Biomechanics
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Lecture - 64
Cartilages, Ligaments and Tendons

Vanakam, welcome to this video on biomechanics. In this week's video we have been looking at biomechanics of soft tissues.

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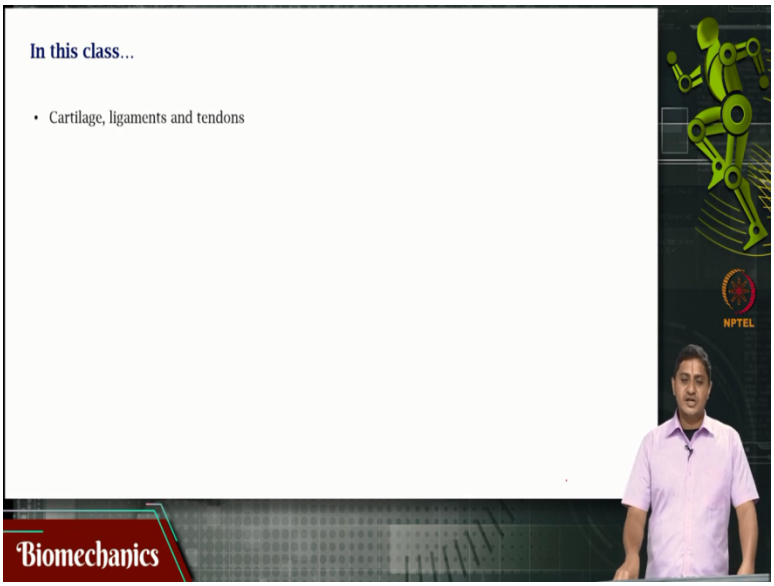

In this video we will be looking at cartilage, ligaments, and tendons.

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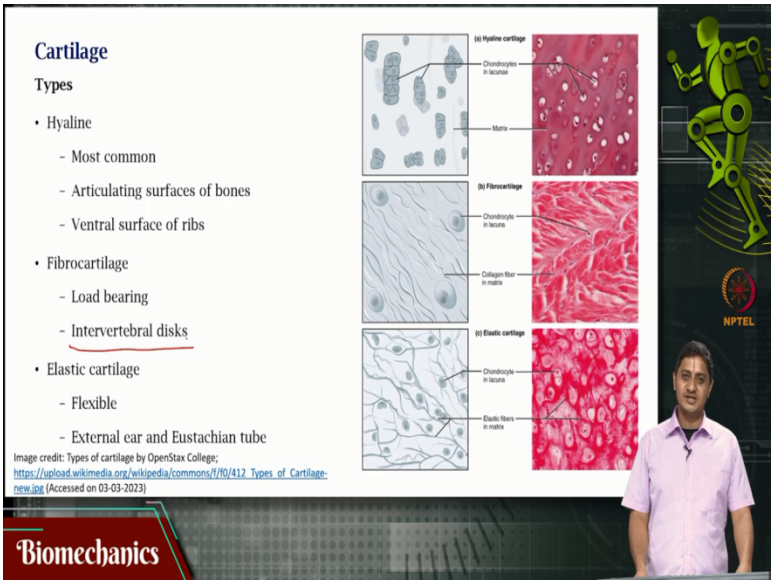

So, cartilage comes in various types. The most common of the cartilages is hyaline and this is present on the surface of bones. It is more like a coating on the bone because bones when they are pulled by muscles they move relative to each other and you want to minimize you know the amount of friction and so that is an amount of cartilage that is present on the articulating surfaces of bones.

Then you have fibrous cartilage, cartilage that is more fibrous than the other types of cartilage this is called fibrocartilage or the fibrous cartilage. These have a crucial role to bear loads load bearing cartilage this is fibrous cartilage also barrels loads importantly are very crucially they are present and found in inter vertebral discs. Now you realize that they have the important function of load bearing then you have elastic cartilage.

Elastic cartilage is the flexible type of cartilage these are present on the external ear and **(()) (02:13)**. So, intervertebral discs are composed of fibrous cartilage. So, it is important function is being achieved by this tissue type or by the cartilage. We know what is its important function, we saw while discussing the biomechanics of spine. If you do not remember pause this video go back to that video watch it for a few minutes and then you will be able to realize what it is that we are discussing.

