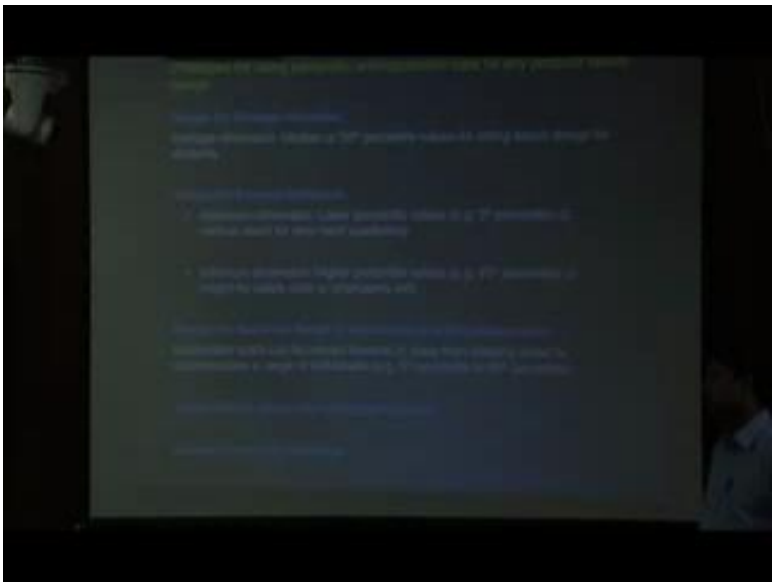
Digital Human Modeling and Simulation for Virtual Ergonomics Evaluation

Dr. Sougata Karmakar
Department of Design
Indian Institute of Technology, Guwahati

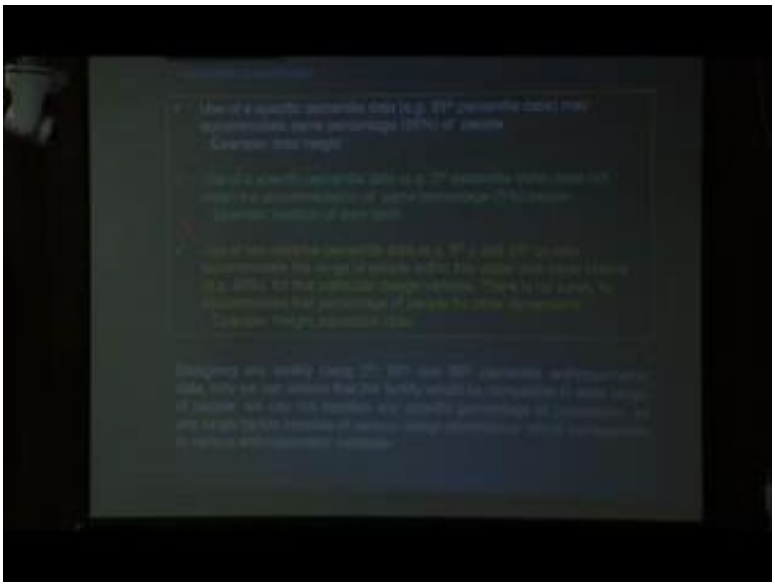
Lecture - 06
Use of percentile anthropometric and bio mechanical data for product design Part IV

(Refer Slide Time: 00:00)



So, after discussing about various strategies adopted by designers or engineers called using percentile anthropometric data.

(Refer Slide Time: 00:21)



Now, we are moving to next slide where some impact some important points are mentioned. So, first one use of specific percentile data for example, 95th percentile data may accommodate same percentage of people or same percentage of people population. So, as we discussed about the example of door height. So, if we talk about door height. So, if the height of the door is decided as per the height of 95th percentile person then; obviously, 95th percentile person will be able to go through that door. While 95th percentile people with 95th percentile standing height or structure is able to go through this door. Then others who are whose height is less than 95th percentile. So, they will also be able to go through.

So, if this height of the door is decided as per the height of 95th percentile structure. 95th percentile structure then what will happen, not only that particular person, but all others whose height value is less than 95th percentile all of them will able to go through. So, using 95th percentile anthropometric data in this particular case is allowing 95 percent of the population to use that particular facility or particular design.

If we come to the next point, use of the specific percentile data - say 5th percentile data does not mean that it will accommodate the same percentage high percent data. We are using we will also discuss about the example of door length. While positioning a door latch on the door, in so this is a door latch. While we are positioning a door latch on the door. So, this is a door latch while we are positioning this door latch and for that

purpose, we are using 5th percentile on this value. Then what will happen, not only 5th percentile. So, in this case for positioning door latch we are using taking the anthropometric variable, vertical all reach and we are also using the 5th percentile value while we are use using 5th percentile value, then not only this 5 percent population, but 95 percent of the population whose hand reach value is more than this. 5th percentile value all of them will able to access this door latch. It means although you are using 5th percentile data of vertical arm reach for positioning this door latch, actually we are allowing 95 percentile of the population to use that facility.

So, use of 5th percentile data, does not mean only 5 percent people will be accommodated. It means using 5th percentile data actually accommodate 95 percent of the population, but in the earlier case we are using 95th percentile data, and at the same time, we are accommodating 95 percent of the population for the specific designed dimension. Now in another case if you use 2 extreme percentile. It is 5th percentile and 95th percentile data, for any facility design then what percentage of the population will be able to use that product or facility.

