Mechanics of Human Movement

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Lecture – 11 Part a
Static Analysis of Spine- Part I

So, we looked at the analyzing the mechanics at the shoulder joint, and in that problem you may have noticed that I had given you many of the dimensions in terms of the body height and the body weight ok.

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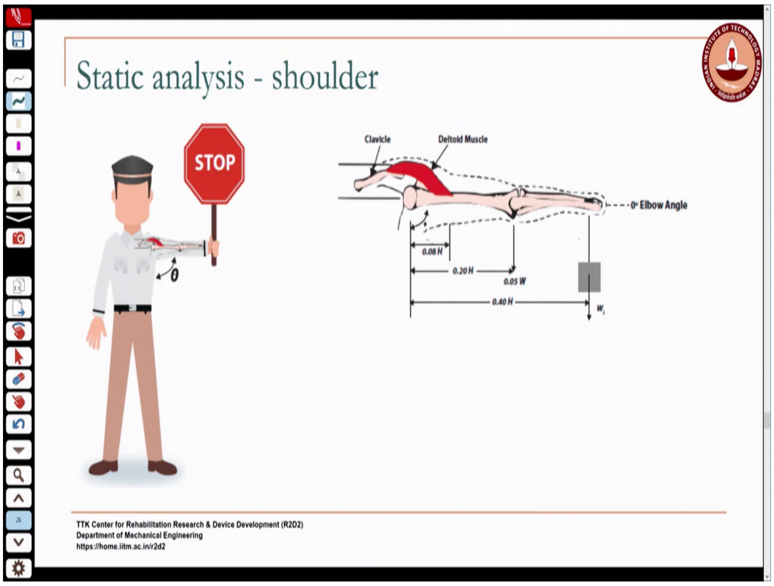

So, the mass of the segments, also the muscle insertion points, cg of the segments, these quantities were all given to you in terms of the body weight and height so, in terms of W and H.

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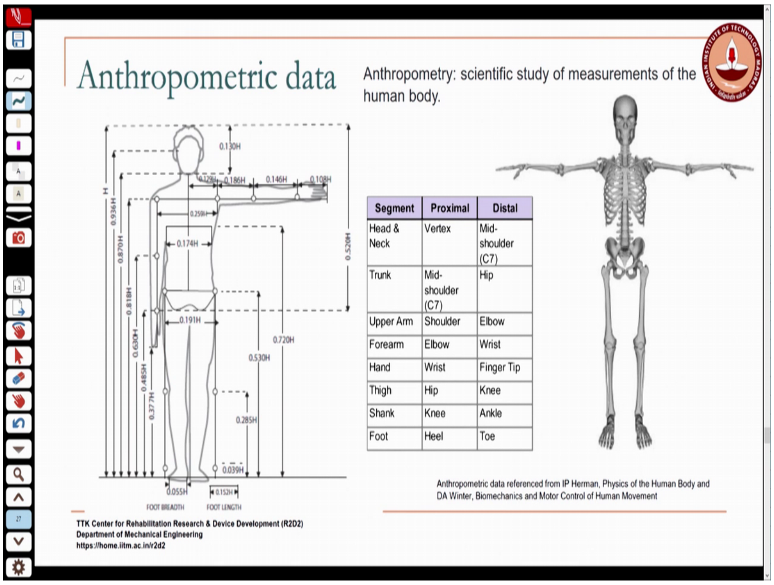

Now, there is actually this kind of data is called anthropometric data, anthropometry is basically a scientific study of the measurements of the human body. So, people have taken done experiments with cadavers or with life pill and try to estimate come up with some kind of a statistical numbers for this body segment parameters. So, you have so, they define various segments in terms of a proximal point and a distal point ok.

So, the vertex would be the top of the head. So, the head and neck if you look at it and the distal end would be your C 7 vertebra. So, from the top of the head to the C 7 vertebra is your head similarly if you tie is defined from the hip to the knee and these segment lengths are all then computed analyzed statistically for a certain population and then you have values that you can use.

So, this anthropometric data is also very useful as a designer things to be used by people right you want to know what is a good angle for me to look at, you know what is the right posture for me to be sitting at when I am looking at a computer screen for instance. If I am pressing buttons or you know how much force can I apply you know what distance, what is my range of motion had different joints product designers use when they are building things you know for this sense ok, how much of a push can you exert in what position, you know if you are sitting what are the dimensions when you design seats.

