Mechanics of Human Movement
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Lecture - 44
Pathological Gait Part II

So, we are looking at various types of Pathological Gait; meaning where the person is still able to walk, but it does not fit into the normal pattern. And, we are trying to see what sort of variations could occur, and what the causes for those variations could be.

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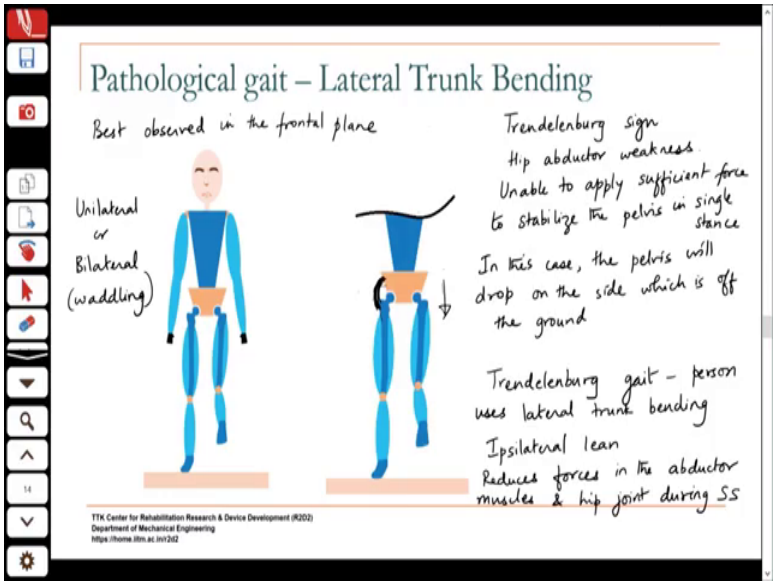

So, we first saw the case of lateral trunk bending is when you have weak hip abductors and so you lean on the side. If you have weak hip abductors the hip abductors play a crucial role, when that particular leg is on single stance to prevent the rest of the body from falling on the swing side. So, the hip adductors are weak then the tendency is to shift the weight onto the side that is in single support. So, that you reduce the momentum and hence the reduce need for the hip adductor moment ok; that is needed to balance the weight of the remaining part of the body.

So, you do that and that leads to; so, if you have hip abductors adductors that are weak on one side then the compensation may be only on one side. In some cases you could have weak hip adductors on both sides in which case you see this waddling gait; the person leans on one side leans on the other and so on; so you see that waddling gait.

We also saw that there could be other causes for lateral trunk bending. Again if you have a painful joint you are again trying to reduce the muscle forces that are applied about that joint. Because, the higher the muscle forces that are applied about that joint the higher the joint forces are going to be. So, if you have a painful joint and you want to reduce that you adopt the same kind of strategy because, your objective is to reduce the pain that is in that situation.

Then we looked at the case of anterior trunk bending where, essentially the person may have a weak knee. The knee may not be able to bear the control; about the knee is not sufficient to ensure stable walking and so; that means, the person probably has weak knee extensors ok. So, the quadriceps basically work to extend your knee and the person has weak knee extensors then stability becomes compromised when load bearing. And so, to compensate for that the person may actually lean forward because that will help to move the ground reaction force ahead of the knee.

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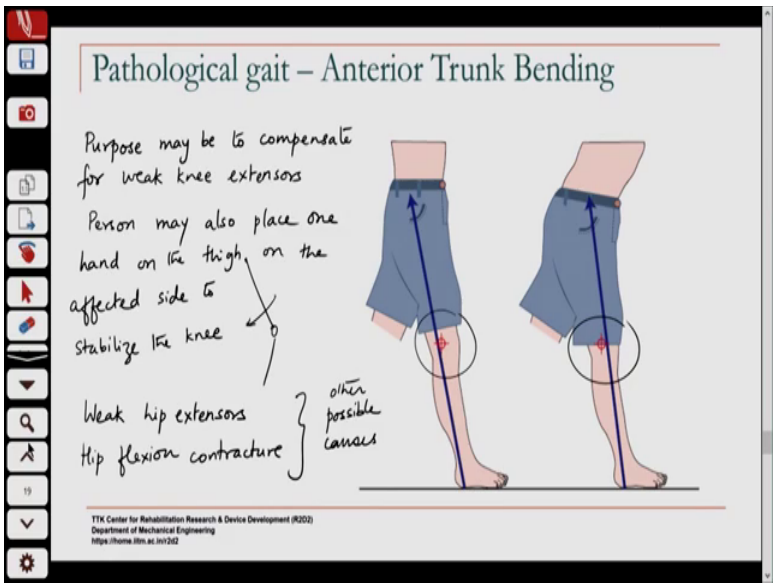

