Biomechanics
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Lecture – 37
Knee Anatomy and Movements

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Welcome to this video on biomechanics. We have been looking at biomechanics of the lower limb, starting with the biomechanics of the hip. They looked at the anatomy, the muscles that are responsible for movements at the hip. And the numerical problem associated with hip. Remember that the hip is quite unlike the shoulder joint in terms of the fact that it requires weight bearing as opposed to the shoulder joint.

So, the amount of movement that you are going to get in the hip joint is different following up with that we have the knee joint.

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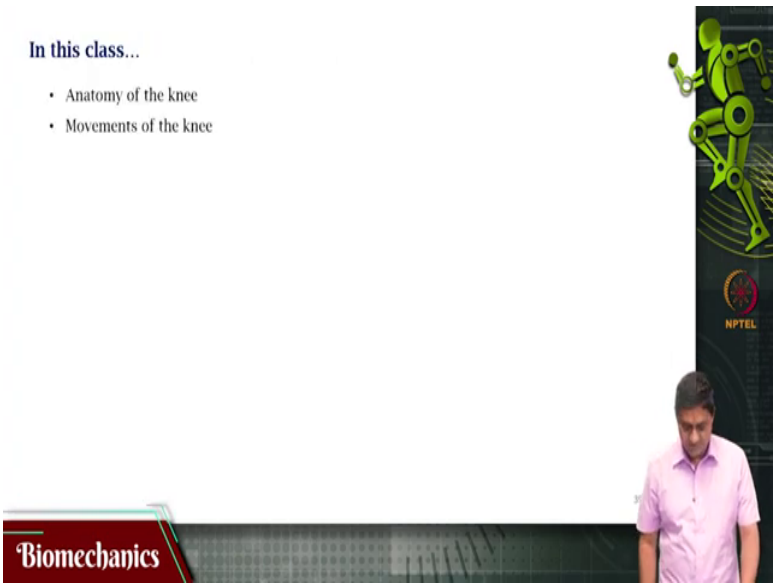

So, in this video, we will be looking at the anatomy of the knee joint and the movements that are possible at an agent. Technically, there are more than one movement possible with the knee joint. But the most major movement of the knee joint is just the flexion and extension of the knee joint. The other movements, although are possible, are quite restricted in the knee joint. So, it is not exactly movements rather movement.

It is a single movement with some other movements possible at some points of time. So, it is movement within bracket s type of situation. Again, the structure defines function or function defines structure principle is followed here. Here, what is the function of the knee joint? Of course, an important function is to provide a flexion and extension. So that it is useful for walking. Remember humans are bipedes.

They will have to carry the entire body weight on the knee joint. So, the entire body weight is carried on the hip joint. From there through the femur which is a long bone it is also a strong bone. Through the femur this weight must be passed onto the knee joint. So, there is a need to maintain stability even at times when there is no movement. So, the movement may not be happening but the knee will need to be stable.

This is a crucial, functional requirement. This defines structure in the knee joint. This is true, even in other quadrupeds, so this is perhaps true in quadrupeds where but then there are four such knee joints. So, their upper limbs are not like elbows in that sense. So that is a slight difference. So, there is a unique case in the human knee joint also. The hip joint is more unique. So, the hip joint is unique. The knee joint is unique by this logic.

Actually, all joints are unique by themselves. So, just saying what is the unique nature of the knee joint is? Something that we will have to look at in the future slides.

