Mechanics of Human Movement
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Lecture – 39
Human Gait Terminologies

So, the process of walking is what we call gait and we started looking at this the last class and we saw that if you look at the legs, they alternately get into what is known as the stance phase, where they are in contact with the ground and the swing phase, where they move through the air and then make contact again with the ground. So, they are not so, they alternate between these roles.

So, in the stance phase, there is a supporting role that they perform, in the swing phase, you have forward progression. So, there is forward progression in stance as well the body is moving. But essentially, if you look at the leg is doing a supporting function during stance and then moving forward during swing.

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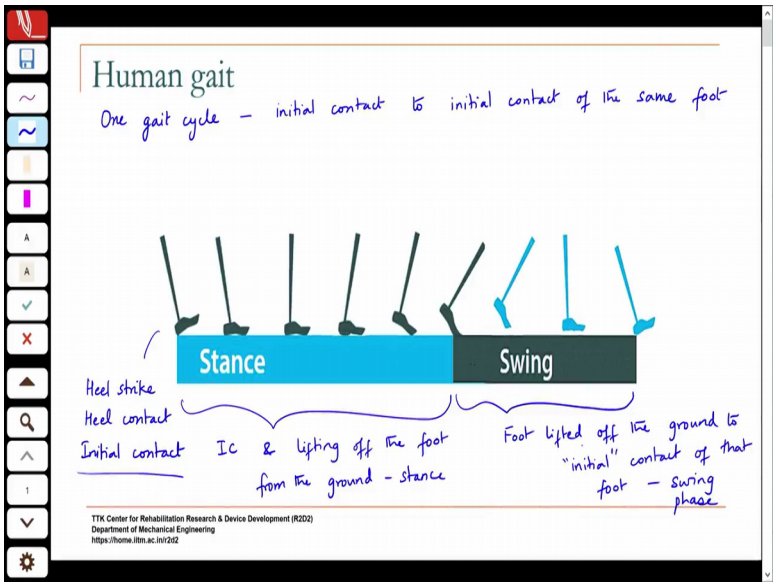

One gait cycle is defined as typically from one event to the same event happening with the same leg, it is the time between one event and the same event between and the most common event that is taken is what is known as heel strike, heel contact or some books prefer to use initial contact. Because, not everybody may walk with by striking the heel first in some forms of gait, the toe may hit the ground first and then.

So, the preferred term is initial contact ok. So, gait cycle is initial contact to initial contact of the same foot and this period between initial contact and lifting the front part of the foot, lifting off the front part of the foot or lifting off the foot from the ground is known as the stance phase and from the time the foot is lifted to again, you know we say, initial contact. Because, it is a repetitive event actually, it is the final contact now, right initial to end the gait cycle to initial contact of that foot is your swing phase, this is actually start to end of the gait cycle, but we still call it initial contact, because it starts the next gait cycle.

So, what we will be looking at more closely is the coordination between the various segments of the lower limbs, because you have the thigh shank and foot of one leg thigh shank and foot of the other leg and the pelvis connecting the 2. And it is the coordinated movements of these limbs that is causing the walking to happen that is causing the gait. So, this right now, we are just looking at 1 portion, you know 1 leg, if you look at it if you look at the leg for some period, it is in contact with the ground, for some period in the gait cycle it is off the ground.

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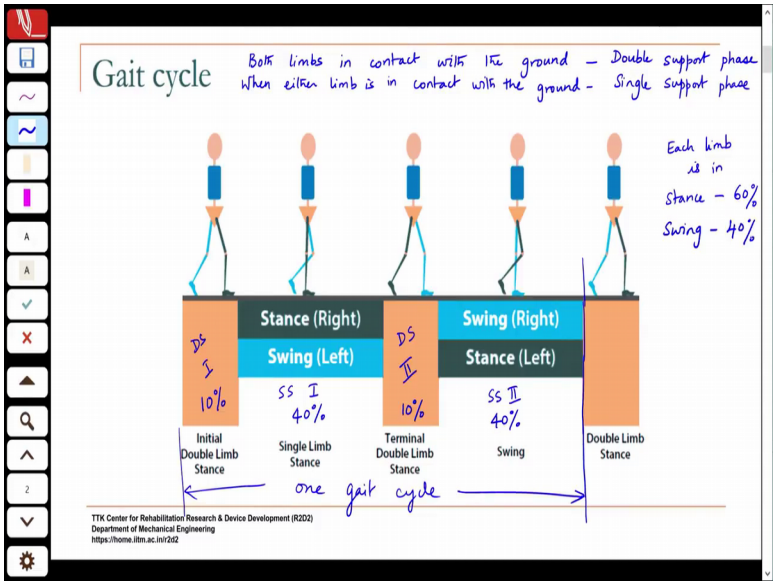

