this the joint typically develops osteoarthritis later in life. So, its a progressively degenerating kind of a pathology in this case, it just becomes worse as it goes along, develops osteoarthritis. So, the skid also happen when there is an anatomical leg length discrepancy this is kind of an excess of knee extension, I will call this EKE also caused by anatomical leg length discrepancy, because it may be uncomfortable for the person you know to stand right.

When they are standing if one leg is shorter than the other, then standing with the weight balanced is difficult and so, it happens that they met tend to hyperextend the knee when they are standing so that all the weight is not on the longer leg. No, actually when they are standing on the longer leg, because all, most of the weight is on the longer leg you know their, that is when this will tend to happen. On the longer leg the knee will tend to hyperextend because they are putting more load while standing. Because it may be difficult for them to stand in a flexed manner on the longer leg right because the other leg the shorter.

So, it may be uncomfortable and so they will end up transferring the weight to the longer leg and hyper extending it. So, this is one type of pathological gait.

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Yet another instance is when you have excessive knee flexion. So, during gait the knee is fully extended when; when does the knee become fully extended?

Student: (Refer Time: 08:15).

Initial contact and in mid stance ok. Knee is normally fully extended. So, twice in the gait cycle; end of swing or initial contact and then close to heel rise and mid stance right, mid stance. So, one or both of these may not occur if the knee tends to be.

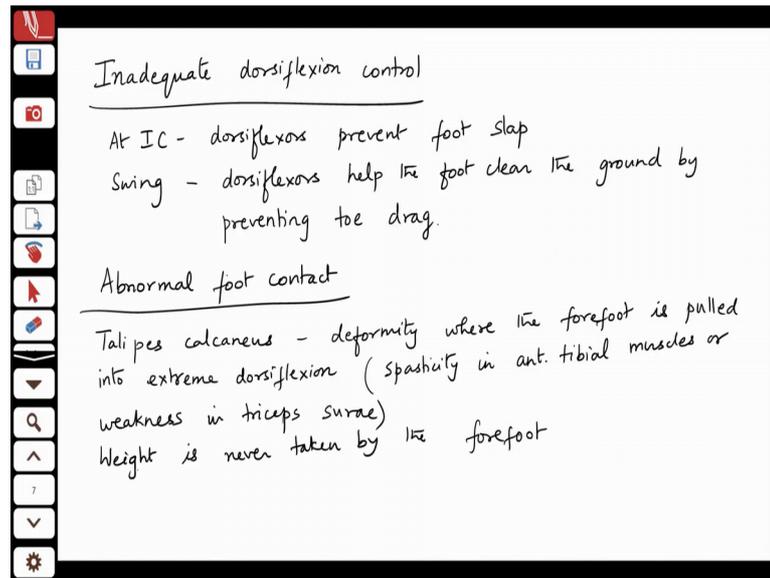
So, there may be a flexion contracture in the knee that prevents the knee from fully extending. So, it will prevent full extent normal extension at its possible at both of these instances in the gait cycle. So, you could have the flexion they could be a flexion contracture or you could have spasticity in the which muscles which would prevent full extension?

Student: (Refer Time: 09:56).

Spasticity in the no spasticity is tightness; spasticity in the hamstrings would prevent full extension. So, these are the knee flexes spasticity in the knee flexes. The other instances if normal plantar flexion of the foot is prevented. So, after heel contact if the foot is not

allowed to plantar flex easily, then again your load line because it is trying to flex the knee would result in excessive knee flexion. So, knee may also flex excessively and again this could become a stability issue. If normal plantar flexion during the loading response is prevented, then you have a case of inadequate dorsiflexion control.

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Again when are the dorsiflexion active.

Student: (Refer Time: 12:08).

Initial contact what they do? At initial contact dorsiflexion prevent foot slap right. So, they act eccentrically to for controlled plantar flexion of the foot, then during swing dorsiflexors help the foot clear the ground. So, these are two instances where, so they prevent the two from dragging. So, this could also be a problem ok. So, have the dorsiflexors do not provide sufficient control then again the person may have to adopt some kind of a compensatory gait in order to clear.

So, we saw the dorsiflexors is if inadequate dorsiflexion control could be your case for your functional leg length discrepancy right because in swing it would not be shortened enough. So, the person may adopt some kind of a gait compensation to achieve a smooth swing phase ok. Then there could be other abnormalities in the foot in the shape some of them are congenital abnormalities.

