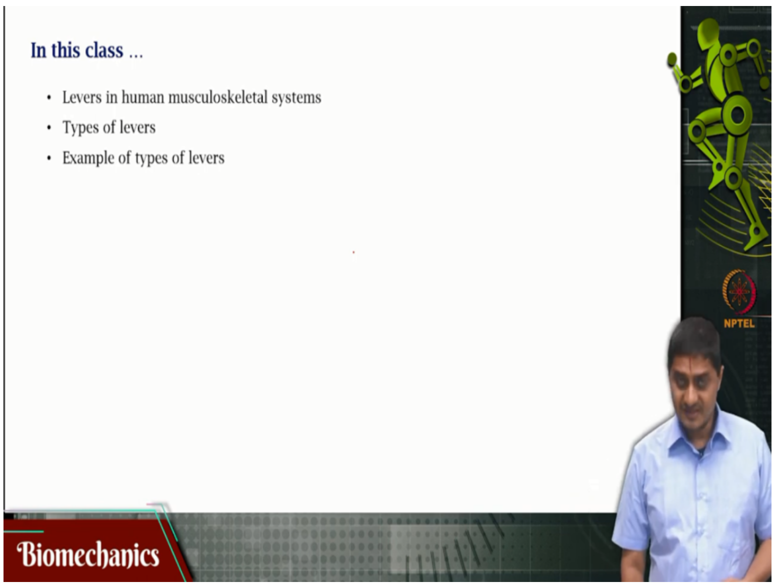
Biomechanics
Prof. Varadhan SKM
Department of Applied Mechanics
Indian Institute of Technology, Madras

Lecture - 06
Levers and Types of Levers

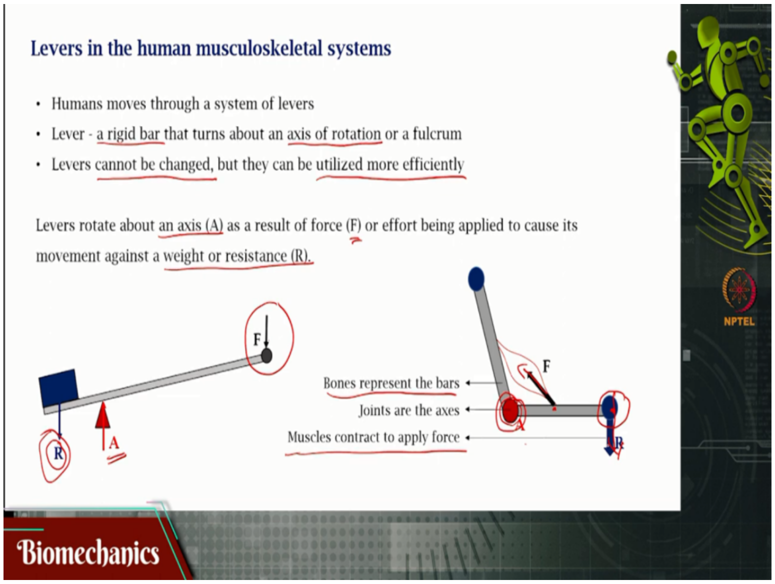
Welcome to this class on biomechanics. We have been discussing introductory mechanics statics and dynamics, so we will continue our discussion on basic mechanics.

(Refer Slide Time: 00:32)



So, in this video we will be focusing on levers in the musculoskeletal system, what are the types of levers, in general what are the types of flavours and types of livers present in the human body in the musculoskeletal system and some examples of the types of livers.

(Refer Slide Time: 00:51)



So, human movements are essentially happening through a combination through a set of levers through a system of levers. A lever is a rigid bar that turns about an axis of rotation or a fulcrum this is something that we know from high school physics. In this case in the human body what is the rigid bar and what is the fulcrum that we are discussing? Well, for the purpose of this discussion for almost all the cases you could consider that the bone is the rigid body under discussion.

