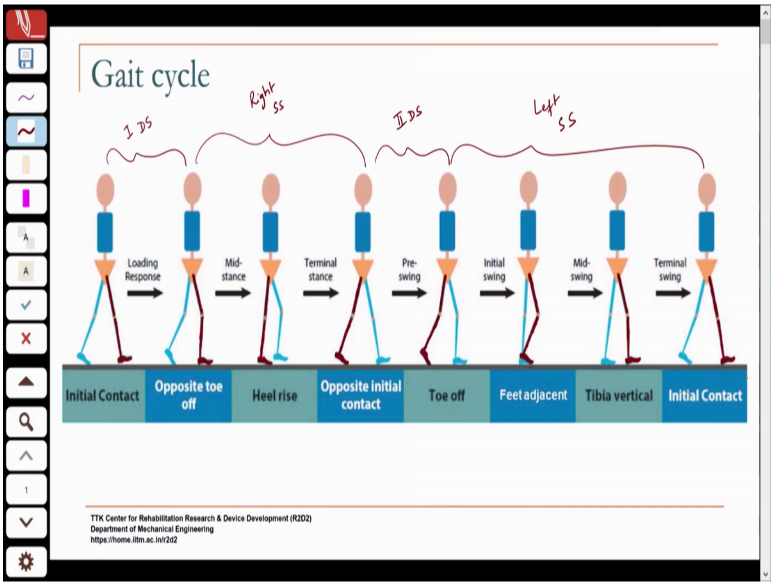
Mechanics of Human Movement

Prof. Sujatha Srinivasan
Department of Mechanical Engineering
Indian Institute of Technology, Madras

Lecture – 41
Characteristics of Normal Gait Part II

We have looked at the Gait Cycle.

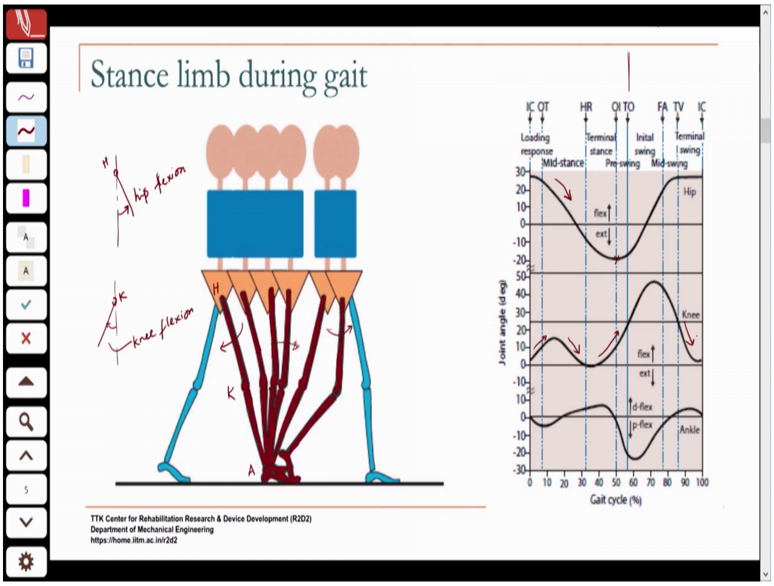
(Refer Slide Time: 00:29)



The individual events in the gait cycle just a quick recap, initial contact, opposite toe off which marks the first double support phase loading response. Then you have the stance face of the supporting limb ok. So, the first stance face or in this case will call it the right leg stance phase. Then the pre swing face from opposite initial contact to toe off of this leg marks the second double support phase followed by single support on the other side which ends a single support.

And then the gait cycle ends then the same leg makes initial contact again. So, as you can see there is a lot of coordinated movements happening at the various joints, and we will look at some of the joint motions today.

(Refer Slide Time: 01:37)



So, what is happening at the hip knee and ankle joints during these various phases of gait ok? So, if you look at the stance limb, so stance is then over the supporting foot the entire body now moves forward ok. So, if you look at the stance limb you can see that you have motions at the hip, knee, and ankle which is what we will look at, you can see that in the hip starts moving is flexed, when it lands on heel initial contact ok.

When the first layer the hip first when the foot lands on the ground, the hip is in a flexed position remember flexion would be with respect to the anatomical the standing position we take that as. So, if this is the vertical, this would be hip flexion then for the knee if this is the vertical this would be the knee flexion. So, we are looking at the light of interest we are looking at is in stance.

So, the maroon leg is what we are looking at ok, because we define the gait cycle as event of one leg to event of the same leg. So, we are looking at when we looked at the gait cycle; we basically looked at some of the events are defined by what is happening with the other leg that is the opposite initial contact opposite toe off etcetera, but our leg of interest is this one the brown or maroon one. So, this is so here if you look at the hip, you have the hip, you have the knee, and you have the ankle three joints. So, you can say that the hip after initial contact starts to extend extremely coming back to the zero position the anatomical position and then going beyond it ok.

So, beyond so the hip extends and then only later it starts flexed. So, it undergoes one cycle of extension and then followed by flexion; one cycle of extension and flexion. This is of course; we are still looking at only the stance phase which is up to this. So, in this case the hip is extending only towards the end of stance face the hip will start moving again.

So, initially it is moving in this direction and then again it starts moving in this direction we can see here that it will start flexing again from the point of opposite to initial contact. If you look at the knee, the knee so this is flexion, this is extension. So, in the case of the knee you may have a slight hyperextension here, but usually you just say it goes up to 0 degrees of flexion full extension.