How much adjustability should you give or what if what would be how would you design the seat. So, that a person has the right posture. So, these are the sort of people and of course, in biomechanics when you are looking at the mechanics you need masses, cg locations, moments of inertia of the various segments;, these are all parameters that you require, when you are doing biomechanics as well as when you are designing products.

So, anthropometric data is very useful for this sort of unfortunately a lot of data that is available is only for a Caucasian population like for instance the Indian population there is really not a database of anthropometric data available and as you all know our body structures are quite different from most Caucasians.

So, in many cases we are kind of you know trying to use that data, but which is not ah, but eventually hopefully has more people start working in biomechanics we will start generating that data for our population. So, for instance in the us then NASA is a big has a big repository of anthropometric data they need they have these measurements for various quantities.

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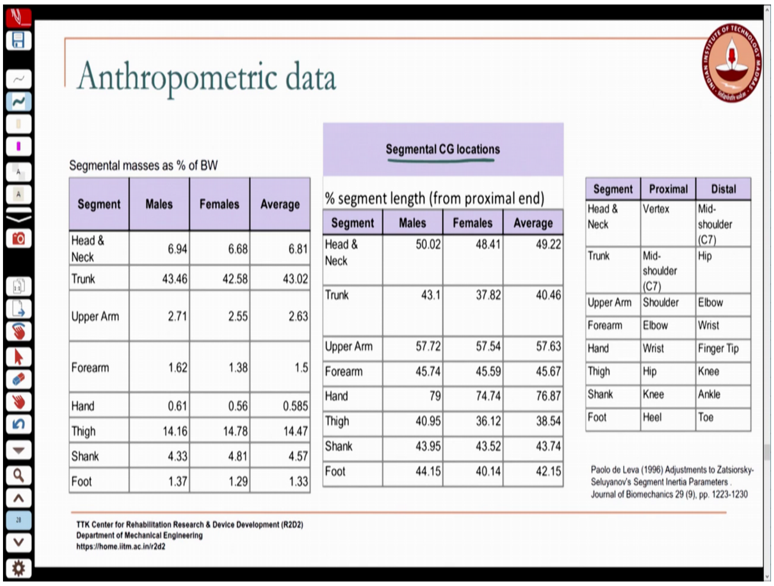

So, in addition to body segment length you have segmental masses and again these are all normalized in terms of the body weight of the person. So, that you can say that if a person has a certain body weight this is likely to be the segmental mass. So, it is mass of the femur or mass of the tibia this or actually mass of the hand because you are actually looking at the whole you know with the muscles and everything not just the bones when we talk about the segmental masses, we are talking about their masses as a whole including all the structures inside not just the skeleton ok.

So, when we talk about the tie we are talking about the femur all the muscles, ligaments, etcetera everything included then if you look at the segmental CG locations, these are usually specified as a percentage of the segment length. So, you have the segment lengths you have the segment masses and then the segment the CG location is given either from the problem then; obviously, it is at 50 percent of the segment length the CG will be at midway between the proximal and distal ends which is what we assumed for the previous problem.

We assume that both you know this is point extended 0.4 times 8. So, this is so, you would refer to such data. So, if some data is not available so, in the previous problem I gave you everything that you needed all the distances all the masses. Typically in a real life problem you would not have that data you would just you may just know that this is the external loading for this particular case.

Now, then I would from the person's body height and body weight I would try to estimate I would go to these tables this anthropometric data tables and then find you know for the segment of interest what would be the mass, what would be cg location etcetera and then move towards solving the problem. So, everything will not be given to you, you would have to go access that data from other segments definite segmental masses and we need the insertion points those are also part of anthometric data that ok.