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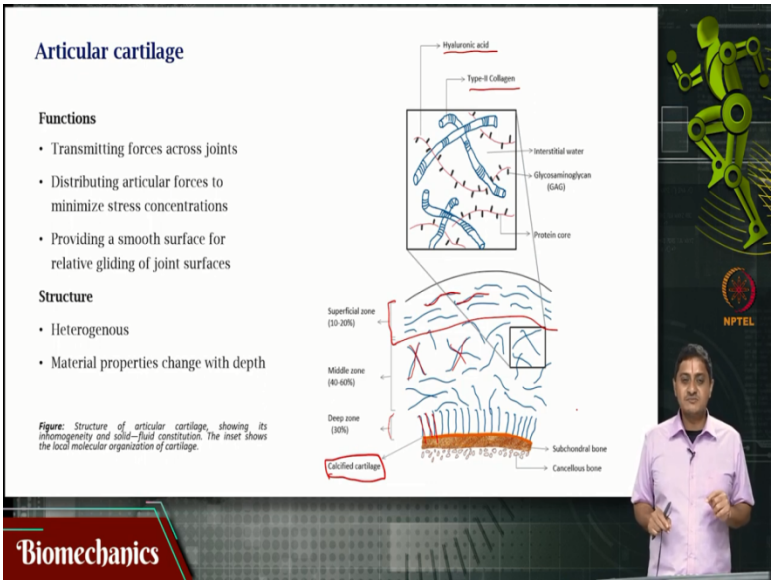

Then we have article cartilage that is having the crucial function of transmitting forces across joints. So, it distributes articular forces and minimizes the concentration of stress a crucial function because if stress is concentrated this might lead to failure of the biological material. And also, it provides a smooth surface for relative gliding of joint surfaces. So, that is gliding that can happen at the joint.

Immediately what comes to my mind is the gliding that happens between the femur and the tibia fibular at the knee joint. What happens at the knee chain? That is gliding that happens between the femur and the bones of the lower leg something that we discussed while discussing the statics of the knee joint. It turns out that the structure is quite heterogeneous and so of course it is composed of hyaluronic acid and composed of type 2, collagen.

And there is water and then there is GAG in between proteoglycans and GAG. And there is no simple straightforward structure its quite heterogeneous and it turns out that as the depth of the cartilage changes the structure also changes. For example, in the superficial zone you have cartilage that is structured like this then you have the middle zone where it is quite heterogeneous then you have the deep zone where it is attached to the cancellous bone to the bone itself.

And this is the calcified its mentioned here this is the calcified cartilage that is the calcified cartilage. So, when you say cartilage this whole thing is called cartilage but then property of the

material changes with depth. Why, because the structure of the material structure of the proteins within this tissue changes with depth. So, everywhere at different scales we are looking at structure function relationships. Here we are looking at you know structure function relationships at the micro and nano level.

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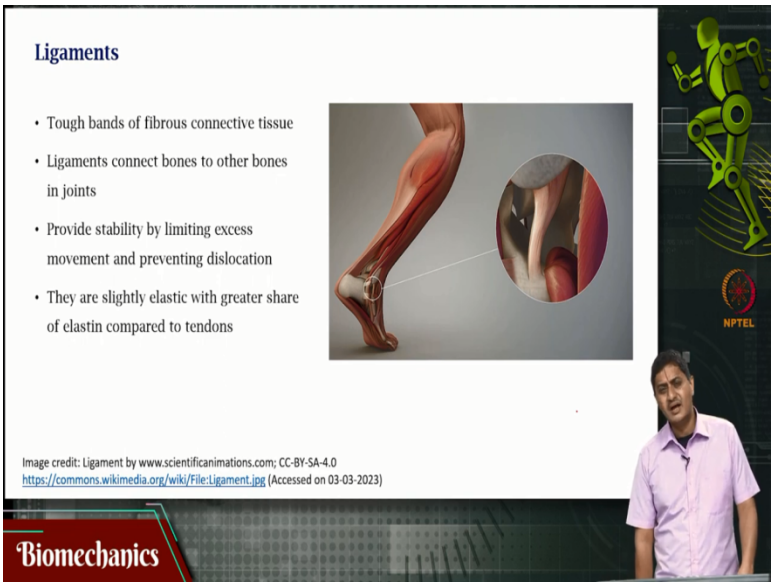

Then we move on to ligaments, these are tough tissues that are fibrous these are fibrous tough bands of connective tissue, they connect and hold together bones. Remember we discussed when we discussed the knee joint, we discussed the crucial role performed by the cruciate ligaments and the collateral ligaments remember. The important role is to maintain joint stability and minimize the possibility of dislocation.

Remember if dislocation happens it can be an extraordinarily painful process to recover. So, any sports injuries that may happen also in general injuries that may happen that the result that cause there are tear of ligaments or traumatic tear of ligaments can result in may result in dislocation, so which involves a painful recovery process. A slightly elastic with a greater amount of elastin when compared to tendons.