So, the bone is a rigid bar that turns about the axis of rotation. What is the axis of rotation? The axis of rotation that we are discussing is the joints about which the movement is happening. For example, our favourite example is the case of the elbow joint I am doing this elbow curls bicep curls I am doing this so that is happening about the elbow joint. So, that is the fulcrum or the axis about which the rotation is happening, what is a rigid body that is making this movement?

In this case this is actually a couple of bones but for the purpose of discussion you could consider this to be a rigid body there is actually two bones radius on ulna that are moving but it could consider that to be a rigid body that is moving about the fulcrum. So, once you have found the lever once there the axis of rotation and the resistance and the force a point of force application are decided, the configuration cannot be changed.

So, once you have formed a lever their configuration cannot be changed. But it is possible for you to utilize it more efficiently by changing the force application or the direction of force applications also so essentially you could try to optimize the function of levers. Levers rotate about an axis in this case marked by A here as a result of an applied force marked by F here this is also sometimes called as effort being applied to it to cast the movement against an external resistance or weight marked by R here.

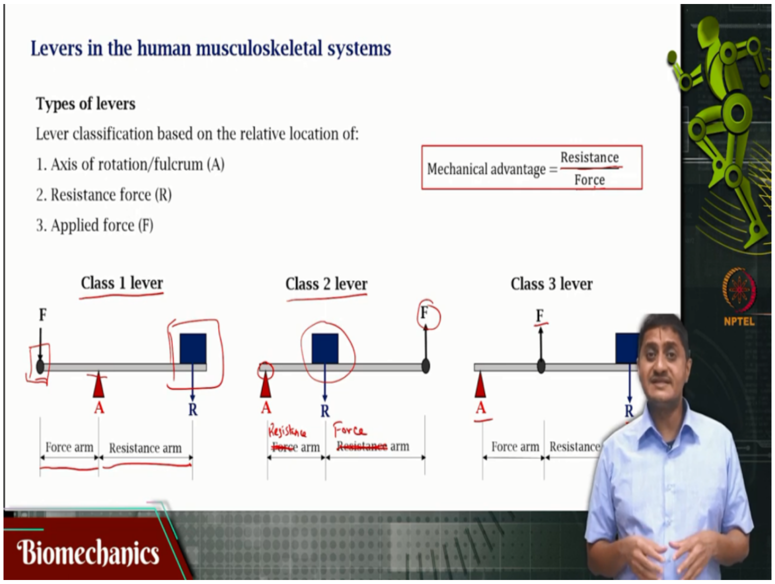
This is the example that we saw in the previous video where we said that a small amount of force applied at this point is sufficient to overcome a relatively large amount of R. Why is this, the case? We said that is because the moment arm or the distance about which the rotation is happening or the distance; from the axis for the force and for the resistance are different and the force have an advantage.

So, the applied force can be less to overcome a relatively larger amount of resistance this is what we saw. So, in this case, here you have a case in which you are having a bone that represents the two bars and the elbow joint is the axis and the muscles that will contract and apply the force. This I am considering this to be the elbow joint but this can be any other joint also. Please note the point of application of this force is here but the resistance is here, is not.

So, axis of rotation is here so the perpendicular distance between the axis and the resistance is much higher than the perpendicular distance between the line of action of force and axis. Note that this might change we will come to that in another discussion this is the line of action of force in this case, this is a line of action of force in this case. So, the momentum is the perpendicular distance between the line of action of force.

Something that could that may change depending on the force that is applied and depending on the mechanical configuration that we are discussing, we will discuss that in the future slide.

(Refer Slide Time: 05:37)



So, depending on the location of the axis of rotation or the fulcrum and the resistance and the applied force levers can be classified into three types, we know this from high school physics but anyway let us refresh this. The case in which the force and the resistance are on two sides of the axis like this a case in which the force and resistance are on two sides of the axis like you have a seesaw that case is called as class 1 lever.