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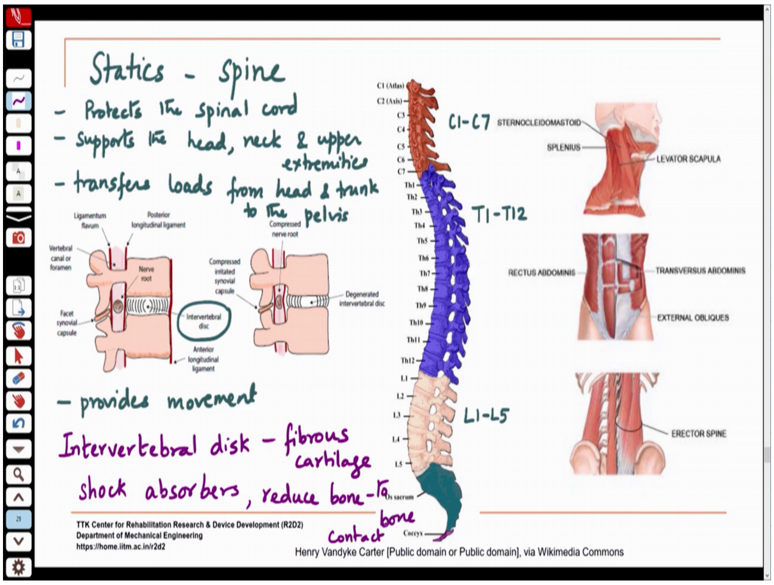

So, now, we move on to the statics analysis of the spine the spinal column we looked at the elbow the shoulder and now we are moving to the spine of the body. So, you have seen the structure earlier you have seen that you have 7 cervical vertebrae C 1 to C 7, we have 12 thoracic vertebrae T 1 to T 12, and you have 5 lumbar vertebrae and then the sacrum and the krawczyks ok.

So, these form your spine, now you can see that if you look at each of the discs you look at then you see that they get progressively thicker and larger as you move down the spine. Now the reason for that is they are bearing more and more load as you are moving down the spine, all the load that is above that portion is being transferred to the lower body and to the ground through this vertebrae.

So, if you look at and if you look at the so, what are some of the functions of the spine. So, if you look at these spinal column it essentially protects the spinal cord runs through this cavity in the you have these discs stacked together in each you know there is a hole through that and the spinal cord runs through this cavity created by these discs stacked together ok.

So, it is protects the spinal cord it supports the head neck and the upper extremities, it basically transfers the load all the proximal loads to the pelvis and you can also it enables you to perform a variety of movements with the trunk. So, the vertebrae these individual units the bones are separated by what are known as the intervertebral discs.

The intervertebral discs are basically fibrous cartilage you remember when we looked at the type of joints we talked about these which allow a limited amount of movement and these basically provide act as shock absorbers they keep the discs separated and they are flexible. So, they act as shock absorbers for this loading and they basically eliminate the. So, you can see the disks progressively get larger because larger load is transferred and they act as shock absorbers in this system shock absorbers and they reduce bone to bone contact.

And so, because they act as shock absorbers they reduce the effect of impact forces on these discs because if you have 2 rigid bones subjected to an impact force, you could do a lot of damage so, these discs basically act as shock absorbers. It is fibrous cartilage it is fibrous cartilage it is ok. So, these are some of the major muscles so, you have in the cervical spine you will have next neck extensors and flexors which connect to the base of the skull ok.

You have muscles that connect to the base of the skull, then in the anterior are parts of the spine you have the abdominal muscles which help to flex the trunk both lateral flex reflection as well as sagittal plane flexion and then you have in the back. So, you these are all pairs of muscles you know here only one side is shown they showing one side, they are showing the surface muscles and then the deeper muscles in this figure and the major.

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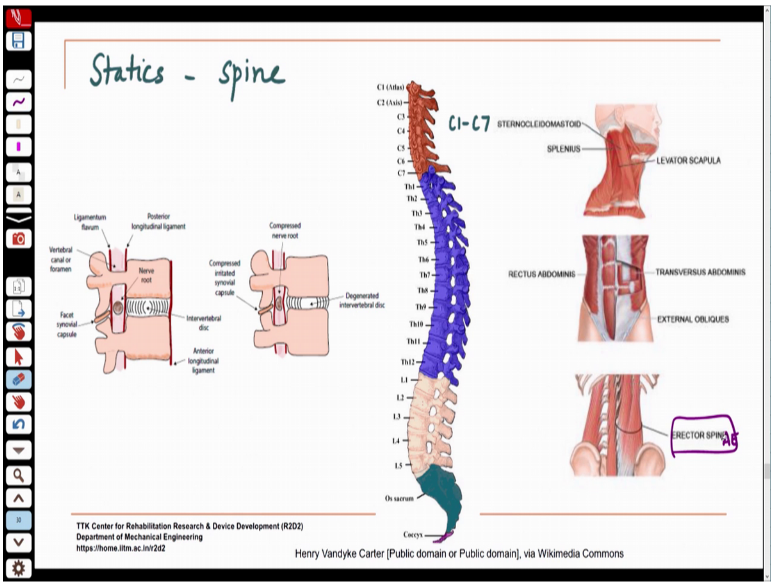

