Applied Ergonomics
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Module – 05
Lecture – 21

Hello and welcome to this applied economics lecture 21, we were in the last lecture trying to do a case study regarding different; two different positions of lifting that is the stoop lifting or squat lifting and in context of that; we had looked at how biomechanically; we could actually classify these two techniques has more convenient or less convenient and the objective here was to assess the biomechanical evidence in support of advocating the squat lifting technique as an investor control to prevent lower back pain.

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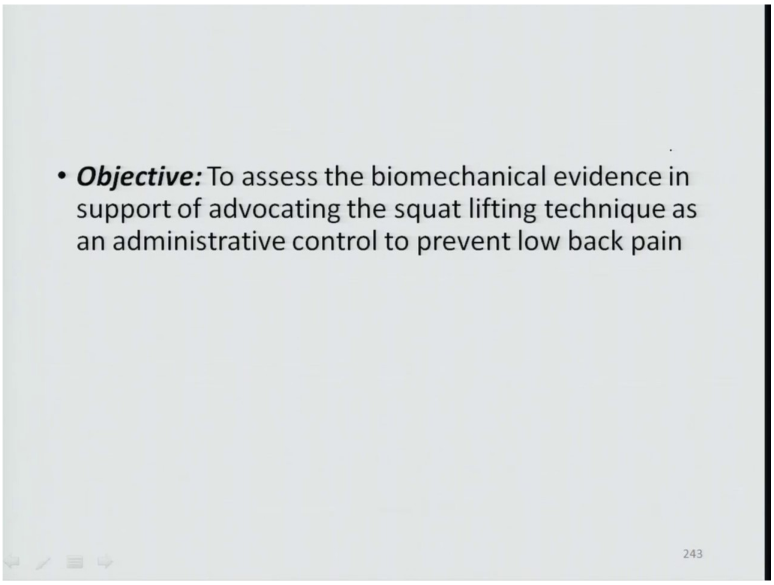

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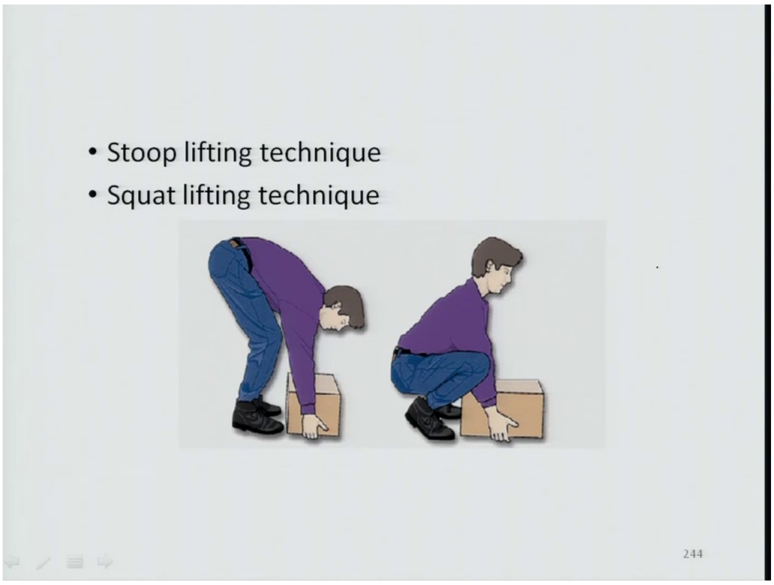

So, these were the two different postures and we basically advocated that in the squat lifting technique there may be a lesser possibility of damage to the musculotendinous structure which is the human body would have.

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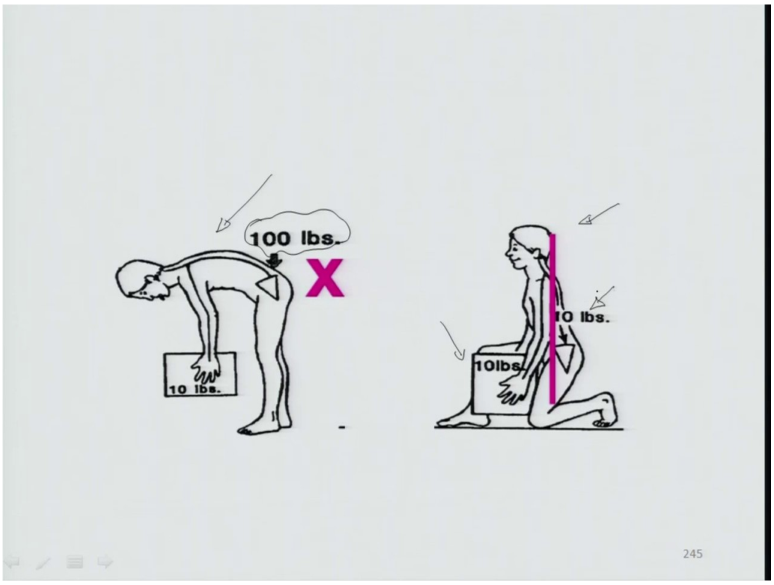

And if I looked at you know the two different load points; we can see that you know in this particular hip joint area; there is a almost a 100 lb; hundred pounds load while lifting a 10 pound which is not a very good situation a particularly for the stoop lifting where as in the squat lifting 10 lb or 10 pound load means actually 10 pound load on the musculotendinous structure as well as the structure of the spinal joints.

