Digital Human Modeling and Simulation for Virtual Ergonomics Evaluation

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Lecture – 03
Use of percentile anthropometric and biomechanical data for product design Part I

Welcome to all to this course Digital Human Modeling and Simulation for Virtual Ergonomic Evolution.

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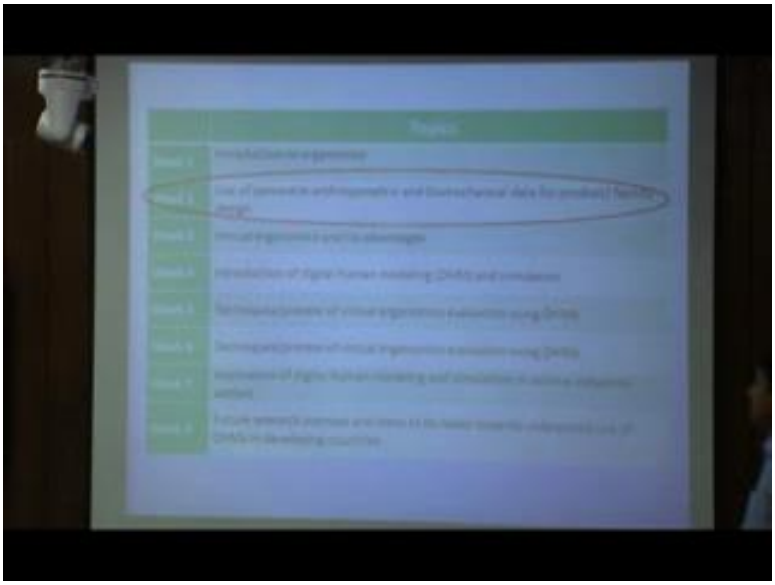

Now, today is the second module called with to user percentile of anthropometric and bio mechanical data for product or any other facility design. Last we discuss about introduction to ergonomics. Now, we are going to discuss about anthropometric and bio mechanical data and different types and anthropometric and biometric data, how these data is used in different types of product or facility design?

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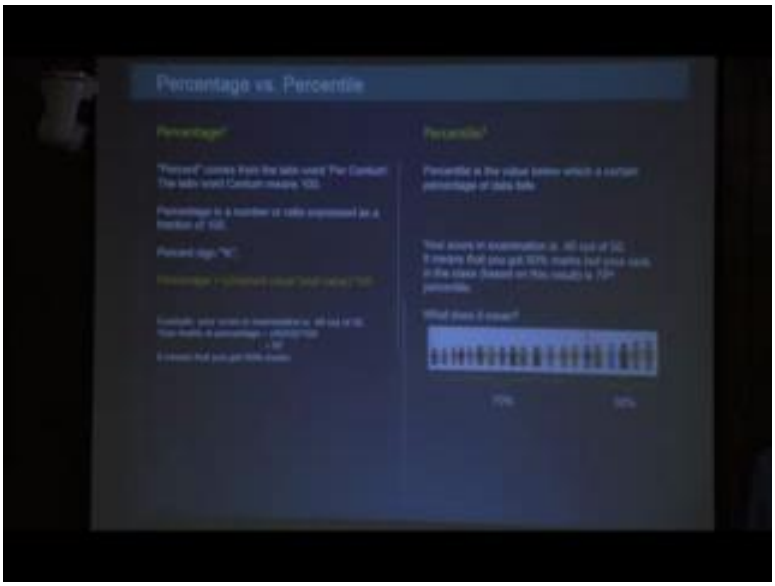

Now, this module 2, before going to discuss about the anthropometric bio mechanics or anthropometric and bio mechanical data, it is better to study little bit about basic statistics which are very much essential to understand, what is percentile, what is mean value, what is standard deviation. If you understand these basic concepts of statistics it

will help us to understand that how percentile anthropometric data or bio mechanical data can be used for different types of facility design.