So, anytime the ground reaction force falls the line of action of the ground reaction force falls behind the knee, posterior to the knee then the knee has a tendency to flex. And, if the control about the knee of the quadriceps muscle cannot exert enough control to prevent that extension or to control that extension; then the person what they do is they lean forward or they place a hand on the thigh to basically provide additional means to extend the knee ok. Because, the muscular force alone is not enough to accomplish that.

So, this is a case of anterior trunk bending. Other reasons for anterior trunk bending could be that the person has a flexion contracture at the hip ok. So, if the person has a weak knee extensor then anterior trunk bending is a compensatory strategy ok. It is a compensatory strategy because, in order to now aid the knee extension you are compensating by bending your trunk anteriorly; if the person has weak hip extensors or weak knee extensors. On the other hand if the person has a flexion contracture then the person cannot extend the hip because of the flexion contracture.

So, it is a gait, the anterior trunk bending is caused by the problem because, the person cannot stretch those hip muscles further because, of the flexion contracture. They cannot extend the hip further and so, they are in that kind of a position. And so, the anterior trunk bending is caused by the flexion contracture rather than being a compensatory strategy for something else ok. So, these kinds of adjustments to the gait can be because of the problem itself or it could be a compensatory strategy; because the problem is something else, but you are using anterior trunk bending to address that problem ok.

So, that is so, typically those are the two things that could happen. Where the problem itself causes the pathological gait or the pathological gait is because of compensation for some other problem ok.

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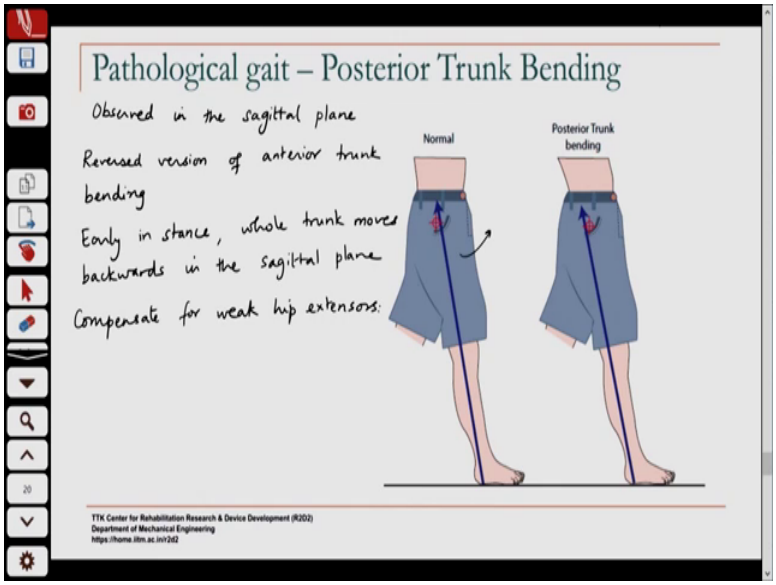

So, another pathology that can be observed in the sagittal plane is the opposite of what we just saw which is now posterior trunk bending. So, the person actually leans back as

they place their foot on the ground, they actually lean back. And this could be; what do you guess this could be because of. In this case you see the ground reaction force, you know like I said the shortcut way of looking at the moments. Ground reaction force is passing in front of the hip which means the external moment created about the hip is a flexor moment, this is hip flexion right.

So, it is a flexor moment which means it has to be overcome by a an internal extensor moment. If the hip extensors are weak then the person may not be able to so, the tendency will be to flex the hip before it is necessary. So, in that case the person may actually do this they may bend that trunk posteriorly which will cause the GRF to create an extensor moment about the hip rather than a flexor moment.

And so, so this is the reversed version of the anterior trunk bending and again it occurs early in the stance phase. So, early in stance as weight bearing begins the whole trunk moves backwards in the sagittal plane to compensate for weak hip extensors ok. So, this is again observed in the sagittal plane.