And compared with tendons, tendons have more collagen when compared with the ligaments. So, there is a lot of elastin in ligaments when compared with tendons. So, they are a bit more or actually quite a bit more elastic when compared with tendons.

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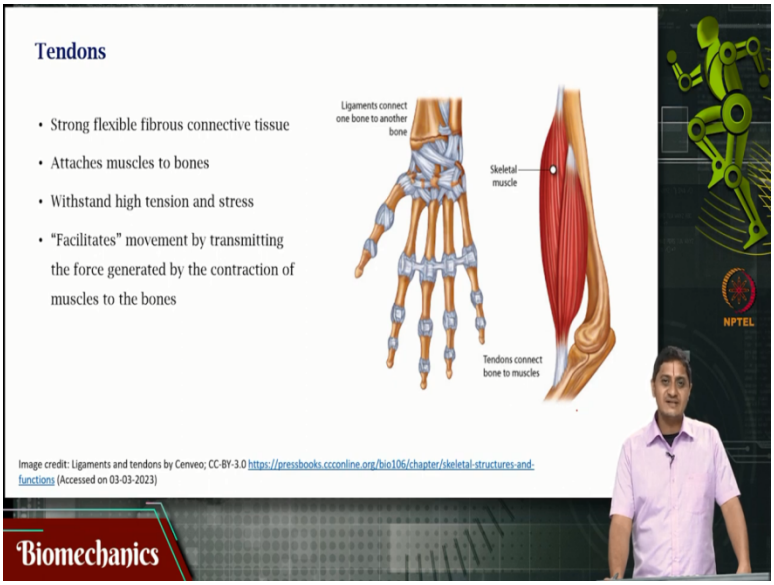

Then we have tendons, these are very strong flexible and fibrous tissue connected tissue and its function is to attach muscles to bones. What attaches bones to bones? Ligaments. What attaches muscles to bones? Tendons. They are essentially very good transmitters of force muscles develop the force and tendons transmit this force to the bones. So, they can withstand high tension and high amounts of stress.

They facilitate movement by force transmission when the muscles contract, they transmit this force to the bones and cause what appears as movements. We restrict our attention to tendons for the rest of the discussion on soft tissues, mostly we will be discussing a lot of detail of tendon. So, we take tendons as the example of soft tissue and we discuss the mechanics of tendons in the rest of the classes.

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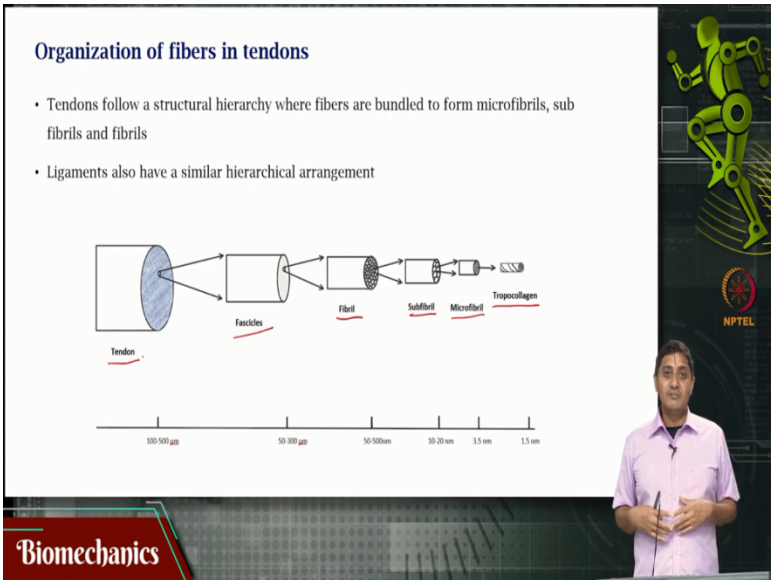

It turns out that tendons are organized in a hierarchical structure. So, there is a strict you know structural hierarchy where fibers are bundled to form microfibrils, sub-fibrils and then fibrils. So, collagen fibers they are bundled together to form microfibril, look at the scales at which we are working. At one and a half nanometer that is where the tropocollagen, we saw this, we saw this while we were discussing collagen in the previous class.

The scale that you are looking at is units of nanometers. Then you have bundles of these fibril bundles of collagen that found a microfiber it is called microfibril but it is actually in the nano scale it is about you know units of nanometer to tens of nanometer. Then you have many of these microfibrils put together that form sub fibril that is having the scale of that is having the size of about pins of nanometers.

