Biomechanics
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Lecture - 15
Muscles – Muscle Fascicles

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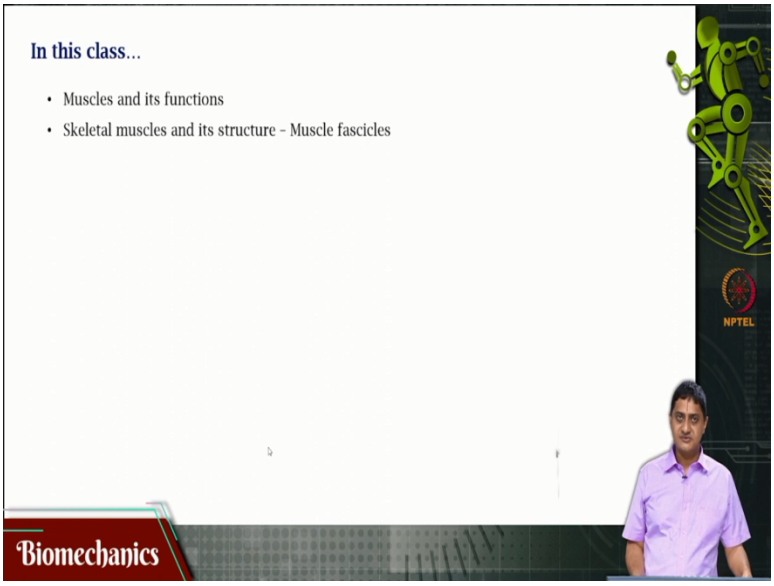

Welcome to this video on biomechanics, in this video we will be looking at skeletal muscles. Specifically, we will be looking at muscles and its functions more specifically on skeletal muscles structure and structure function relationships. So, we will get started with our discussion on structure function relationships and focus on muscle fascicles.

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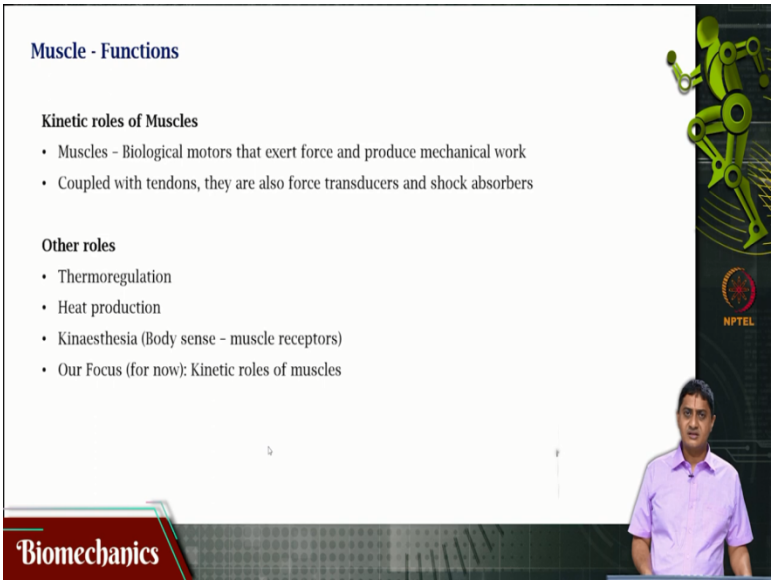

So, muscles are essentially biological motors that produce force and produce mechanical work, so they are the equivalent of motors that we see in electrical engineering. So, they essentially produce work or force and they also do some other work because they also act as shock absorbers tendons, also act as shock observers. In addition, muscles are coupled with tendons are also very good force transducers they measure how much force is being transmitted serially.

So, they are very good force transducers, they are responsible for transmission of force and they absorb shock and they produce work and force. There are some other roles that our muscles are known for thermal regulation or in other words you know heat or regulation of heat in the body kinaesthesia or an idea of where your body parts are relative to each other note that this is slightly different from the technical definition of proprioception, this is kinaesthesia.

So, giving a sense of the body, body sense this is achieved through the wonderful sensors of length and velocity that we have in the muscle which are called as muscle spindles. So, here that is just mentioned as muscle receptors and they are also already mentioned that they are also force producers they produce force and do mechanical work. In this course we restrict our attention to the role of muscle as a force producer and as something that does mechanical work.

