Mechanics of Human Movement
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Lecture - 10 Part b
Static Analysis of Shoulder- Part II

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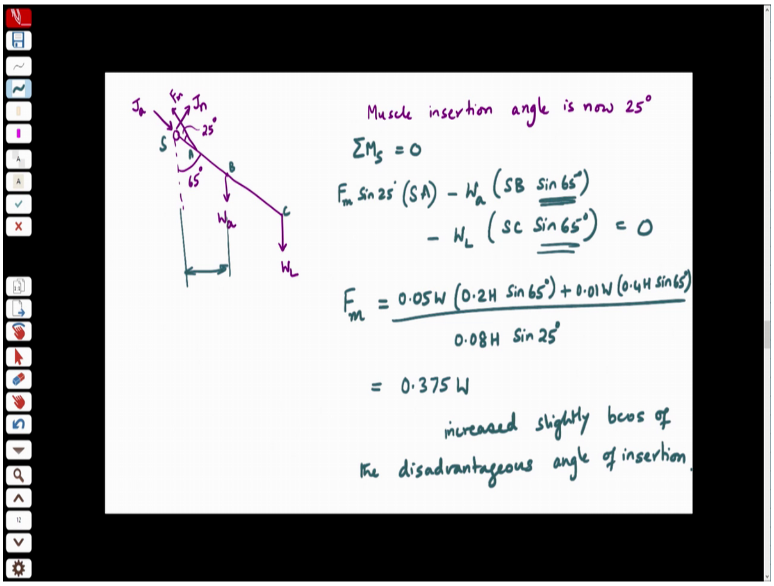

Now, so I have W L; I have weight of the arm, now when you look at joint reaction forces; it is always a good idea to take the 2 perpendicular components along the axis and perpendicular to the axis because you are looking at the dislocating or stabilizing component and the component.

So, you can take this as J a axial component and J n normal component. And now in this position you know that muscle insertions can change the angle changes depending on your posture. Let us say the muscle insertion angle has now changed to in this particular orientation is now 25 degrees ok.

So, the same muscle now it is pulling at an angle of 25 degrees. Earlier it was pulling at 30 now it is pulling it an angle of 25 degrees and this angle here is 65; now, now do the same analysis and see what you have gained or lost. So, let us just say we are looking at the muscle force; so, let us just say sigma M about the shoulder equal to 0.

So, I can write it as F m sin 25 into if this point is A, this is B, this is C; oops SA minus W a into SB sin 65. So, I can just take I can take this load and take the perpendicular momentum to compute the moment about that joint minus W L into SC sine 65 equal to 0. So, essentially if you look at it by moving the load closer ok; you know by changing the angle from 90 to 65; I am reducing the external moment by this much from what it was earlier by sin 65 ok, so I am reducing that.

So, you would expect that perhaps the muscle force would decrease compute it and see what happens and you end up getting 0.16 are you sure? So, I got something else.

Student: 0.37.

Yet 0.375 W; so, whatever advantage you gained by moving the load closer by reducing the momentum of the load, you actually lost because the muscle insertion angle changed; sin 30 was in the denominator earlier, now sine 25 is in the denominator. And that actually slightly increased the load on the muscle right; in reality though this is a simplified analysis, I am assuming only one muscle is acting I have not looked at any of the antagonists for this particular exercise right.

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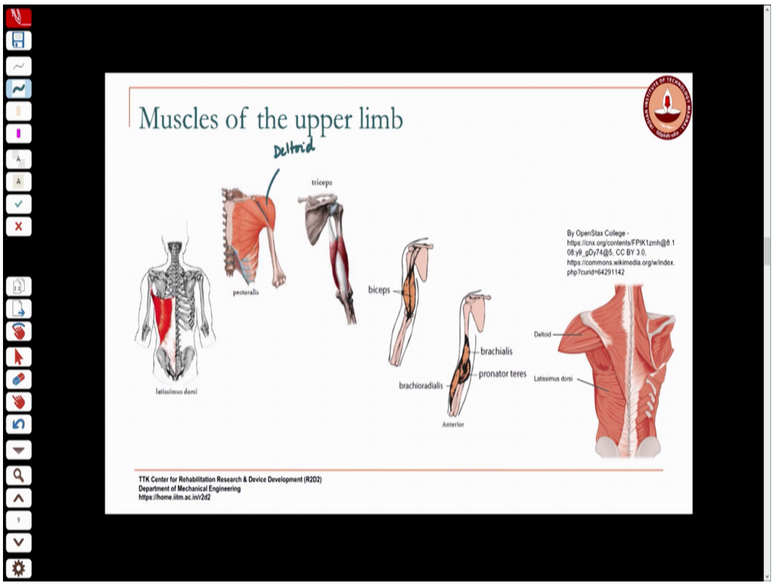