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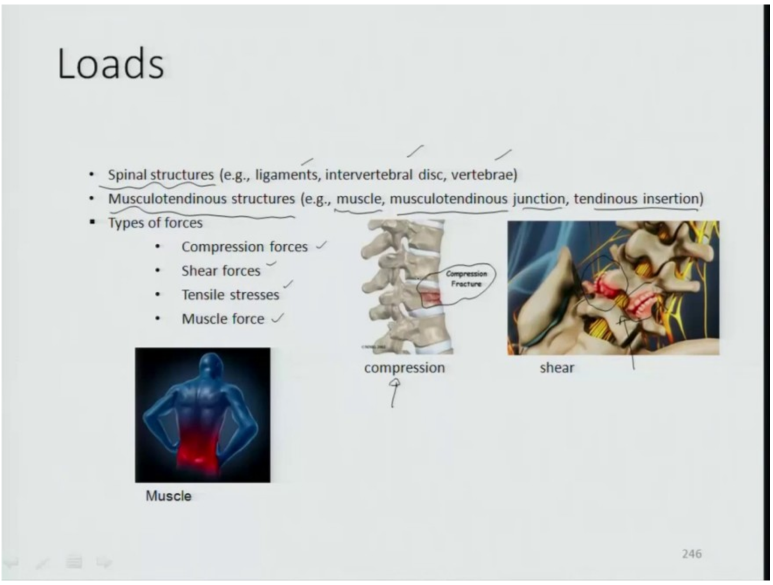

So, basically if we looked closely at how you can categorize these joints pelagically. So, you will have the basic spinal structure which contains the ligaments the in vertebral disc the vertebrae so on so forth; then there are these musculotendinous structures which are responsible for creating all the active components the forces between these joints. So, that they are able to rotate with respect to each other and move with respect to each other.

So, there are components like muscles musculotendinous junctions; tendinous insertions so on and so forth and the type of forces that such joints to produce are compression forces, shear forces, tensile forces, stresses and muscular forces and these are some defects which are shown here; for example, what can shear do in terms of damaging the spinal structures or what can compression and subsequent compression fractures do for over all you know joints strength etcetera is illustrated in this particular schematic.

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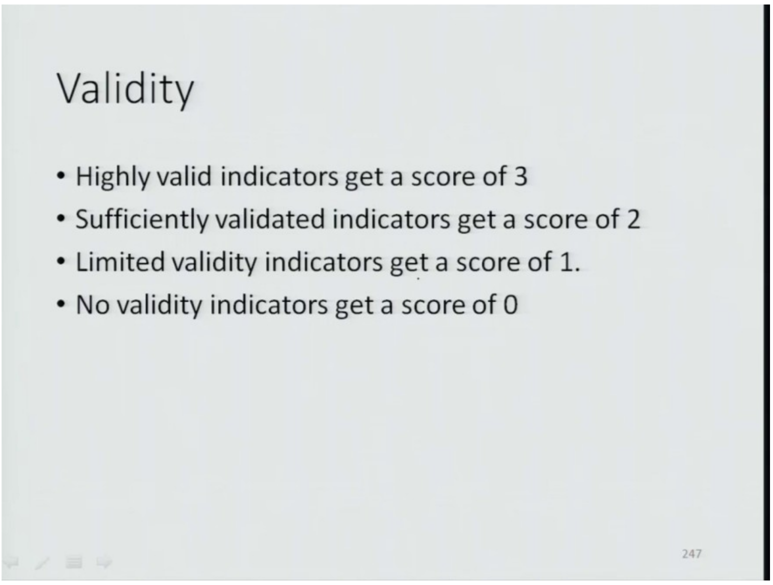

So, what this study indicates is that you have different techniques through which you can get such forces some of them are you know through you know measurement of let us say the intra spinal pressure or even like the intra muscular pressure and what this study is basically is about that you list search techniques and then on the other hand list these different compression forces, shear forces, tensile strengths stresses and try to evaluate which technique would be suitable for you know measuring what kind of force in the spinal structures.

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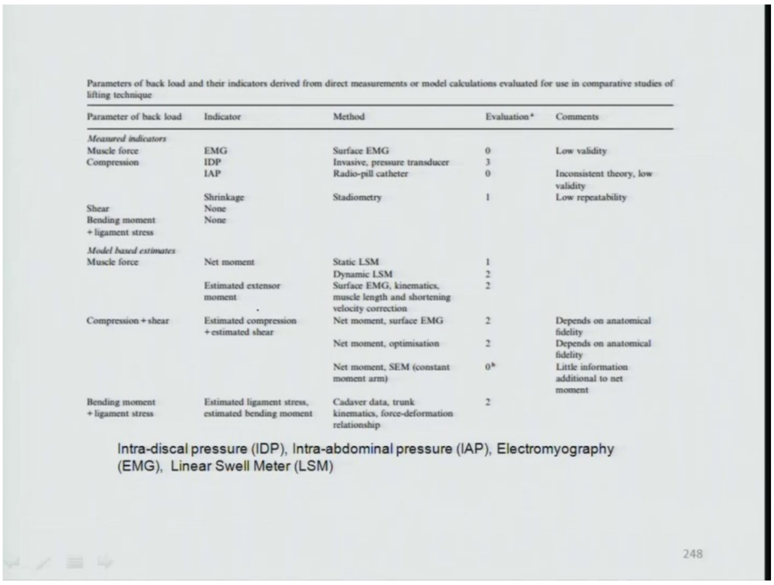
Parameters of back load and their indicators derived from direct measurements or model calculations evaluated for use in comparative studies of lifting technique

Parameter of back load	Indicator	Method	Evaluation*	Comments
Measured indicators				
Muscle force	EMG	Surface EMG	0	Low validity
Compression	IDP	Invasive, pressure transducer	3	
	IAP	Radio-pill catheter	0	Inconsistent theory, low validity
	Shrinkage	Stadiometry	1	Low repeatability
Shear	None			
Bending moment + ligament stress	None			
Model based estimates				
Muscle force	Net moment	Static LSM	1	
		Dynamic LSM	2	
	Estimated extensor moment	Surface EMG, kinematics, muscle length and shortening velocity correction	2	
Compression + shear	Estimated compression + estimated shear	Net moment, surface EMG	2	Depends on anatomical fidelity
		Net moment, optimisation	2	Depends on anatomical fidelity
		Net moment, SEM (constant moment arm)	0[b]	Little information additional to net moment
Bending moment + ligament stress	Estimated ligament stress, estimated bending moment	Cadaver data, trunk kinematics, force-deformation relationship	2	

