Mechanics of Human Movement
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Lecture - 09 Part a
Static Analysis of Elbow- Part I

So, last class we started looking at the how we go about doing Static Analysis, what are the rules, assumptions that we are going to make when we apply the principles of statics to the human body. So, today we will start with looking at doing some Static Analysis on the upper limb on the arms ok.

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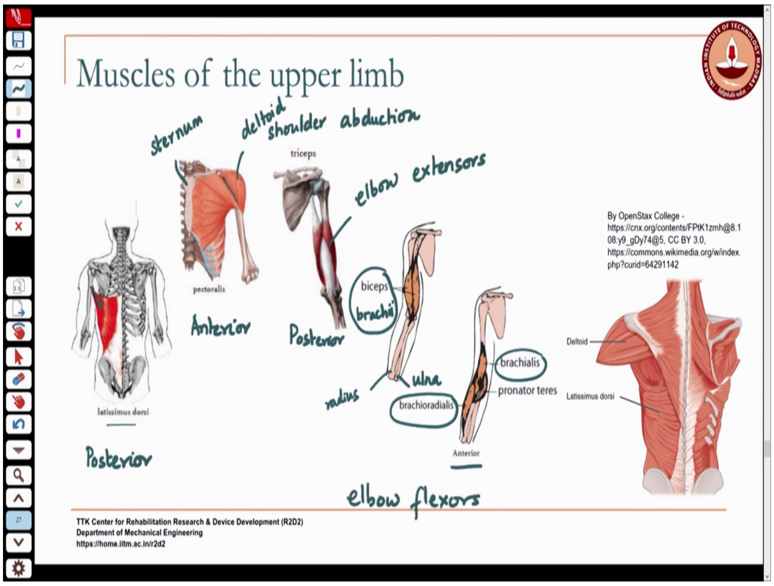

So, we will start off with first looking at some of the major muscles because they are going to be the actuators. So, in your static analysis as we mentioned; we will typically take a muscle.

Our objective would be when the limb is subjected to some external loads known a body segment parameters namely masses of the limbs, locations of CG etcetera. We will then and also the muscle what muscle would be acting on that limb. We would then try to find out what kind of force does the muscle have to apply in order to sustain the external loads that we are looking at.

And what would be the forces that are generated; the reaction forces generated at the joints when such a load is being sustained; so, that is our objective. So, some of the muscles of the upper limb that or the upper body if you look at it you have what view is this; the first one? This where I where you see the latissimus dorsi, can you figure out what view? This is the posterior view remember you can see the posterior view.

So, this is the posterior view; so the latissimus dorsi is one of the muscles that inserts into the humerus. So, the humerus is the upper arm and the lower arm, you have the radius and the ulna; so you have; so if you look at the muscle and you know that it can only apply tension; you can kind of figure out what sort of motions it is going to influence. So, if this muscle contracts what is the effect do you think it is going to have on the humerus? So, it is going to exert; so it is an adductor addition ok.

Based on the view from the transverse plane ok; so, if it is on the inside if it is inserted on the inside and it pulls; then it is going to cause medial rotation. If it is inserted on the outside on the lateral side and it pulls it is going to cause external rotation. So, you can figure out from the way the muscle knowing the insertions the origin in the insertion; you can figure out how it is going to affect the limb to which the muscle is attached.

Then this view, which view is this? This is your anterior view; you can see that you have the pectoralis which is the chest muscles; which go from these. And then this is an important muscle that we will be looking at and this is called the deltoid. So, the deltoid muscle can you guess what movement it would affect at the shoulder? Ok this muscle here the deltoid is that is actually there are three portions of the deltoid muscle the one in the middle affects abduction.

So, it will cause shoulder abduction; this again is a posterior view and for the forum you have the triceps which are the elbow extensors. So, they cause extension of the elbow; the triceps muscle and then in the anterior view; you actually have three muscles which cause which are considered elbow flexors. So, this biceps; the brachialis and the brachioradialis are all elbow flexors. If your forearm is supinated like in your anatomical position; then your primary elbow flexor is your biceps muscle ok, in most other orientations the brachialis actually flexes is the primary elbow flexor.

But if the forum is supinated then the biceps; so, that is why if you are working the biceps you are always carrying a weight like this and working the biceps if you do this you are not working the biceps primarily. So, or you know when they do pull ups; then again it is your biceps which are your prime biceps brachii which are your primary elbow flexors.