So now, if you look at it in terms of both the legs ok, what you will find is initially, so, when 1 foot makes initial contact with the ground the other foot is still in contact with the ground ok. So, during walking during a gait cycle, there are periods where both limbs are in contact with the ground and that is called the double support phase. In fact, the

existence of a double support phase is what distinguishes walking from running. So, as you walk faster and faster the periods of double support starts shrinking and when double support goes to 0, then you say that now, you are running ok.

So, the existence of a double support phase is what distinguishes walking from running. In running, you may have both feet off the ground for a short period that is called the flight phase anyway. So, when one limb is in when either limb is in contact with the ground, we call that the single support phase and the single support phase is very critical for stability ok. Stability during the single support phase is a very critical aspect of walking and as we go through this, we will see how the muscles coordinate to ensure stability in the single support phase.

Because, you are supporting the entire body weight, using a single limb and a very reduced support base, base of support. So, maintaining stability during the single support phase is a very critical aspect of bipedal walking. If you look at quadrupedal walking like a lot of animals do right at any point of time, you may have 3 limbs in contact with the ground and that gives you the tripod stability, in many 4 legged animals, you have the tripod stability.

So, even if 1 limb is of the ground it is still stable, in bipedal walking like the way we humans walk that we do not have that ok. So, support in the single support phase is very critical, stability during that phase is very critical ok. So, if you look at the gait cycle, you will have an initial period of double support or double limb stance. So, both the limbs are in their stance phases ok. So, remember with respect to the limbs, we talk about them being in stance or swing with respect to the ground, we talk about it in terms of it being double support or single support.

So, initially both the limbs are in stance that is your double support phase, then say we are looking at the right leg, the green one. So, here it starts off with when it first contacts the ground the other limb is also on the ground. So, you have a double support phase, then after a while the other limb has lifted off the ground that is moved into swing. So now, this limb is taking on the entire supporting function then after a point the other limb swings through, the blue limb swings through and again makes contact with the ground.

So now, you have this limb has still not left the ground so, you have again another. So, this is double support 1, double support 2, it starts off with. So, if you are looking at the

gait cycle, it starts off with a double support phase then, you have this is a single support phase, you have another phase of double support. Now the other limb, once that makes contact this one lifts off that assumes the supporting function, the single support function.

So, this is single support 2 and this is for the, this is basically, the stance of the left limb and then now the right limb swings forward and makes contact again. So, this once it makes contact that ends the gait cycle. So, gait cycle is this from here to this is 1 gait cycle. So, 1 gait cycle has 2 periods of double support and 2 periods of single support and the approximate proportion is you have 10 percent, 40 percent, 10 percent, 40 percent ok. If you look at it in terms of the stance and swing each limb is in stance for how much? 2 double supports 60 percent and it is swing it is in swing for 40 percent of the.

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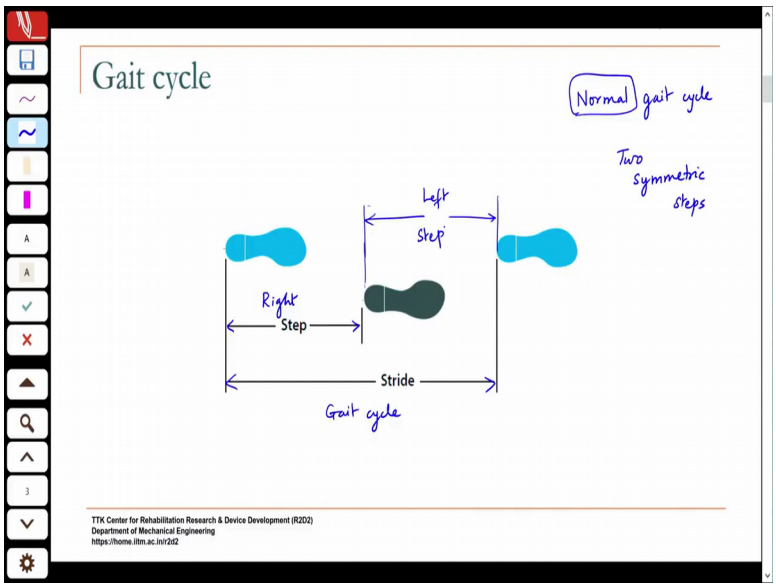