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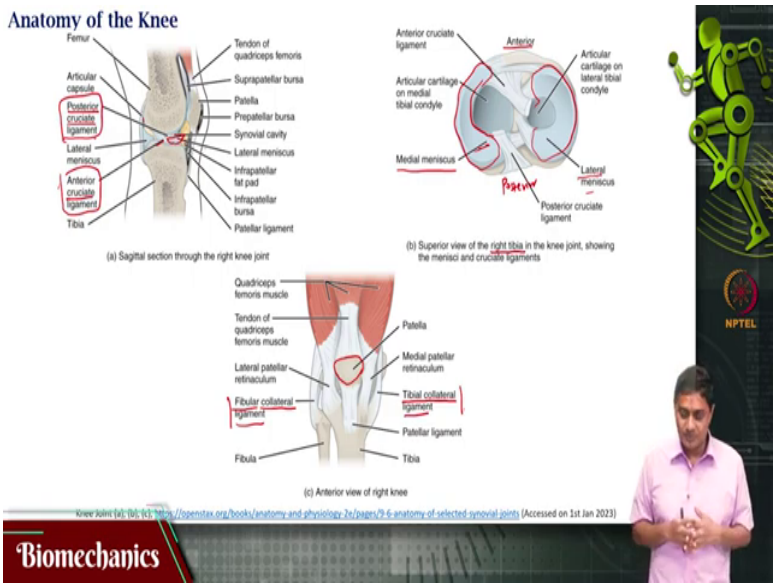

The knee joint is the largest joint in the human body. In the sense that the size of the joint is large and it is composed of three articulations. Although, there are only three bones that are involved that is the femur which is the more proximal bone or the thigh bone. This is the bone that is interacting with the patella or the kneecap. So, the kneecap under knee you will see this roughly triangular shaped bone that you see.

It is called as patella or the kneecap. It is a sesamoid bone. It is a very unique bone in that there is only one of this type it is a very unique bone. So, this bone is embedded within the quadriceps tendon so, it is a very unique bone. So, the movement happens along the quadriceps tendon, as the tendon is pulling. So, it is a very unique bone. So that is the patella which is a sesamoid bone and that is the femur which is the thigh bone.

And then there is the tibia which is the bone in the shin so called shin bone or bone in the lower leg. There are two bones in the lower leg, just like you have the radius and ulna. You have the tibia and fibula. There are two bones in the lower leg. But most of the load bearing work on most of the work for the purpose of a discussion here. Most of that work is done by the tibial bone.

So, in that means what are the three articulations that we are discussing? So, when we say a joint, this joint is composed of three articulations I said. But what are the three articulations? Because it is not like patella and tibia are going to interact. Because they both are the more distal parts of the joint that we are discussing. So, it turns out that femur itself has two quantiles one that is more medial and one that is more lateral.

So, if I have like this, the medial side, that part of the femur that is more towards the mid line of the body. And that part of the femur that is more towards the side of the body. So, there are two condyles of the femur that interact with two condyles of the tibia leading to two joints. So, tibia and femur have two joints. So, you can consider this to be technically two joints tibiofemoral joints.

Two tibiofemoral joint or the medial tibiofemoral joint and the lateral tibiofemoral joint or you can consider these to be a single joint because it is two bones that are interacting. But technically these are indeed two joints. So, these are medial and lateral tibiofemoral joints, there are two joints. And on top you have the patella femoral joint. This is where the patella interacts with the femur. So, this is the patella femoral joint.

So, there are three articulations within the knee joint which is why it makes the largest joint in the body. Important function of knee joint is to produce movements in the sagittal plane. What are these moments called? Do we remember that? Remember in the first week of the course or in the first two weeks of the course, we discussed movements in the sagittal plane, movements in the frontal plane, movement in the transverse plane, etcetera.

The moments that happen at the knee joint are all happening in the sagittal plane or at least most of the movements that we discuss are happening in the sagittal plane. What are these moments called? If you do not remember now, is the time to pause the video go back and check these movements. These are called, of course, flexion and extension. The knee functions as a hinge joint allowing for flexion and extension at the knee joint.

So that is the major movement of the knee joint. Here is a view of the patellar bone. This is the sagittal view of the patellar bone and this is the femur look at because this is sagittal view. I will not be able to look at the medial and lateral epicondyle or the medial and lateral condyle of the femur in this case. So because this is the side view or the sagittal view.

