



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

Lecture – 31
Spine Anatomy and Movements

(Refer Slide Time: 00:31)

In this class...

- Anatomy of spine
- Movements of the spine

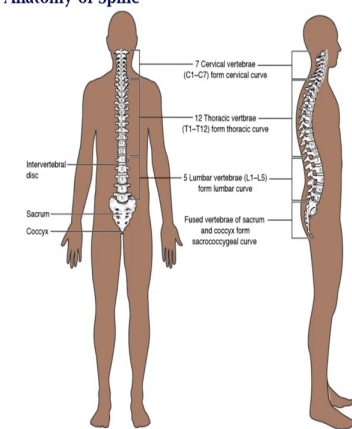


Biomechanics

Welcome to this video on biomechanics in this video we will be looking at biomechanics of the spine; spine by mechanics. So, in this class we will be looking at the anatomy of the spine and the movements that happen in the spinal moments of the spine.

(Refer Slide Time: 00:43)

Anatomy of Spine





33 vertebrae

- 7 cervical vertebrae (C1-C7)
- 12 thoracic vertebrae (T1-T12)
- 5 lumbar vertebrae (L1-L5)
- 5 fused sacral vertebrae
- 4 fused coccygeal vertebrae

C1 (Atlas) → Supports the skull and forms the atlantooccipital joint with the occipital bone.

C2 (Axis) → It forms the atlantoaxial joint with the atlas. Primary movement of this joint is axial rotation.

Vertebral Column, <https://openstax.org/books/anatomy-and-physiology/pages/7-3-the-vertebral-column> (Accessed on 20th Dec 2022)



Biomechanics

So, what is the spine it is a set of individual bony structures 33 in number that are attached together that are separated but at the same time also are attached between which there can be small movements but within them there cannot be movements. So, each of this unit which is a bony structure is called as a vertebra, vertebra in singular vertebrae in plural right each of this 33 vertebra or vertebrae within which there can be no movements between them there can be a small amount of movement.

Although a small amount of movement only is possible between this vertebrae because there can be movement across several vertebra at the same time all these moments combined together to produce a net moment that is very visible and sometimes substantial. So, we will start with understanding of this. What is the purpose of this vertebrae this set of bones or this column of vertebra that are present in the back is called sometimes vertebral column right.

What is the purpose of this vertebral column? There are some two three purposes for this vertebral column. One purpose is to support the head in particular in humans because we walk with the bipedal stance that is we walk on two legs and our hands or the upper limbs are free they are not used for walking unlike quadruplets they are bipeds because of this reason the head is you know held at the top not just that.

And because in humans proportional to the body weight the head is very heavy proportional to the body weight when compared with other animals this is true because they have a human server very big brain right. Because of this reason the head is very heavy there is a need to support this weight of the head how if because if you do not support the head then the head will fall down right fall down inside the thorax right fall down inside the thorax that is not a desirable situation.

So, you will have to support the head. So, one primary purpose of the vertebral column is to support the head and the neck and other such structures supra you know structures at the top right. And also while you are supporting the head and the neck you also want to allow for movements of the head and neck. For example you can watch in the sagittal plane I can make that this is that moment I can also make that moment lateral flexion extension that moment.

I can also rotate my head like this these moments are also allowed. So, you want to support while at the same time you want to allow some movement of the head right. So, this is

achieved by the presence of this vertebral column by this system. Also another purpose is to provide protection for the nerves that are coming from the brain and that supply information and take information to the brain that is up that essentially this set of nerves.

Supply information or commands to various parts of the body and also receive information about the state of the body for example from various nodes back to the brain. This information goes through a set of nerves that pass through a very safe cannot do it or a very safe hollow path right a hole within which they pass what is the purpose. It is like this pipe you consider this rigid body which is the pipe.

If you have seen electrical if you have seen electrical connections at your homes you will see that the electrical cables are going inside plastic pipes what is the reason what is the reason for the electrical cables to go inside the plastic pipes to protect them to protect them from the elements maybe because of environment the electric cables might be affected or maybe some small animals like rodents might bite them which might cut the electricity for example.