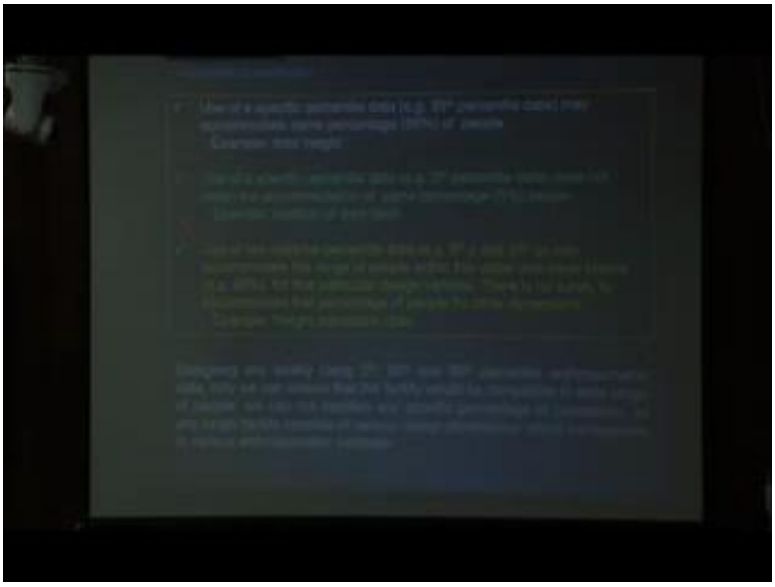
So, in this case we can take an example of height adjustable chair. If height adjustable chair or height adjustable height, adjustable table if this table surface can move up and down, starting from the while you are seated like his way. If this is the elbow rest height this is the design dimension that is the table top height for that purpose corresponding anthropometry is elbow rest height if we use starting from 5th percentile elbow rest height to 95th percentile, then in between this two fifth percentile to 95th percentile, the whole 90 percent population will be able to use comfortably.

So, using 5th percentile and 95th percentile data for a particular design dimension, they are actually you are covering 95-90 percent of the population. So, from this scene what we can conclude using a specific percentile data, does not always mean that we are accommodating the particular percentage of the population, we may use this percentile data, but actually you are accommodating in this case 95 percent of the population. On the other hand we are using 5th percentile and 95th percentile data for the same design dimension, and we are accommodating 95 percent 90 percent of the population. So, we can mention in this way while we are using a specific percentile anthropometry data for designing a specific dimension of a product or facility. Then we are accommodating in different situation different percentage of the population. Sometime it is it may be 90

percent. Sometime it may be 95 percent sometime it might be some other percent. So, we have to understand that which percentile use of which percentile data, actually accommodating what percentage of the population

Designing, if you read this one - designing any facility using 5th, 50th, and 95th, percentile anthropometry data only we can ensure that the facility would be compatible to a wide range of people. We cannot mention any specific percentage of the population as, any single facility consist of various design dimension, so in earlier case.

(Refer Slide Time: 06:12)



First we will discuss about this chair dimension. Then we discuss that for different parts of the chair if we talk about the seat pan height or seat pan width, or seat pan depth for that we use different percentile of anthropometric data. Or different design dimension. So, if we mention we have designed this seat width as per 95th percentile seat depth, and if we say that the whole chair will be used by 95 percent of the population, it is not possible. Because for different design dimension. We need to consider different percentile of anthropometry variable anthropometry variable. That is why we can never mention that we have designed any facility only using 5th percentile anthropometric data, or 95th percentile anthropometric data, because different dimension of the particular product requires, different percentile of different anthropometric variable.

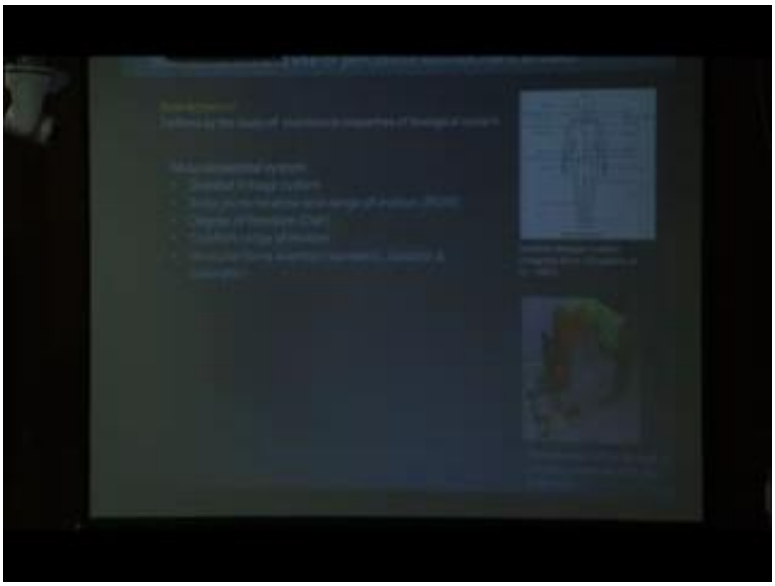
So, not only that, say some facility has been designed as per the height of 95th percentile person. Or say this chair has been designed if you take the example of chair. You have

designed the seat height, or as per the fiftieth percentile popliteal height. Then we can we how we mention, that only 50 percentile of the population people will be able to use, or 90 percent of the people, will be able to use we cannot specifically mention, because even for a single individual all the body dimension may not be of a particular percentile value. People take a example of this door height also. For this particular person whose head height or structure is 95th percentile, he can go through this one, but if we consider other variable say for example, for this door width, also we have used 95th percentile body width or shoulder width, for door width also we are using 95th percentile shoulder width. So, in that case this person his height or her height is 95th percentile.

But, his shoulder width may be more than 95th percentile also. In that case if we design this door width as per 95th percentile shoulder width, of the population, that particular person may not be able to use that door, because it is matching with his structure or vertical height which is 95th percentile, but his or her shoulder width is actually more that 95th percentile. So, it is not possible for the particular person to go through the door.

So, that is why this statement is very important. That using 5th, 50th or 95th percentile data, we can only mention the wide range of the population we will be accommodated, but we never can mention that it will it will accommodate a specific percentage. We cannot mention 90 percent or 50 percent or some other percentage, because so many other factors are also associated with this. Any single product or facility comprises of so many variables design variables. And for each design variables there is requirement of corresponding anthropometry variable. And out of the anthropometry variable which percentile we need to use we have to decide that one.