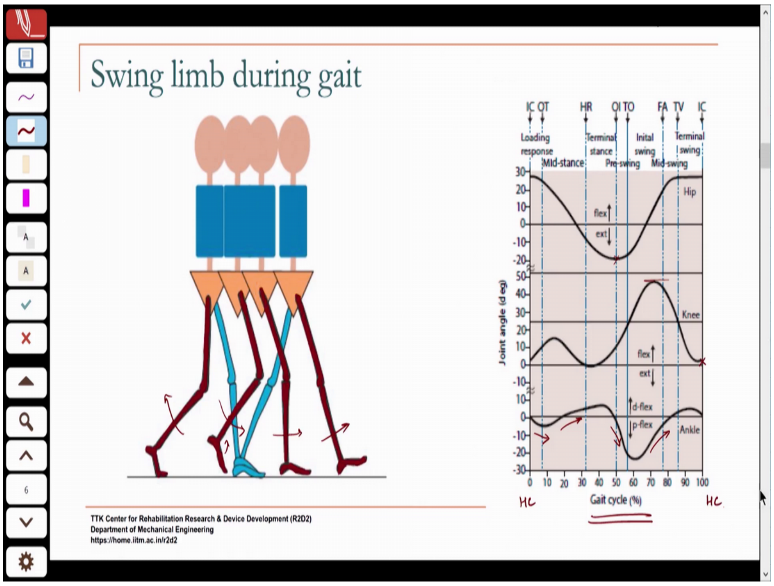
So, initially you say that in the knee there is some flexion you see here that at heel contact it is almost fully extended and that is necessary in order to keep it stable you know so that it does not. So, you have full extension at initial contact and then there is some flexion about up to about 20 degrees of flexion soon after right after loading response ok.

So, during loading response the knee actually flexes a little bit and that actually provides a shock absorbing mechanism. Because heel contact happens with an impact and this bending of the knee provides some shock observed. So, you have some initial flexion and then the knee extends again. So, during most of stance the knee stays in the extended position because you need to stabilize the knee the weight bearing as the weight as the weight on the stance limb it starts going into single support you want to keep the knee extended, you want to keep that joint extended.

So, that the load passes through that without buckling ok, to maintain stability the knee stays extended and then only towards. So, during mid stance you can see it is fully extended, then after it crosses over you will see to prepare for swing now it starts flexing ok. So, towards terminal stance it starts flexing.

So, in the case of the knee you have flexion, extension, flexion again, and extension again. So, you have two cycles of flexion and two cycles of extension in one gait cycle two times the knee flexes and extends. So, the maximum knee flexion can go anywhere from depending on the walking speed, depending on the person the height of the person etcetera can go anywhere from 50, 45 to 60 degrees of flexion that is the maximum knee flexion during walking. So, it flexes and then starts extending again partly due to gravity ok. So, it lifts up to a certain where the point to the point of maximum flexion.

(Refer Slide Time: 08:19)

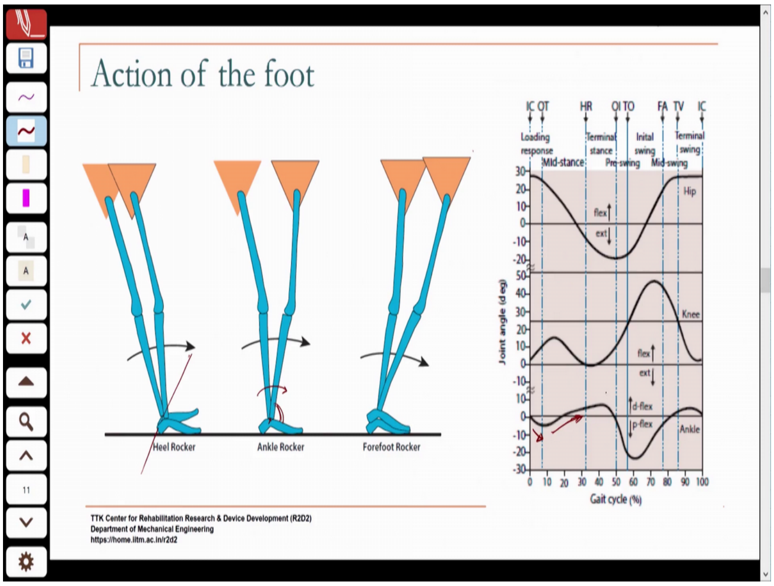


And then as the limb you will see here you can see that it lifts up goes to a maximum point and then starts extending again. So, initially it lifts up, then starts moving forward and it achieves nearly full extension to prepare for the next initial contact ok. So, with a fully extended knee you will come to the next initial contact, but the maximum flexion add the knee occurs during the swing phase ok.

Maximum extension of the hip occurs during the end of stance face you can see here terminals end of stance you have maximum extension of the hip, and maximum flexion again happens almost in the swing phase and it stays fairly constant from there ok.

The mid swing onwards to the end of swing phase the hip flexion stays fairly constant it is the knee; it is the shank moves about the knee to achieve the full knee extension. You can see here that the hip flexion stays fairly constant and then if you look at the ankle.

(Refer Slide Time: 10:15)



If you look at the ankle you see here that initially you remember I told you at the foot sorry at the ankle, or at the foot the foot action if you look at it, you have initially the heel rocker. So, it is the foot is pivoting about the heel, it is pivoting about the heel, and achieves foot flat and that motion is what motion is that for at the ankle?

Student: Plantar.

That is plantar flexion. So, you can see here it at initial contact the foot is a neutral; neutral is 0 degrees ok. So, at initial contact the foot is in neutral then it plantar flexes ok, you can see that at the heel you know because of the heel rocker it the foot moves about that and it plantar flexes. Then when it is pivoting about the ankle you can see that this motion this angle is reducing which is dorsi flexion.

So, it is moving in the direction of dorsi flexion and does that till terminal stance ok. So, it is in a dorsi flexed state and then when it moves on to the forefoot rocker, that is here then it starts plantar flexing. So, if you look here you can see the foot is highly plantar flexed towards toe off ok.

The maximum plantar flexion occurs at the end of you know at toe off, end of pre swing that is when the that is when you are when we will talk about the muscles, but that is when your calf muscles essentially provide that push off ok. The max the plantar flexion at the ankle is maximum ok, and then after that you will see that now the foot again starts moving towards.

So, you had plantar flexion, dorsi flexion, plantar flexion again, then moves towards dorsi flexion again. Why does it do that? Because now you want to clear the ground. So, your leg is in swing and if it stayed plantar flex like that the chances of stubbing your toe are high or you will have to do other things. You will have to move your hip up higher, or you know make other compensations to help it clear the ground. So, instead what it does is? The foot dorsi flexes now, and then once it clears the ground as it moves towards extension it comes back to the neutral position.