So, basically this is a sort of a you know you can say a parameter of the back load and their indicators then I from direct measurements or maybe even some model calculations sometimes evaluated to for using comparative studies of both the lifting techniques that is the squat technique as well as the stoop techniques. So, it so happens that some measurements are possible through either measuring the IDP which is the intra discal pressure in the spinal area or the intra abdominal pressure this is in the abdominal muscles then there are electromyography plots and linear swell meters these are different techniques for measuring the force indicators; whether they are muscular compression forces or shear or bending moment on ligaments stresses in the spinal region or even you know there are certain instead of measured indicators.

There are also some model based estimates which would give you an idea about the muscular force and the compression plus shear or the bending moment in different bony part of the systems of system and there are different indicators which are the either the measurement technique or a particular model through which you can get such forces and shearing stresses and. So, in for example, in the muscular force category the compression can be measured through physically through either electromyography or measuring the intra-discal pressure or even measuring the intra-abdominal pressure.

And what has been done as a study is that there are certain methods which are deployed to obtain these measurements this muscular force compression measurements for example, the surface EMG can be used in case of measuring the muscular force compression and although the data that is indicated from the surface as a function of the depth in the muscles as relatively low validity to prop what happens within the muscle. So, there is a indicator which has been rated now and so, if you look at; if the indicators do not have sufficient validity you give a score of zero if the indicators have a limited validity you gave the score of one and then it two; it sufficiently validated if it is a highly validated indicator that this would indicate whether there is a higher amount of a compression force or shear stress.

So that such indicators are such rated number three; so, in this same manner these indicators this different techniques are rated with respect to the measurement here of the different forces like the compression force or bending moment ligament stresses so on so forth and some of them have low validity some of them have very high indicator for example, this you know IDP measurement which is actually invasive where you place a some pressure transducer inside the region of the you know disc which you want to measure actually.

So, the intra discal pressure is directly coming as a consequence of whatever is being felt by the pressure density transducer at that level. So, this is a relatively high level of validity. So, every time this reports the right data of the IDP or the; so, the muscular the muscle force compression. Similarly, there is this radio pill catheter which is used for the abdominal pressure, but then it has relatively lower validity towards the ascertaining what is the muscle force compression in the spinal region.

So, there is some inconsistency that the abdominal pressure increase means spinal pressure increase. So, it may not be always necessary and then there is also a stadiometry a technique which absorbs the shrinkage; shrinkage is the indicator measured through this which has an evaluation rating of about one. So, such things have also been done for the model estimates and from this evaluation mechanism there are certain critical believers you know which would be needed to understand more appropriately what are the muscular compression forces and so, taking the high indicators you could actually now do an analysis regarding the stoop or a squat system.

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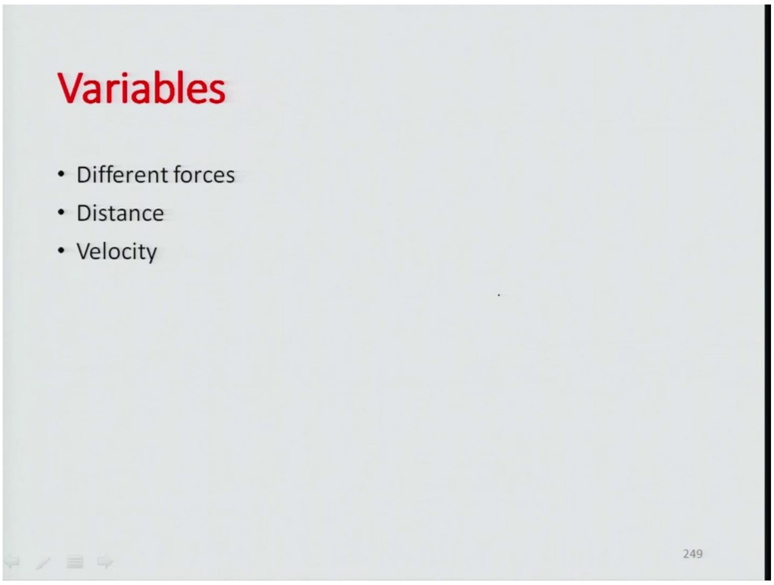

And there are certain results which come in line with this when you subject the human system to different variables like.

Let us say different forces of compression or bending moments different distances across which you can move the masocolate musculotendinous structure or at different velocities in which you move the musculotendinous structure to execute motions in both the lifting techniques.

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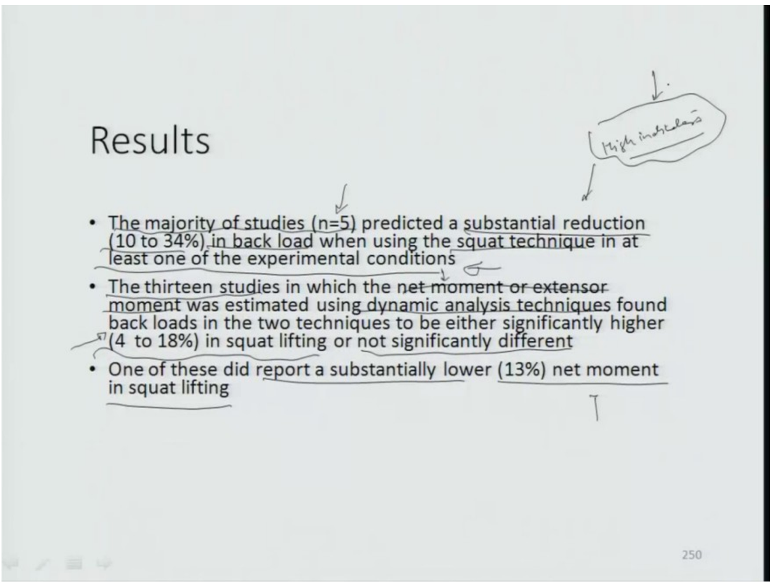

And so, the results indicate that the majority of the studies namely five studies made in this paper predict substantial reduction about ten to thirty-four percent in the back load when using the squat technique as opposed to the stoop technique in at least you know one of the experimental conditions in which such measurements have been done.