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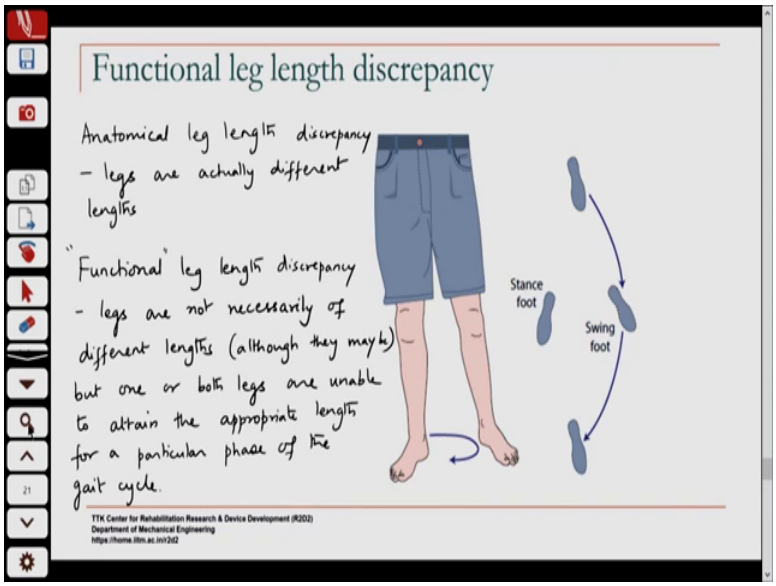

Now, we come to something called a functional leg length discrepancy. So, a leg length discrepancy is essentially there is a difference between the lengths of the leg, but why do we call this a functional leg length discrepancy. So, there are two kinds: one is there could actually be an anatomical leg length discrepancy. So, this has to be differentiated;

the functional leg length discrepancy has to be differentiated from an anatomical leg length discrepancy. So, this is when the legs are actually different lengths.

So, you can measure the leg length accurately by using like a long leg X-ray or you know using a tape measure you know and knowing the prominences in the leg you can measure the leg length. And, some people for various reasons may have what is known as an anatomical leg length discrepancy. The functional leg length discrepancy is slightly different in that, the leg lengths anatomically may not be different. So, when the person is standing and you measure the leg lengths you may not see a difference in the leg lengths. But you call it functional leg length discrepancy because when you are walking leg lengths kind of change ok.

So, if you look at from the hip to the lowest point on the leg ok, they vary as you walk. So, when we say functional leg length discrepancy, we are talking about that leg length not being what it should be for normal walking. So, an example: suppose in the swing the leg length is longer than what it should be then you are going to stumble. Because, you know appropriate actions need to happen about the hip, knee and ankle in order to shorten your leg sufficiently during the swing phase. If that does not happen then you could have a problem.

So, that is an example of you know functionally the leg is not able to achieve the correct length that it needs to be to accomplish walking successfully. Similarly, in the stands phase like for forward progression you know that the knee, you know the knee is extended and the body weight moves about it like a an inverted pendulum right; in the mid stance you have the body weight. So, you actually have what you call leg lengthening because the knee is in full extension, the ankle you know you have movement apart.

So, again if it is not able to achieve that again you have a problem with the walking. So, that is what we mean by functional leg length discrepancy. Here the legs are not necessarily of different lengths, although they may be; it is possible that the functional leg length discrepancy is caused by an actual anatomical leg length discrepancy also. But one or both legs are unable to attain the appropriate length for a particular phase of the gait cycle ok. So, that is why it is called a functional from a functional point of view it is not attaining the right length for walking.

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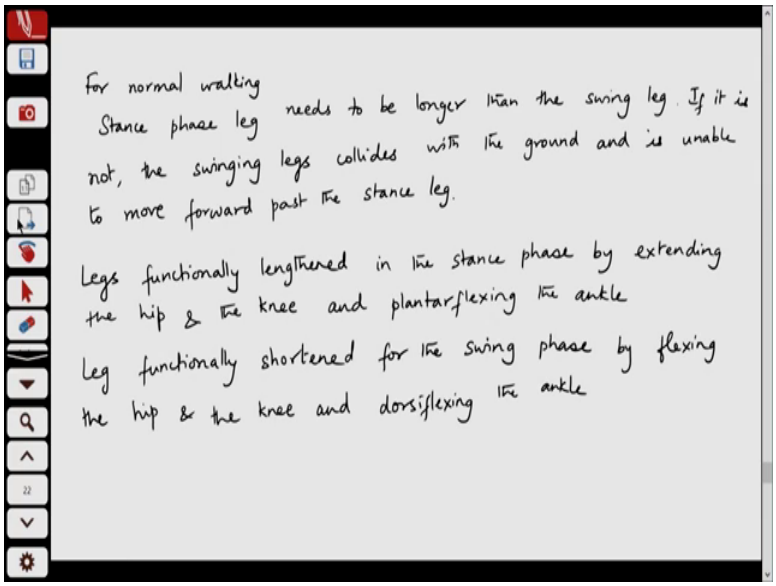