So, that for the next heel strike it is again positioned neutral again ok. So, if it is in the neutral position, it can again plantar flex easily because you want foot flat right after initial contact. You want the foot to contact the ground to establish a base of support that is why the foot gets into this neutral position in preparation for the heel strike.

So, each of these have functions you know the motions at the various joints are for a reason and this cycle is repeated. So, this data the patterns that you will see across various age groups, across you know different people will be more or less the same and that is the reason we are able to sort of generalize this analysis and say that this is what will be observed across people.

So, if you look at data if you collect data from a bunch of people you will see that the standard deviation is you know it is a fairly narrow band. You will see that it will fall it is the mean plus plus or minus standard deviation if you plot, it will give you a nice band fairly narrow band.

So, it means that for most of us we tend to follow, this kind of a movement and most of these this data is valid for what we call the self selected walking speed. So, you take the data at the self selected walking speed of the person, then you normalize it over the gait cycle ok. You look at the joint angles, you look at the joint angles and you normalize it over the gait cycle.

So, you identify heel contact heel contact of the same leg, so that is 0 to 100 percent. Then you normalize it over that gait cycle, and then when you plot this you will get a fairly predictable plot for most people. If you take plots of different categories like say a person who walks with say a locked knee ok. So, if the knee is locked while walking then this thing is completely gone.

So, now you will see there are compensations made in the other angles and you will find that that will be a different set of joint ankles. The person may still be able to walk, but their walking pattern will not follow this ok, or when we see pathological gait we will look at some of those cases what happens? When some of these motions are restricted or there are pathological conditions that you know cause some of the muscles that are responsible for this coordinated movement they loose control. Because if you look at it you have to have for instance in swing; the hip has to be flexed, the hip has to be flexed, the knee has to be flexed, and the ankle has to be dorsi flexed in order to clear the ground.

So, these things happen have to happen you know the timing of these is also very critical you cannot have hip flexion; you know you cannot say that I can have hip flexion whenever I want as long as it follows that more. If you look at this, it is the combination of these three that achieves the particular function in the gait cycle that is why we say the movements have to be coordinated about the various joints.

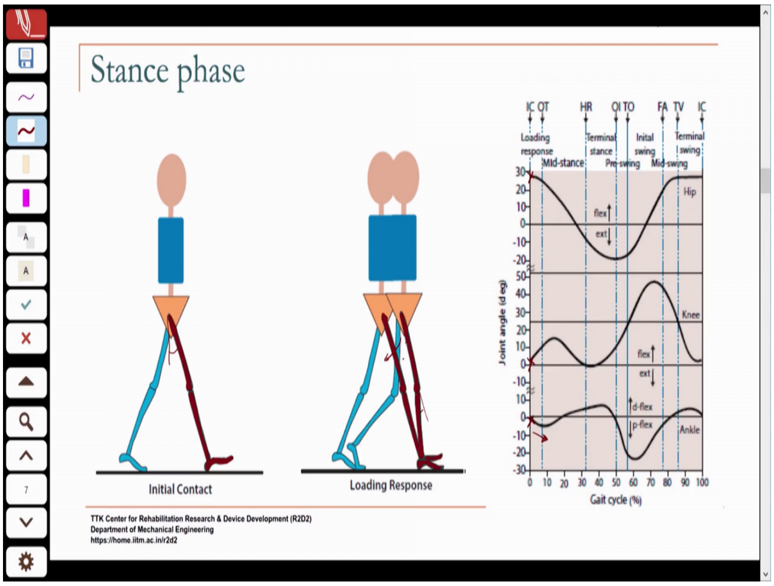
Because although the range of motion so range of motion alone will not determine I cannot have 2 or 3 links connected by free moving joints and say that I can achieve walking. The walking has to follow this pattern of movement at the individual joints in order to successfully accomplish the weight acceptance, the forward you know some shock absorption, the forward progression, and the successful swing.

Successful swing means you have to clear the ground at all you know the entire time that the foot is in swing, there should be no interference with the ground and the leg has to become ready for the next initial contact ok. So, a lot of many when you design artificial joints for instance you know say you want to replace say a person has had an amputation, and you want to design a knee joint for that person to enable them to walk.

Some of these considerations you have to look at functionally what is happening? In order to be able to create a successful replacement that will do this in a coordinated fashion and it can be a challenge. Because if you look at it you know you could go for active prosthesis which have motors at every joint and you know which will coordinate this kind of, but that it adds a lot of weight also aid adds a lot of expense.

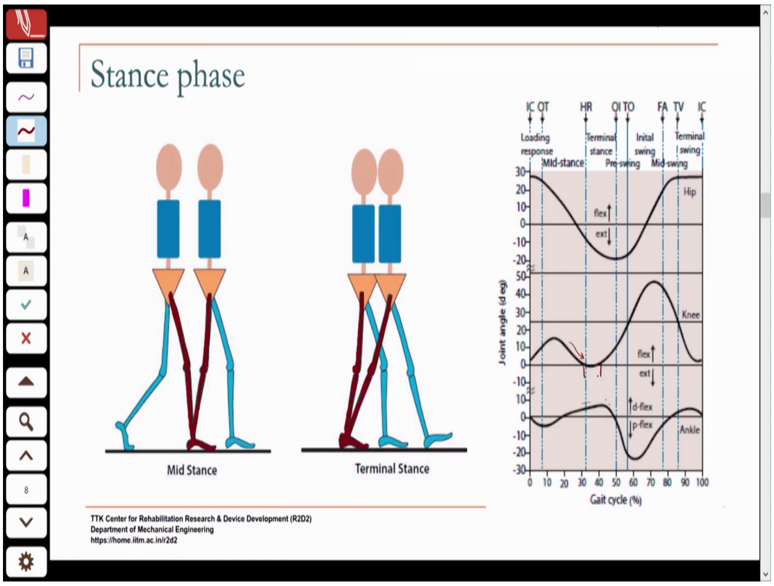
And what about your power source that is something you will have to carry around with you. So, you know one of the research areas that I work in is how to create passive replacements you know which are not more, but which are not powered, but only use the residual human power whatever is available and how do you design prosthesis that will still enable close to normal gait for the person ok. So, it is a very interesting area for research, because it is a very you know replicating walking using a mechanical system, it is a very challenging task.