So, the full name is biceps brachii; biceps just means the muscle has two heads; it inserts it joins into one tendon, but it originates it has two heads which insert into different places. Triceps again has three heads, here you can only see two because one head is below it is a deeper muscle. Then the pronator here is the muscle that causes this pronation you can see if it pulls on the radius; you saw how it pivots about the ulna, so this is what causes that rotation about that the pronator; yes.

So, this is just some of the basic musculature that you may encounter when you are dealing with analysis of the upper.

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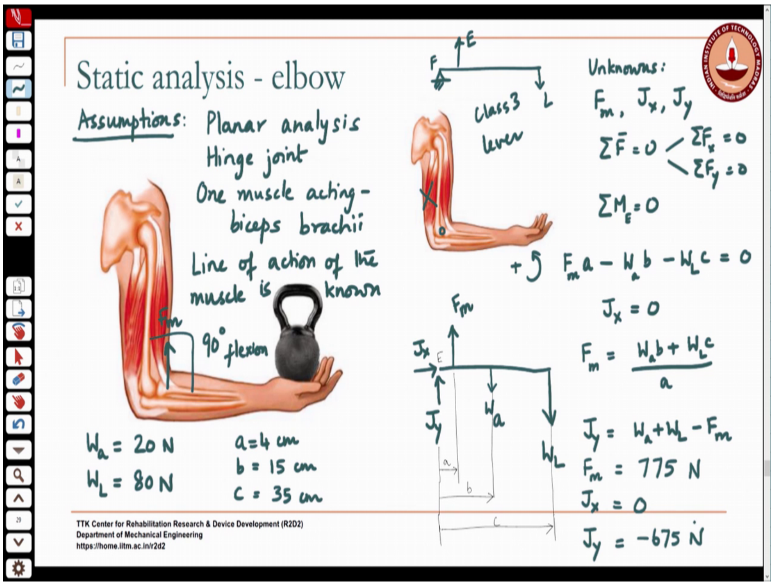

Now, let us go ahead with doing a static analysis of the elbow. So, what are the assumptions we are going to make? It is always important to be assumptions. So, actually if you look at elbow flexion it is here you have the triceps here. So, the biceps are the agonist the; they are the ones you have an external load that is trying to extend the elbow.

So, if you want to hold it in the flexed position your biceps are your agonist and the tricep to happen. So, in most cases we will only look at the agonist muscle; see we want to rest we will do a planar analysis in the sagittal plane ok, we are only looking at. So, we are assuming that the elbow is essentially a hinge ok; we are looking at the elbow as a hinge joint which causes rotation in the sagittal plane. So, we are doing a planar analysis and we are assuming that elbow does not change ok. So, we know a single position, but we are assuming that it is a hinge joint; so it is like a pin oops ok.

So, if you look at the free body; so in this case because it is in the supinated position we assume that. So, let us forget about the triceps for the analysis purpose we assume that only one muscle is acting and we assume that that my muscle is the biceps. So, we are neglecting the effect of the other muscles and also the ligaments, all the other structures. And we assume in this case that say the line of action of the muscle is known.

And in this case, let us assume that the muscle pulls analyzing where the elbow is in 90 degrees flexion. And at this instance I am saying the muscle is perpendicular to the forum; the muscle action is perpendicular to the forum. So, if I draw this; so in this I have if I isolate this I have a pin joint. So, I have a J X and a J Y; which will act at that joint. I have a load W L of the forum. That I assume haps you know I know that distance because that is from the anthropometric data. I know that it acts and in this case we can assume that the forum is uniform. And so, we cancel it of the length of the hump or some other known distance.

And then I am making the assumption that I know that the muscle acts at a particular distance. So, let us say; so this is my elbow E, this is my point of muscle attachment. So, I know this distance, I know this distance let me call it a, call this b and I know where the load acts let me call that c. So, from the elbow these are my distances ok.