So, we have if you look at natural walking then you have for normal walking stance leg needs to be longer, longer than the swing leg. So, this is necessaries the swing phase leg has to shorten, but the stance phase length leg also the knee extension is a means of lengthening. So, that when it is lengthened like that you are you are also moving up the swing leg that is all part of the mechanism for shortening the swing leg also; these a lengthening of the stance leg. If it is not the swinging leg collides with the ground and is unable to move forward past the stance leg.

So, how is the leg functionally lengthened in the stance phase, in normal walking what are the actions? If you look at the movements about the hip, knee and ankle what happens; legs functionally lengthened in the stance phase what happens at the hip.

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By extending the hip and extending the knee and what else. What is happening at the ankle, to extend the leg?

Student: Plantar.

Plantar flexing of the ankle; so, three mechanisms at the hip, knee and ankle ensure that the stance leg is lengthened during the to allow the to give enough space for the swing leg departs. In addition so, this is for the stance leg, the leg is functionally shortened in

the swing phase. So, you have both mechanisms happening lengthening on one side, shortening on the other to ensure that; for the swing phase how is that happening by.

Student: You are.

You are flexing the hip, you are flexing the knee and you are.

Student: Dorsi.

Dorsi flexing the ankle; so, it is the exact opposite of the lengthening. And remember the legs have to interchange their roles. So, they have to be able to do both. So, if they can do one and not the other that is still a problem because, it is not as if one leg can be the stance leg all, the time the stance and swing legs keep alternating ok. So, there are various problems that could occur, that could cause this kind of a functional leg length discrepancy.

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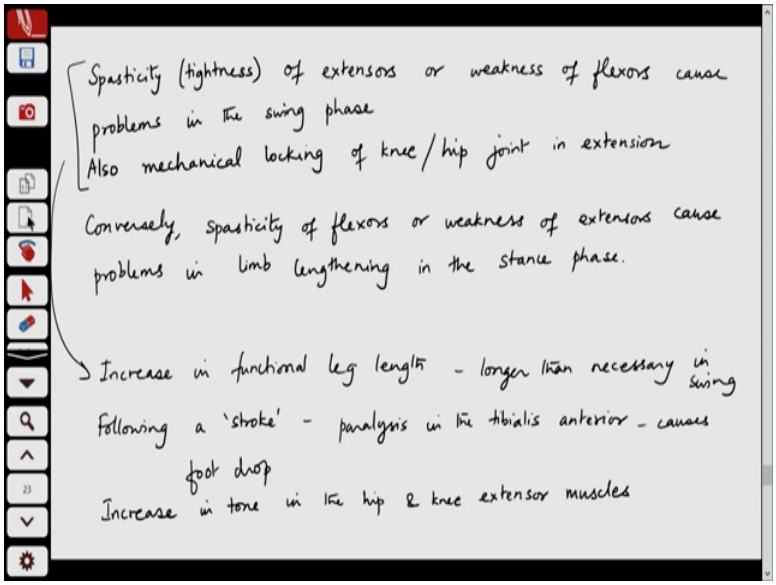

If you have spasticity: spasticity is tightness of the muscle right of extensors or weakness of flexes. Again this is necessary for flexes are necessary for shortening, extensors are necessary for lengthening ok. So, they could cause problems in swing. So, cause problems in shortening basically, say you sorry; here when you have tightness of the extensor that is actually causing a problem with shortening the leg, not with lengthening the leg right. So, both these tightness of the extensor and the weakness of all the

weakness of the flexor both cause problems in shortening ok. Because, the extensors will a tight extensor will prevent deflection comfortable flexion.