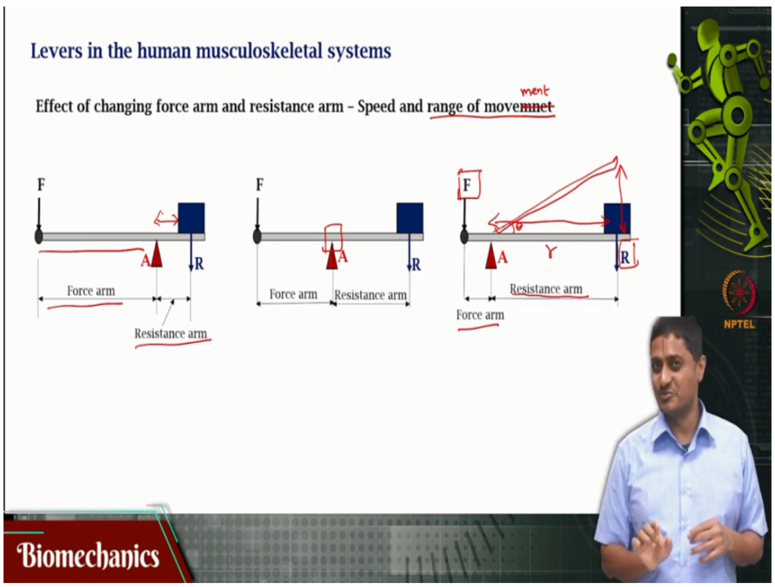
A case in which the axis is on one side the resistance is on one side and the forces and the other. In particular when the resistance is between the force and the axis it is called a class 2 lever and when the force is between the axis and the resistance it is called a class 3 lever many of these things we know from high school. Note the perpendicular distance between the force and the axis is called force arm.

And between the resistance and the axis is called as resistance arm these are the things. And by the way this is the resistance is it not the distance between the axis and the resistance is the resistance arm and the force and the axis is the force it is a small error that I am just correcting. So, types of lever is something that we know from high school but something that we need to remind ourselves of now.

Which type of lever is most prevalent in the human body? There is no such a requirement it turns out that the human body has all these types of levers we will see that in a future slide. What is mechanical advantage? Mechanical advantage is the amount of resistance divided by the amount of force. So, when you apply less force that can overcome a greater resistance that means that the mechanical advantage will be greater than 1.

When you have to apply a larger amount of force to overcome a relatively smaller sized resistance that would mean that it is not a mechanical advantage, in that case mechanical advantage will be less than 1. That does not mean that mechanical advantage itself or is necessarily always a desirable quantity that is not the case as we will see in a future slide.

(Refer Slide Time: 08:44)



Now suppose I have a situation in which I can change the force arm and the resistance arm as per wish, let us consider a simple case of class 1 level and I can move the axis of rotation let us say for example. Now if the axis is exactly in the middle such that the force arm and the resistance arm are equal. In that case an equal amount of force will be required to overcome a specific resistance, obvious no specific.

Now suppose there is a case in which the force arm is much greater than the resistance arm. In this case a smaller amount of force is sufficient to overcome a larger resistance mechanical advantage. But there may also be cases in which the force arm will be smaller than the resistance arm. In this case the system will have to produce a much greater force to overcome a smaller resistance because the system is at a mechanical disadvantage.

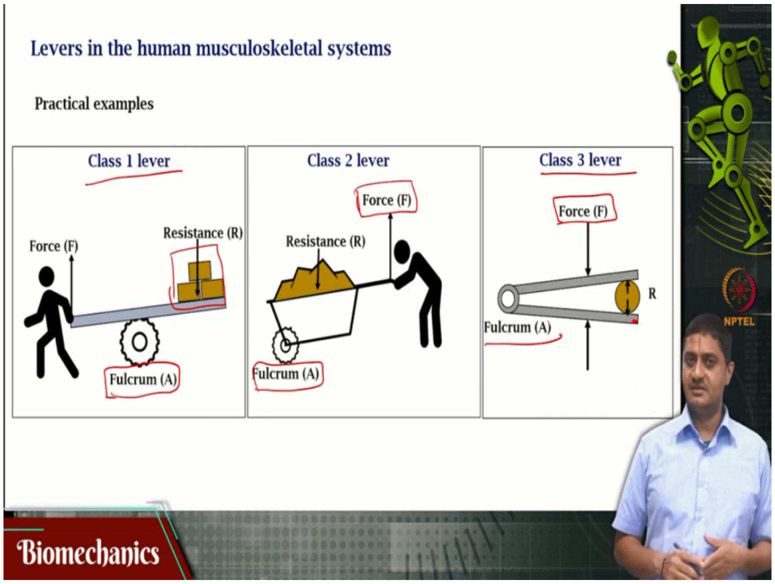
That does not necessarily mean that this is undesirable there are spaces and places where mechanical advantage is a desirable quality. And then there are places where mechanical advantage may not be so desirable. Because this resistance arm in this case is very high a small change in the theta, the small change in the angle let us say a force is produced and this forces as great this force is sufficient to move this resistance.