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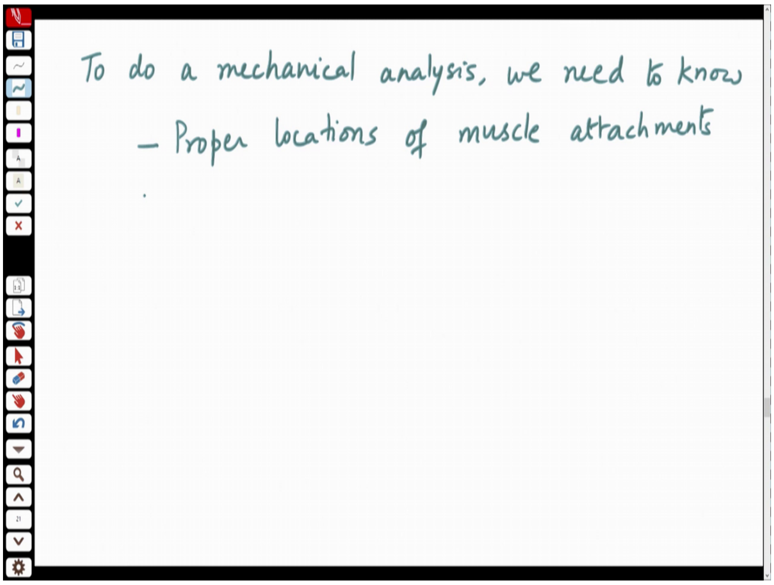

So, now I basically how many unknowns do I have in this free body diagram? I have 3 unknowns, right.

So, I am assuming a particular direction for F m; so only F m, J X and J Y. So, now, I just apply the equations of static equilibrium which would be sigma F equal to 0 which basically gives me two equations sigma F X equal to 0 sigma F Y equal to 0 and then sigma M equal to 0; so, I can take moments about the elbow. So, if I take moments about the elbow J X and J Y are eliminated; so, I have only one unknown.

So, if I let us counter clockwise is positive. So, I have F m a minus W a into b minus W L into c equal to 0. And from this from sigma F X equal to 0, I will get what is the value of J X? J X is 0 in this case because there are no external loads acting along the longitudinal axis of the forum and of course, I can find. So, I can find F m from the first one and J Y will then be equal to W a plus W L minus F m. So, let me now give you some values and I want you to quickly calculate.

So, let us say the weight of the arm is 20 Newtons; which is about 2 kgs; weight of your forearm is about 2 kgs; 20 Newtons, the weight of the load that you are carrying is you are carrying an 8 kg. So, about 80 Newtons and I will give you a equal to 4 centimeter, b equal to 15 centimeter and c equal to 35 centimeters.

Can you quickly calculate and tell me what are the values of F m, J X and J Y; next few classes please make sure you bring your calculators because we will be solving problems. Anybody? 75 Newtons.

Student: (Refer Time: 17:10).

J X is 0, we found that and J Y is?

Student: Minus 675.

Minus 675 Newtons; that means, it is acting in the opposite direction ok.

So, if you see here the muscle force that is developed is almost 10 times the load that is being carried ok. So, and that is because of the small moment arm at which the muscle acts. So, the muscle is capable of developing this large force because in the body; the moment arms are generally pretty small. So, the muscle the force capability of the muscles is pretty high and what you lose you know in terms of having to apply a greater force in terms of the speed.

So, because still acts here right; your external load moves through can move faster. So, that is the compromise that is made in the body, you have to exert not move faster ok. So, and what kind of a lever would this be? Here if you look at it this is essentially a lever you have the fulcrum at the elbow, you have the fulcrum at the elbow.

You have the effort applied and this is your load ok; so this is a class 3 lever in the body. Now this is at 90 degrees of flexion right. So we said to support the load if I am holding my holding the load in this manner it with my elbow flexed 90 degrees this is the even the joints you can see experience pretty high loads ok.

So, this is that is equivalent to a 67 kg load at that joint; so that is. So, our body is capable of handling pretty high loads.

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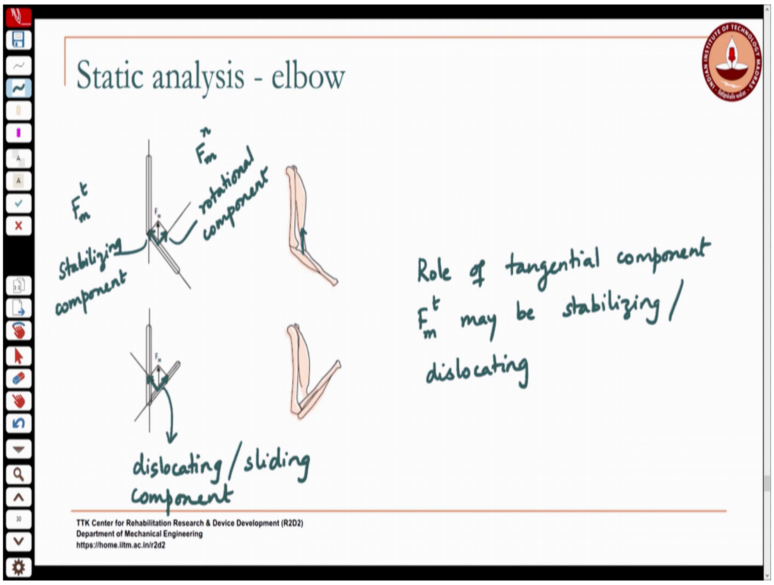