(Refer Slide Time: 20:21)



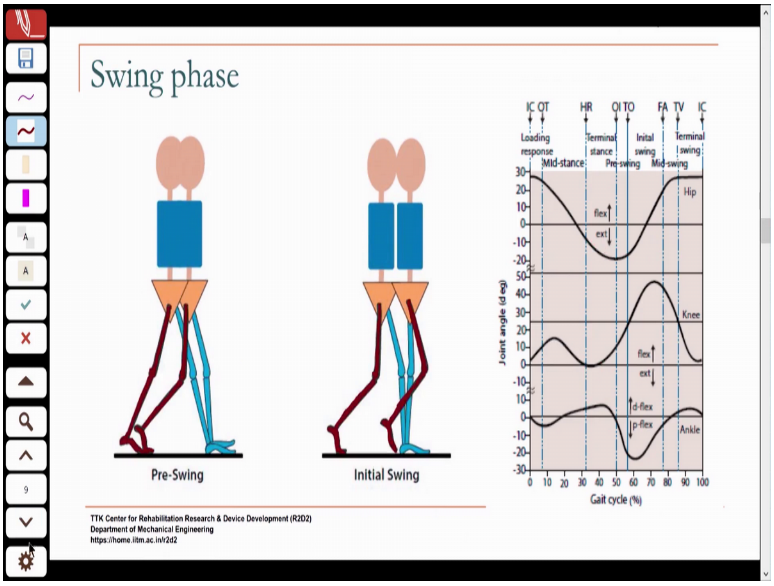
So, yeah this is just in a little bit more you know it is broken down so, that you can see clearly. So, you see from initial contact foot is neutral, knee is extended, hip is flexed. So, this is angle would be about 30 degrees, this is 0, this is again 0 with respect to that. So, then loading response you see that now the foot is plantar flexed, then the knee is slightly flexed ok. And you have the hip is starting to extend. So, from here to here you see that the flexion angle of the hip has come down.

(Refer Slide Time: 21:27)



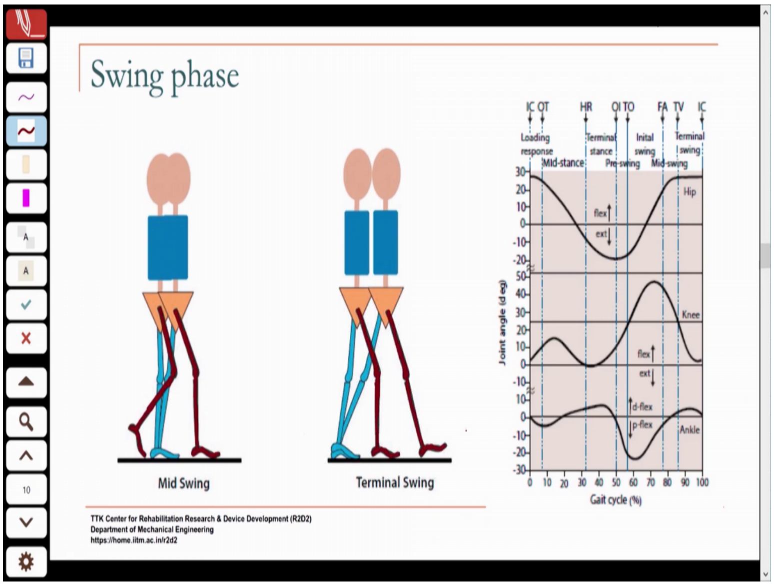
Then here mid stance you see now the foot is moving into dorsi flexion, the knee has again extended ok, then you have the hip further extending. So, it is now almost straight it crosses the 0 mark of the hip and then towards terminal stance. Now the foot initially it is you reach maximum dorsi flexion here then it starts to plantar flex ok. So, towards terminal stance you see the maximum dorsi flexion here, and then the knee remains in the extended position and then your hip is extending past the vertical.

(Refer Slide Time: 22:29)



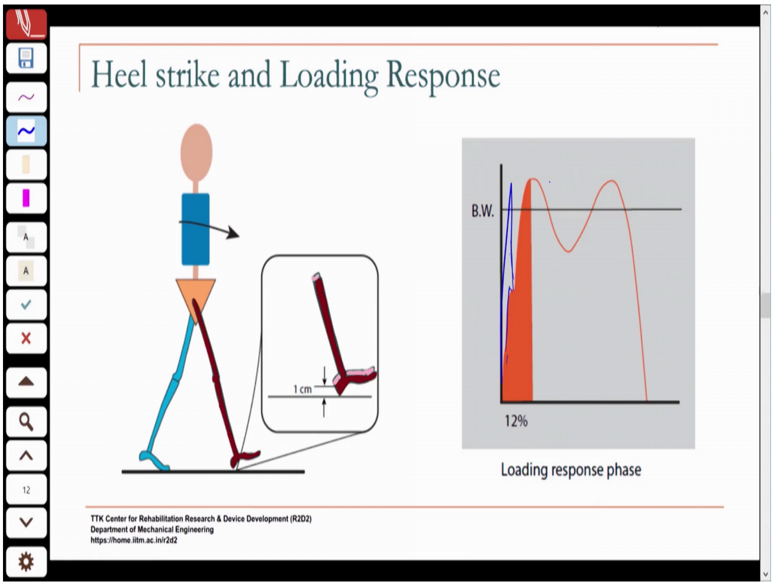
So, it moving in the direction of extension, pre swing you start seeing the plantar flexion of the foot, plantar flexion of the foot the knee starts flexing, the hip is now moving back into flexion. So, as you are trying to lift the leg of the ground your hip is starting to move into flexion, initial swing, more hip flexion in order to be able to lift the rest of the leg of the ground. Initially it is plantar flexed, but the as soon as it goes into swing it starts moving in the direction of dorsi flexion ok.