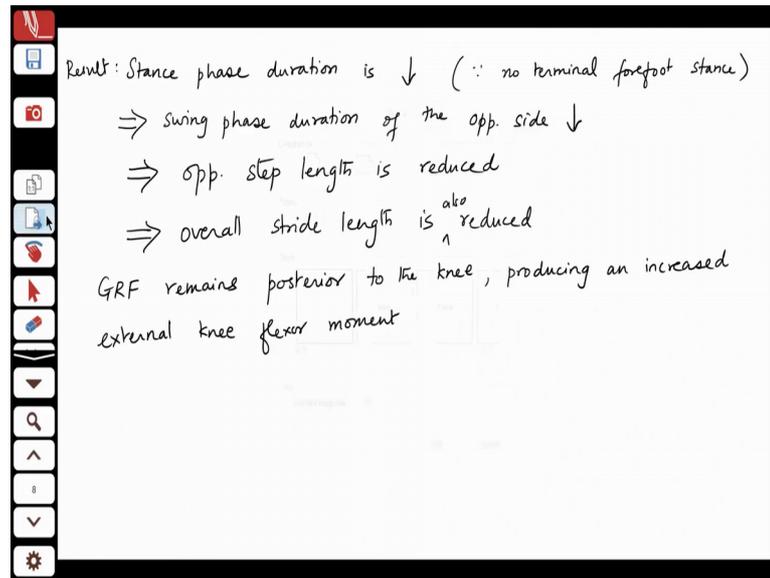
So, you could have like a deformed foot in some way, which prevents your normal heel to toe kind of an action while walking. So, the normal case initial contact happens with the heel and then the loading progresses to the toe. It might happen that in some cases that is not the part of the foot that hits first, the heel is not what heads first there could be some deformity in the foot an example would be.

So, these would be cases of abnormal foot contact. So, you could have something called Talipes calcaneus, where this is a deformity where the forefoot is pulled into extreme dorsiflexion. So, it could be because of spasticity in the dorsi flexor muscles, in the ankle dorsiflexors the tibial the anterior tibial muscles tibials anterior or it could be weakness in the triceps surae which are your calf muscles. So, if the antagonist is weak right the agonist then becomes too strong. So, the foot will be pulled into extreme dorsiflexion.

So, in this case what happens is the forefoot is never able to take the weight, in an extreme case the foot may never be able to be flat on the ground. So, weight is never taken by the forefoot. So, what happens to the stance phase on that leg? The duration of that is what will happen to the duration of stance phase? You cannot do this transfer the weight onto the forefoot. So, the stance phase on that leg gets reduced, which means the swing on the other side is reduced, which means the step length on the other side is reduced.

So, this is an instance where because of a problem in one leg, the step length of the other leg is reduced because you are able to spend less time on the leg with the deformity or the problem.

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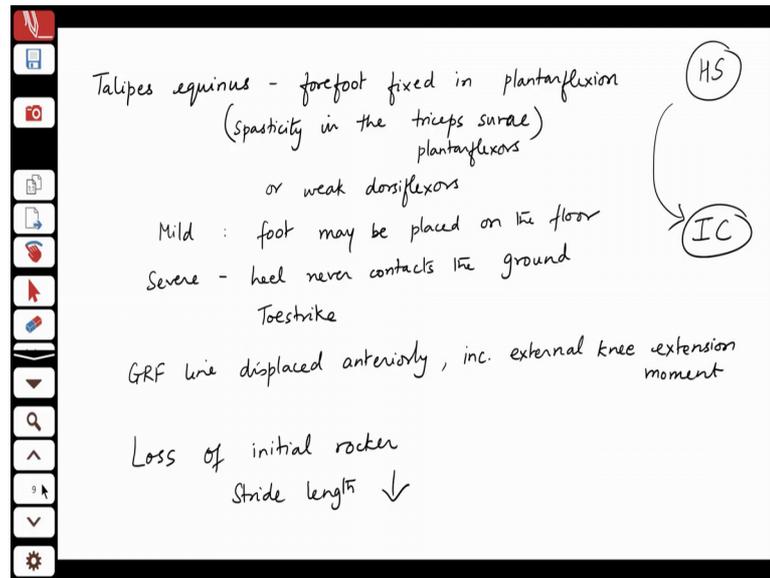


So, the result of this is stance phase duration is reduced because no terminal stance right no terminal fore foot stance, because the foot is not able to get to that at all no terminal fore foot stance or terminal rocker ok. And therefore, the swing phase duration on the opposite side, sits a off the opposite side is reduced; therefore, the opposite the contralateral step length is reduced and because of this the overall stride length is also reduced.