Because of various such reasons to protect the cables you provide a conduit or you provide a rigid body support within which the cables can go the rigid body itself is not conducting electricity but this cable is conducting electricity this is a flexible cable this is the nerves that pass through within the vertebral column. So, the vertebral column is relatively rigid right not rigid between vertebra that is something that we will discuss right.

Within each vertebra it is made of bones each vertebrae is essentially a bone that is a rigid body relatively rigid when compared with the nerves itself that is a need for this nerves to be protected. So, for that purpose you have this protective conduit within which these nerves travel. So, the spinal cord or the vertebral column essentially provides a housing within which the nerves can travel nerves or the spinal cord can travel down to inferior structures.

Inferior means not something that is inferior in quality inferior in technical language from the viewpoint of biomechanics means something that is located at the lower side of the body. Inferior means does not mean that it is bad superior means does not mean that it is good. So, period means it is at the top environment something that is at the lower part of the body. Technical language not English not just English a bit more than that.

So, coming back there are two major purposes of the vertebral column one is to provide support essentially to hold the weight of the head and the neck. Why is this important especially in humans remember we said at the beginning of this course this is a course on human biomechanics especially in humans holding the head in this particular position high especially in bipedal stance is a very critical biomechanical task.

Considering that the weight of the brain weight of the head with respect to the body weight is very high this is essentially a very challenging biomechanical task right that is one purpose. Head and the neck will must be supported then also in addition provide a safe conduit safe rigid body cannot do it for the flexible nerves of the central nervous system from the brain to provide command and receive information from the rest of the body these are the two major purposes of the vertebral column.

So, in this vertebra, there are how many we said there are 33 vertebra of which seven are located at the level of the neck these are called C1 to C7 C refers to cervical vertebra cervical vertebra there are seven of them and there are 12 vertebra at the level of the thorax; thorax means chest and the back for example this part of this thorax. And five vertebra lumbar vertebra right L one to L five.

Now thoracic vertebrae are named T1 to T12 and there are five vertebra that are attached together these are called sacral vertebra and four fused vertebra four attached vertebra called coccyx or coccygeal vertebral. There are many ways of counting this if you count this five fused vertebra one and these four fused oxygen vertebra is one then the total sum will come to seven plus twelve nineteen plus five twenty four plus two 26.

But then we usually count this as five sacral vertebra and four coccyx vertebra for coccygeal vertebral. Among this 33 vertebra the seven that are located at the level of the neck. So, at this level from approximately here to here right in this distance there are seven vertebra that is located in this there are two very special vertebra the first two at the top are called Atlas and axis. C1 vertebra is called as Atlas ok it has a special function and shape.

What is the function of the Atlas right it provides space for the head or the occipital bone to rest yeah already said what is the purpose of the vertebral column? To support the head. So, the atlas happens to be the vertebra on which the skull on which the head sits on. So,

essentially it provides a receptacle a seat a sort of a seat for the head to sit on. So, the shape is such that it will seat the head.

So, the joint that the atlas forms with the occiput bone of the head of the skull is called atlanto occipital joint is called as Atlanta occipital joint. This joint provides for some movement at the level of the neck. So, the head movement some of the head movement is enabled by the Atlanta occipital joint. So, some movement of Atlanta occipital joint is possible about 14 to 15 degrees here I am moving a lot but that is not entirely with Atlanta occipital jet about 15 degrees of movement is possible at the level of the atlanta occipital joint.