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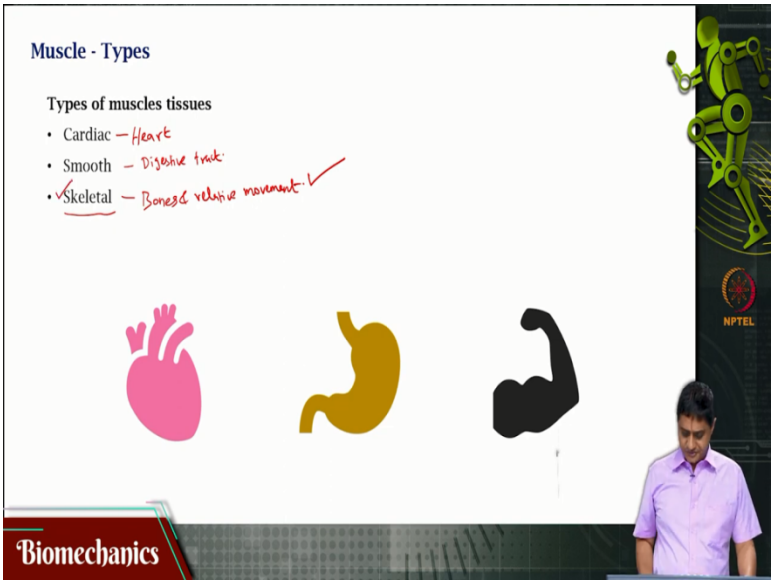

Broadly we classify muscles into three types, one is cardiac muscle this is a special muscle there is only one of this muscle in the entire body that is the heart. It is a single muscle that belongs to its own type that is the cardiac muscle. Then smooth muscles this is what is seen in the gut or in the digestive tract then you have the skeletal muscles these are responsible for generation of movements.

For example, walking or talking or moving your hand, making gestures these are all essentially done by skeletal muscles. So, there are these three types of muscles cardiac muscle which is heart muscle, how many muscles are there. There is a single muscle that is the heart muscle. So, the heart is not composed of cardiac muscles, the heart is a single muscle and that is called cardiac muscle it is a single muscle the whole heart is made of one muscle.

Then you have smooth muscles that you find in the gut or the digestive tract. Some important functions that this tract performs although we will not be focusing on such functions of these muscles, these two muscles. Our focus in this course we restrict to skeletal muscles, skeletal muscles means those muscles that attach and two ends to two different bones and when they contract they produce a relative movement between these two bones.

Those that are attached to bones hence the name well it these are the muscles that are attached to bones and hence the name skeletal muscles. So, we restrict our attention to this type or the skeletal muscles in this course.

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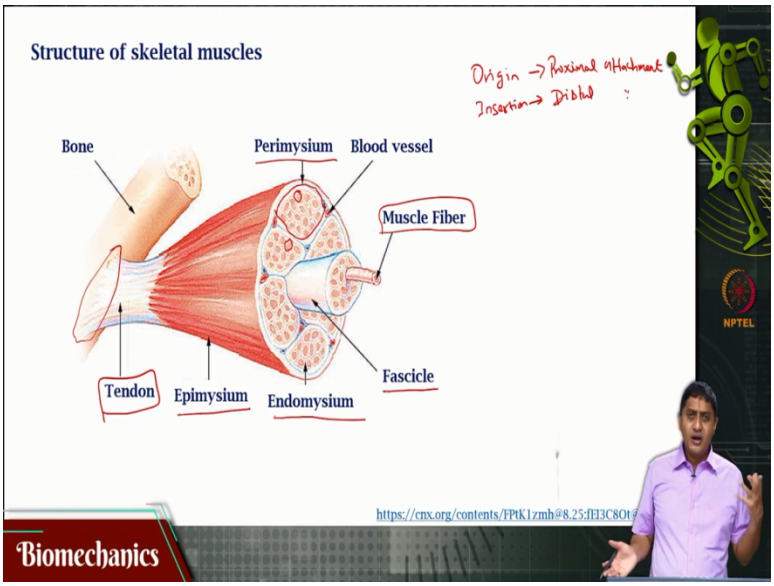

So, a skeletal muscle is having this organized hierarchical structure. So, on the outside you have the muscle itself which is composed of several small bundles of fibres or fascicles which themselves are further grouped into smaller bundles as seen here for example. And if you take one of these bundles and see within that you see it is composed of several muscle fibres. Many muscle fibres put together make up what is called as a fascicle or muscle fascicle.