Muscles in the back are what are known as the erector spinae

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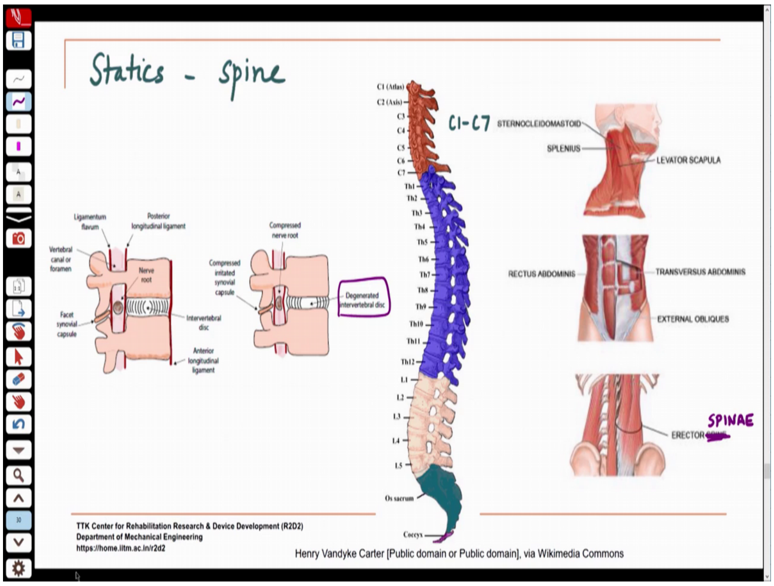

These are the muscles in the back which are responsible for extension of the trunk and which are basically acting to prevent your trunk from falling forward due to gravity ok. So, these are your back muscles, they run along the entire length of the spine and that is what is keeping you erec that is why it is called the erector spine.

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These yeah when you are subjected to yeah, but yeah to the.

Student: (Refer Time: 14:53).

To gravity yeah only in the lying position they would be relaxed, if you are in the standing position to maintain your posture they probably because it is a very delicate balance right, you have such a small base of support your feet from such a small base of support. So, any swaying is trying to destabilize my body so, these muscles are what are keeping me erect ok.

So, sometimes if these discs get affected. So, if the spine is subject why is it important to study the mechanics of the spine you know. So, we are going to look at bending tasks, lift things tasks, you know because these are the sort of activities that really load your spine and why is that important, why is it important to know, how it loads the spine, because if you overload or if you subject it you know if you damage.

For instance the discs ok, then you are reducing the shock absorbing capacity and also if the discs because the discs are flexible they kind of bulge out and then you have the spinal cord here and then, you could actually impinge on a nerve and that is very painful. So, a lot of back pain happens because of this kind of impingement because of damage to the discs you may have heard of slipped discs.

Say that if the force along the spine is too much then the discs may bulge out or even slip between 2 of the vertebra and then it starts intruding into the space where the nerves are and if it impinges or compresses a nerve root can be very very painful. The other kind of the other kind of injury that can happen to the spine is a vertebral fracture.

So, the bones could actually crack if there is a you know if in a car accident or something like that you have heard of spinal cord injuries right. So, that could be the vertebra may fracture, it may affect a nerve and you may lose all sensation you know below that region which does it that this signals travel through that spinal cord. So, it is very important that you protect your spinal cord.

So, depending on the level of the spinal cord injury you could have the consequences could be very different ok. If you are talking about the cervical spine even hand function goes away trunk control is affected. So, the lower the spinal cord injury the better of the person will be because more of their functions, but anywhere even in the lumbar vertebra you lose your lower limb function ok so, everything below that control of that becomes affected by a spinal cord injury.

So, the discs and ligaments by virtue of their shape provide intrinsic support to the spinal cord and the external support is provided by the muscles by the muscles contracting around it and keeping things.