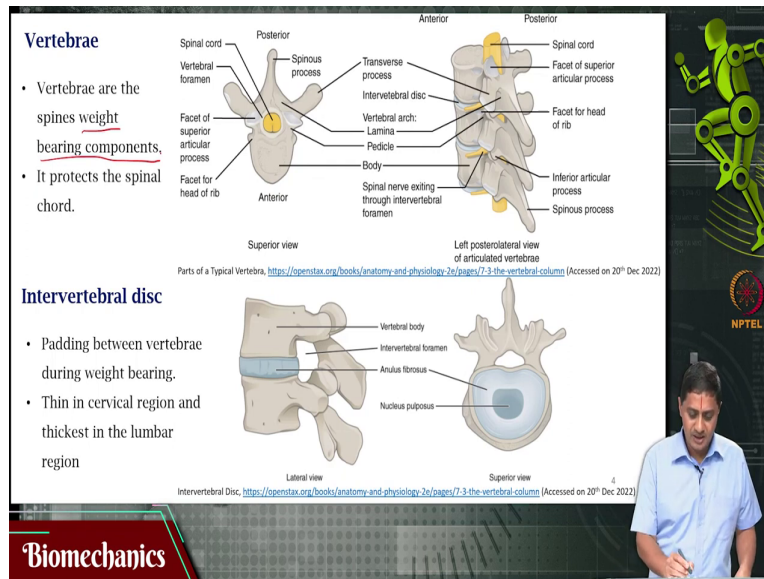
But otherwise it does not allow movement in the other two dimension flexion extension is possible in this moment it is possible but these movements are not possible. So, that means that it is providing for stability of the head its main purpose is to stabilize the head and although for a very small amount of moment about 15 degrees of movement at the level of the atlanta occipital joint friction extension only in this moment.

So, flexion extension right in this moment. So, that moment alone is possible and the next bone is called axis. This bone forms the so-called atlanta axial joint. So, there is atlas at the top which is the first C1 vertebra and axis at the second that approach is C2 right The Joint between Atlas and the axis is called Atlanta axial joint right. So, this joint allows for more movement at the neck level right. There are two three movements that are possible in this case right.

It performs a large amount of rotation like that and a lot of head rotation is possible at the Atlanta axial joint at the Atlanta occipital joint only for 14 or 15 degrees of flexion extension is possible but at the Atlanta axial joint a major moment is the rotation like this, this rotation. Also in addition the atlanta axial joint also provides for flexion extension right about 14 degrees or 15 degrees of flexion extension mainly and some amount of lateral flexion for example lateral friction means movement in the lateral direction that direction.

So, these are the purposes of the cervical vertebra or the movement responsible at the level of the Atlanta occipital joint under Atlanta axial joint.

(Refer Slide Time: 14:31)



Let us move on to other vertebra what are the other purposes other vertebra that are there thoracic vertebra lumbar vertebra right sacral vertebra and then oxygen deprivation between vertebra some moment is possible. So, they are joined together but they are not joined together in all dimensions. So, some small relative movement between two vertebra are possible. So, a major contribution of the vertebra is to bear the weight of the structures that are above them.

So, by this logic as the vertebra descends down as the vertebral column descends down the structure of the vertebral column or the vertebra in the vertebral column changes why is that? Because the weight gets added as you go along. So, the initial vertebra are necessarily designed to bear smaller amounts of load when compared with vertebra at the inferior level why is that because at the inferior level a larger amount of weight needs to be born is it not so, something to keep in mind.

So, each vertebra has a body that is a that is a particular body and then there is a region through which the nerves can traverse I mentioned in the purpose of the vertebral column that it is going to carry nerves that supply various parts of the body right. This part is called neural Arch this part is called neural Arch and some other bony processes that are responsible for stability and also for regulating movements for aiding movements of this vertebral column.

Another crucial component in the vertebral column is the intervertebral disc. This is not a bone this is fibrous cartilage genius structure right. It is more like a rubber pad it is a fibro cartilaginous pad supporting pad that is present between two vertebra it is intervertebral disc

not inter vertebral disc more like a padding more like a rubber pad between two vertebra inter means between intra means within is it not.

Intervertebral discipline this is a disc or this is a pad that is present between two vertebrae. What is the purpose of this why do you need a padding because it turns out that vertebra themselves are bony structures when they interact with each other there can be unwanted forces between them and you want to make sure that force transmission is along the directions that are desired and not in directions that are not desired right.

