Mechanics of Human Movement
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Lecture - 09 Part b
Static Analysis of Elbow- Part II

So, let us say they all are contributing to this particular action. So, I have let me see if I can show you.

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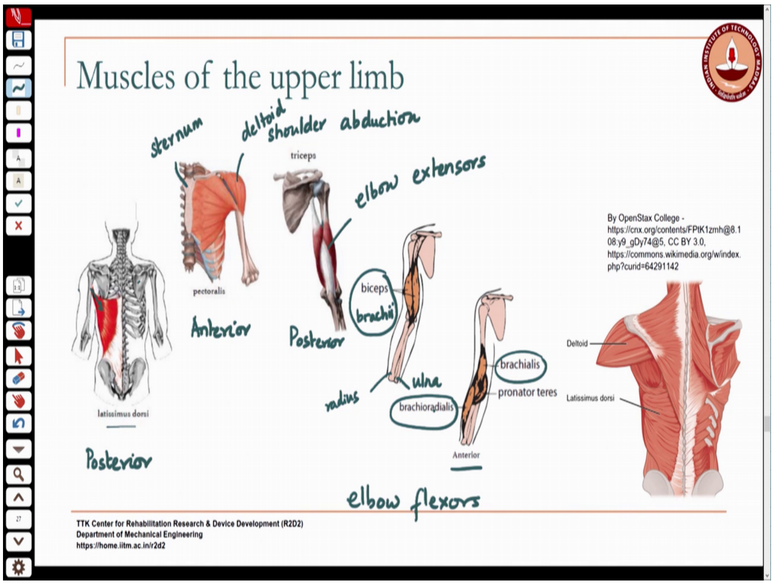

So, you have the biceps, you have the brachialis and the brachioradialis; so, let me try to draw that.

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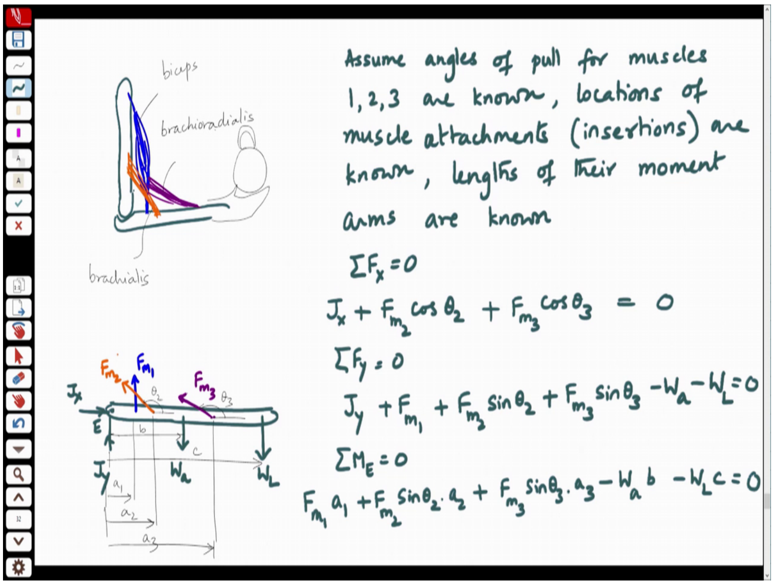

So, if I have just an approximate; so if this is my forearm, then I have the biceps; you will have to use your imagination. Then I have the brachialis; acting something like that and then I have the brachioradialis, which inserts somewhere here ok. And then I have the arm basically carrying the load; so this is the brachialis, biceps and the braccio.

So, now when I draw the free body diagram; I have the elbow, I have my let me use the same F m 2 and then I have F m 3.

Student: (Refer Time: 04:08).

F m no they are not, you can see here the sample the muscle always pulls along that like a 2 force number right when I cut the weight and J Y; I also have the weight of the arm and I have the weight of the load ok; so, again muscles insert are known. And I have to now look at what happens when I write the equations for static equilibrium. So, let us say these are the angles; so this is theta 2; the line of action of muscle and theta 3 ok, from the long axis I know those angles at which they act.