And at each of this hierarchical level there is a fascia like covering that is there to protect. And sometimes also to transmit some forces these are called as endomysium, perimysium, epimysium etcetera and the muscle itself continues on to become the tendon and attached to the bone here. Note that there is a difference between tendons and muscles, muscles can be neurally controlled whereas tendons only transmit produced force but muscles can produce force.

So, there is some fundamental difference between the two we will be seeing the role of tendons in biomechanics in future classes. But for now, the muscle continues on to become the tendon and then attached to the bone. That part of the attachment that happens on the proximal side is called origin. We know this we have seen this in a previous class. And that part of the attachment

that happens on the distal side is called insertion distal attachment. So, this is the broad hierarchical organization of a muscle.

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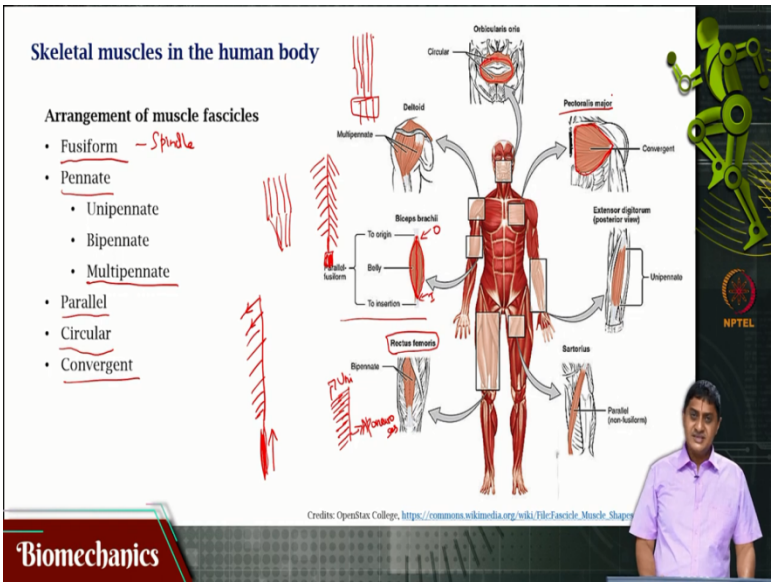

And depending on how these fascicles are arranged within the muscle. We can classify the muscles into several types, one is the spindle type muscle also called as fusiform muscle of this type for example, this is a fusiform muscle. This has fibres of different links are rather fascicles of different lengths because it starts at this point and it ends at this point. Is it not? Because the origin is here and the insertion is here.

A fascicle in the middle will have this much length and a fascicle at the circumference at the edge of this will have this much length. But suppose I was to take the fascicle at the edge and elongate it, you will see because there is this curvature the length of the fascicle that is on the edge will be much longer than the fascicle that is in the middle of this muscle. So, it has fascicles of different links.

Note that all of these will have to produce and transmit forces this is something that we need to remember. So, this has fascicles that different length, so it is a continuum of fascicles. Then you have pennate muscle. Pennate muscles are those that have fibres that are parallel to each other, so the fibres themselves are parallel to each other like this. But the attachment of these fibres is not

directly to the tendon but happens through what is called as an internal tender or an upper neurosis.

In future classes I may use this quite frequently I may say that this is aponeurosis, this is aponeurosis. Aponeurosis means is that attachment to which the parallel fibres independent muscle attach which then transmits this force to the actual external tendon which attaches to the bone. So, there is a difference between this internal tendon or upper neurosis and the real tendon that attaches to the bones.

Because the internal tendon attaches to muscle fibres on one side and attaches to the external tendon on the other side, it does not attach to bones. So, this is a unique feature of pennate muscles and sometimes what happens is these pennate muscles come in many flavours sometimes you will only have this kind of an orientation of fibres. This has only a single orientation this is called as a unipennate muscle uni means only one orientation with respect to the internal tender.