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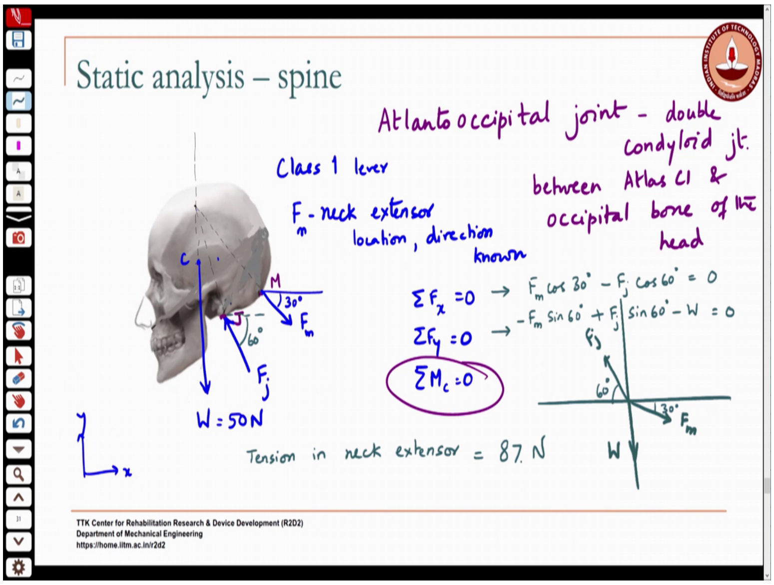

So, let us start off with the top of the spine. So, you have your head which is which connects to the spine by means of does anybody remember what joint that is Atlanto occipital joint, it is the joint at the base of your skull with the first cervical vertebra.

Does anybody remember what kind of a joint it is.

Student: (Refer Time: 19:30).

It is no that that is it that is enough that is the Atlanto axial joint that is between C 1 and C 2 it is not between the pivot joint. So, this joint is a is actually a double condyloid joint, it is what I loves this and this motions in the frontal plane and this saggital plane ok.

What you are talking about is the atlanto axial joint which is the pivot joint which allows the head rotation ok. So, this is the joint double counted joint between the atlas which is C 1 and the it is called the condyloid sorry occipital bone of the head. So, essentially you can think of it as a hinge joint for a sagittal plate analysis. So, let us see what sort of forces need to be exerted so, again your head is pivoted. So, you have the joint somewhere here ok, you have the muscle attachment somewhere here ok.

Now, I want to know so, I have the weight of the head say acting somewhere like this now what kind of a lever system does this form. So, the force applied by the muscle would be something like this ok, be pulling on the back of my head to keep this is a leaf, what kind of a lever is this? It is a class one lever you have the fulcrum the joint is the fulcrum.

So, it can pivot about that so, you need this is your load this is your effort right. So, it is a class 1 lever now. So, there are 3 forces acting on this body I have a joint force, there is going to be a joint force at this that is I am assuming there is one muscle acting the muscle is the neck extensors ok. I am assuming I can say it is the resultant of all the neck extensor muscles neck extensors is the muscle force it is acting then I have the weight of the body.

So, again static equilibrium if I know the, I should know the angle at which this muscle acts say oops. So, let me give you some. So, what do you know about F m, I know the location where it adds and I know the direction in which taps ok. So, this is something I could find from anthropometric data. Then let us say the head base 50 Newton's and let us say the CG of the head is at this point C we know that as well and let us say F m acts at 30 degrees to the horizontal.

Now I have an F j so, this is a 3 force system. So, I could always also solve it. So, I could use my usual sigma. So, I have let us say F j acting like this I can do a sigma F x equal to 0 sigma F y equal to 0 and sigma m about some point equal to 0 or because it is a 3 4 system and these forces are not parallel there is an easier way that I can find the direction of F j because I know the direction of F m I know the direction of F w.

So, I can just the 3 forces have to pass through the same point. So, my F j the direction will essentially become will pass through, along the line joining the point of intersection. So, if this is this and this is j then my F j is along this point my j the direction of F j becomes determined. Essentially what am I doing, when I use the 3 4 system when I say they form a 3 4 system I am essentially using this equation. I am saying if all the forces pass through a point then I am basically just using up the moment equation.

So, then with this now I know this angle theta. So, if I have W and let us say I know F j. So, I can basically just apply these 2 equations and find the joint reactions and the muscle force. So, then if you can quickly let us say for this particular case we find out that this is now making an angle of 60 degrees to the horizontal let us say let us say this is 60 degrees this is 30 degrees ok.

Now, can you quickly compute what the tension in the neck extensor muscle will be, this gives me ok. So, that is.

Student: 87.

86 87. So, your neck extensors again it is just to keep your head erect it is exerting a tension of about 87 Newton's to keep it from falling forward.