And you have to understand that these are being studied on the basis of only the high indicators where the indicator refers to exactly the level at which accuracy of precision can be obtained for physical measurements or even modeling related predictions about thirteen studies conducted in which the net moment or extensor moment extensor moments are individual joint moments net moment is when all these joint moments take place; what is going to be the net moment of the whole system. They were estimated using a some dynamic analysis techniques some modeling technique and they found that the backloads in two techniques to be either significantly higher in squat lifting four to eighteen namely particularly when we are talking about the net moment.

But the extensor moment which is only a local phenomena around a joint let us say there is a joint and the joint exert certain amount of moment which performs the bending about that joint. So, that is not significantly different. So, although the net moment basically becomes different; so, therefore, the levels in which the extent surreal moments changed between one joint to other they are much higher in this particular case. So, one of them of course, reported a substantially lower about thirteen percent net moment on the squat lifting case.

So, certainly through these studies using a techniques of measurements or models which are high indicators of the compression pressure of the bending moments within the intra spinal region or the musculotendinous structure associated with the intra spinal region one can predict very easily that in all the cases squat lifting happens to have a better performance in terms of giving lesser loads to the whole structure in comparison to the stoop lifting.

So, it is a sort of conclusive evidence you know or study that how these two lifting techniques are different. So, one can do such kind of probing studies. So, to ascertain whether one is better than the other to get a gauge of really what is the you know internal anatomical pressure behavior between you know two different positions; two different let us say ergonomically designed activities and based on that you have some evidence that one is better over the other. So, such positions which are considered to be better or normally useful for the purpose of ergonomic design of any activity which will probably recover in one of the later sections while designing sitting arrangement, etcetera.

Such kind of pressure differentials such kind of measurements and sometimes some models also are really needed for checking what position is better or what position is not better for example, for people using bit different such orientations.

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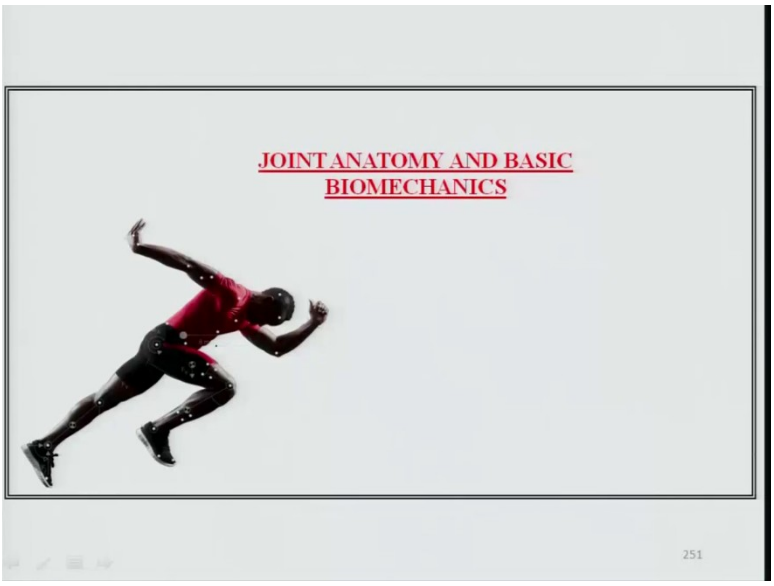

So, now we will look at little more about the joint anatomy and the basics of biomechanics that how with respect to different joints this is all rotation and translation then say you know rolling action between the different areas of the joint they can severe as one executes different motions by his limbs his or her limbs the body.

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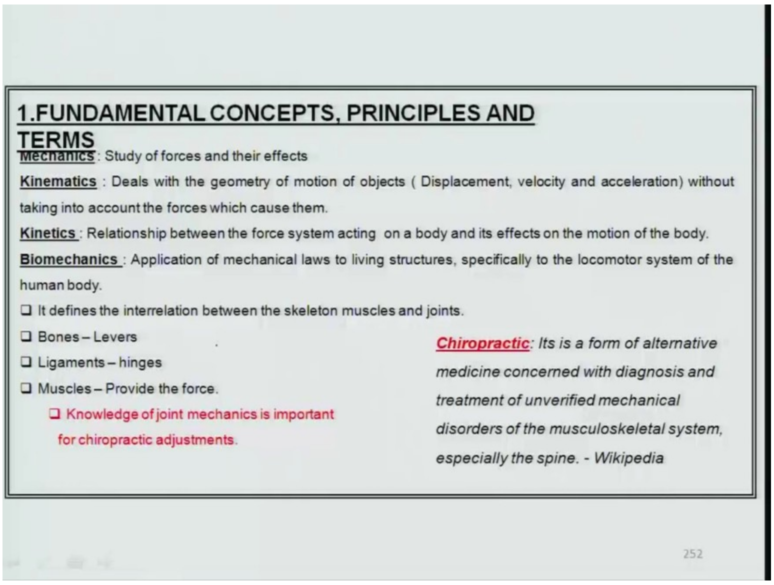

So, if you look at fundamentally to the basic principles; we already know that mechanics is really related to the study of forces and their effects and kinematics deals with the geometry of motion of the objects particularly the displacement velocity the acceleration of members moving with respect to each other and this is typically done without considering the forces for taking into account the forces. So, that is primarily what how kinematics is defined. So, is kinema the motion related effects and then there is yet another kinetics which is the relationship between the force system acting on a body and its effect on the motion of the body.