But here you have the rectus femoris one of the big muscles in the thigh this is a bipennate muscle. So, if this is the internal tendon it will have fibres that are parallel to each other attaching on one side and fibres that are parallel to each other but inclined at an angle different from the other side like, this is a bipennate muscle. It turns out that there are many other ways in which this configuration can happen.

Sometimes there are multiple orientations in which these parallel fibres are present in the same muscle attaching to the same internal tendon. If there are many such parallel fibres attaching at different angles to the internal tendon that is called as a multipennate muscles. And one more thing to remember about pennate muscles is that if I sum the forces produced by all the fibres and find that value.

And if I find the value that is transmitted to the external tendon you will find the sum of forces of all the muscle fibres is much greater than the force that is felt by the external tender slightly inefficient system. Why would you do this? Why? Because if I had parallel fibres like this that

go on to become the tendon like this. Then you are essentially having a series connection. So, all the forces that are produced by the parallel fibre muscle will get transmitted to the external tender.

Actually, there is only a single tendon in that case there is no internal tender in the case of a parallel fibre muscle but in a pennate muscle because the internal tenderness attaching to the external tendon in this direction. For example, let us consider a unipennate muscle, this is the unipennate muscle force is produced in a fibre along its axis in other words this is the direction in which force will be produced in the fibre.

The vertical line that I have drawn is the internal tendon and this attaches to the external tendon here for example. Force felt at the external tendon is in this direction. Now you see using our principles of vectors because this muscle fibre force is at an inclination to the external tendon you realize that only a component of the muscle fibre force is felt by the external tendon that the maximum value that can be felt by the external tendon is the sum of the forces that is produced.

That is what is happening in the parallel fibre muscles case. So, if you have some pinnation that means that you will have an inefficient system in terms of having less amount of forces. That is being felt by the system but why do you have pennate muscles that is the question that is something that we will discuss in a future slide. Then you have the parallel fibre muscle I already gave an example this is the case in which fibres are parallel to each other.

And then they transmit the fibre forces to the external tendon or the tendon. In this case there is only a singleton the tendon. Then there is this unique muscle which is a circular muscle that does not necessarily attach to this in the bones it is a circular muscle that contracts opens and closes. And is responsible for many functions including eating including speech different languages, so very unique muscle.

Then you have convergent muscles, muscles that converge that that have very large number of fibres at one end and all of them converge to one set. An example is the pecs, the pectoralis measure the chest muscles producing. These are examples of convergent muscles.

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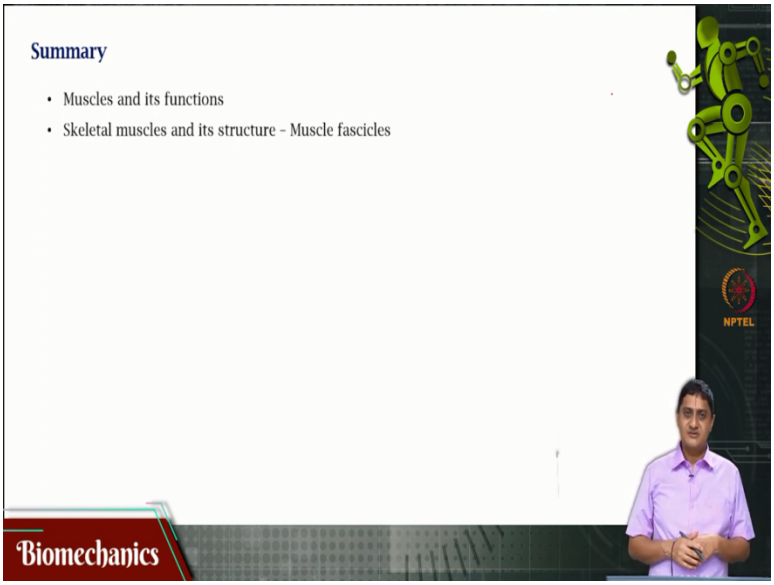

So, in this video we saw an example of various types of muscles. We saw what are muscles and their functions and different types of muscles in terms of whether they attach to the bones or not and within the skeletal muscles these are different types. With this we come to the end of this video, thank you very much for your attention.