(Refer Slide Time: 09:58)



Now, after discussing about what is anthropometry, and how to use percentile anthropometry data for different types of facility or product design. Now we are moving to biomechanical data. So, first what is biomechanics? Biomechanics actually we can define as the mechanical property of the biological system, or human body; is a biological system as it is a biological system. So, if we consider or if we discuss about the various mechanical property of the system, then that is coming that can be mentioned as study of biomechanics under biomechanics.

We discuss about musculoskeletal systems skeletal linkage system, as we have already discussed in our earlier slides that human body is made up of various bones and joints and we can represent human body like this type of linkage segments. Second body joints location and range of motion. For each of the body joint range of motion is also different. And also that range of motion varies from human to human for me if this spatial extension of elbow joint, for me if it is 120 degree for someone it may be 130 degree.

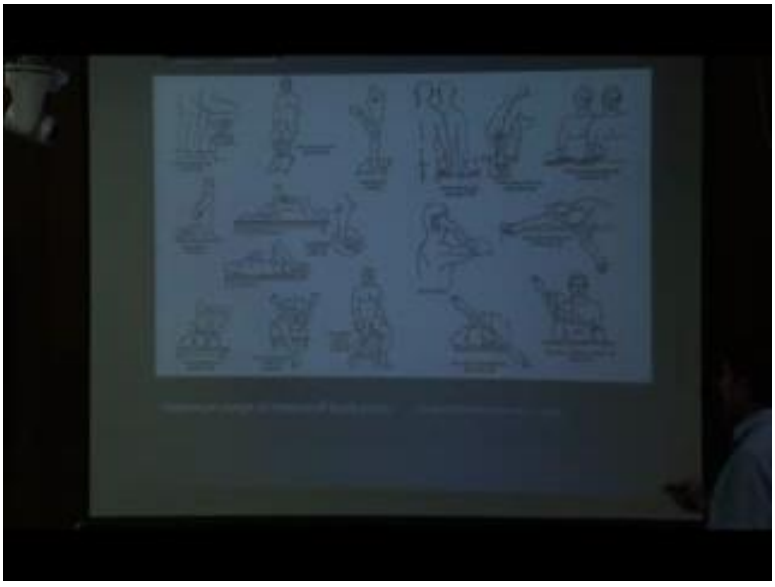
So, range of motion is also different from person to person. Then degrees of freedom each body joint also have different degree of freedom. First if we consider shoulder joint shoulder joint has 3 degree of freedom. One is abduction direction this in this direction another is forward backward this is spatial extension at the same time rotation is also there. So, 3 times of degree of freedom is there, for 3 degree of freedom for shoulder

joint, similarly if we consider the elbow joint. In elbow joint only we can find one degree of freedom. That is friction and extension. Then comfort range of motion.

Although for this elbow joint, friction and extension is happening this is a total range of motion, but out of the total range of motion the whole range of motion is not comfortable for walking. So, only the mid is mid range, where we are mid range of the motion or the elbow joint is considered as the comfortable, for sustained for prolonged activity or for working on various types of tasks. So, out of the total range of motion, we need to define also the comfort range. Out of total range of motion of the body joint we have to define a specific joint and if a particular joint. It is an elbow joint if this is the total range of motion, then we can mention if, this is if you call this is 0 degree and this is say 120 degree. So, within this range of motion, we are mentioning only this mid portion 0. So, 80 degree to 110 degree within this range it is comfortable

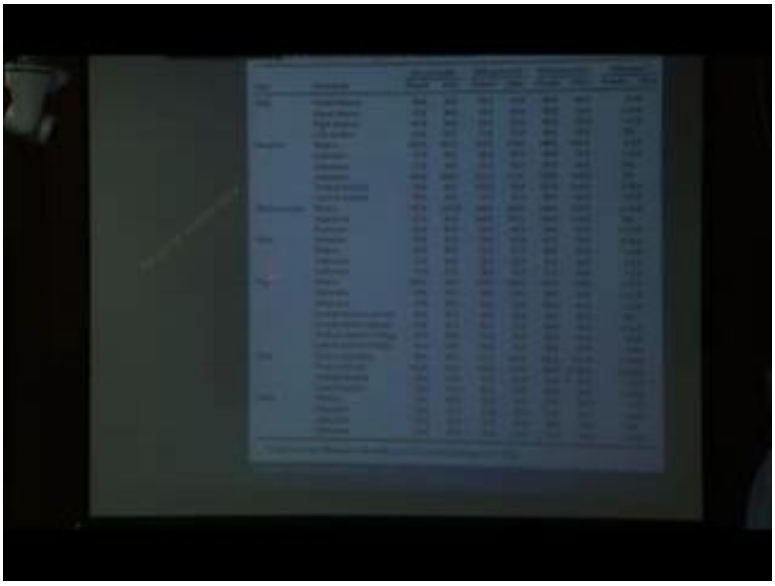
Then there is muscular force exertion. For various types of knob operation pull push force pulling pushing, all for performing different types of activities, we need to exert our muscle force. So, that is also discussed under biomechanics. So, there is one example, where we are measuring the leg force or leg strength at a particular angle, of this knee joint that is 130 degree. At 130 degree angle, how much one individual can exert the force vertical downward force?

(Refer Slide Time: 13:43)



Similarly, as I mention, for different body parts joints, the range of motion is also different, and the degree of freedom is also different. So, we can go through this type of information and the range of motion of different body parts are defined and for this purpose also, there are different database for different population, population to population range of motion varies. Although, the degree of freedom is same because for a human body joint, and a particular joint degree of freedom is fixed, it may be one degree of freedom or 2 degree or 3 degree, but it is same for all individual. But the range of motion is different from individual, to individual as well as from population to population.