And basically biomechanics which have earlier defined as the application of all the mechanical loss particularly due to living structures; so, specifically to the loco motor system of the human body. So, it defines for example, interrelation between the skeleton muscles and joints it also considers bones to play a leverage role I will come shortly to it how fulcrum and liver can be associated with different joints it also helps in ascertaining ligaments as hinges; hinges which would provide interaction between let us say two different components of bone members which has having a relative sliding with respect to each other and then there are muscles which would typically be the loco motor the one which provides forces for doing such action.

So, the knowledge of joint mechanics therefore, is very important for sometimes you know the just for chiropractic adjustments which is about alternative medicine concerned with diagnosis and treatment of unverified mechanical disorders of the musculoskeletal system especially the spine. So, if you could know that some displacement is occurred or some deviation is occurred from the routine structure which is creating a sensation of pain and how you could actually re orient back into the normal you know orientation by giving it motion in the opposite direction, which are about all these adjustments that we have talking in this particular slide. So, if you need to really do this if you need to understand the both kinematics as well as mechanics of all these components the bones the ligaments the muscles to give a high degree of you know inter relation knowledge of motion between these components. So, if we looked at again fundamentally how the musculoskeletal structure is going to result in different leverages.

So, we first need to again look at what is a lever.

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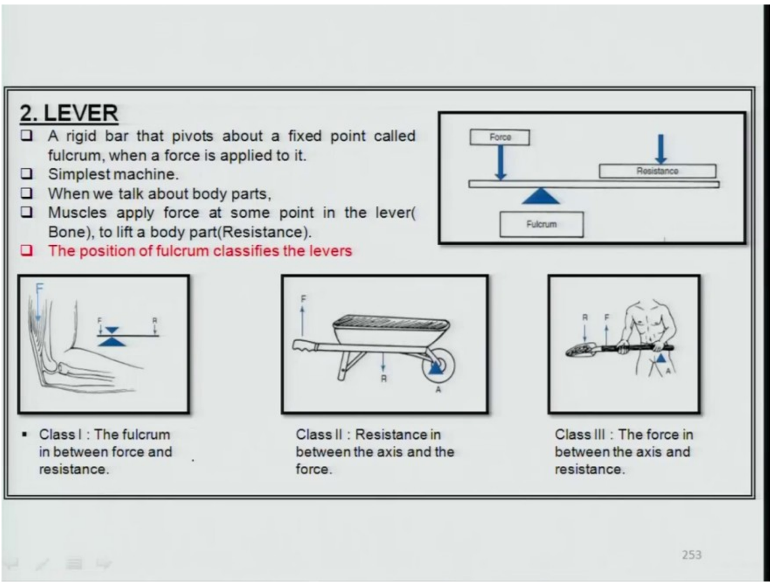

So, for example, here there is rigid bar, it is pivoted about a fixed point which is also known as a fulcrum and there is a force applied on one side which results in some kind of a force into force sum and there is balance of moment about this particular point of fulcrum which is able to by using greater arm you know lift of a much higher resistance or a load.

So, it is one of the simplest machines that one can think off and basically when we talk about body parts like the limbs or even the spinal region etcetera they are all subjected to lifting of loads etcetera through what we know as the leverage action. So, muscles apply the forces; for example, let us say we talk about this particular orientation of the hand when we are trying to lift something so; obviously, the upper portion of the hand right here is able to give a force a force which is going to be able to lift the lever arms. So, whatever force is generated in this region you can think of this as the fulcrum point.

Because we do not change the orientation of this it is fixed with respect to the shoulders. So, if this is the fulcrum point I could generate a load which would be able to about the fulcrum point with the greater arm be able to lift a load which is probably higher in comparison to the muscle muscular force that this part of the hand the upper arm was giving onto the fulcrum.

So, this is given here. So, this is in a way a sort of lever you can lever of the first principles. So, it is a class one. So, again there is a class two where the resistance in between the axis resistance is in between the axis in the force. So, this is the fulcrum point in such cases and the resistance that you are wanting to lift is actually around this. So, you have to begin categorize different motions within the body where this is possible and there is a force on the other side which is able to lift up the load which is placed in between the fulcrum and the load fulcrum and the force.

Similarly, there is a again a third category with the force is in between the axis and the resistance for example, in this case the force that you are providing by this arm is about this fulcrum points which is being given by this other arm of the particular you know body and it is able to lift the resistance. So, the force comes in between the resistance and the fulcrum points. So, these are the different orientations in which you can use the limbs so that they can have different principles of lever and leverage action.

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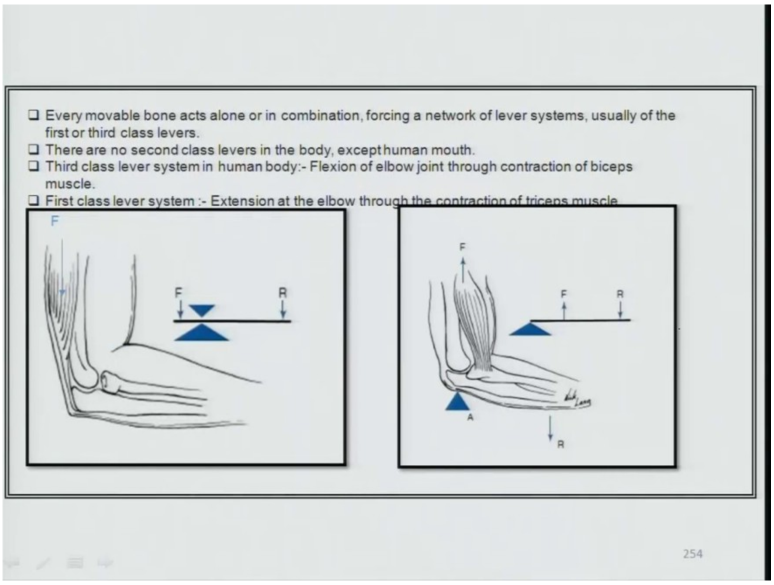

So, every movable bone acts alone or in combination forcing a network of lever systems usually of all these different classes that you saw in the last slide the first to third class and there are no second class levers in the body except human mouth; there is only one or two regions where in the mouth where you could actually have second otherwise first and the third are utilized almost always within the limbs.