(Refer Slide Time: 23:11)



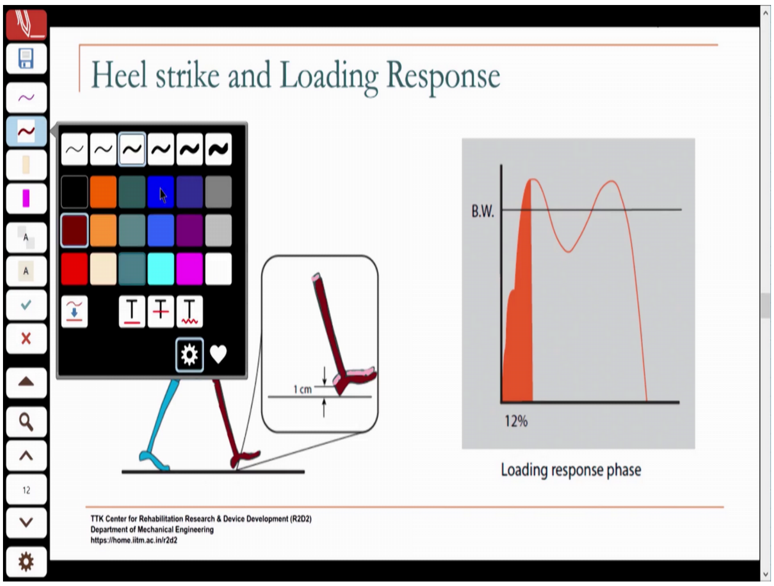
And you can see from because this has to clear the ground. So, you have the hip flexed, the knee flexed, ankle, dorsi flexed till it starts moving into full extension at terminal swing ok. So, here you have hip flexed, knee extended, and foot back to neutral we have looked at this.

(Refer Slide Time: 23:39)



At heel strike when the leg extends the heel is actually slightly the way it is positioned, it is actually slightly above the ground, it is like about a centimeter above the ground. And what happens is you actually then plant it down, it has to fall which creates an impact ok. So, the body actually falls when you strike the heel it, so the leg extends and then to plant it to make contact with the ground there is a fall of about 1 centimeter.

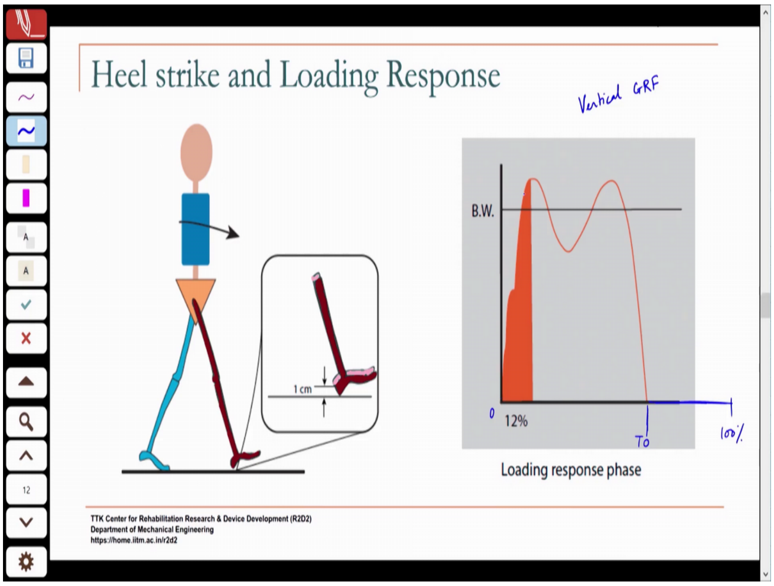
(Refer Slide Time: 24:31)



And so you will see that in most cases if you look at the force plate so a force plate is a way of measuring the ground reaction force. So, in a gait lab you would have like a force plate which basically measures the ground reaction force when the person strikes it. And in this case it is probably filtered out, but you will see something like this, you will see a spike at healed contact which is because of this impact with the ground. And that will vary depending on the kind of ground that you are walking on right.

So; obviously, you will feel the shock more if you are walking on very hard ground whereas, it will be attenuated if you are walking on softer surfaces. So, you will see that the spike sometimes what happens is it gets filtered out, but you will see some you will see some level of a spike in the at initial contact in the ground reaction force and that is because of this impact. And this is a picture of the vertical ground reaction force.

(Refer Slide Time: 25:53)



So, you have three components of the ground reaction force you have the anterior posterior component ok. By now you should be you should not wonder what I am talking about. When I say anterior posterior component, you will have a medial lateral component and then you have the longitudinal component, or the vertical component of the ground reaction force.

And the vertical component of the ground reaction force is the most significant component. So, if you look at the medial lateral and the anterior posterior components they are only about say 10 percent of the vertical component of the ground reaction force. Because your body is accelerating and decelerating in the sagittal plane ok, it is the up and down movement that is significant.

And you will see that this ground reaction, the vertical ground reaction forces the significant component. And you will see this is called the m shaped vertical component of the ground reaction force. You can say that so if you are standing right then the maximum your ground reaction force will be is just your body weight.

So, here if you see this where you think this is? What is this point? If this is for one leg what is this point? What is happening here? What is the event that is toe off of the leg? So, in your swing you have 0 ground reaction force, so if this is the 100 percent of the gait cycle say this is 0; then this is your toe off point, this is the stance phase.

So, initially it is starting to take the load so that is their double support phase. This 12 percent is your double supporter; it is starting to take up the load. And you can see here that you have two characteristic peaks when it is actually more than the body weight. So, what does that tell you? What is happening to the center of mass?

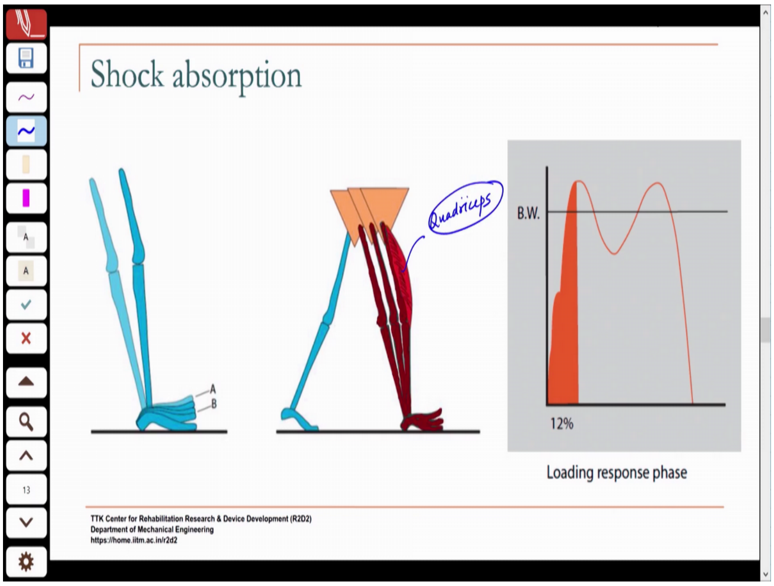
Student: (Refer Time: 28:20).