So, because of this, because of the absence of the foot flood the GRF remains posterior to the knee center and so, you may have again a case of excessive knee flexion because of this deformity in the foot. So, you can see how they are all interlinked, you know and how deformity or a pathology in one part affects the other joints and the challenge goes up. So, if the deformity is in the foot you know that propagates to the other and all of them have an effect on the gait.

So, GRF posterior to the knee, external knee flexor moment. So, what would be the internal moment that the knee would have to exert? It would have to be an extensor moment to control the external flexor moment. You have to be very clear between external and internal moments. Internal moments are produced by the muscles external moments are produced by the contact forces gravity etcetera. Most cases gravity results in the gravity plus the muscular forces results in the contact force of the support, which causes the external moment above the joints.

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Another kind of foot deformity is Talipes equinus. This is the opposite of the other one, here the forefoot is fixed in plantar flexion. So, the previous case was excessive dorsiflexion, here it is plantar flexion and this could be because of spasticity in the yeh spasticity in the triceps muscles calf muscles, which are the plantar flexors, could also be because of weak dorsiflexors and or weak dorsi flexors. So, in a mild case of this the foot may be placed on the floor. So, you could dorsiflex the foot by applying an external load basically.

So, the foot you may be able to place it flat because of the external load. In a severe case the heel can never make contact with the ground. So, the person walks with a fore foot gait, foot severe heel never contacts the ground. So, in this case your primary method of contacting the ground would be toestrike. So, you do not have a heel strike at all heel contact, there is no heel contact there is only toe contact.

So, that is why when they talk about the gait cycle they prefer to use the term initial contact, earlier a lot of literature used to use heelstrike. But because this does not include cases where the heel may not be the first portion of the foot to contact the ground, they went to a more general initial contact of the foot ok. Terminology of using initial contact instead of say heelstrike or heel contact because in pathological gait, it may happen that the heel is not the first portion of this foot to strike the ground.

. So, in this case what happens is because the foot is what strikes the ground what happens to the GRF? The GRF will pass anterior to the knee. So, it stabilizes the knee, but eventually its going to end up in your hyperextension of the knee. So, many of these instances of pathological gait can actually make things worse as you go along, because they affect because of the compensations it affects the other joints and you could have additional problems that come because of walking. And that is the reason some of some people might eventually choose to use some other method of mobility instead of walking. Because all these problems become progressively; some of these problems become progressively worse.

So, because you have toestrike, you have GRF line is anterior and therefore, you have an increased external knee extension moment. And in this case again your stance is shortened because you are losing the initial rocker. When you go from heel to toe, when you rock like that then you have your full stance. Here you are in the previous case we lost the forefoot rocker. Here you are losing the initial rocker and therefore, again your stride length will be reduced, will be reduced yes.

Student: (Refer Time: 27:54) because beyond the other leg the stance like.

Swing phase of the.

Student: Deformed leg.

deformed leg, why is that?

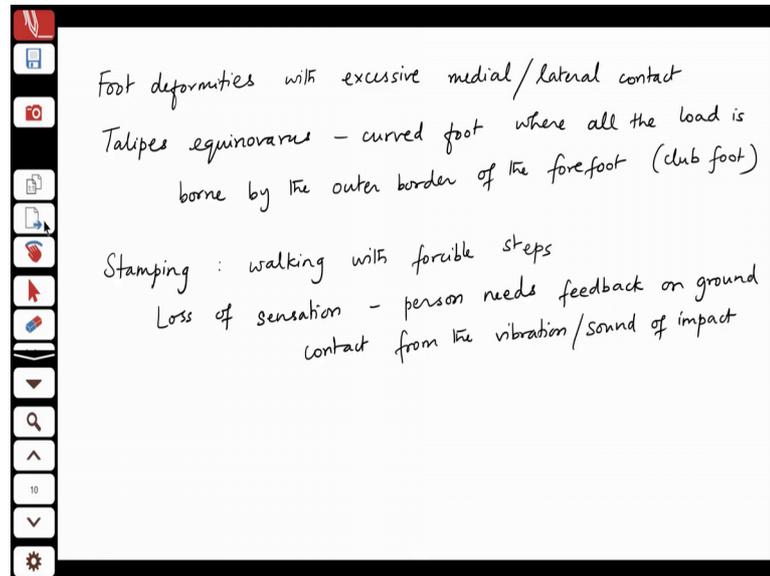
Student: Because it goes beyond the other leg, then it (Refer Time: 28:16) have to contact (Refer Time: 28:19).

Yeah if you have premature toe contact. It is possible that step length on the side is also reduced; step length on the side, but most likely you will try to make some compensation with the other good leg. So, that you clear the you try to go in to full swing on this leg then contact with the toe. But yes it is very likely that because you know you will not be able to clear the foot cleanly, that you will contact earlier than you normally. So, yes it will overall it will affect the stride.