So, third class lever system in human body is for example, flexion of elbow joints through contraction of bicep muscles and similarly first class lever system could be extension of the elbow through the contraction of the triceps muscles. So, these are some basic ideas of how you can either flex or extent muscular system creating different positions of fulcrum points with respect to force and the resistance you can see the force here is in this direction this is the fulcrum point this is the resistive points.

Similarly, the forces in the other direction all together and there is fulcrum point here which is leading in a resistance in the other direction. So, something like you can say you know in one case you are lifting or flexing in other case you are trying to extend you are extending; so, extensional. So, this is the first class system and the second the third class system is basically flexion of the elbow joint.

So, this is how you understand joint mechanics we would also like to organize a reference co ordinate system for the body to a give shape to.

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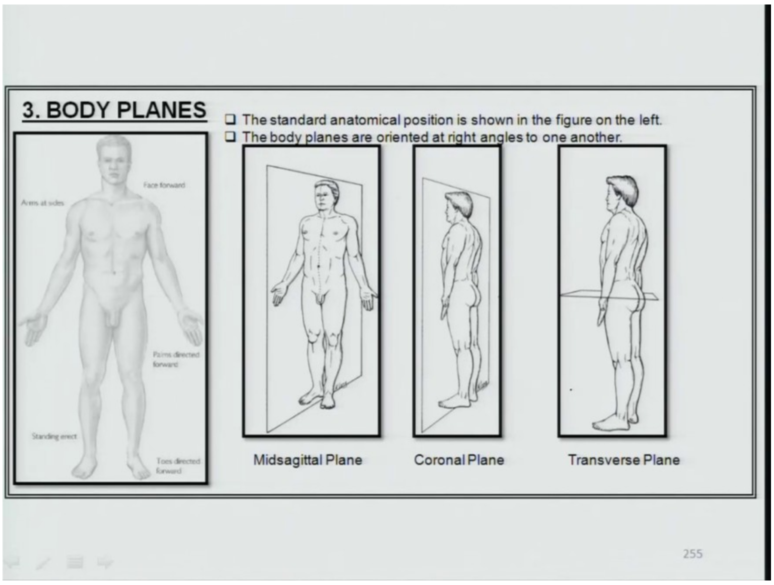

So, for example, you know if there are different body planes across which you could see what is going on in terms of muscular movement or movement of the musculoskeleton structure. So, there is a midsagittal plane for example, if this I am let us say a concerned person through which you know this analysis is being done.

So, the midsagittal plane really would be something that will divide the body from top to bottom into half and half. So, this particular plane right here for example, is the midsagittal plane there is also a coronal plane coronal plane is actually parallel to the human body. So, if it cuts the body; for example, from here all the way to the legs in the center region of the body with body being in the same plane as the plane itself is called a coronal plane and then there is a transverse planning yet which is actually going to divide the upper portion of the body from the lower portion.

So, this actually is a transverse plane. So, we have a different plane windows through which you could categorize and now all the motions which take place are with respect to the axis across such planes which are formulated.

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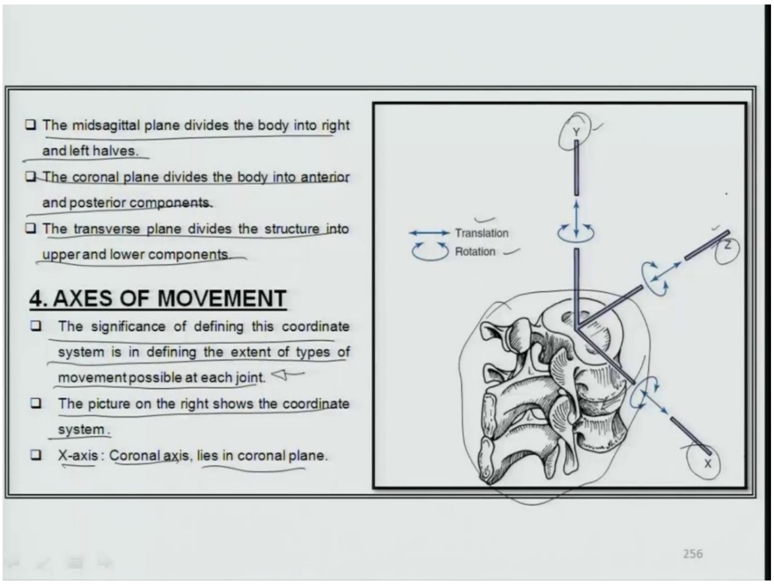

So, the midsagittal plane divides body into right and left half; the coronal plane divides the body into anterior posterior and the transverse planes divides the structure in to upper and lower half components. So, this we must understand before going ahead. So, what we did is that we studied what are the basic principles in terms of kinematics we also studied some of the concepts related to lever we also studied some of the concepts where you know we could see how body planes are categorized you just co ordinate them in a proper manner and organize to have some let us say numerical values associated with the positions like rotation or translation etcetera and then we start studying excess of movements. So, when we talked about axis of movements the significance of finding this co ordinate system is in defining the extent of the types of movements possible at each joint of the body.