So, if you look at it this angle at which the elbow is flexed makes a difference in the effectiveness of the muscle force. So, if I were trying to hold the same load instead of at 90 degrees flexion at an angle greater than that. So, in this case for instance.

Then the muscle force actually gets, there is a component of the muscle force that contributes to the moment applying the momentum. And there is another component that acts along the longitudinal axis of the forum and that is a force that actually acts to either stabilize. So, in this case if it is flexed like this; if it is flex greater than 90 degrees; the muscle force provides a contributing stabilizing force to the joint, it holds it together; so that is called destabilizing component.

It is trying to push it into the cavity; the two bones together. This component is called the rotational component of the muscle force. Here the assumption we are making is that the angle of insertion is still the same. Whereas, in actuality you will see that as your elbow flexion changes, you can see that the angle of insertion is also going to change ok. And we will see that in another problem, but here let us assuming that this is always pulling in a direction which is vertically ok.

We say that so, the actual angle of insertion with the long axis of the forearm is changing; you are assuming that it stays vertical right in your global system. So, the muscle is always pulling in that particular direction; so you have this rotation. Now if it is flexed less than the 90; then if you look at the components of the muscle force, you see that this component is now not stabilizing the joint, but it is actually dislocating, it is attempting to dislocate the joint ok.

So, it is trying to come apart the joint is trying to come apart when this angle is lower; it is also called the dislocating or sliding component. So, basically the role of we will call this rotational component F m normal, because it is normal to the long axis of the forum. We will call this component F m t tangential; so, role of tangential component F m t may be stabilizing or dislocating.

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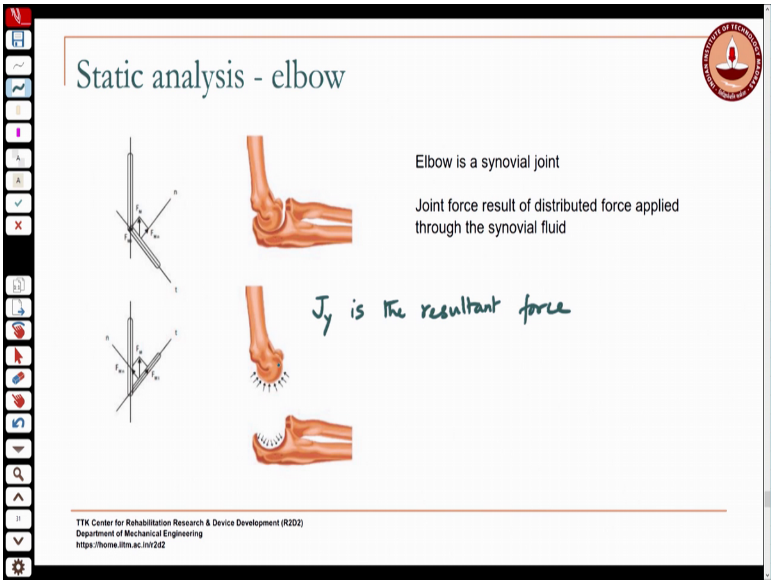

So, if you look at the actual the joint you know; you compute it as a pin joint, you compute it as a net force; we computed F Y right? As acting downwards, compressing the joint; in actuality it will be a distributed force. Because of the synovial fluid present in between the two bones; they are not indirect no it is not a point contact ok. Your, F J or sorry your J; J Y is actually the resultant of this distributed force at the joint contact.

So, in most synovial joints that is what happens; if you see here you know it is like a fluid pressure right you have this fluid it is like a lubricant in between the two bones. If you see here it acts normal to the joint surfaces, but all the horizontal components cancel out in this case you have a net force along the y axis.