So, it is possible that say if I look at say the muscles like the latissimus dorsi; if that is that is in an antagonist position when I have, but I have stretched it out right. So, that may actually be exerting a greater force when I am holding it up like this than when I am when it is not stretched as much the passive tension in it would be lower when it is not stretched as far.

So, this analysis with a single muscle does not tell me the whole story ok; it just tells me that this agonist muscle ok. Now actually has to exert a greater force because it is angle of insertion has changed, it is an angle of insertion is more disadvantageous now, but unless you do a more complete analysis of you know what are the muscles acting against this particular action this is the muscle causing this or holding it in this position, but there are muscles that are also. So, that that is where you have to go to more sophisticated analysis like the optimization.

For instance where you have multiple muscles and then you decide these are probably going to be. So, this is; so you have to remember that this is an analysis that gives you some insight, but does not give you the true picture completely because it is a model and it is a simplified model, it is a fairly simplified model; so this is the case. Now look at the third situation where, so here it has actually muscle force is actually increased slightly because of the disadvantages.

So, whatever advantage you gained by reducing the momentum about the shoulder of the external loads; you lost because of the disadvantages angle of insertion of this muscle. Now the third situation, you realize that it is too low you know I am the traffic is not going to be able to see it early enough to stop; you now bend your arm at the elbow and hold it up like this hold up the sign like this.

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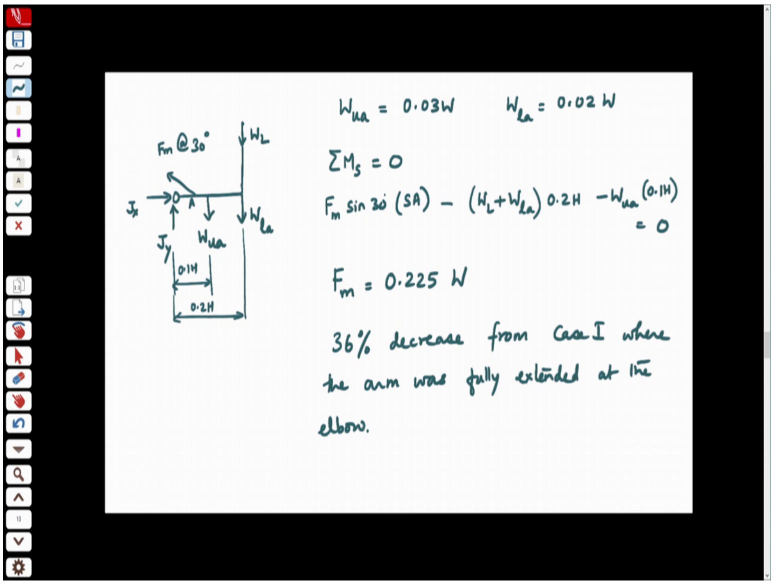

So, let us draw the free body diagram for that case. So, I have the weight of the load, the weight of the arm; the lower arm. So, not the full weight it just the weight of the lower arm is now acting here right; if I bend my earlier hand the full weight of the arm acting at this point, now the weight of the lower arm will be acting here and the weight of the upper arm will be acting somewhere between in the in this.

So, let us say this is now the weight of the upper arm and then I have my muscle force again acting at 30 degrees. Now that my shoulder has come back to this 90 degree abduction I have and then I have J X. And now I have to tell you that initially weight of the upper arm is 0.03 W, weight of the lower arm is 0.02 W. Remember I had given you the weight of the whole arm is 0.05; if you look at the structure the upper arm is generally heavier than the lower up yes.

Student: Isn't the weight of the lower arm (Refer Time: 12:19).

It is acting at that point right.

Student: Yes ma'am.