So, both these affect the swing phase; sometimes if you have an assistive device that mechanically locks the hip or the knee that also causes problems with this ok. So, again in the swing you could have problems with, if you have mechanical locking hip joint in extension. Why would somebody lock their knee or the hip joint in extension because, one of the primary requirements for walking a stability; stability is very critical. So, if you do not have the stability, if the person has weak extensors and they are not able to maintain the stability then it is basically like two rods connected by a loose spring. So, when you load the rod it is not going to be able to bear the weight, the knee will buckle.

So, in many cases what they will do is they will lock the knee in full extension. So, weight bearing is there, but that will affect the ability to swing, because that knee is locked. And, that is why they will have to adopt some compensatory strategy. The opposite of this would be spasticity of flexors and our weakness of extensors cause problems in limb lengthening in the stance phase. So, the limb is too short for the stance phase, again the other limb has trouble moving forward ok. This can happen so, sometimes this increase in the functional limb length. So, this is a case of increase in functional limb length right, it is longer than necessary longer than necessary in swing.

So, this could be caused sometimes due to a stroke. So, following a stroke a person could have paralysis in the tibialis anterior muscle, the ankle dorsiflexion and this could cause the foot to drop. So, the foot cannot be in the neutral or dorsiflexed position that muscle is not functioning very well. So, that foot tends to drop and what happens that increases the functional leg. Because, the dorsiflexion that is required at the foot at the ankle to for foot clearance during the swing phase is now compromised. Because, that is compromised you have a problem with the functional leg length in the swing. And, in addition they may also be what is called increase in tone increase, in tone meaning increase in the activity in which leads which is basically the stiffness the tightness in the hip and knee extensor muscles. So that means, they are too strong that could also be a fallout of the stroke.

So, hip and knee extensor muscles become spastic they become tight; that means, flexing against these muscles because, these are the antagonist muscles for flexion hip and knee

flexion. So, flexing against the muscles these muscles becomes difficult and you may also have the foot drop where, because of your weak dorsiflexor the foot is no longer able to stay in the neutral or come to the dorsiflexed position to enable the foot clearance. So, a person with this kind of an issue may choose different strategies for compensation ok. So, two people with the same clinical condition may actually adopt different strategies for their gait ok.

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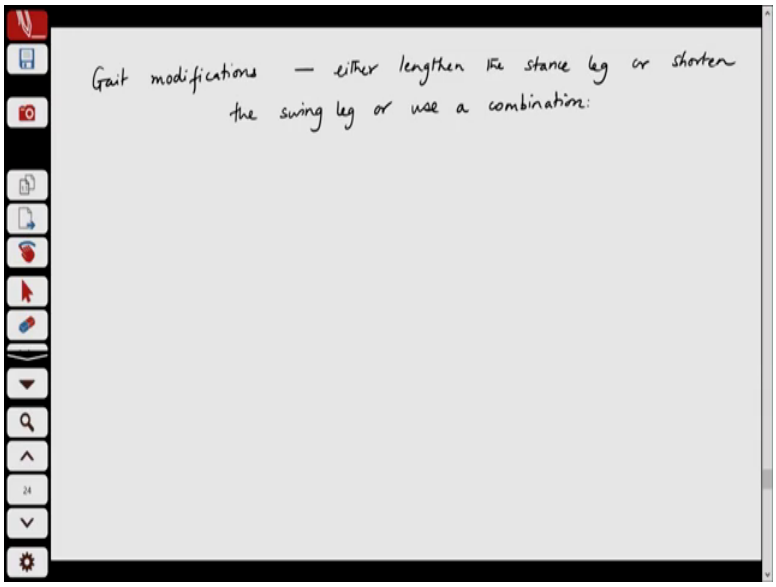

So, the gait modifications that would be required is you want to either lengthen the stance phase leg or shorten the swing phase leg or use a combination of these strategies. So, essentially the solution that you find to the problem may be your very own solution ok. Because, it will also depend on you know other factors such as pain, you know tolerance to pain, the distance that you are going to walk. You know different the environment in which you are operating in all those play a part in the strategy that you adopt to compensate for a problem like this.

So, one strategy is, is what is known as circumduction.