Student: Stride.

Both step lengths may be effective and so would in this case, and therefore the stride length would also be reduced. So, in this case both the step lengths will probably be shorter than normal.

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In some deformities you would have um excessive medial or lateral contact. Even in so called normal walking right you see if you look at the shoes of some people, you will see they are worn out more on one side than the other because you tend to contact one side more than the other. You see the, from the wearing pattern on the shoe you can make out. So, in some foot deformities the foot itself you know if there is a deformity which makes the foot more likely to contact medially or laterally, then that could also affect the.

So, this is the clubfoot that we were that I mentioned earlier and that is talipes equinovarus. So, this is a curved foot, where all the load is borne by the outer border of their foot by the lateral border. Outer border of the forefoot this is called also called a clubfoot.

So, this again would have an impact on the persons walking. In some cases at the person lacks sensation in the foot and this can happen in the case of say diabetics; you know they may lose sensation in their foot and then you will find that one way of adapting to it is by walking with a stamping kind of a gait. Because, you want that audible feedback that you have made contact with the ground ok.

Because since the sensory perception is missing you need some other kind of feedback to let you know that contact has been made. So, this is walking with forcible steps. So, they need the audible or the vibration of that impact with the ground in order to realize that they have made. So, loss of sensation could be the cause and the person needs feedback on ground contact from the vibration or sound of impact. So, they actually have to feel it through the body basically in order to be able to. Then couple other you could have insufficient push off.

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Insufficient push-off because forefoot cannot be loaded normally

- problem w/ triiceps surae
- problem w/ Achilles tendon
- pain in the forefoot

Asymmetry in gait timing

Shorten stance on affected leg

Shorten swing, ∴ shorter step length of opposite leg.

Abnormal walking base

Frontal

valgus knee

varus knee

Larger walking base

① bias of abducted hip / valgus knee
→ Lateral trunk bending

② bias of instability & fear of falling - bias sensation or proprioception is affected.

If the forefoot cannot be loaded normally loaded normally, it could be because of problems with the triceps, problem in the tendon, achilles tendon you could have pain in the forefoot etcetera. So, you again will have asymmetry in the gait timing because you will be spending more time on one foot than the other.

So, you will shorten the stance on this is another case where you would shorten stance on affected leg. Shorter swing therefore, shorter step length on opposite step length of opposite leg. So, the two steps will be asymmetric, then you could have an abnormal walking base. So, this could be either because of a so if you look at the knee if you look at the frontal plane hip, you could have what is known as a valgus knee ok.

So, this you can remember like this, this is an L this is called a valgus knee in the frontal plane and the opposite of that would be this varus knee. So, this is like the R right this is your varus knee. So, this is a view in the frontal plane, in the frontal plane you people

may have this kind similar to the excessive here knee high the knee hyperextension or flexion contracture you could have in the frontal plane, you could have a valgus or a varus knee.

So, these could be reasons why your step width is greater than or less than normal. So, if you have a problem with the alignment of the knee in the frontal plane, then if you have a valgus knee then your step length will be wider than normal or if you have an abducted hip ok. So, if you are walking with. So, deformities that happen in the frontal plane can affect your step width right. So, if you have your hip abductors, your hip is in an abducted state then again that could be a reason for a wider walking base.

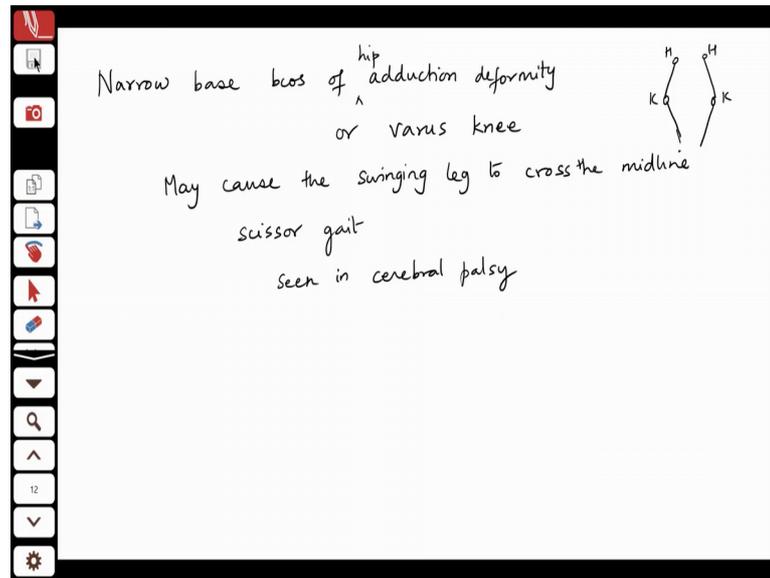
So, then what will happen? You will have to do the increased trunk movement. Remember we talked about the lateral trunk bending, if you have a wide walking base. So, if there are other things that cause the wide walking base like the valgus knee, then you may have to do this lateral trunk bending to maintain your balance while walking.