The center of mass is going up and down it is accelerating.

Student: Up and down.

Up and down, and that is why you can see the peak the two peaks in the ground reaction force ok. So, that is the characteristic m shaped curve for the vertical GRF that you see.

(Refer Slide Time: 28:53)

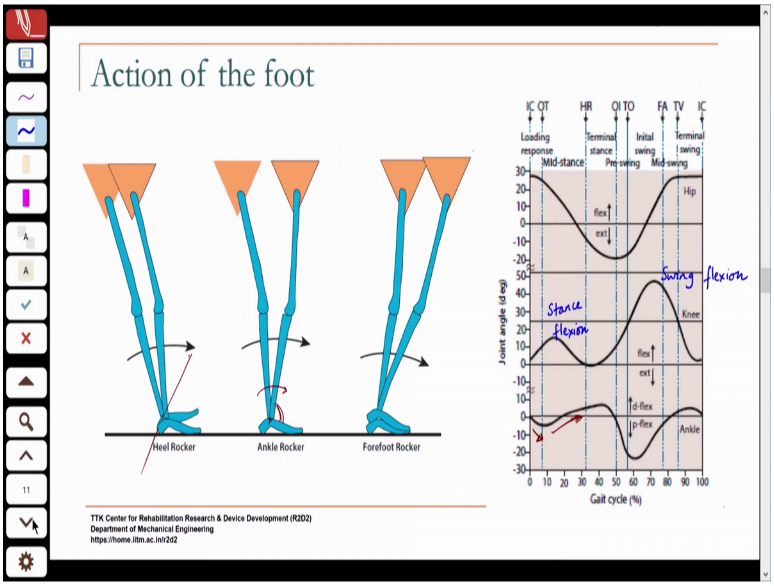


Now in this loading response this is where the shock absorption or and there are a couple of mechanisms; one is the foot starts you know you achieve foot flat, so that is one mechanism. So, there is movement about the ankle the movement of the foot, the heel rocker causes the foot to move down the flat again with you have a muscle, the tibialis anterior which will allow that to fall gradually instead of slapping the ground. So, that is one aspect of the shock absorption and then you have the flexion at the knee, the controlled flexion at the knee.

So, because when there is loading when you can see that there is significant loading the leg is now starting to take over the weight bearing duty from the other leg; the other leg is moving into getting ready to move into swing. So, it is transferring the body weight to this stance leg. So, as it is taking on this additional load there is also some new flexion that is happening, so that is knee flexion that has to happen in a very controlled fashion.

So, that is what muscles are these? The quadriceps muscle plays a very important role in stabilizing the knee when it enters the stance phase. Because without that you would have uncontrolled no if you have uncontrolled movement at the knee you are just going to fall down ok. So, the quadriceps muscles role is very very important when you in this controlled stance flexion.

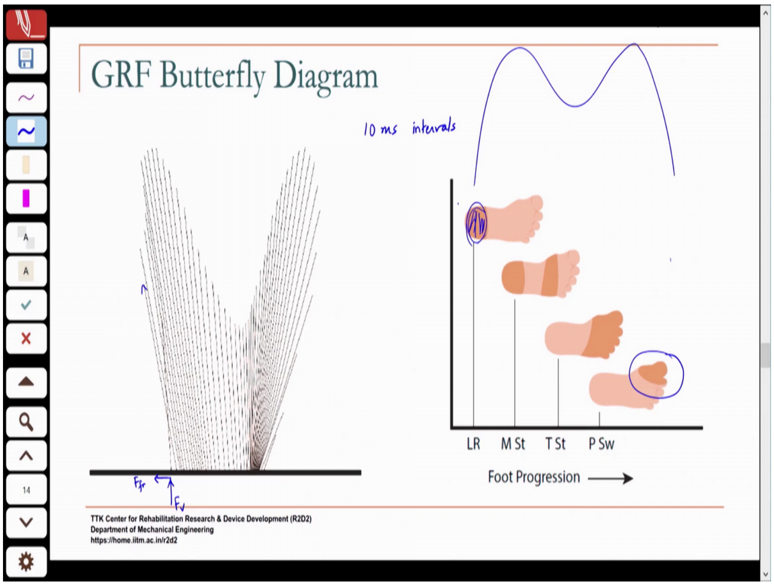
(Refer Slide Time: 31:05)



So, the flexion at the knee there are two of them; one is stance flexion which is about a maximum of 20 degrees and the other one is swing flexion. So, at two times in the gait cycle you have flexion of the knee; one at stance you have it for shock absorption and in swing you have it for forward progression. So, the quadriceps muscle is very important in controlling the stance flexion of the knee ok.

And that happens in the loading response and after that again so it moves from flexion it has to move back into extension and the quadriceps are your knee extensors. So, they will be responsible for bringing it back to extension; first as it is flexed as it is flexing you have eccentric contraction in the quadriceps to control the flexion and then you have concentric contraction which causes the knee to extend.

(Refer Slide Time: 32:25)



So, this is what is known as a ground reaction force butterfly diagram. So, they take the data. So, typically this data may be obtained at say 10 millisecond intervals. And you see that so this is gives you the magnitude the normalized magnitude. So, it is usually divided by the body weight it is a normalized magnitude of the ground reaction force and the direction of the net ground reaction force in say 10 millisecond intervals over here.