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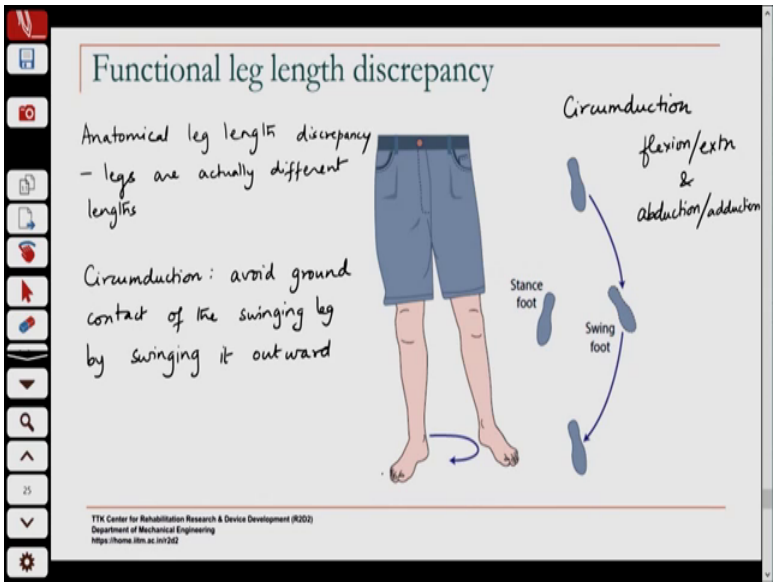

This is circumduction; you know what the movement of circumduction is it is a combination of flexion extension and abduction adduction. So, the end of the limb actually moves a longer. So, it moves along an arc because the limb moves along a conical trajectory. So, from the person; if so suppose the persons leg is no longer than normal for the swing phase; what they may do is they may abduct and then swing it from the hip, because they are not able to shorten it the normal way in this sagittal plane alone.

So, they use a combination of movements in the frontal and the sagittal plane in order to achieve this ground clearance. Because, essentially what you are trying to do here is to clear the ground for the swing phase. This kind of gait is very commonly observed in people who wear braces with locked knee joints ok, because the knee cannot flex at all and in many cases the and they would have a problem in the foot as well. And so, they would have a device that basically puts the ankle in neutral ok.

So, they may not be able to dorsiflex the ankle dorsiflex or so, the ankle may just be a solid ankle ok. So, since there is no ankle movement allowed they would not be able to dorsiflex or plantar flex. And so, they end up adopting a circumduction gait ok, where they are using abduction adduction as well as flexion extension at the hip to clear the ground. So, here in circumduction you avoid ground contact of the swinging leg by swinging it outward. This is one strategy that can be adopted, if to compensate for a functional limb lengthening. It could be it could be a problem on the stance side.

So, again in that case if the stance leg has a problem then and if you are not able to flex the other leg enough to clear the ground then this may again be a strategy. But, this strategy is typically used when the limb shortening is the problem. When the limb cannot be shortened then the person uses a circumduction gait to solve the problem. The other kind of other strategy that a person could use so, circumduction is one strategy, the other strategy is known as Hip hiking.

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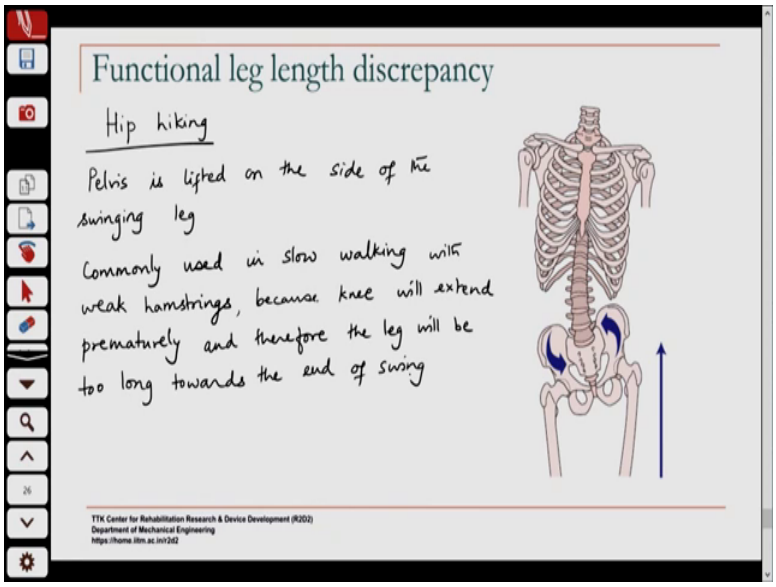

So, what the person does is the pelvis is lifted on the side of the swinging leg. So, you use your abdominal muscles basically, your trunk muscles and the spinal muscles to lift the pelvis on this. Because, you are not able to do something at the enough at this hip knee and ankle say or one of them then you now move it up, you know you move you lift the pelvis itself using your trunk muscles and so that you shorten the leg during walking. So, you lift and then swing forward lift the hip; so, this is called hip hiking. So, this is commonly used in slow walking so, a person with weak hamstrings. So, what did the hamstrings do?