So, you have you could have larger walking base because of abducted hip or a valgus knee leading to lateral trunk bending. Or you may adopt a larger walking base to have a sense of security, because you are walking base you know, in the double support your walking base is defined by sorry your base of support is defined by your walking base.

So, you may choose to spend more time in double support with a wider walking this because you have a fear of falling. So, that could be another and that could be because you also have some kind you know if your proprioception is affected. Remember I told you about proprioception, your ability to figure out where your limbs are in space or if there is some sensory problem, then you may adopt a more conservative gait, you may not you may take smaller steps you may take you may adopt a wider walking base in order to feel more stable.

So, these are causes for. So, these the abducted hip or valgus knee could result in a wider walking base or it could be because of instability and a fear of falling because sensation or proprioception is affected.

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The narrow base would be because of an adduction deformity at the hip or a varus knee. And this could cause, say if you have a varus knee then your swing phase could be affected. Because you are actually if you look from the transverse plane you are crossing the path of the other. So, you have what is known as a scissoring gait and this is frequently seen in children or people with cerebral palsy.

So, they have a varus knee and so as it swings forward right it can sorry its a varus knee. So, as it swings forward it can collide with the other leg. So, they may have to physically separate it in some way, in order to enable them to walk. So, they may have. So, if they are using a walker, they will actually use like a block in between to keep their legs separated, to prevent this kind of a colliding happening with the because of the narrow walking base ok.

So, it could its called a scissoring gait that kind of gait. So, this may cause this swing face to cross the midline, the swinging leg to cross the midline and this is called a scissor gait seen in people with cerebral palsy.

Student: (Refer Time: 43:44).

This is varus, varus knee because you are its like this in the frontal plane right ok. So, as it is moving the shank is crossing the midline. So, this is the hip like this, this is the frontal view from the frontal plane. So, in many cases some of these can be. So,

pathological gait could be either temporary or it could be more of a long term case. Temporary would be if you had an injury, you know you may use some kind of an assistive device like a crutches yeah.

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So, there are some assistive devices that could help with may be some of the load is borne by the assistive device, which enables which lowers the load on the actual body and helps the person to still walk because you are essentially now carrying a smaller load.

So, in all this if you seen in walking, the upper portion of the body is basically seen as a passenger unit. So, its the lower limbs that are making the movements to sort of transport the passenger unit along with the lower limbs of course, but you know its the upper part of the body essentially stays like a.

So, if you can reduce the loading on the limbs, then crutches etcetera perform that function, because one they also provide you a wider base. So, you also have this tripod stability. So, if one leg is off the ground, you have three points of contact with the ground. So, you have a larger base of support.

So, you can maintain your balance and it, but of course, crutches can be quite there are different forms of crutches, you have these are called the forearm crutches, and these are the axillary crutches they go under your armpit right. And sometimes long term use of

this kind of a crutch can actually cause problems with your shoulder cause problems with shoulder pain and things like that. But in many cases for short term use they would be fine these are system device and the reason you know you want to get back on your feet.

So, even when you have an injury, you want to get back on your feet and start walking with some kind of an assistive devices because so many of the muscles in your leg are involved in walking. You know the bones all look and with the body as I mentioned many times, you have to keep things functioning for it to not weaken and atrophy.

So, because of that people say if you have an injury, yes you know you have to rest, but do not completely. So, bed rest is probably you know one of the most difficult things to get back to recover from. Because if you are on bed rest then basically everything becomes starts functioning at a lower level, and so you have to then build up strength to get back to your normal functioning, but these sort of crutches. So, forearm crutches and auxillary crutches can help with some kinds of mobility because they would also be able to or a cane we saw that abductor weakness in the during single stance. We saw how a cane can still help a person walk we did that back, when we did the static analysis. So, these are devices that can help reduce the loads or transfer the loads to other parts of the body so, that the person can still ambulate on in this manner.

We will next look at assistive devices that are more complex, in the sense that are either replacements for a limb, and then we will look at what are some of the design considerations we need to have so that, they are able to enable the user to walk ok. So, that is what we will continue in the next part of the course.