It is an external force. It is an external force that is acting that is going to have an influence on the force at the shoulder.

Student: (Refer Time: 12:37).

Because, this is not why not consider?

Student: Joint forces are there.

You could do that then you would have an equal and opposite you would have it in the if you just consider the free body from shoulder to elbow; you would still find the effect of this external force as a joint force ok. Say now I do not consider because the joint forces are internal I do not put them in addition to this I am only applying the external forces.

And now let me compute the; so let me say this weight of the weight of the sorry; the length of the upper arm and lower arm are equal right. So, we had here what? What this was.

Student: (Refer Time: 13:46).

0.4, 0.2; so, the weight of the upper arm acts at 0.1 this is 0.1 H and these 2 their momentum is 0.2 H. Now calculate the muscle force again sigma F X equal say if you just want to calculate the muscle force, you can just use the moment equation because that will eliminate 2 unknowns J X and J Y.

So, using the muscle equation I get F m sin 30 into SA. So, what do you get; minus of W L plus W lower arm in to 0.2 H equal to 0.

Student: (Refer Time: 15:10).

Sorry, thank you; minus upper arm in to 0.1 H equal to 0.225. So, you get F m equal to 0.225 times the weight. So, now you see a significant decrease in the muscle force that needs to support this external load. So, this is about the 36 percent decrease from case 1, the first case where the arm was fully extended at the elbow.

So, again here if you look at the muscle force the X component is your stabilizing component or dislocating component depending on the angle ok; is it trying to pull the forearm sorry pull the arm out of the socket the shoulder socket or is it trying to press it in to that and in the case of the shoulder your socket is actually quite shallow.

And the ball is you know you have this ball and socket joint, but the socket is fairly shallow which is why you have a wide range of motion at the shoulder. The range of motion at the shoulder joint is the highest among the joints in the human body. Even the hip the hip is more stable you do not you do not get the same range of motion you cannot do this with your legs; right you can do a lot of the range of motion at the shoulder is much higher than at the hip joint, these are the 2 ball and socket joints that you have and you find that at the shoulder.

It is because if you look at humans we use the arms and our hands for a lot more activities that require that dexterity; that range of motion right. And the loadings on the arms are lower relatively lower than the loadings on your hip and your lower limbs because the entire body weight is being supported by the lower part of your body. So, the arms are actually free to do more things and so, you have the body is designed; so, that you have a larger range of motion.

You have way more degrees of freedom if you count the number of degrees of freedom starting from your shoulder to the tips of your fingers. So, many things you can do; so many degrees of freedom if you look at a person playing a piano; the number of degrees of freedom they are coordinating to accomplish that task it is mind boggling really.

So that is, but because the shoulder is also you know shallow and it is also more susceptible to injuries. So, if it is easier to dislocate dislocating your shoulder is much easier than dislocating your hip. So, if you carry too much load in a position where it is likely to you know or if someone applies a force; then the muscle force is actually contributing to the dislocation, then the chances of shoulder injuries become higher. So, what you gain in motion you lose in stability.

So, it is not a very stable joint; so just for just look at the range of motion.

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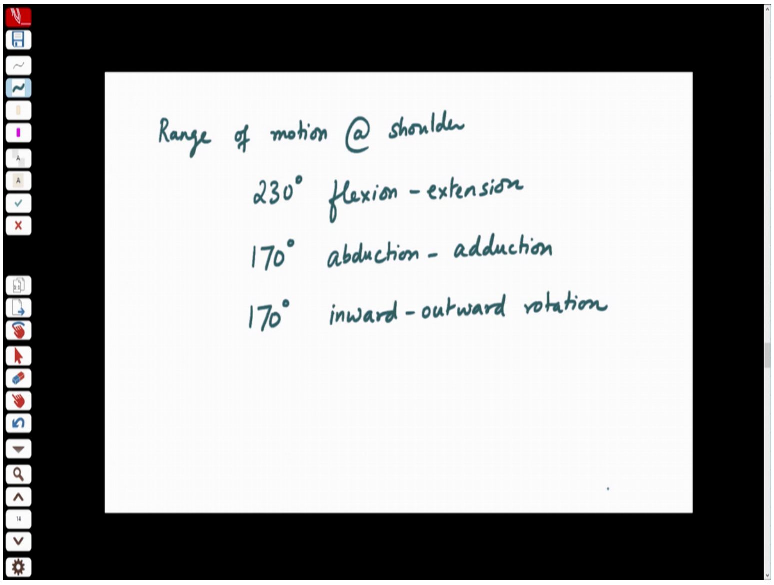

If you see the range of motion at the shoulder joint; you have 230 degrees of flexion extension, you have 170 degrees in abduction, adduction and another 170 degrees of inward and outward rotation ok.