They flex the knee and also so, if you have trouble with flexing the knee to shorten the leg, then if you have weak hamstrings the knee tends to extend prematurely right; because knee will extend prematurely. So, before it is ready to. And therefore, the leg will be too long towards the end of swing, end of swing ok; it lengthens too quickly. Because, you have to have you know before you are ready for the next he will contact

the leg has lengthened too much, because of the weak hamstrings. And therefore, you have a problem with the typically this is not used for lengthening due to a plantar flexed ankle ok. Hip hiking is not very effective if the person has a plantar flexed ankle, but otherwise that hip and knee are ok.

So, like the drop foot case, hip hiking is usually not the strategy that they would use. Hip hiking is used more in the case where the problem is that the knee because, of the weak hamstrings ok. Then the third type so, we have looked at two cases for functional leg length discrepancy the pathology is the same, I mean in the sense I can say it is the same, but the cause is the or the effect is the same; there is a functional leg length discrepancy. But the strategies could be different the causes could also be different because different muscle groups or joints may be involved.

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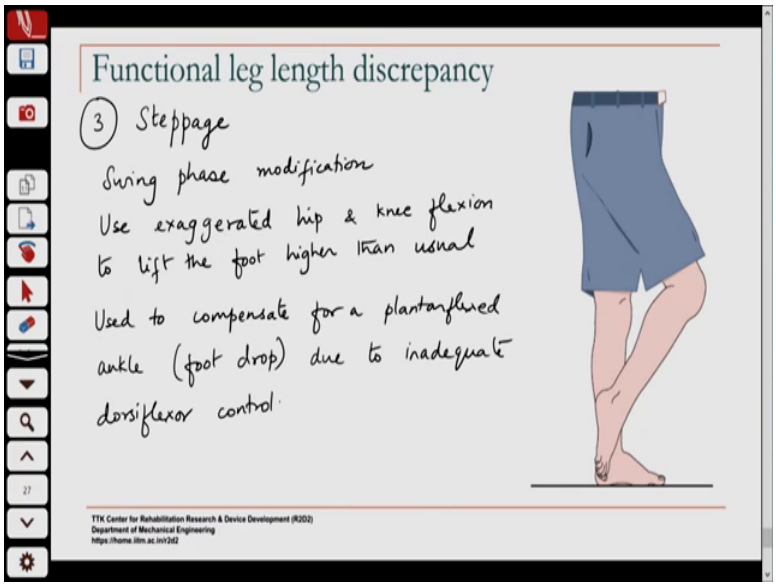

So, the third kind is what is known as steppage ok. In steppage so, here a person may have the drop foot ok; what you do is you basically increase your hip and knee flexion to compensate for the increased length of the foot ok. So, for what you cannot do at the foot, at the ankle you compensate for it by increasing exaggerated hip and knee flexion ok. So, you have it is a very simple you know it is again a swing phase modification; use exaggerated hip and knee flexion to lift the foot higher than usual.

This is typically used to compensate for a plantar flexed foot. So, what we call the condition is called foot drop and this is due to inadequate dorsiflexor control ok. So, if

the ankle dorsiflexors are weak then you would use steppage. So, you basically have an exaggerated swing, you kind of flex your hip and your knee more than necessary to compensate for this.