In fact so, this intervertebral disc are strongly attached to both the vertebra the vertebra at the top and the vertebrae at the bottom. So, thus providing or kind of uniting them kind of connecting them the purpose is to provide padding between this vertebra and pass on the weight pass on the weight helps in weight bearing. So, essentially to facilitate smooth weight bearing smooth transmission of the weight from the top to the next level from the vertebra at the top to the vertebra at the bottom between two vertebrae the purpose is to facilitate transmission of weight in the direction they said right.

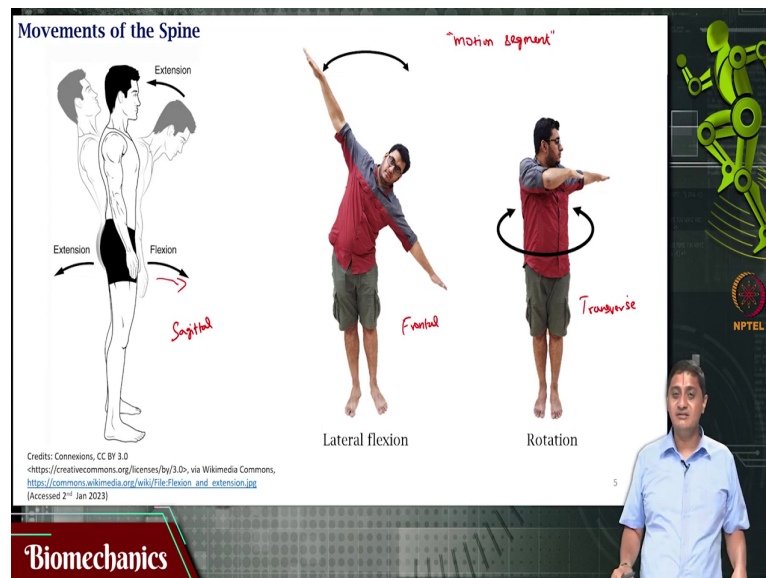
If not what happens there can be shearing between vertebra the shearing for example if this is one vertebra this is another vertebra and there is no intervertebral disc what can happen is this kind of shearing can happen which is not a desired feature is it not. In this case the weight in this vertebra should pass on to the weight in this vertebra that has to be that is maintained by this pad like mechanism which is the intervertebral disc.

By this logic also that means that the intervertebral disc must be thin at the cervical region and relatively thicker at the level of the lumbar vertebra and the sacrum why is that because as you go down the weight increases. So, the necessity for padding also increases. So, the intervertebral discs become thicker as you go down as you travels along from the top of the vertebral column to the bottom of the vertebral column.

So, the thickness of this patch increase because there is a higher need for weight bearing as you traverse from the top to the bottom of the vertebral column. So, within the each vertebra you have this neural Arch which is divided into two parts one is the annulus fibrosis which is on the slightly on the periphery of the vertebra. And so, that part which is on the peripheral which is on the periphery are more towards the outer part of the vertebrons annulus fibrosis.

Then at the center you have what is called as nucleus pulposus right this is what is found within a vertebra right this is the view when you are looking from the top right Superior View.

(Refer Slide Time: 20:20)



So, within the vertebral column two vertebra and the intervertebral disc and the soft tissues between this vertebra together it constitute what is called as a motion segment. It is possible for motion or movement between two vertebra right. So, two vertebra the intervertebral disc between them and other soft tissues between them together constitute a motion segment right that within which movements can happen right.

And this is the basic functional unit of the spine right the moments that happen or the motion segment between two adjacent or consecutive vertebra movements are very very small right. However when we move for example when we want to bend down I am making that bend that is a very visible large movement of the spine how is this possible because there is relative movement between many consecutive segments many consecutive vertebra of the vertebral column all of these moments add up to cause a net change in the angle that is what is becoming visible as the bend as the flexion of the spine right.