So, first we start with percentage. So, what is percentage? All you know in the class today may ask you got 40 percent marks or 80 percent marks, and then what does it mean? 80 percent you got; 80 percent marks means out of 100 you got 80. If your exam is in 50 marks then out of 50 you got 40 marks. If you calculated then what is out of 100 then out of 100 is coming 80. So, percentage can generally be described as or defined as a number or ratio expressed as the fraction of 100. Generally, it is denoted with this sign percentage sign.

The word percent comes from Latin word called per centum, what does it mean? It means 100. So, already as I mention in this 1 percentage is calculated. Now, you got out of 50, 40 marks and after calculation we can say you got 80 percent marks, but in your class your marks is such that your rank in the class is say, for example, I am telling 78 percent. So, you got 80 percent marks, but your rank in the class based on the marks is 78 percentages. So, what does it mean, percentage is defined as percentage of something.

So, now to understand that if we look at the definition of the percentage, percentage is the value below the certain percentage of data falls says, for example, people ask all the students to be in queue in their height ascending order of their height then same listen to you. So, you your height could consider here it is the marks, but if you consider it as height. If we consider that your height says, for example, 170 centimeter is such that your percentage value is coming to 70 centimeter, 78 percentages.

What does it mean below your height value, how many other students are there? 70 percent students are there and above your height how many students are there? There are 30 percent students. Similarly, in case of marks also, you got 80 percent marks that are out of 50 you got 40 marks. It is your telling it is 78 percentage. What does it mean? It mean you got your marks is such that it is had that 70 percent student marks and it is lower than 30 percent student marks. Another example, if I mention that your percentage or your rank and far as per score 60th percentile, what does it mean? 60th percentile

means below your marks, how many student marks are there? Below your marks another 60 percent students got the marks below your mark another.

Similarly, above you how many student got marks 40 percents student got more than. So, that is why your position or rank in class is 60th percentile. So, in this percentage and percentile is completely defined percentage going your marks is converted out of hundred that is the percentage, but rank by expressing the percentage it means, it will consider the marks as data all student marks. If you tabulate in ascending order or descending order then say someone got 40, some 41 in this ways someone say out of 50, but 49. In this way, if we arrange the marks in ascending or descending order, we put like this way.

So, someone got 38, someone 39, someone 39.5, 40. In this way someone got 48, 49 someone got 42, 50. If this the scenario and I am telling you got 48 marks and this marks I am telling, if your rank is 90th? You got 48 marks out of 50 and your rank in the class is 98 percentages. 1 does not mean, how many mean another 10 percent student. Here are 10 percent students who got more than you and here 95 percent students who got less than your mark.

So, 98 percent means any specific percentage you got 48 marks and that marks is 90th. It means 90 percentage data marks, data is below this 48 and 10 percent of the total data is above this 48 and those data actually corresponding to students means 40, 90 percent student got less than your marks and 10 percent student got more than your marks.

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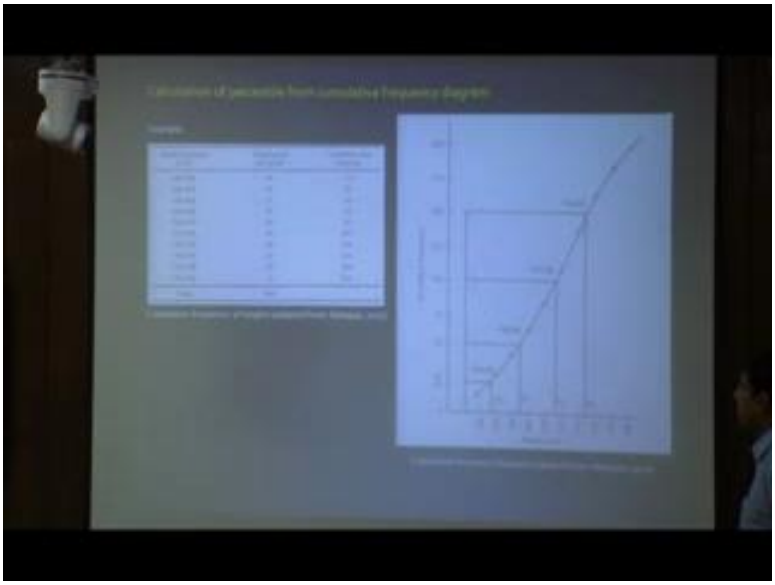

Same thing you can give the example of height. So, this is the marks, similarly, if you discuss the same thing with the height.