Here, I will be looking at how the femur interacts with tibia one of the interactions and the patella? These two I will be looking at. So, here you have the gliding motion of the patellofemoral joint that is possible here. That is one and then there is at least one tibiofemoral joint that you can see here that. There are ligaments that are present whose job it is to stabilize and provide for motion or allow for motion only when required.

That is a matter of detail that we will discuss in some time. So, when you look at the sagittal section, you are seeing this patella and the femur and the motion that happens here but at the patellofemoral joint. Then when I am looking from the front anterior view of the right knee this is for the right knee. So, when I am looking at the right knee here, I can see again this also shows some muscles and some tendons because that is important.

Because the patella itself is embedded within the tendon. So, the movement as the tendon is moving then the patella moves. So, it is a very unique bone. We discussed this. So, if I am looking at the right tibia in the knee joint. What I am able to see? This is the right tibia and this part is the front part and this is the back. So this is the tibia. This part is called as a medial meniscus. This part is called as the lateral meniscus.

Something to keep in mind is that there are these ligaments that cross over from one side to the other. We will discuss that in a bit and there are also ligaments that are present on the same side. So, we have to take some time and discuss them. So, a major function of the knee is to hinge or is to act as a hinge joint. A major function of the knee is to act as a hinge joint allowing for flexion and extension at the hinge joint, at the knee joint.

Also, some amount of abduction adduction is possible but this is possible only when the knee is flexed. So, when the knee is extended, it is more like a lock. It cannot rotate or abduct adduct when it is fixed. It is a very unique system. So, when the knee is flexed that is possibility for movement to happen on the side or as in some rotation, some abduction adduction very small amount.

Actually, even this movement is quite restricted but when it is extended, when the knee is extended. It is main function is to pass on the weight from that it is receiving from the femur down to the floor down to the ankle joint. So that is the major job. So weight bearing is a

major role in while it is extended, while it is flexed. Already that means that maybe it is trying to move and it is getting lifted off the ground.

Then there is no purpose for weight bearing then this lock is removed. So, very unique joint in that sense. Only when it is flexed or only when it is slightly flexed a small amount of movement is possible or rotations and abduction adduction very small amount is possible but only when flexed. At extension, no movement in any other plane is possible is very unique for that.

So, the construction of the knee is very unique in that it is well, constructed for weight bearing in the extended position. But it is vulnerable to injuries when it is hyper extended. Much of the sports injuries happen because of the hyperextension of the knee just one. Check for one of the common sports injuries is the anterior cruciate ligament. the ACL is quite frequently hurt or damaged in this.

Because of hyperextension that happens we will see that in a bit. Also possible are twisting or any lateral or sideways movement of the knee, when it is locked. So, one problem that happens quite often with the osteoarthritis. In other words, weakness that develops throughout the body is seen in particular in osteoarthritis. One of the projects that we began working on at some point before the COVID time was studying varus thrust in people with osteoarthritis.

And people with osteoarthritis what happens? Is that let us say that there are two parts. So, let us say this is the femur and my index finger is the tibia fibula, let us say. What happens is that? When you are looking from the front in the frontal plane that kind of movement on the sideways which is very unusual in healthy people this is called this is a very crude explanation of the problem it is called varus thrust. A problem that happens in people with osteoarthritis.

But in healthy people this kind of movements are almost impossible or almost never seen. So, until and unless someone experiences the disease, we do not even realize that there is this kind of a problem that exists, something to keep in mind. This stability that we take for granted is provided for by the construction of the knee. By construction it is like this.

So, movement at the patellofemoral joint is primarily to increase the moment arm of the quadriceps tendon. Quadriceps tendon attaches at the patella but what is the moment arm? Let us go back to the basics and find out. This is the perpendicular distance between the line of action of force and the axis of rotation. When this is increased so, in a way the size of the patella or the patella itself increases the radius around which the tendon is gliding through.

Or it acts like a pulley around which the rope which is the tendon which is quadriceps tendon will have to glide through. This way, it increases the mechanical advantage of the quadriceps tendon. So, it has to do less work. Consider that the quadriceps muscle will still be producing thousands of neutrons of force, despite the fact that it is already gaining some advantage because of this unique design.