Student: (Refer Time: 21:21).

The other ligamentous structures and the muscles, the capsule, the connective tissue around it; so if you had a skeleton without all that you just had the joint, you will probably be able to make it go the full round ok. Any questions?

Student: (Refer Time: 22:04).

So, that is basically by you know when you can produce more motion.

So, in your case itself if you do not perform a certain type of activity; you feel stiff and then slowly if you practice that you start stretching the soft tissue and the muscle and all that right. So, in the case of you know when where they train for flexibility right; they work on their muscles and their soft tissues to achieve that flexibility. So, that in some people you know you have their joints are such they may be like this double jointed, you may have seen you know they can actually move their arms and ways that most of us cannot move. So, there may be some difference in their structure which enables them to do it.

See it is essentially 2 2 bones meeting at a joint and then you have all these things that are surrounding that joint. So, how they and in the end it is all living tissue in some sense right; it is all the muscles, bones, ligaments everything is living tissue that you are talking about. So, in the human body essentially its use it or lose it. So, if you have if you do not use a muscle. So, if you have a fracture for instance why do you need to go into therapy you know if you have not used a certain set of muscles the muscles actually start shrinking it is called atrophy they start shrinking.

And then; so then you have to go through an exercise program to actually start building the strength up. So, if you are you know if you have some health problem and you are bedridden for some time you cannot suddenly just get up and walk because your muscles have become week. So, you need to build up the strength it is the same thing with flexibility everything it comes from doing what doing something repeatedly.

If; if you do yoga the first time you are not going to get the same range of motion that you get at a particular joint right, but if you keep practicing it if you keep stretching; every time you stretch a little bit more the soft tissues will allow that and that is how you gain flexibility ok. So, it is possible, but most of us in normal activities of daily living do not really push our muscles are usually operating at the very low end of their capabilities.

We are not pushing our muscles to the extremes that they are capable of; you see the ones that are pushing them are like the athletes, the weight lifters you know when you look at that most of them are started out like us right; everybody starts out as children becomes adults and, but you can change the structure of some of these by your diet by the appropriate exercise etcetera. So, concentric actions eccentric actions you know different.

So, when you look at strength training itself is a very fascinating area and a lot of people do research on how best to build up the muscles so that they can exert the kind of forces you need to know. You cannot do it if you if you just go and start lifting a load you are going to injure yourself pretty badly because, but it is something that you can build up to. So, that is why it is a gradual building up that happens a person does not become a weightlifter in a day; it is the muscles have to be trained to do that. A gymnast does not become a gymnast in a day, a ballet dancer does not become one in a day.

You know they the ballet dancer supports their entire weight on the toe ok; most of us will not be able to do that it comes from and if you see their foot it is it is plantar flexed so much that is something that most of us would not be able to achieve that kind of range of motion. So, when we talk about this range of motion; we are talking about in normal you know without really doing anything special.

What is the range of motion that you can; this also changes with age as you get older your muscles you know the composition your body composition changes muscle compositions change. So, if you look at a scan of a muscle of a 50 year old versus the muscle of a 20 year old; you will see there are differences in that that is the normal process; that is the normal process of aging and growth. So, you grow up to a certain point then your body starts decaying whether you like it or not.

You can you can maintain it at a certain level because of what you do; which is why exercise and all that is important. But in the case of the body it is very true that if you do not use something you lose it the body just assumes you do not need it and says let me die, but it is something else ok; so, it is very important. So, when physical activity is important for that reason because and it is important even when you are young you know; good diet physical activity all these are important even when you are young because that is going to determine how fast your decay is ok.

And also of course, the habits that you develop will stay with you. So, it is very important that you take good care of what you have been given. So, that you can put it to use and so that it will serve you well for your lifetime alright.