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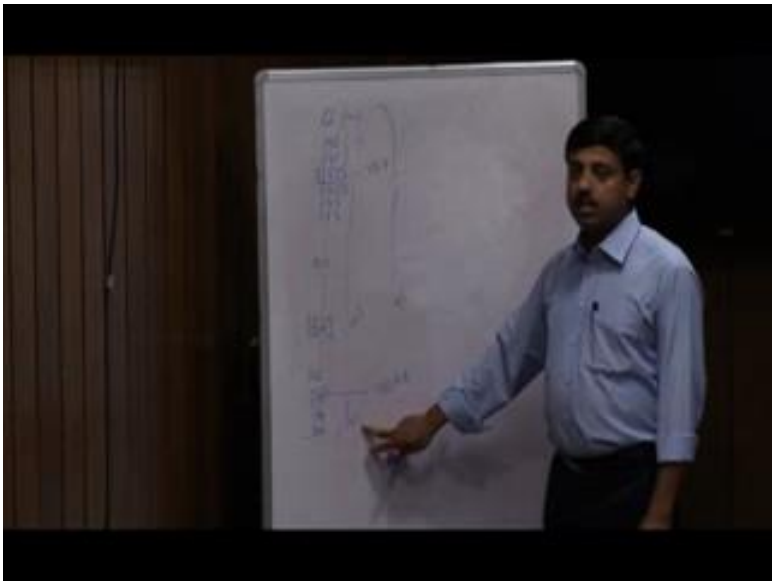

So, in a class room there are so many students, someone's height is 140 centimeter. This is the height side, height expressed in centimeter, 140 centimeter. So, 141 centimeter, 142

centimeter, 142.5 centimeter, 143 centimeter again, 143 centimeter, then this 145 centimeter, 148 centimeter, 160 centimeter, 180 centimeter, 178 centimeter. So, in this way we can put the height value of all the students starting from 140 centimeter and it is ending at 180 centimeters. If you measure the height of the all the students and put those height values in ascending order then we are getting this type of data set.

Out of the data set assume this is your height, 142 centimeter, 140 centimeter is your height value and in this height data said, we are telling this is such a data this data is 5th percentile. If you mention thus in this data 142 is 5 percentages, it means height percent data are below this 142 centimeter and 95 percent data are above this. So, 5 percent data are below this 142 centimeter and 95 percent data is above this 142 centimeter.

Similarly, if you mention your height is 148 centimeter and if I say nothing, say 177 meters. This is 1 height value, this height if you mention this 95th percentile, if you mention 177 centimeter which is 95th percentile, what does it mean within this data said 177 centimeter is saturated data above that height percent data is there and below that 95 percent data is there. So, if you discuss about this 1 that in this data set while it is arranging ascending order if you mention that 177 centimeter is saturated data in this data set, if we call this is 98 percentile, it means above this how many data are there 5 percentage of that are there and below this value how many data are there 95 percent data are there, that is why it is 95th percentile.

Now, how to calculate percentage there are different methods. So, 1 required to calculate percentile value from this frequency diagram. So, what is frequency diagram? So, the height of a group particular group; height starting from 160 centimeter and it is ending at 180 centimeter and now we have divided small interval 160 to 162 centimeter, 162 to 164 centimeter. So, within this group 160 centimeters to 162 centimeter within this set, how many students are there? Say 10 students are there. 162 to 164 centimeter, how many students; 50 students are there. So, this called frequency or number of individual in the particular room.

So, it is very clear in this way the whole range, we can divide into small intervals and within each internal how many members are there we can tabulate it. So, that is

frequency or number of individual in the particular group. Now, what is cumulative frequency? What we present here, 160 to 162 centimeter within this 10 people are there, but 162 to 164 centimeter there are 15 individuals.