So, if you look at the foot distance between, when one foot makes contact with the ground and then the other foot makes contact with the ground that is called 1 step; that is 1 step and a stride is also the gait cycle because, that is from the point of contact to the point of contact of the same foot. So, in 1 gait cycle the distance, you cover is a stride ok.

Sometimes gait cycle is also referred to as a stride, the swinging limb is what determined. So, in a what is known as a normal gait cycle. So, we use the term normal just as sort of a to capture, I would say the most commonly observed set of data because,

normal is again you know like you have with say, you know medical cholesterol levels or blood pressure everything a lot of this depends on age, it depends on gender, it depends on other factors as well ok.

But when we talk about a normal gait cycle, we are talking about a large percentage you know, if you take a certain age group of individuals, you will observe a similar pattern. So, that pattern when you confirm to that pattern, we call it a normal gait cycle and something that deviates from that pattern is what we call abnormal or pathological gait.

It may be perfectly fine. So, what is normal for somebody may not be normal for someone else and they may still be able to walk efficiently or do what they need to do efficiently, but for practical purposes, we call this as a normal gait cycle. So, in a normal gait cycle you have 2 symmetric steps. So, there is really no difference between your right stepping and this step, where the right leg swings through and makes contact. So, this is known as this is the right step and this is your left step, that is your left step.

So, in some forms of pathological gait, you may find that the right step will not equal the left step, the right step plus the left step will be 1 stride, but you may have some kind of asymmetry. So, normal gait cycle is a symmetric gait cycle and you have 2 symmetric steps here. Now let us look at the gait cycle in more detail. So, you have if you look at a stride or a gait cycle, you have the stance and the swing periods ok.

If you look at the limb, you have the stance and you have the limb and they have different functions to perform in each of the 2 periods. So, if you look at stance, the primary function initially, when the foot makes contact, when that limb makes contact with the ground, what you are trying to do is shift the weight from one leg to the other. So, the initial task of the limb that makes, when it starts in the stance phase is for it to basically, accept that weight and start taking over the support function that is called weight acceptance.

And then now after this, weight is accepted by this limb, the other limb leaves the ground and. So now, this stance limb has to perform the function of single support. So, it has to take over the supporting function, while still maintaining the forward progression. So, you do not just; you do not just say I will take over the single support and just stand, there you are still, you still have to continue to move because, that is the function of the walking ok.

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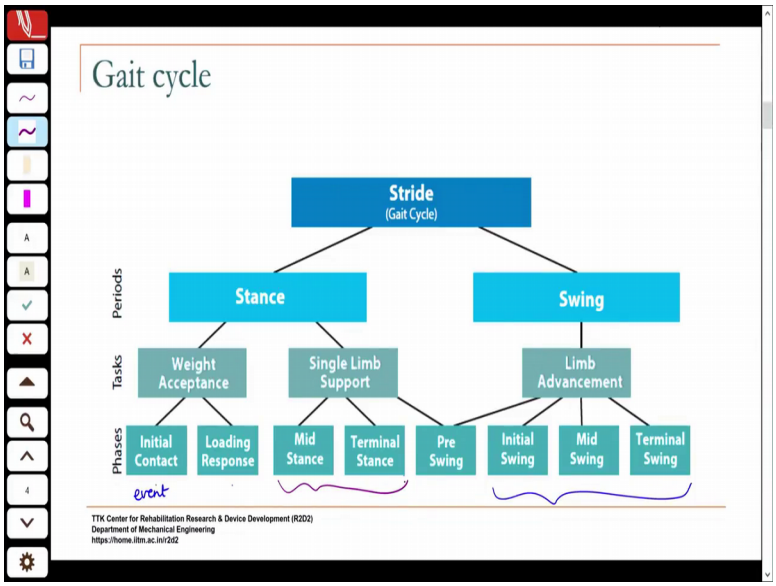

So, that is the primary function. So, you first accept the weight because, you have a swinging leg that just makes contact with the ground starts taking the weight of the body and then supports it solely for a certain period of time then, when that limb goes into swing. So, when it is done with the single support and towards the end of it is single support. Now the other leg has started accepting the weight that is your second double support phase ok.