(Refer Slide Time: 14:38)

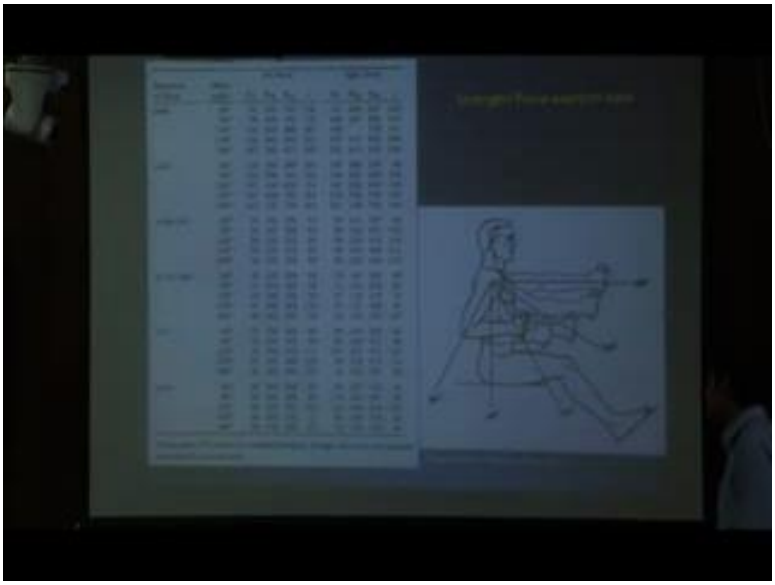


So, we here is a sample of range of motion data. Adopted from (Refer Time: 14:45) 2010. So, here this is the percent 5th percentile 50 percentile and 95th percentile data. For different body joints neck mental flexion (Refer Time: 14:55) flexion right rotation left rotation. So, for this joint neck joint this type of flexion (Refer Time: 15:00) and (Refer Time: 15:03) action you can mention as this is flexion and (Refer Time: 15:07) flexion as extension also. So, flexion extension or rotation data it is tabulated here. So, we can calculate. So, for a particular population we can measure the range of motion for particular body joint. And after measuring the range of motion data from a good number of subjects, we after collecting from a big sample, then we can calculate various percentiles - 5th percentile 50th percentile 95th percentile or any other percentile as per our requirement.

So, this data base then we use from different design say for example, one for opening the door how much force should be exerted so; obviously, in that situation we should use 5th percentile data to push force it just. So, while if we have the database for a particular population for push force data, and right hand push force data, then what we can do, on that data we can identify the 5th percentile value and accordingly with the 5th percentile value push force data. If we design or if we determine what should be the actuating force for, door opening, we can use that 5th percentile data.

Similarly, in some other situation say for example, 95th percentile data or fiftieth percentile data. So, as per our requirement, we have to choose that one. Some other door where entry is restricted, for that purpose we can go for higher percentile of pull or push force because it is not for easy access. So, actually what we discuss that is about, pull push force data. The earlier sorry here is mistake this data was related to range of motion, for different types for different body joints; this is a range of motion data.

(Refer Slide Time: 17:28)

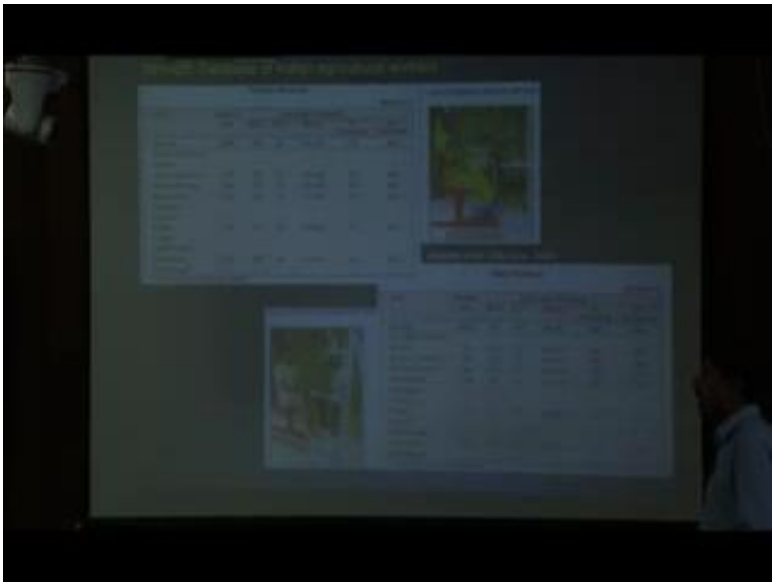


Similarly, this is the data for push pull different types of force data. For different body part body segment or body joints, we can measure the pull push force in different directions. So, in this picture it is shown the in various direction how much hand pull force we can exert. So, this data actually adopted from (Refer Time: 17:59) 1972. So, in this way, for they designing any facility while we are thinking about the range of motion for operation purpose, if you want to operate a knob open want to open some or there is a

moving machine part, how much this the proprietor has to move that button or move that control from one point to another point. So, what should be the comfortable range of moving of his hand?

So, that you need to decide, if we design the facility as per 5th percentile data range of motion then what will happen all other person whose range of motion data is more than fiftieth percentile everybody will be able to use, means 95th percent of the population will be able to use it. So, from this purpose if we use 5th percentile range of motion data, for some of the moving parts of a machinery or moving parts of the control then, that will be very much usable for wide range of population. On the other hand if we go for this. This is range of motion data. Similarly it will go for force data or muscle strength data. In that case also as per our requirement, we can use various percentile data; 5th 50th or 95th percentile.