So, it is captured on the force plate and this and because of the weight, it looks like a butterfly wing. So, it is called a butterfly diagram the ground reaction force diagram is called the butterfly diagram, so this represents the net. So, you can see that initially you have a purely vertical that, that is your dropping of the foot and the impact a purely vertical ground reaction force.

Now what happens is? So, as your leg is swinging forward you have in addition, so you have you plant the foot you plant the heel, you have the vertical ground reaction force. But the you know as the leg was swinging, it also has a forward velocity. If you look at the heel, at the instant it is going to hit the ground it also has a forward velocity because it swung forward like that right, so that horizontal velocity when as soon as you apply it on the ground has to be reduce to 0.

So, what acts to reduce that to 0? You have to have.

Student: (Refer Time: 34:30).

Friction, you have to have friction on the floor, on the ground to arrest that forward movement of the foot. So, initially say you have a vertical component and you have to have a horizontal frictional component. So, this is your vertical and together now so you can see quickly the ground reaction force direction change changes to this. The resultant of those two makes the ground reaction force may an angles it like that.

So, friction at the start of the gait cycle acts in this direction, it acts to stop the, it is it adds to neutralize the horizontal velocity of the foot which is acting forward, so friction has. Now you know that when you push off the ground right you are actually pushing the ground back. So, in that case friction acts forward and that is what is accelerating your body ok.

So, friction has varying roles to play during walking. So, at heel contact the direction of friction is opposite, so that is what happens. So, if you on a slippery on ice if you try to walk on ice or on a slippery floor what happens? If you are not careful which way will you fall ok, if there is what happens to your foot?

Student: (Refer Time: 36:33).

It just slips like that it slips forward because there is not enough friction to arrest that movement and you just fall backwards ok. Whereas at push off it does not enough friction what will happen?

Student: (Refer Time: 36:55.).

Then you try to push like that and you do not get that grip and you just fall forward ok. So, depending on which part if the gait cycle you are in if you are in a slippery floor. So, typically what we tend to do is on a slippery floor you tend to walk with your you do not do this heel to toe walking, you would not do the heel to toe walking, you will try to sort of plant your foot like that and you do not go through.

So, if you look at the kinematics of somebody walking on a slippery floor the joint angles will look different from what they are doing when they are walking on a floor that has sufficient friction ok. Because as we saw when we looked at the kinetics of movement the supporting, the ground reaction forces play a large role in influencing the motions that we are able to do. And in the case of walking it is both the supporting force which would be your vertical ground reaction force as well as the frictional force which influence the walking which enable us to walk the way that we do ok. So, the role of fraction is very important.

So, this butterfly diagram basically gives you the magnitude and the direction of the net ground reaction force at each of this instance. So, after this is of course, swing phases, so it is, so this is only for the stance phase of that leg. So, this would be above 0 to 60 percent of the gait cycle, when you looking at the butterfly diagram ok.

Now when you look at if you look at the soul of the foot ok, basically this ground reaction force is the distributed force right. So, if you look at so it acts initially it acts over an area on the heel of the foot, then in next aspect when the foot is planted on the ground when it is in foot flat, you have most of us have an arch in the foot.

So, if you see here it is the heel and the ball of the foot over which the ground reaction force. So, the ground reaction force is the resultant of all these is the resultant of this distributed loads. And then as you move towards terminals stance, it essentially move to the forefoot, this area on the forefoot.

Because your heel has now lifted off the ground so it is the ball and the forefoot, some portion of the ball of the foot and the forefoot which over which this force is distributed and then at push off essentially it is concentrated near your big toe. So, the toe is actually a very important part of the foot when it comes to walking.

So, if somebody has had diabetes and they have their toe amputated there walking will change. Because an important aspect you know the toe plays an important role that area of the foot plays an important role at push off so yes.

Student: He is showing the other (Refer Time: 40:50).

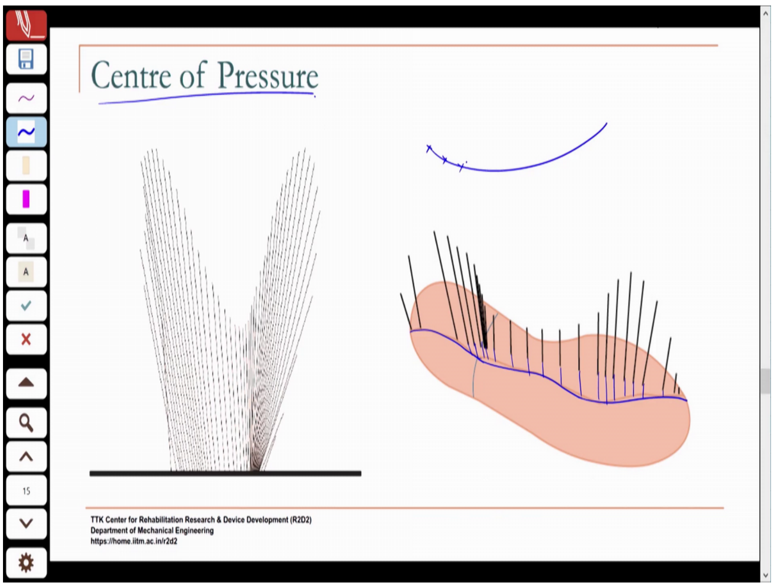
Yes.

Student: So, the four sessions being shown that is not the full body.

No it is not full no it is not. So, you already it is not a full body it varies from so the normal force on that area where I am just showing you the areas over which the force acts. Because as you said you know it this is your normal, if you look at the vertical ground reaction force initially it is in a at a impact you may have this, but over load it is it is starts increasing, This is not proportional to the areas that are shown here basically if that is I your question ok.

The actual magnitude so the resultant of each of these will be different will be equal to what you see in the curve for the vertical JRF, but these are the areas over which the force acts as you progress. If you look at what is known as the center of pressures, so this is the center of pressure is the resultant of the vertical forces, the pressure you know over acting over those areas right ok.

(Refer Slide Time: 42:29)



So, I can say that the net vertical GRF acts as at a certain point on the foot. I can reduce it to a certain point on the foot that point is called the centre of pressure. The resultant of the normal forces on a particular area and the point; the point at which that acts is your centre of pressure. So, if I look at the movement of the center of pressure, then you will actually see that the path that it follows, it is I do not know what happened here this figure, But it actually moves like this the path of the center of pressure moves in this manner.