The other leg now has made contact with the ground and has started accepting the weight and then this limb now prepares for, prepares to leave the ground and move forward. So, that is called limb advancement because, essentially what you are doing is you strike the ground this one lifts off moves forward strikes the ground then, this one lifts off moves forward strikes the ground. So, you have this alternating pattern of the leg being in stance and swing. So, now in this, we will look at some of the phases in more detail ok. So, let us look at those aspects of ok. So, we will start defining each of these.

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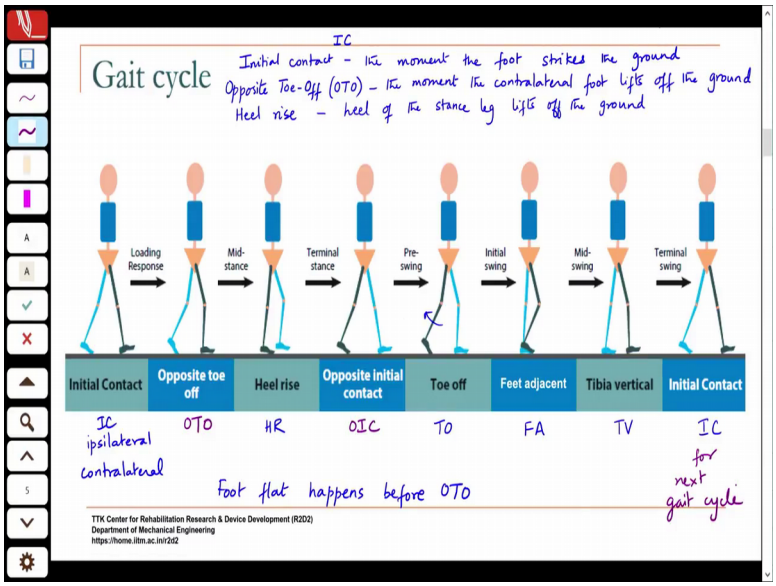

So, initial contact. So, here is a gait cycle start off with I am looking at the green limb ok. So, that is my limb of interest, I am looking at a gait cycle, when it makes initial contact to initial contact of the same limb. So, this is 1 gait cycle that I am looking at. So, initial contact is the moment, the foot strikes the ground.

So, if you look at the stance phase, it is divided into initial contact loading response. So, there are various phases of stance initial contact is more like an event it is not. So, much of a phase it is that the others are like phases. So, there is a time period over which that happens. So, this is an then you have what is known as loading response mid stance, terminal stance and pre swing and we are look at each of these in the next slide.

And then you have the swing is divided into pre swing sort of overlaps both stance it is it is the period between the end of stance and the beginning of swing then the swing phase, itself is divided into 3 initial swing, mid swing and terminal swing. So, let us look at some of this. So, first if we look at the events so, you have initial contact the moment that the foot strikes the ground.

Then the next event that you can look at is opposite toe. So, initial contact is typically abbreviated as IC, opposite toe off this is followed by. So, initial contact is followed by opposite toe off. So, it is OTO and that happens then you can see the blue leg is now lifting off the ground. So, you have the green leg, which is below leg you are looking at

and then the other leg is your blue leg the moment the other foot it is also called the contralateral foot.

So, the contralateral implies, it is the one that is other than the one of interest ok. So, you have these 2 biomechanical terms ipsilateral and contra the other lateral foot. So here, the ipsilateral leg is my right leg because, I am looking at forward progression in this direction and the contralateral leg would be the left. So, the moment the contralateral foot lifts off the ground.

So, that is my opposite toe off then the green leg, which is in stance. Now you observe that the heel of that foot starts to rise ok, you have heel rise, where you see you know as the term implies the heel of the stance leg or heel of the single support leg lifts off the ground because, now you are in single support anyway.