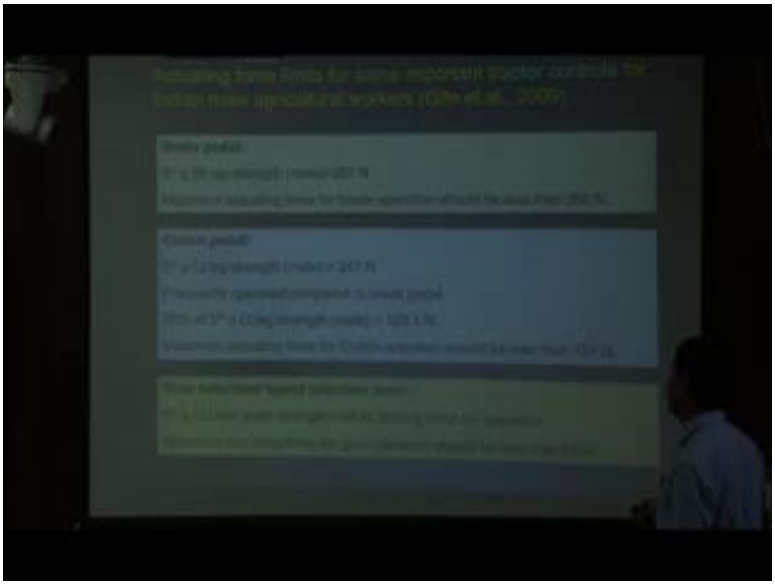
(Refer Slide Time: 19:29)



It would be much more clear if we check the specific case example, in this case this is also one sample data, this is collected from adopted from (Refer Time: 19:39) 2009. So, this is the database for Indian agriculture worker. So, this is the female agriculture worker. So, it is showing the leg strength of right leg, sitting in that situation. Leg strength is measurement is going on. This is for male person the same this is for right leg strength data. So, for this purpose for different states of India, the data has been collected both for female as well for male, and it has been tabulated at in different percentile mean

standard deviation value, and 5th percentile or 95th percentile value. So, this data can be used for designing various types of agricultural tools and equipments.

(Refer Slide Time: 20:29)



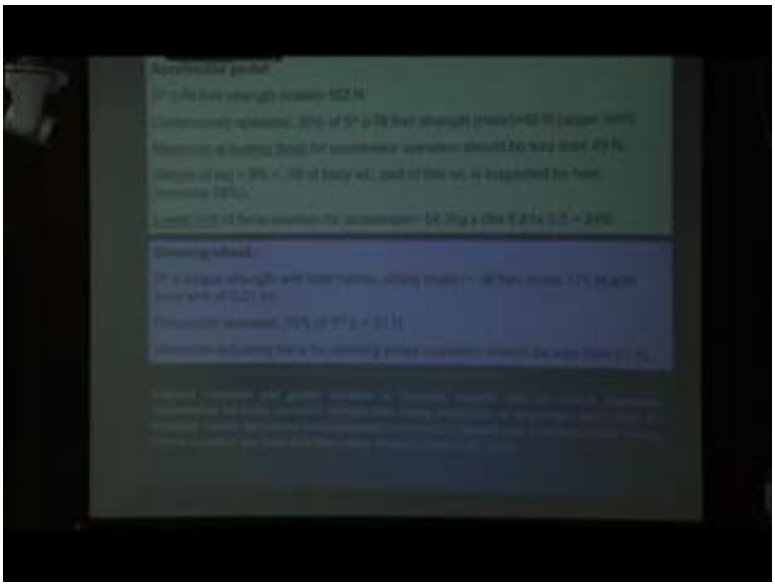
So, now if we take a specific example say, actuating force limit for some important tractor controls, for Indian male agriculture workers. So, in that book detailed in 2009 they have shown that how percentile biomechanical data means percentile strength data force data, we can use or for deciding, the actuating force for difference tractor controls. If we think out the break button, break button is operated by right leg. Now right which percentile data should, we use we have the database or leg strength data or right leg is available, out of that database we will take 5th percentile, right leg strength data for male because generally in Indian scenario tractor is been driven by male only. So, 5th percentile right leg strength is 261 Newton.

So, maximum actuating force for operating this brake pedal should not be less than 260 Newton. If it is less than 260 Newton, then what will happen? With just minimum force, while unintentional brake will be pressed. So, it is minimum value should be 260 Newton; obviously, all others whose force capability is more than, that they will be able to operate that on use the brake pedal. Because their right leg strength is more than this 5th percentile value. So, 95th percent of the population, male agricultural worker, whose right leg strength is more than this 261 Newton all of them will be able to operate the brake pedal.

Similarly, for clutch pedal – Clutch, Clutch is operated by left leg. So, 5th percentile left leg strength data for male agricultural worker is 247 Newton. And this control is frequently used for that purpose instead of using 100 percent strength. You should go for 50 percent of left leg strength. That is half of this. 247 divided by two. So, it is coming 123 point 5th Newton. So, as clutch is operated equivalently. So, 5th percentile left strength data is 247. Out of that only 50 percent we will consider. So, that is coming 123.5 Newton. For that purpose of maximum actuating force for a clutch operation should not be should be less than 124 Newton, so if actually clutch pedal. Operation force is 124 Newton then; obviously, all the other person who is already you have considered 5th percentile. So, 95th percentile of the population can use that on. As it is frequently used again we have deduct deducted it by 50 percent. So, actuating force in this case is 124 Newton.

Now, next gear selection, 5th percentile and push strength is used that is 49 Newton. So, maximum actuating force in this case will be less than 49 Newton.