So, the picture in the right; for example, show such a co ordinate system. So, you have the X, Y and Z co-ordinate based on all these three planes intersecting with respect to each other which talks about how these joints are positioned with respect to each other. So, that they can move relatively in a certain direction following some sign convention that the moment could be either translational or rotational at different places. So, it is somehow to define that structure of axis through which all the movements can be suitably studies just as you do in kinematics the study of links or linkages or members.

So, the picture on the right shows co ordinate systems and X axis is basically the coronal axis lies in the coronal plane similarly the Y axis is one can see this is the portion of the spine that is being shown here at least the bony portion of the spine. So, the Y and the Z axis correspond to the midsagittal plane and the transverse plane. So, that is how the axis of motion or moment undefined.

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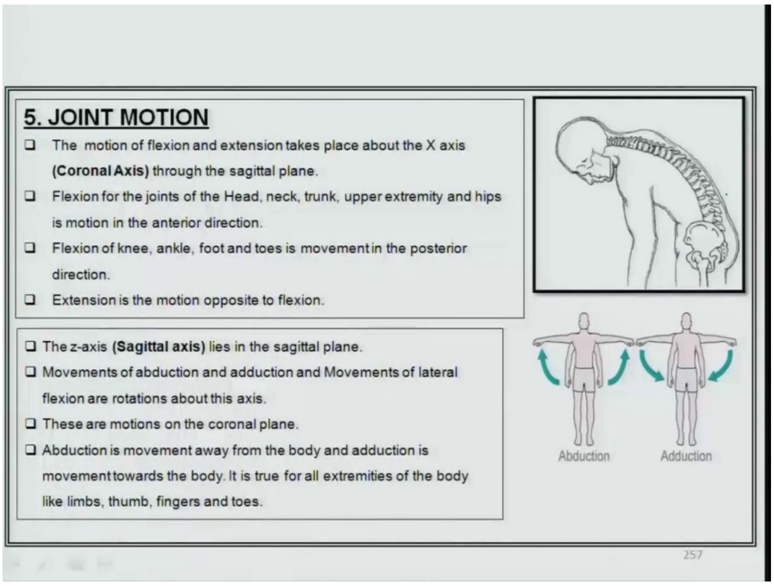

So, let us now start talking about the joint motion with respect to all these different axes. So, let us study join motion. So, you know the basic motions that will be concerned about here is mostly flexion and extension and if this particular subject here is bending forward; for example, and so, this forward bending is in a way rotation in the midsagittal plane around the X axis; so, or the coronal axis. So, this is called the forward flexion. So, similarly if you try to bend backwards the whole pressure will be shifted from your spine to let us say the toes the ankle the toe; the foot; the ankle and then of course, all the way to the hip joint.

So, that kind of a backward motion is also a flexion towards the posterior. So, all such flexion motions are considered to be rotations about the coronal axis in the sagittal plane and similarly if you talk about extension; extension is just the motion opposite to the flexion. So, which our side is extending is basically providing the extension in the structure the bone structure. Similarly, I could do the same by lateral flexion. For example, if I bent more on the right side or the left side for example, this is a right bending, I am being doing and then this is the left bending.

So, essentially what I am trying to do is to move or rotate the spinal system in the in the coronal plane now with along the X axis. So, this is again something which we know as the later flexion similarly if I wanted to move my arms around and let us say if I wanted to either do an abduction where the arm goes from normal position all the way to let us say shoulder height and then back from the shoulder height back to the to the normal position which is called as adduction. So, all these motions including the lateral flexion as well as abduction and adduction can be considered to be across the; you know the coronal plane along the X axis. So, in this manner you are trying to categorize and the different movements in terms of forward motion backward motion side motion and feeding the axis system that you have developed in the last slide I talked about two such motions.

So, that is how you can study joint motions in a organized manner you can see for example, here you know there is this medial and lateral rotation of the extremities the rotation of the spine occurring about the transverse plane.

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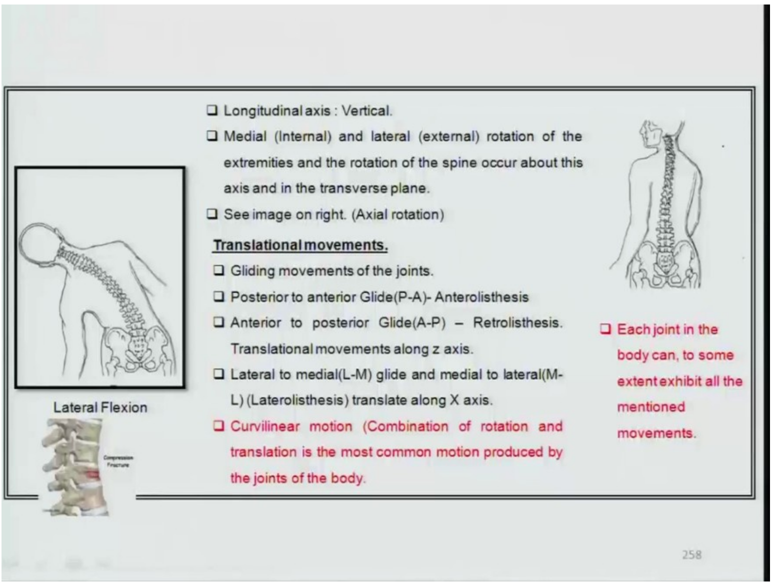

So, if I wanted to bend you know the let’s say; for example, the body. So, without in the standing in the same position if I want to bend the body to the left or the right what I am essentially doing is across the transverse plane which separates the lower portion or the body from the higher portion I am trying to execute a rotation again along the X axis.