So, if you look at the green, you have it making contact then you have the entire foot in contact with the ground because, what happens is after you contact the heel, your foot actually plantar flexes and makes contact with the ground fully. You strike and then your foot goes flat lets called foot flat and that happens before the opposite toe off because, that is how you are accepting the weight you take you strike then, you create your base of support and then the other leg starts to lift off the ground.

So, you have and after foot flat, now this the limb moves forward and slowly, now the heel starts lifting of the ground that is your heel rise. So, actually opposite before opposite toe off foot flat happens So, the heel first rises and then as the heel is rising because; that means, now that foot is the support foot is being unloaded right because, you have less and less contact. So, you are now preparing for the other foot to make initial contact, the other foot makes initial contact.

So, that is your OIC Opposite Initial Contact heel rise OTO IC ok. So now, this indicates that you have from heel contact of this foot, now you have opposite initial contact or opposite heel contact so, that is 1 step; I am done with about 50 percent of my gait cycle ok. Now the other limb is sort of doing the same thing that this limb did in the first half ok, it starts it undergoes foot flat and then you know slowly it will start the body will move over that limb and then the heel will start rising on that other; in the meantime, while that is doing that this leg ok, you had the heel off. Now the toe leaves the ground of this leg, the leg that was doing the supporting.

The green leg, the toe leaves the ground that is the leg of interest. So, you have the toe off of this leg, now when it is swinging? So, it lifts up like this, it swings up and then starts moving down aided by gravity as well as some muscle control, but mainly it starts moving down. So, there is a certain time, where the other limb is performing the supporting function, this thing has swung up and then start swinging forward. So, the 2 feet are now adjacent.

So, this is your feet adjacent. So, you notice an instant, where the 2 feet are adjacent. So, I have I am supporting on one leg, this leg is off the ground and as it swinging forward my feet are adjacent and then as it is swinging forward my tibia, there is in the green leg. I noticed that my tibia starts extending right it is preparing for the next initial contact as it is swinging forward. So, there is an instant where the tibia is vertical and then my knee starts extending to make the next initial contact ok.

So, this is one gait cycle, you are looking at both the limbs you have. So, if you look at the gait cycle, the initial contact, heel rise, toe off, feet adjacent, tibia vertical and the next initial, these are all with respect to the limb that you are observing. 2 events opposite to off and opposite initial contact that is for the contralateral limb that you are observing those events ok. So, these 2 let me. In fact, put them in a different so, opposite toe off and opposite initial contact ok.

This is a gait cycle and this is something, you should be able to reproduce you should know, what these various events are you should be able to draw these diagrams, do not tell me, I did not warn you ok, this is something you because, this is something we will revisit again and again and again ok. So, it is very important that you become familiar with these terms and that you learn to reproduce this diagram ok.

Now, the phases ok. So, you have initial contact the time between initial contact and opposite toe off, that is when you are doing the weight acceptance that is called loading response ok. So, if you look here that is when, the weight acceptance starts with the event of initial contact and continuous over that phase of loading response. So, loading response is the phase between initial contact and opposite toe off ok. The time between these phases are, not equal ok, it is not equal, but it is just represented in this manner for clarity. So, loading response is the phase between initial contact and the opposite toe off

ok. So, it is the double support phase essentially, the first double support phase is when the loading corresponds to the loading response phase.

Then you have mid stance and terminal stance, which correspond to and also pre stance. So, mid stance and terminal stance are when you have single limb support ok, then the limb of interest is doing all the supporting. The supporting function is done entirely by 1 limp and you notice at the end of terminal stance opposite initial contact takes place ok so, a single support end.

So, when opposite toe off opposite initial contact; that means, that limb is in swing it is lifted off the ground toe off. So, the blue limb is in swing during, the time that the green limb is in single support. So, in the single support phase, you have mid stance and terminal stance and then pre swing is between the time, now you have made opposite initial contact ok. So, pre swing is not a part of single support ok.

So, pre swing is your second double support phase. So, initial double support phase is loading response, second double support is you are making is a loading response for the other leg, which corresponds to pre swing of this leg ok. So, in pre swing, pre swing is between the time there is opposite initial contact and toe off of this leg ok. Now this leg is in swing, this leg is in swing. So, you have the initial swing is when it lifts up off the ground actually goes back a little bit and then starts moving forward ok.