In that case a small change in the let us say it moves to a configuration like this for example by some theta. A small change in data will have a greater change in the distance by which R can be moved this is the advantage that you get with range of movement range of motion. Also, likewise because this R this distance is greater it turns out that. The speed with which this capital R the resistance can be moved also is higher.

So, in some places there is a necessity for the human body to move faster and further in those places you will be compromising a greater amount of force so you will be at a mechanical disadvantage to have a greater range of motion and a greater velocity speed of motion. In some cases, it is the mechanical advantage that is desired. In those cases, of course because of that reason because of the same reason the range of motion and the velocity of motion will be compromised.

So, you cannot have both a mechanical advantage and a great speed of motion and a great range of motion you will have to choose. So, depending on that specific joints may either have a very large range of motion and a very fast motion or can overcome a very large amount of force but need not necessarily have a large range of motion. So, depending on that the type of lever is chosen.

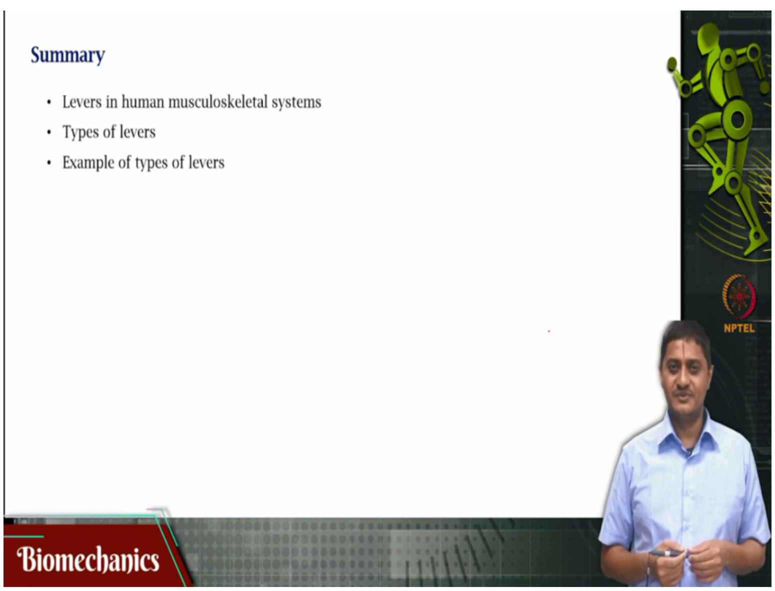
(Refer Slide Time: 12:50)



Let us remind ourselves of some practical examples of the types of levers remember. So, this person is trying to overcome this resistance offered by these blocks and in this case the fulcrum or the axis of rotation. Axis of rotation is between the applied force and the resistance no this is a class 1 lever we know this. The other case is when a person is moving this cart, in this case the resistance is acting between the axis and the force, this is a class 2 lever.

And then you have the case of the nutcracker, in this case the applied force is between the resistance and the axis of rotation, this is a class 3 level this is an a case of the nutcracker.

(Refer Slide Time: 13:47)



So, in this video we have seen the types of levers and the use of levers in the human musculoskeletal system. And some examples of the types of levers and we have seen the use are the application of different types of livers in human motion. Why? In some cases, it might be desirable to have a mechanical advantage whereas in some cases it might be desirable to have a greater range of motion and speed of motion. With this we come to the end of this video, thank you very much for your attention.