So, assume the angles of pull are known; hence of muscle attachments or the insertion points and lengths of their momentums. So, now if I do J X, F m 1 does not contribute anything to that plus F m 2 cos theta 2. Now I am pick a F m 3 cos theta 3 equal to 0; m 1 plus fm 2 sine theta 2 plus F m 3; sine theta 3 minus W a minus W L equal to 0. And then sigma m about the elbow, if I take that to eliminate J X and J Y all the components axial components will not contribute to the moment right.

So, it is only the perpendicular; the components that are perpendicular there the Y components that will contribute to the moments. So, let us take I have let us say this is a 1, a 2 and a 3 and these are still b and c; the locations of this is b and this is c. So, I have F m 1 3 into a 3 minus W a into b minus W L because I am taking the clockwise moments as negative; c equal to 0.

So, now what are my unknowns in this?

Student: (Refer Time: 09:12).

Something's wrong? So, if I look at these equations.

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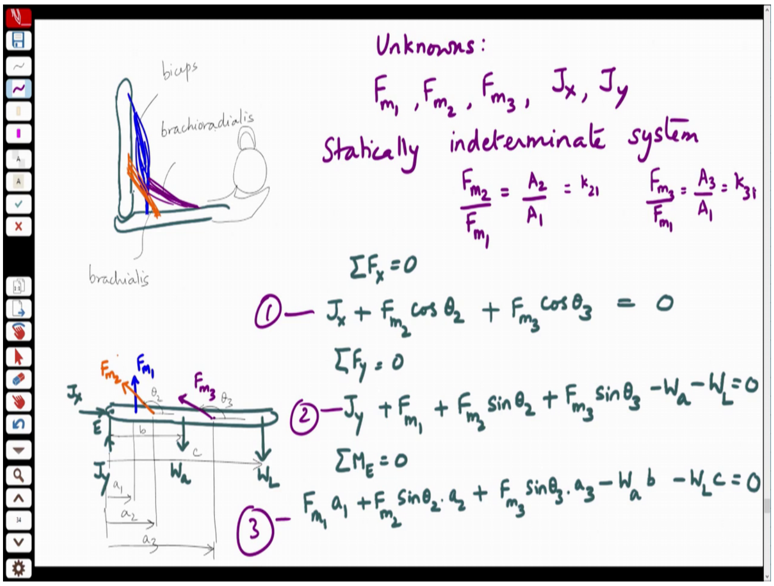

Then my unknowns are I do not know the magnitudes of any of the muscle forces hm, but how many equations do I have?

Student: (Refer Time: 10:08).

1, 2, 3; so, I have more unknowns than equations which makes it a statically indeterminate system. So, there is additional information I need in order to be able to solve the set of equations. So, what are possible; what other information could I use to solve this system? I need some more information I need 2 more relations right something connecting. So, what are possibilities?

Student: Ratios.

Ratios are forces. So, is there a way I can find out how the forces are going to be distributed among the muscles? One obvious way is to based on muscle cross section area. So, I can say that each muscle would produce a force that is proportional to its?

Student: (Refer Time: 11:20).

Cross sectional area right. So, that is one relationship I could use.

So, I can relate then that will give me a ratio. So, I can say F m 2 by F m 1 equal to a 2 by a 1 and I can call this k 2 1. Then I could say F m 3 by F m 1 again or between F 2 and is a 3 by a 1, I call that constant k 3 1. So, now all the muscle forces can be expressed in terms of one muscle force; basically F m 1. And the other 2 muscle forces are only are proportional to this F m 1 based on these constants k 2 1 and k 3 1.

So, with this additional information; I could solve for that. Other ways of knowing are through what are known as EMG Electromyography; basically measures the electrical activity of muscles ok. It will not tell you how much force is developed in each muscle; it just gives you the signal when a muscle is active. So, when you are doing this it will tell you at least which muscles are actually active; they put electrodes on the skin and look at the whether the muscle is active at that instant or not.

So, if you know for instance that a certain muscle is not active; you can eliminate that or if the activity of that it will tell you when the activity starts and stops. So, it will also give you an idea of. So for isometric forces there is some sort of a relationship between the EMG signal and the force that is developed in the muscle it is not true for eccentric and concentric actions.

But for; so for a statics problem like this looking at EMG and correlating that to the ratios in which the forces are developed in the muscles may be to do. So, that instead of using the cross sectional areas; I could look at EMG data; other more sophisticated techniques include doing some kind of an optimization. So, I say that I want these 3 forces to act such that the overall muscle forces are minimized.