So, that is your initial swing and that initial swing is still the time it goes, it lifts off the ground and then comes back such that the feet are adjacent. So, that is your initial swing period then mid swing is when it moves forward now. So, if you look here you have initial swing. So, they are the limb is advancing it moves forward. So, here you have the feet are adjacent, now the tibia has become vertical. So, you see here from this configuration, its moved forward such that the tibia is now moving further forward such that it is vertical.

So, that becomes mid swing and then from this point on, now you have to prepare for the next initial contact in these 3 the limb is off the ground. The green limb is not making contact with the ground, it corresponds to the swing phase of this leg ok, if you look at the blue, it is sort of this whole thing is sort of offset for the blue length ok. So, terminal swing ends then, you make initial contact or final contact, which would be initial contact for the next gait cycle, initial contact for next gait cycle.

So, this is a repetitive mechanism we use, alternating between the legs to move the center of mass of the whole body form, we can see predominantly, it is this coordinated movement you know things have to happen. So, it requires a lot of neural control, it is not an easy tasks walking although, it appears that way is not an easy task because, it requires a lot of coordination between the muscles, we have not even started looking at, imagine if you take 2 sticks or 4 sticks assume, the 4 sticks, you build a model like this like the stick diagram, I have here, what are the chances that you can make it walk? That will give you an appreciation of the control it requires to make these coordinated movements. Now I can make a stick figure like that, but can I make it move in this coordinated fashion ok.

So, that is where the challenges in walking, the coordinated set of movements you know with so, many limbs connected by joints because, imagine you have a joint here. Look at this leg, the other leg is lifted off the ground, I have 2 sticks like this right and I am trying to support the entire body weight on that requires a lot of muscular control. We will look at what are some of the key muscles that are involved in working as we go along ok, but this is very important knowing the gait cycle, what are the events, what are the phases. So, this is something, you have to be very become very comfortable with them because, I will not be going back and trying you know, if I just say pre swing or if I just say opposite to off, you should be able to visualize, what it is that I am talking about.

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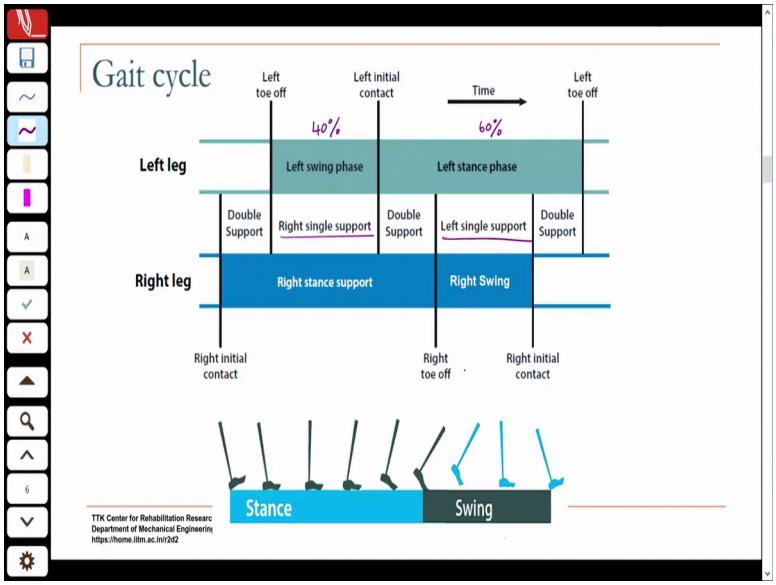

So, this is this is a picture you have to commit to your memory in order to and these terms also you have to become very comfortable with double support, single support. So, it should give you a picture, when I when I talk about that you should be able to connect it to, what I am talking about in the gait cycle. Again knowing which is stance, which is swing you know the same thing in a different manner, you have double support right, single support, double support, left single support. So, in a gait cycle each leg participates in 1 single support and 2 double supports each leg, if you look at each leg it participates in.