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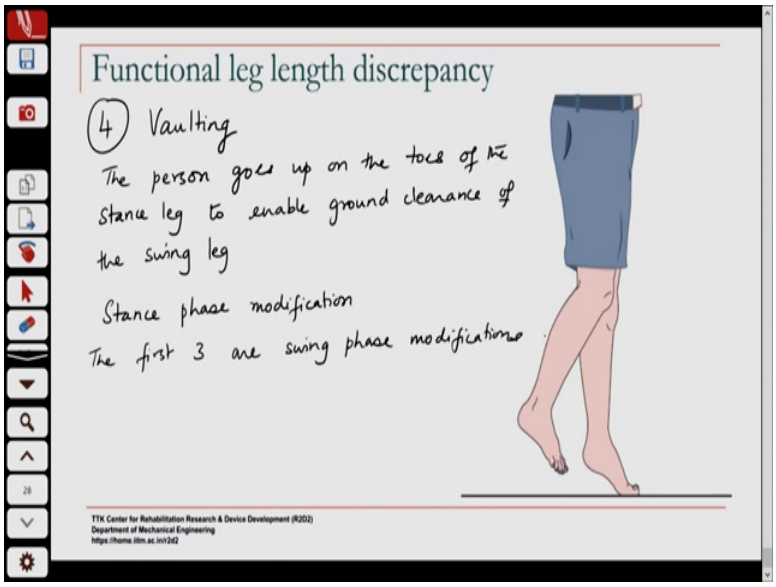

The fourth strategy is called vaulting and this is actually; so, they have a problem with this swing leg. They have a problem with shortening the swing leg, but they compensate instead by x by extra x lengthening the stance leg more than not they normally would. So, essentially they are going on tiptoe on the good leg ok. So, the problem is not with that leg the problem is with the other leg ok, but they are using the stance leg to compensate for the lack of insufficient shortening in the swing leg.

So, here in vaulting the person goes up on the toes of the stance leg to enable ground clearance of the swing leg. So, they are basically lifting up the whole body mass on the stance leg in order to let this swing leg. So, it is a pretty expensive way in terms of energy cost, energy intensive way. So, a person who would walk like that would get tired quite easily because it is not very energy efficient.

So, this is called a stance phase modification, the others were all swing phase modifications. Steppage or circumduction or hip hiking, they were all modifications that happened in the swing phase for dealing with the problem of that particular leg ok. In the case of vaulting it is a stance phase modification. So, it is a modification on the other leg

on the contralateral leg to deal with the problem on the swinging leg, this is a stance phase modification. So, the first three were swing phase modification.

So, again these could also be used when and when we look at artificial limbs, we will see that if the knee is not designed properly in a prosthesis a prosthesis is a replacement. So, if a person has an amputation at the above the knee ok, part of that thigh is amputated and they are using an artificial knee. And, if the knee does not flex enough then you could have a problem with the swing phase. And, the person may feel more comfortable compensate because they have controlled more control over the good leg, the unaffected leg.

So, they may adopt a strategy like this, they may adopt a strategy with a good leg in order to compensate for something over which they do not have as much control. So, that is a possibility, again it could also be used if they have hip flexor weakness because again the linked leg is lengthening too quickly. So, because the knee is sorry did I say knee flexor weakness, hamstring weakness and then the leg length lengthens too soon and they may have to adopt a strategy like this. In some cases so, these are the four strategies that are used for functional leg length discrepancy.

So, you have looked at the two main functions for walking that are required are weight bearing and limb advancement ok. So, these various strategies are to ensure one or the other. So, anytime you are locking the knee that is for weight bearing for stability, anytime you are trying to there is a problem with the swing phase then you have to adapt to ensure that the limb advances for the next step without stumbling, without falling. So, the falling could be because of different reasons; if the knee is not stable then you are likely to fall while weight bearing. If the swing is not smooth and does not clear the ground, if the leg does not clear the ground then you are likely to fall because of stumbling ok.

So, either way for successful walking you have to have all this coordinated movements and the body adapts, if there are conditions that prevent these from happening then the body makes adaptations. In order to still be able to walk although the gait will not fit into your normal gait pattern, with many of these pathological gaits the energy consumption also goes up ok; anytime you are doing hip hiking or you are doing circumduction you are causing movements of the center of mass that are either not smooth or lifting it above

you know what is necessary then because, you are working against gravity you are looking at increased energy consumption.

So, many times pathological gait is not as energy efficient and in many cases a person may at some point decide that walking on two legs is not worth it ok, I had rather use a more efficient form of locomotion and may end up adopting or using a wheelchair for instance. So, they may end up using other devices because if the biped walking, walking on two legs becomes too energy inefficient then that can be quite problematic ok.

So, we will continue with somewhat a couple more instances of pathological gait, and then we will start looking at assistive devices and their influence on walking.