Despite that it is producing thousands of neutrons. If this design was not present then the amount of force that may need to be produced by the muscle will be huge something to keep in mind. So, what is the function of the quadriceps muscle? So, quadriceps muscle connects on the anterior side of the thigh. So that means it is going to perform that movement. It is going to perform the extension movement of the knee.

We will discuss the muscles in a later video but just mentioning here. So, something to keep in mind is the structure of the bones themselves, provide for the interaction that happen between these bones. So, femur it is construction or it is two condyles are more convex or more rounded. In comparison, tibia and where interacts with tibia, at least in the tibiofemoral joint is more slightly flat or concave.

So, there is a structural arrangement such that this interaction is relatively smooth. So, femurs condyles interaction with the tibia leads to motion in which there can be both rotation that happens at the so, there can be rotation that happens here. Here, we are only seeing one of the two tibiofemoral joint, the rotation that happens here as well as some gliding also happens. So, rotation causes the movements that we see as flexion and extension.

And that gliding is what stabilizes the knee joint to prevent unwanted movements? So or to perform the main function of the knee joint which is weight bearing at extension. So, between the tibia and femur, there is also some meniscus. There are two meniscus shown here is one

of them the lateral meniscus. Example, what are these? These are pad like you know cartilage, fibro cartilage is material pads that are going to provide some kind of cushion.

Some kind of interacting material between the two bones that are interacting. So, here you see some part of the lateral meniscus and this part you see the medial meniscus here. So, responsible for providing the padding between the two interacting bones. On top of all this you also have at least four ligaments. Actually, there are more ligaments that I am not discussing for the purpose of the discussion here.

We restrict our attention to two types of ligaments, those ligaments that attach on the same side of the body or when you are looking from the different they do not cross over to the other side or the same side ligaments also called as the collateral ligaments. These are two types one attaches to the fibula, the fibular collateral ligament. The other attaches to the tibia are the tibial collateral ligament. Collateral means same side, so, they attach on the same side.

Then there are a set of ligaments that cross over from the medial side to the lateral side and there are two of those. The one that crosses over on the front side is called as the anterior cruciate ligament. The cruciate ligament that crosses over on the front side cruciate means crossing over anterior means on the front side. The anterior cruciate ligament is one that crosses over on the front side.

And there is one more that is the posterior cruciate ligament that is on the back side that also crosses over from the medial side to the lateral side. Between the anterior cruciate ligament and the posterior cruciate ligament, the posterior cruciate ligament is a stronger one, whereas the anterior cruciate ligament is the relatively less stronger one. The function of the anterior cruciate ligament is to prevent movement on the hyperextension side.

So, when there is this hyperextension that happens in sports, sometimes it leads to this **(()) (20:40)** of this. So, to review the knee joint we have three articulations, all of them in a single capsule. That one is the medial tibiofemoral joint and the other one is a lateral tibial femoral joint and the other one is a patella femoral joint. These are the three articulations that have that are present within one capsule which is the knee joint.

And there are special ligaments that are present to prevent unwanted movements. Those that are present on the same side are called collateral ligaments. There are two of these fibular collateral ligaments and tibial collateral ligaments. And then those that cross over are called of cruciate ligaments. And then there are two of this the anterior cruciate ligament and the posterior cruciate ligament.

And there is padding between the tibia and femur that is called meniscus, the medial meniscus in the lateral meniscus. And the function of each of these are discussed. So, essentially, the movement of the tibia against the femur in the sagittal plane is the only movement of interest for us which is the flexion and extension movement of. So, the extension of the tibia against the femur responsible through the quadriceps muscle.

And it is mechanical advantage is increased by the presence of this kneecap or the patella which is a special sesamoid bone, let me discuss.