Student: Then it comes vertical here.

It only comes because you are talking when you talk about pressure you are looking at the vertical force, the resultant of the vertical force that. So, you will see that and you can actually use this center of pressure, and show that I perhaps I meant you can show that the action of the foot is equivalent to a rolling motion of a circular arc.

So, you can say that so in if each of these points you know if you center of pressure you take it and plot it in a shank coordinate system. Then it is equivalent to the foot moving, rolling with this kind of a circular arc from heel to toe. So, it can be modeled in that fashion this movement of the center of pressure can be modeled using like a rolling foot that is.

Student: (Refer Time: 44:35) it is like the cap.

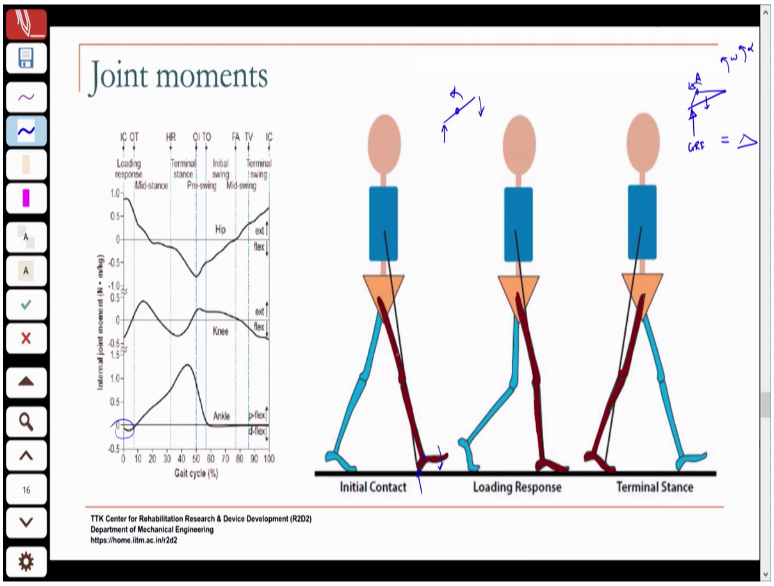
It is like a cap, but it actually is a nice circular arc you can get for normal walking you can get a nice circular arc. So, you do not could be an irregular shape right, but here we are talking about a nice rolling motion of a circular arc. We will look at, so if you look at joint movements.

So, where does the control you know you had this ground reaction force, which is acting on this accelerating body. Essentially the center of mass is accelerating as it goes from one as it goes through once stride, and you have this ground reaction force acting on this multi segmented body and you have to have where is the control coming from? The control is coming from the muscles which act to maintain these postures in a specific manner.

So, as you are walking you are essentially changing your posture you are essentially changing the angles at the various joints in a very specific manner and that happens because of muscular control. And to understand that we can take a look at here I have this external force the ground reaction force acting on say the leg and it is going to since it is a segmented body, I mean it is a segmented system with joints.

If I look at the various joints if I look at this force and look at the various joints I can get an idea of how things are going to move ok? And then what are correspondingly I can then compute what are the necessary movements that have to be applied about the joints in order to control this movement.

(Refer Slide Time: 46:49)



So, if I take for instance right after heel contact, if I look at the ankle ok. Now I have a joint at the ankle this is the foot segment ok. So, if I apply a force like this on that segment the tendency of that is to plantar flex the foot right. So, I have something that is pivoted here, if I apply a force here this is going to moved up which means to control that movement I need to apply a dorsi flexion moment.

So, if you look here you can see at the ankle the internal moment that has to be applied at that particular instant is a dorsi flexion moment. Remember it is not calculated in that fashion because if you are doing a proper calculation, you have to take into account all the forces that are acting on the foot ok.

So, this is just a way to sort of get an intuitive feel for how things are going to be? So, if I have an ankle like this, if I apply a GRF like this, I also have to consider the fact that this has a mass. This is probably moving bits and then you know draw the kinetic diagram you know I would have some angular velocity angular acceleration etcetera which would be taken into account to determine the net joint moment that is my inverse dynamic analysis.

That is the way I would actually calculate these moments. I cannot just look at it and say I cannot estimate it based on these times that distance that is going to be my internal joint moment that would be incorrect ok. But this just gives you an idea this just gives you an idea of how things need to be controlled and you know how the internal joint moments may be acting.

Another example if I look at this if I extend this up to the neck you know I could say that there is a moment about the neck, but that would be absolutely incorrect to say that right I cannot do an analysis, but as far as the hip knee and ankle are concerned and the lower you are.

So, ankle you can be fairly accurate with this kind of an approximation knee becomes a little bit more inaccurate, hip more inaccurate, and neck you are completely out of there is no way you can look at it like that. But this tells you so if you look at it initially as soon as it hits you can see that the, it passes either in front of the knee or through the knee.

So, it essentially has an extension moment, but as you go into loading response you remember that as when this lands then it actually moves behind the knee the GRF. The GRF vector moves behind the knee because the knee is now flexing ok. So, now to resist that movement, the knee starts applying and extension movement to control the flexion. So, the knee moment has to start moving in the extensile direction, the quadriceps start acting to provide an extensor moment at the knee because that is needed for controlling the knee flexion.

And then if you look at the hip in both cases it is acting to flex the hip. So, the moment at the hip is an extensor moment to control the flexion. So, this can give you like a rough picture of what the internal moment should be and that will help you determine which muscles should be acting at these different phases of gait, so that is the purpose of that. But this is by no means an accurate way of calculate and that is not how these.

So, this data is from the book by Whittle Gait Analysis by Michael Whittle and this is calculated the proper way taking into account the kinematics as well as the segment masses and inertial parameters ok. So, taking into account omega, alpha, feed segment as well as the weight of the segment, but for understanding to kind of gauge what kind of a moment will? If you know the GRF pattern, then you can say that oh at this instant this is sort of what should be happening at the various joints? It gives you a clue to that and from that you can figure out what muscles have to be acting at different phases of the gait cycle which we will go into in the next class.