So, the right single support is from left toe of the left initial contact that is your right single support right, single support corresponds to the left swing phase ok, left single support right swing corresponds to left single support so, those 2 overlap, when one leg is in single support, it means the other leg is in swing. And stance includes the double support phases, when I say the limb is and stance that is why that is 60 percent. So, you have 60 percent stance phase 60, 40 percent swing phase, if you look at the leg.

Because, the leg participates in both the double support phases 40 plus 10 plus step, yeah from initial contact to toe off is your stance, it is not single stance initial contact to the time, it lifts off the ground is the entire stance phase, it includes 2 double support phases ok, the initial double support and the final double.

Student: ma'am, but that is the term, you told that is a pre swing.

Which one?

Student: Initial.

No initial contact to toe off of this that leg right initial contact to right toe off, what you are talking about is left initial contact to right toe off ok, get the picture in your head. It is a little tricky, which is why I am going slowly because, it takes time to absorb this ok.

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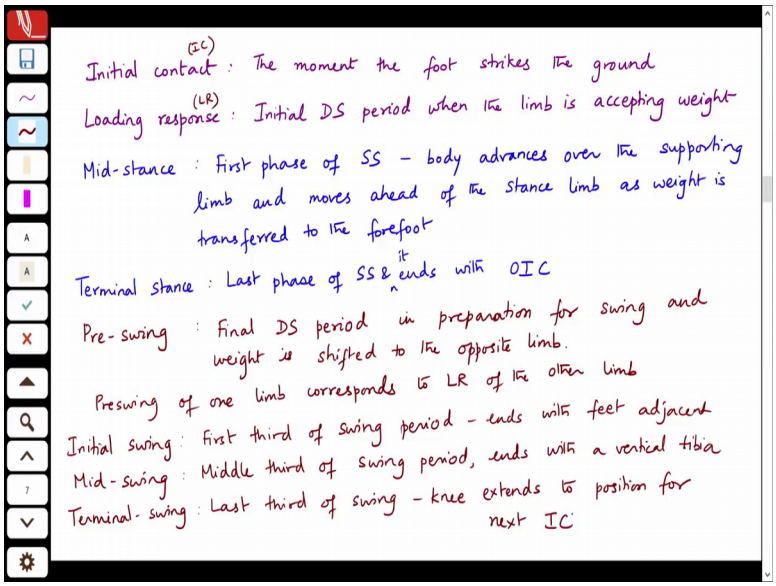

So, let me just write down some of this. We will start off with it, initial contact loading response many times these are abbreviated. So, LR would be your loading response, this is the initial double support period DS double support when the limb is accepting the weight. Mid stance, first phase of single support so here, the body advances over the supporting limb and moves ahead of the stance limb as weight is transferred to the forefoot, fore foot implies the front part of the foot.

So, if you look here mid stances, you have this limb being the only supporting limb because, toe off of the other leg has happened. Now the entire body moves over this, you can see here this configuration to this configuration, the body has essentially moved over this limb, moved over like this over this limb and the body weight has now moved to the forefoot, this is the only supporting limb, the other limb base of the ground ok. So, this is your mid stance transfer to the forefoot then the terminal stance is the last phase of single support and it ends with, how does it end?

Student: Double support.

What event last fail it ends with?

Student: Opposite initial contact.

Opposite initial contact it ends with opposite initial contact good, then pre swing is the second double support or the final double support period in preparation for and weight is

shifted to the opposite limb. So, this corresponds to loading response for the other limb, pre swing of this limb corresponds to loading. So, the same thing double support right please pre swing of one limb corresponds to LR of the other limb. Initial swing is the first third of the swing period and this is where the maximum knee flexion occur.

So, the leg swings back and then starts moving forward. Mid swing is the middle third of the swing period ends with the vertical tibia, the initial swing ends with feet adjacent and the terminal swing were the final knee extension achieves the maximum step length. So, that is what and you are going to plant the foot. So, you have extended the knee fully so that, you can place it for the next heel contact. So, it is the last third of swing knee extends to position for next in a shell contact ok.

And that ends the gait cycle. So, today we have looked at the key events in the gait cycle, the key phases in the gait cycle, the phases are the times between 2 events and their tasks. So, basically the task is support move forward; support move forward. So, when you are supporting also the body is moving forward ok, there is continual forward progression that is happening during walking that is the purpose of walking.