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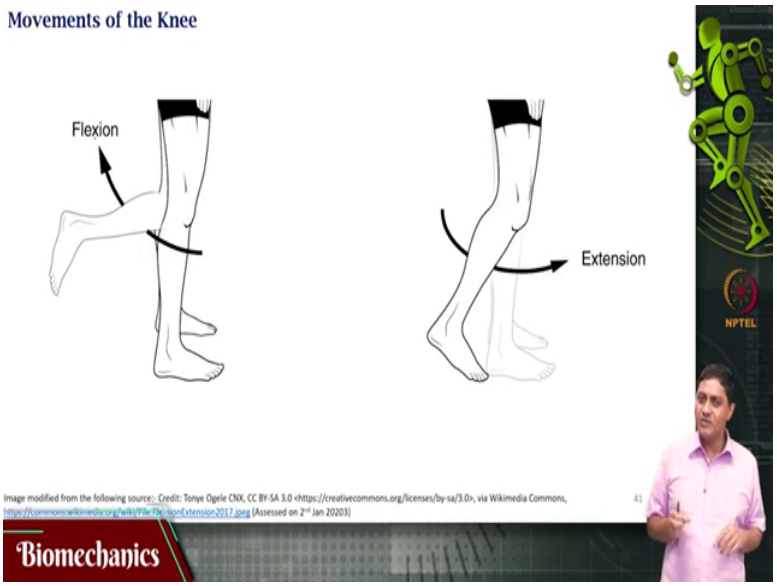

So, what are the movements at the knee joint? At the knee joint, there are only two movements that are possible or only two movements are of interest, essentially flexion and extension. Actually, when compared with the elbow joint, the knee joint is not a good hinge joint. It is not a perfect or relatively more faithful hinge joint, so, to speak. It is not only a hinge joint.

Because when it is flexed, small amounts of movement, small amounts of rotation and abduction adduction are possible in the knee joint. But only when it is flexed, when the knee

joint is extended, it is essentially a weight bearing. It is a locked joint that is going to pass on the weight from the top that it is receiving from the hip through the femur to the ankle. So that is the purpose when it is extended. When it is flexed, a small amount of movements are possible in the other directions.

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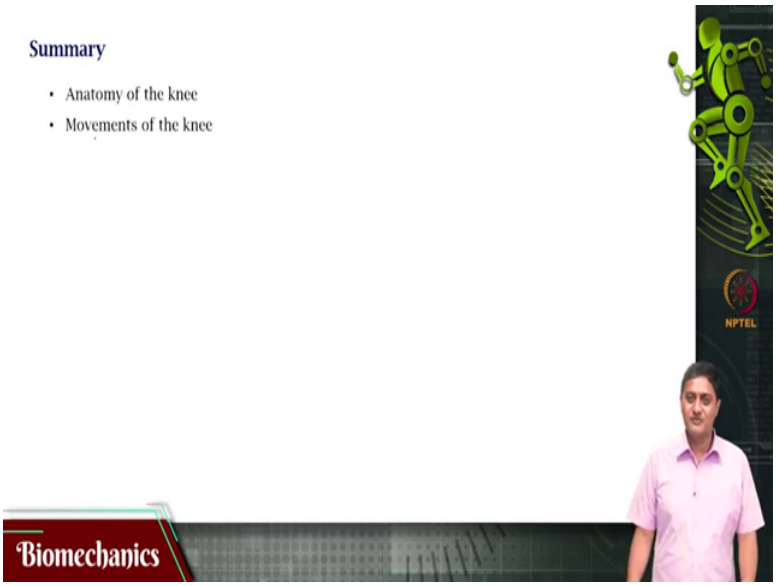

So, in this video we saw the anatomy of the knee. We saw structures that contribute to flexion and extension of the knee joint and the movements that are possible. The special nature of the knee joint and it is construction. So, here again that function is defined by the structure. Something to keep in mind or rather function is what led to the structure? This is a debate that we will continue to have as part of our discussion some structure function, relationships within biomechanics. Thank you very much for your attention.