But the rotation is taking place along the transverse plane. So, you have learnt that how forward bending reverse bending side bending side motions and let us say a motion of the upper portion with respect to the lower portion are along typically the sagittal plane the midsagittal plane the coronal plane as well as the transverse plane. So, this is again on an organized way in which you could record all these movements with respect to each other you can also talk about translation movements particularly translation movements related to the joints you see this is how the structure of the spine actually would like and. So, in some cases there is a possibility that the there is you know posterior to interior glide of one of the components.

In fact, this is actually a defect which happens in the spinal system due to injury etcetera which is also known as anterolisthesis. So, what would happen is that one slide or one section or of the bone of a let us say the spinal cage would slide towards the; you know interior side or the front side from the posterior side. So, basically let us say something where this thing slides in front over the other bone which is below it and similarly the way the retrolisthesis is for the interior to the posterior there is gliding action of one bone with respect to the other.

So, these some defects which can be caused or even there is during the flexion or the let's say extension there are these kind of small phenomena only if the extent of motion is beyond a certain level which is beyond repair then we call it at disc slip otherwise we can consider that to be routine or normal similarly there is a lateral to medial glide or medial to lateral glide which is also known as retrolisthesis surface which is again translating along the Y axis of motion. So, just look into how I had categorized before and trying to figure this out. So, you know if there is also curvilinear motion.

Which is actually a curvilinear motion which is actually a combination of all the rotations as well as the translations and this is typically the most common motion produced by the joints of the body you have to remember there are tendencies and there are you know muscles and ligaments which are present all around and so, we know they are enabled the human body is really enable to handle such curvilinear motions with combinations of rotation and translation to a certain extent.

But if it goes beyond that then you know it goes beyond repair and then you have to put them back together into the right orientation. So, each joint in the body therefore, to some extent can exhibit all the mentioned movements within some limitations beyond a certain range if such movements happen they would lead to permanent damage or set and then you have to really repair it through its no longer you know pre parable through chiropractic means, but you have to actually go ahead and do surgical techniques in order to put things back into place. So, that is how I would record all the sort of motions related to the joints let us not study a little more about joint functions that how joints would typically function.

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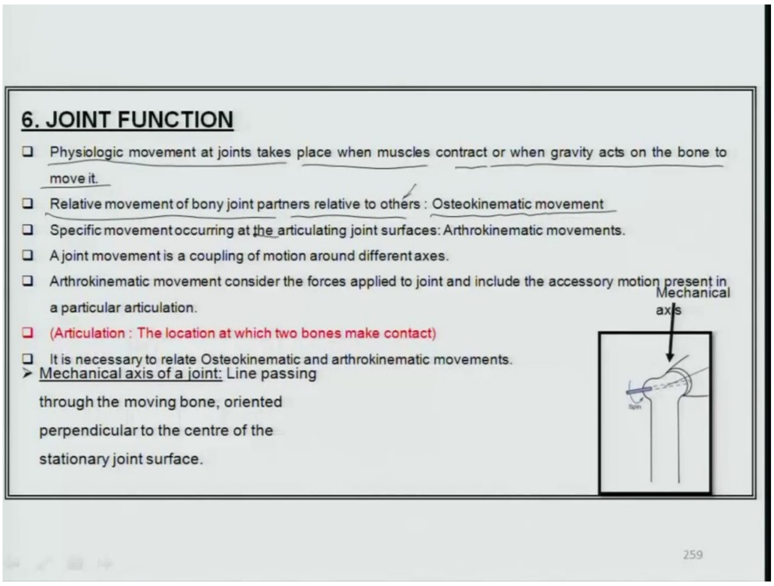

So, the physiologic movement ad-joints mostly take place when muscles contract or when gravity acts on the bones to move it you have to understand. So, there is a sort of a needed structure of the muscles in the bones and so, if supposing the muscles produce enough forces to lift a bone in the upwardly manner with respect to another. So, there is some gliding across the bone to bone interface, but mostly the loco motor there is a muscle which is giving all the force. So, the relative motion movement of the bony joint partners relative to each other is typically referred as the osteokinematic movement and the specific movement occurring in the articulating joint surfaces because of such motions.

So, relative motions for example, let us say between the upper arm and the lower arm is both these bones moving with respect to each other you know. So, this let’s say for example, this point is moving with respect to somewhere here in a certain co-ordinate frame in a certain manner, but if I look at what is happening across this joint typically there is some sliding action which is happening and some rotation or a rolling which is happening between 2 different members which are now being integrated with a muscular structure which is around it. So, osteokinematic movement is related to what is happening locally at the joint vis-a-vis the osteokinematic movement which is relative to what the gross bone one is moving with respect to the bone. So, it is necessary that both the osteokinematic as well as the orthokinematic movements be considered together in unison when you are trained model how bio mechanistically different members are moving with respect to one another.

So, if I looked at the joint and try to figure out what is the mechanical axis of a joint this will typically be a line passing through the moving bone oriented perpendicular to the centre of the stationary joint for example, So, a typical you can see that this joint you know it is a rotational motion which is being executed here in form of a spin across this particular axis which is actually the mechanical axis around which the joint exists so; obviously, if I look more into the detail of how and joint would move relative to each other when we consider the orthokinematics aspects. So, there is of course, some kind of a convexity and concavity across which there is a relative motion.

So, I would like to end this lecture there in the interest of time, but in the next lecture I will take this half that how there is rolling between the concave and concave convex surfaces inside joints and then how there are lateral motions. And if there are than any specification relations that we need to obey when we talk about a concavity moving over convexity or vice versa and then we will try to sort of look into how ergonomically; we can design different postures which are going to be beneficial for the human body if prolonged for a certain amount of time without damaging the musculoskeletal system consistently. So, with this I will end this lecture.

Thank you very much.