(Refer Slide Time: 24:10)



Similarly, accelerator pedal, 5th percentile right foot, because accelerator is operated with right foot, so that is 5th percentile data is one 63 Newton. Continuously operated so, we can use thirty percent of that, now we have to saw that there is 50 percent. Now it is thirty percent, 50, 50, 5th percentile of right foot leg strength data is on 63 Newton, as it is continuously been used. So, we will use thirty percent of the 5th percentile right foot

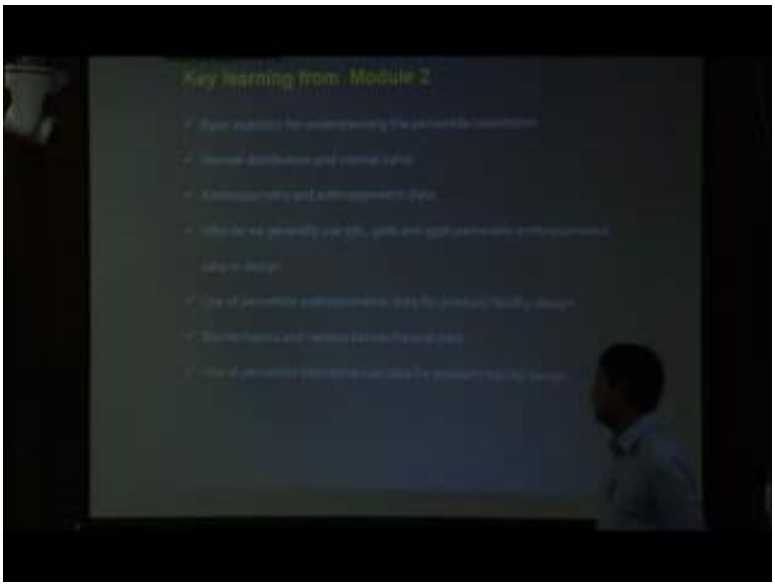
strength that is 49 Newton. That is upper limit. Now maximum actuating force for accelerator operation percent, we can mention as 49. Now weight of the leg is 90 percent of the whole body. If whole body weight is 54.7 kg for an average person and 0.9 percent of that is the weight of the leg, and this is the g value gravitational force a gravitational acceleration, and point 5 is if we consider half of that. So, 24, lower limit. So, only the weight of the leg, due to the weight of the leg we can exert and we have considered 50, 50 percent of that that is due to that is into 0.5, 24 Newton.

So, it is lower limit should be will be 24 Newton whereas, the upper limit is 49 Newton. So, upper limit is decided based on the 5th percentile of the right foot strength. And is 30 percent, but lower limit is decided as per the weight of the leg. That is the 0.9 percent of the whole body weight, into gravitational acceleration into 0.5; means there are considering 50 percent of the leg weight which is coming to 24 Newton. So, during beside this the actuating force, for accelerator pedal, we have to set all limit maximum 49 Newton and minimum is 24 Newton.

Similarly we can also decide the steering wheel. For regional variation and gender variation, of isometric strength data are crucial for harmonic consideration, for using percentile strength data. So, quarter to 2006 mention that it is very important to use regional strength data for various types of facility particular in this case, we get the example of agricultural tools, but in general regional isometric strength data, is very much important for various product or facility, design because from one area to another area, due to ethnic variation due to geographical location variation strength of the human being varies.

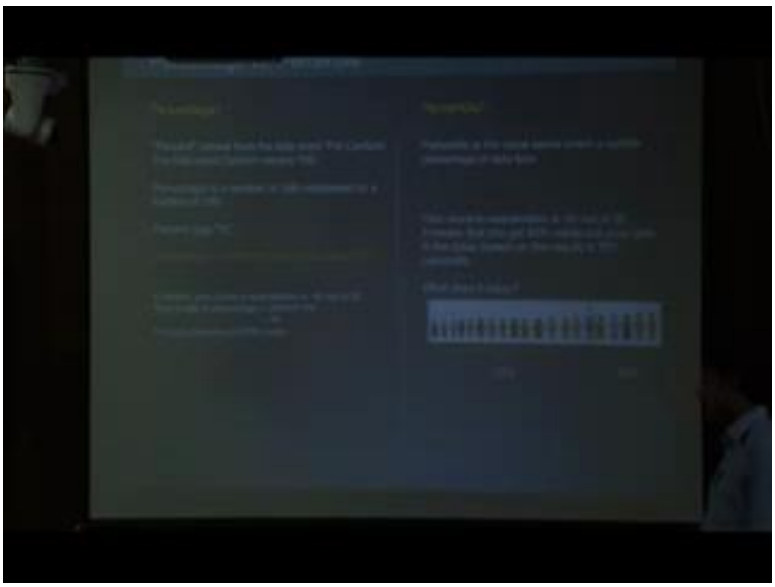
For that purpose we cannot adopt blindly adopt some equipment or tools, from the specifically developed for one region, directly cannot adopt for another completely different geographical region, or the population is completely different their strength data will also be different.

(Refer Slide Time: 27:43)



Now, key learning's from module. So, suppose whatever we discussed in module two. So, first we have discussed if we recapitulate. So, this is the key learning.

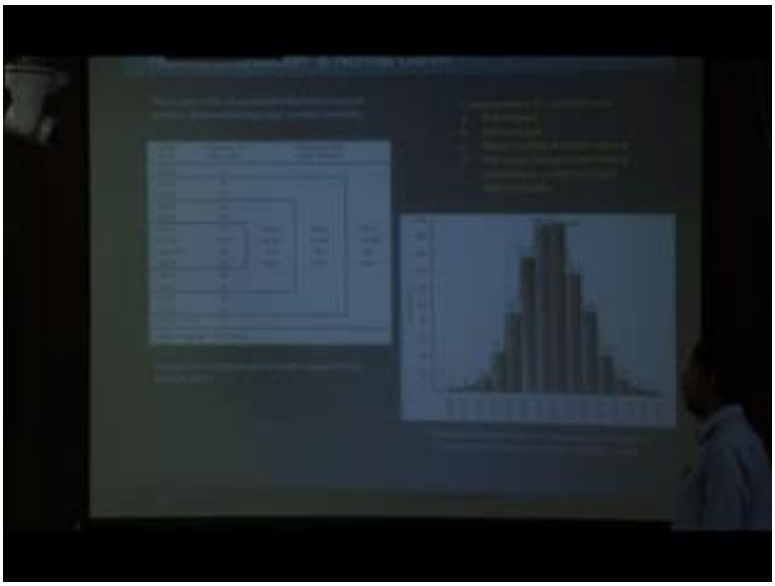
(Refer Slide Time: 28:04)