Then you have fibrils whose size is anywhere between tens of nanometers to hundreds of nanometers. Now when you are discussing hundreds of nanometers you are actually getting closer to the micrometer because 500 nanometer is half a micron so is it not. Then you have many of these fibrils put together that form a fascicle this is actually in the micro scale. This size is actually in tens of microns to hundreds of microns.

Then you have tendon itself whose size whose dia is about you know hundreds of microns to yes, the whole tendon might be having a size of you know centimeter squared. But you know when

you are looking at sizes you are looking at hundreds of microns too millimeter scale. So, this bundling of collagen fiber to microfibril to sub fibril to fibril to fascicle to tendon is very similar to the hierarchical structure in a muscle fiber, in a muscle.

You have muscle, then you have muscle fascicle, then you have muscle fibril myofibrils, then you have in the end like you have tropical collagen in the tendons you have sarcomere in the muscle. We saw what is the sarcomere, what is its function in the muscles module remember.

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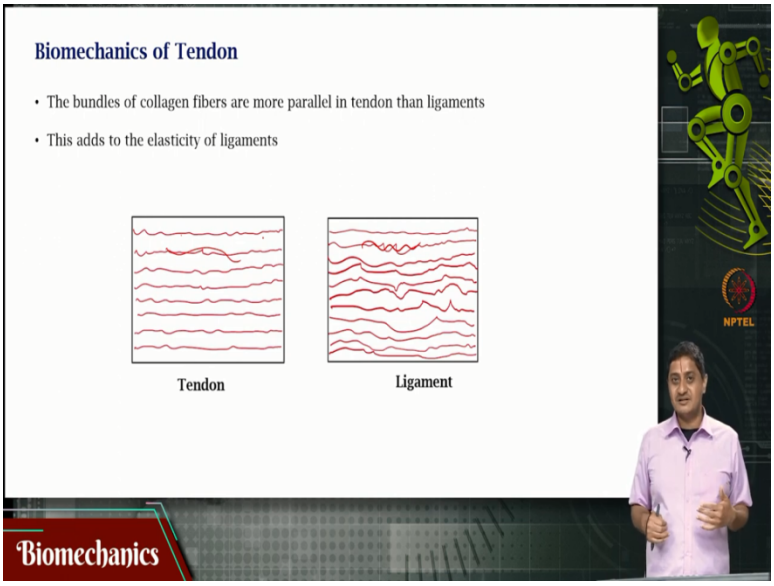

Fundamental difference although both ligaments and tendons both of them have collagen. A fundamental difference between ligaments and tendons in terms of their function is dictated due to the structure. Bundles of collagen fibers are more parallel in tendon than in ligaments this is why elastin dominates more in ligaments than in tendons, this is why elasticity is more in ligaments.

So, it is not merely the composition but also the structure as you can see this is you can just visually see you know these are less parallel and these are more parallel. So, the structure of the collagen fibers, so it is not merely the composition but also the structure or the way in which these are arranged that matters.

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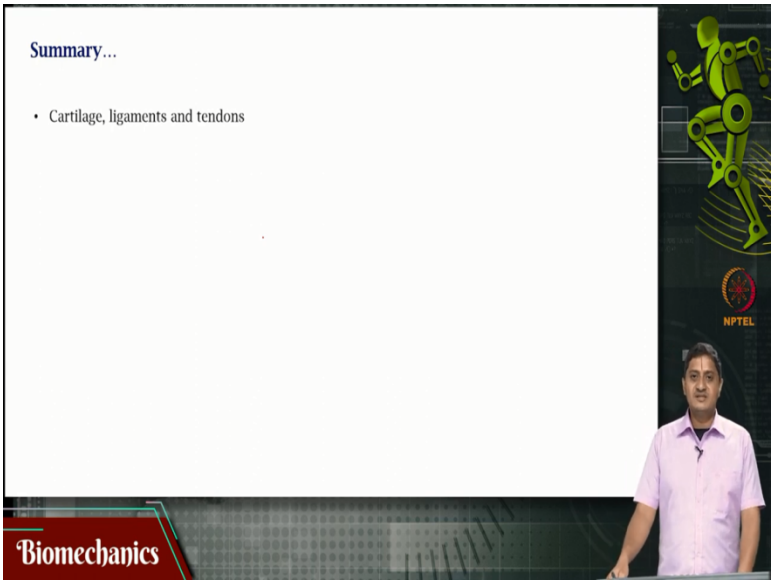

So, in this video we looked at cartilage, we looked at various types of cartilage, fibrous cartilage, articular cartilage. We looked at ligaments and how ligaments are more elastic when combined with tendons and then we looked at or we began our discussion on tendons, tendons we will discuss at much greater length in the future videos. So, with this we come to the end of this video, thank you very much for your attention.