So, they all add up and because of this there is a possibility for the spine to have a considerable amount of range of motion a lot of range of motion and what are the various possible movements that are that are there. One is flexion extension flexion of the spine and

extension of the spine that flexion extension right that is what is shown here. So, when I move forward such that the face goes towards the ground right.

Like this when I move forward that is called flexion and when I bend backwards for example that is called extension or hyper extension right that is the other possibility. Here is my student PhD student Anurag who is showing the movement in the sideways direction of the lateral direction is showing the possibility that you can make that movement right this is not a moment that is happening at the hip you might not be able to see my hip but I am telling you that this movement is happening at the level of the spine right.

I can make that later moment on the right side and then on the left side right these are lateral flexion movement that is possible in addition I can also do that right that is rotation right. So, there are these three possible movements that are possible. So, the net moment that is possible at any level of the spine is a function of the sum of the movements that are happening above that level and in each motion segment the restrictions are the constraints are different.

So, not all the vertebrae can move the same amount. So, there are constraints that are placed at the anatomical level because of various factors as to what internal organs are present to what extent these are possible to move on many other such constraints so, because of this the net moment that responsible at the level of any vertebra changes. So, between two vertebra the or between any motion segment or between multiple motion segments the amount of movement of the range of motion that responsible is different.

Something to remember is that we should not confuse moments that happen at the level of the hip with the moments that happen at the level of the spine right. So, if you consider within the sagittal brain I am doing that versus there is a forward motion of the hip that is happening because of movement of the thigh the femur for example right. So, there is movement that is happening at the level of the spine and then there is moment that happens at the level of the hip we should not confuse these movements as spine movements.

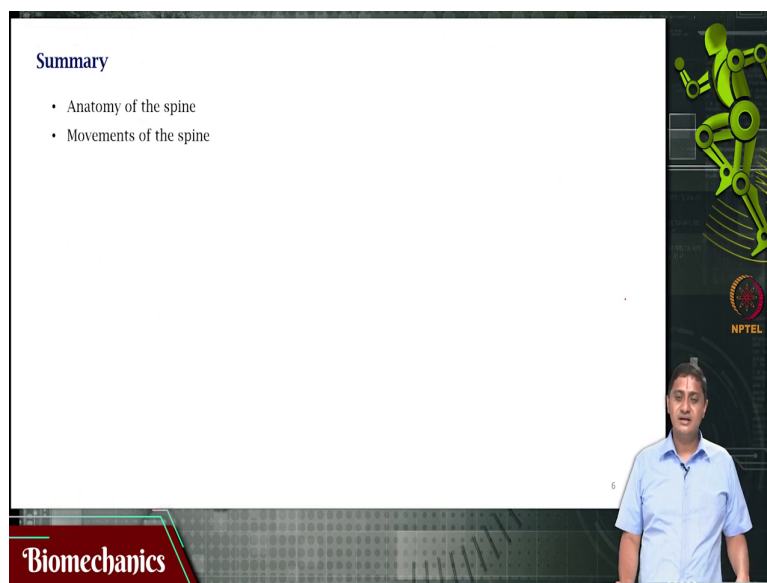
Not all of them consider spine movements something to keep in mind. Then of course we all know what are the moments that are possible in which planes. This movement that flexion extension it is happening in sagittal plane right it is happening in sagittal plane. Then this

moment the lateral flexion the sideways movement happens in frontal plane and then if I perform a rotation that is happening in the transverse plane something to keep in mind.

Remember we discuss anatomical planes and axis way back in the first or second week of this course I requested to go back and review that content once right which planes in these movements are happening fraction action is happening in sagittal plane lateral flexion is happening in frontal plane and rotation is happening in transverse plane all these movements are possible within the spine.

So, vertebral column allows for movements in all the three dimensions and any amount of movement that is possible in any of these three depends on at the level of which vertebra you are making that movement and constraints at that level of the vertebra. So, the details we will skip for now we will see in future videos.

(Refer Slide Time: 25:58)



With this we come to the end of this video in this video we discussed a brief anatomy of the spine and the movements that happen at the level of the spine. Thank you very much for your attention.