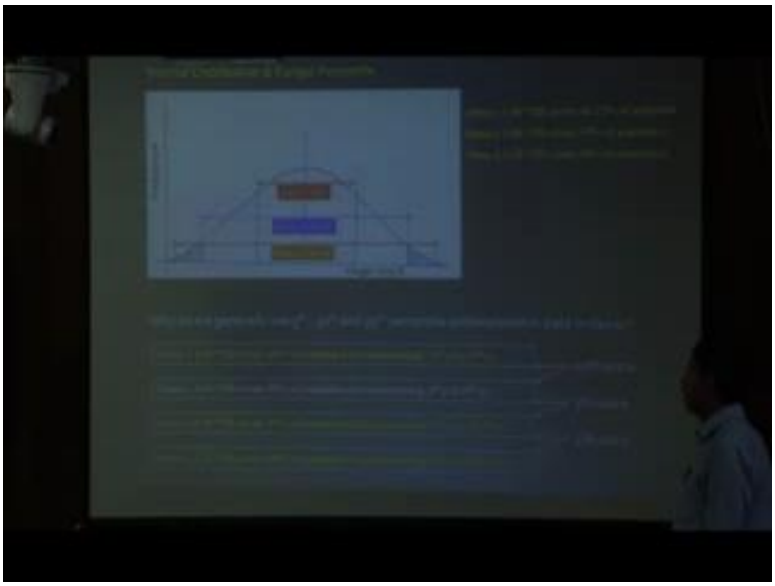
So, we discussed percentage and percentile. How percentage is different from percentile how to calculate percent various percentile data.

(Refer Slide Time: 28:15)

(Refer Slide Time: 28:18)

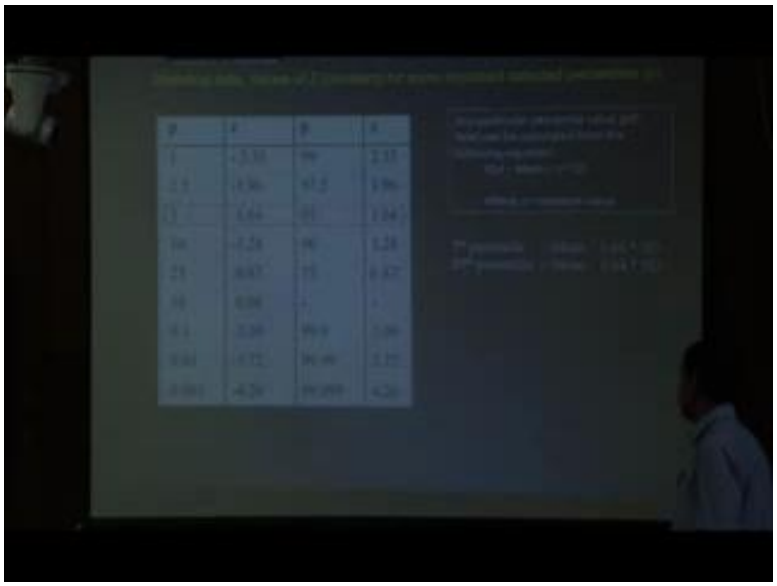


(Refer Slide Time: 28:21)

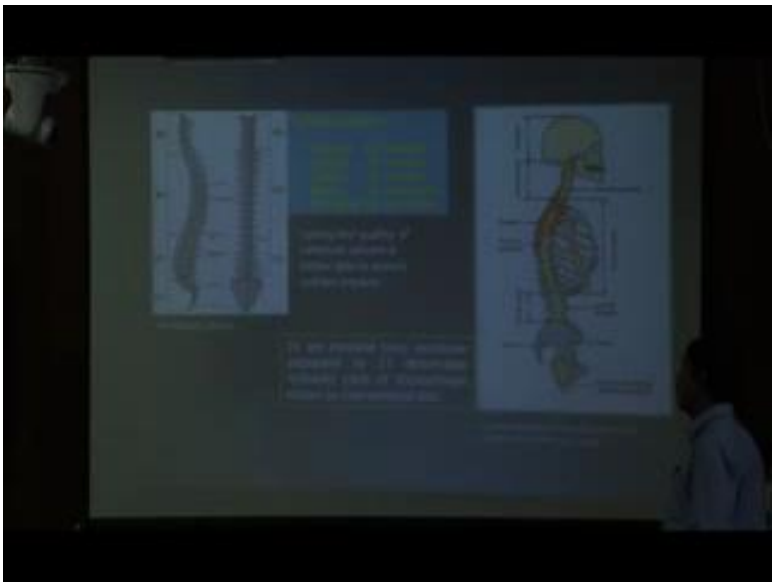


Then measures of central tendency then what is standard deviation. What is normal distribution? What is normal graph from normal graph? How we can define how we can calculate various percentile data. At the same time why for various design purpose we use a 5th 50th or 95th percentile data. We discussed here specifically highlighted that, with one standard deviation, you can accommodate 68 percent, but if we increase that little from one standard deviation 1.64 standard deviation. Then actual we can accommodate 22 percent extra, but beyond that that increment is less. So, we will not go for that one. We will restrict our self at this level. So, we will consider for our design purpose, we will use 5th percentile to 95th percentile data, to accommodate 90 percent of the population.

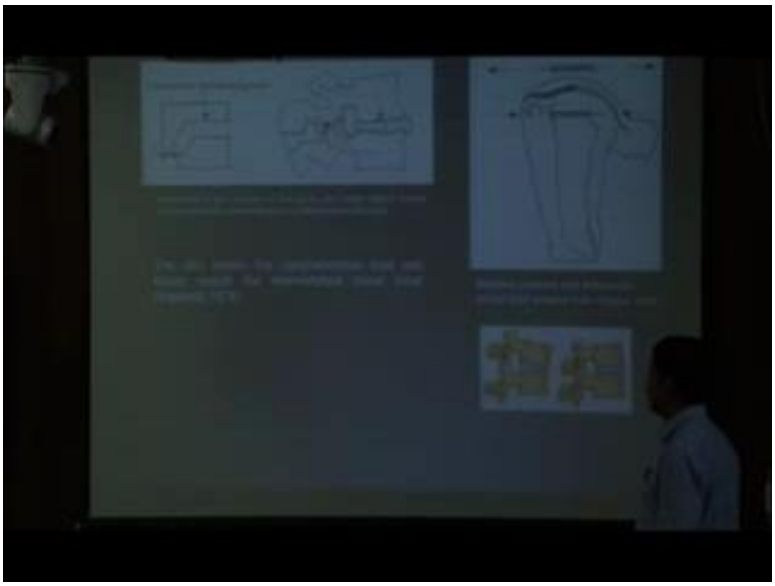
(Refer Slide Time: 29:10)



(Refer Slide Time: 29:13)



(Refer Slide Time: 29:16)



Similarly, we discussed about the body planes landmarks then our vertical column structure of the physical anatomy of human body.

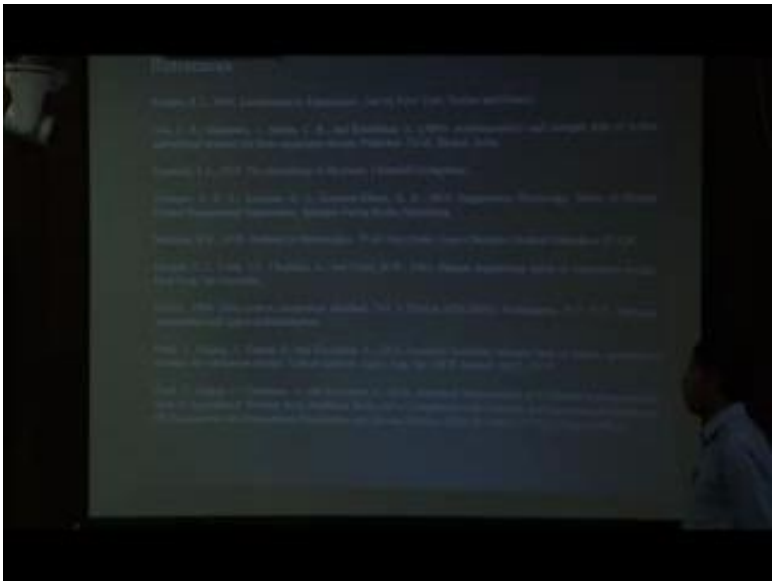
(Refer Slide Time: 29:23)

Then we discussed about the anthropometry. What is anthropometry what is biomechanics then various types of anthropometric data. It is percentile calculation biomechanical data. Percentile biomechanical data, it is used for design purpose and also we took the example of how percentile anthropometric data is used for this type of bench design and. So, many people or multiple users are there at the same time. How we can

use various percentile anthropometric data for designing a specifically chair, then what strategies are adopted by designers or engineers for using percentile anthropometric as well as biomechanical data.

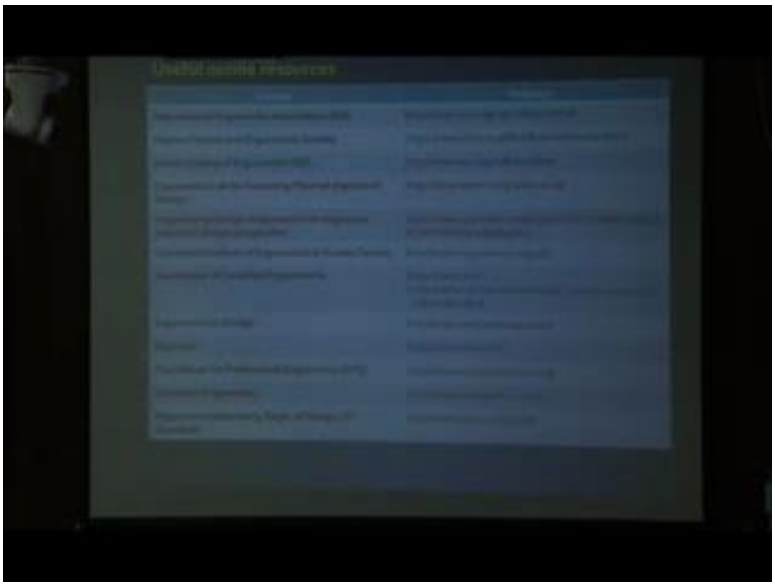
Then we discussed about all these then we took of example of this particular tractor controls, and how we can use different types of strength data. So, overall key learning from this module 2 is basics statistics, for understanding the percentile calculation normal distribution normal curve, anthropometry and anthropometric data, we mentioned why we use 5th, we use 5th 50th, and 95th percentile data for various design purposes. Then how we use percentile anthropometric and biomechanical data for our designing for product and various types of people made on any other facility.

(Refer Slide Time: 31:04)



So, this is the list of references. So, all this references has been used for this. So, students who are going through this particular course they can explore all this references. So, they will get more insight about this subject.

(Refer Slide Time: 31:25)



Not only this references apart, from those references in module first also, I give this type of useful online resources. So, you can explore all this you online resources, where you will get enough information regarding overall ergonomics, anthropometry, biomechanics, and not only that if you say this type of say humanics ergonomics. In this case you will find various databases on various anthropometric data biomechanical data. So, all those data will be available on this type of slide.

Apart from that I also suggest you to go through these 2 specifically these 2 resources. Ergonomics layout or assessing physical aspects of design, you can explore this one and also engineering design algorithms for beginners industrial design perspective. So, these 2 resources are also very helpful for the students and also beginners to understand the subject ergonomics and various ergonomics aspect of product design. So, thank you this is the end of module 2.