But in case cumulative frequency, it is coming 25, how 10 plus 15 is equal to 25 means actual in this position what you are writing. So, first 1 while we are talking about cumulative frequency it means it is actually below that 160. At 160 it is starting from 160 and ends at 164 centimeter, within this range how many people are there? Total 10 plus 15, actually this 25 is coming within the room 160 centimeter to 164 centimeter.

Similarly, in this case this is 17 for the particular group range; 164 centimeter to 160 centimeter, within this there are 17 numbers of students and some number of individuals and, cumulative frequency 42 up to 166 centimeter starting from 160 to 166 centimeter, within this range how many students are there? 42 only we have to sum of 10 plus 15 plus 17 that are coming to 42.

So, in this way the cumulative frequency we have to add in each group whatever is the frequency or number of individual that we have to sum up 1 after another. In this group 174, 172 to 174 centimeter within this range how many students are there? 29 students are there, but first cumulative frequency in that particular group cumulative frequency is 136 centimeter, how these 136 centimeter is coming there you have add starting from 10 up to this 29 then it is coming to 136 centimeter. So, 136 numbers of students actually belongs to in to that group starting from 160 centimeter and ending at 174 centimeter starting from 160 and ending at 174 within this range total number of students is 136. So, in this way cumulative frequency is calculated.

Now, you may plot that cumulative frequency, how it is plotted in the graph cumulative frequency diagram? In case of cumulative frequency diagram as we mention we have to sum up the frequency. So, 162 to 164 centimeter, why do you say how many students are there that value you have put over. So, 160 to 162 centimeter, how many 10; 160 to 162 we are putting 10 there then next 162 to 164 centimeter within this it is 50, but cumulative frequency earlier talking about then that is 25 see here, put here 25 next 42 in

this way whatever cumulative frequencies are there because on the x-axis, we are putting the height and on y-axis we are putting cumulative frequency.

So, whatever which is the cumulative frequency in the particular against we kept against the particular group you have to put here. So, in this way in different this small intervals whatever intervals are given within each interval. We have we have to give cumulative frequency then you are getting this type of graph. So, here how many total 200 students are there? 200 student's data we can plot like this way.

Now, in this plot what is happening? So, 200 will later 100 percent students. Now, for particular say 150 numbers of students, 150 numbers of students is coming like this and it is intersecting at this point on the graph and it will come there then you are getting the value. So, if 200 is 100, 200 students is considered as the 100 percent students. There 150 means 70 percent, 100 means 50 percent, 50 means 25 percent. So, 100th square, consider it 100. So, 100 number of student, 100 students will 50 percent students. So, because total students 200, 50 percent students the height value is below this value that is we can easily from this data we can identify what is the height value on the x-axis in the table. You can mention that values coming to 0.72 per centimeter.

So, below this 171.5 centimeter, how many students are there? 100 students are there that 100 students actually refer 50 percent of the student population. So, this value 171.5 that you can call 50th percentile, in this we can calculate the 50th percentile value. So, 171.5 centimeters this the value in the data set below that data how many students are there? 100 students are there, 100 student means 50 percent students because total students are 200.

Similarly, say if we concentrate on this 50 number of students, 50 number of student means 70 percent students, 25 percent students out of 250 student means 25 percent student those 25 percent student height value is actually below this point, but in this point of this point is 168.84 centimeter. So, 168.84 is such a high value in the data set below this value 50 number of students will 25 percent students are there, 25 percent of students are there mean this value you can mention as 25th percentile student, below this 25th percentile height value. So, 25th percentile high value is 168.84 centimeter means

below this value 25 percent students means 50 students are there and above this how many students are there above this height value remaining portion means remaining 75 percent students are there.

Now, again we are going back to the definition of the percentile. So, what is percentile? So, percentile if we mention 78 percentile, 78 percentile means this is inner data set this is the specific value below that value 70 percent data are there above that 30 percent data. Now, how it can later generalize definition percentile can be defined as a particular point in that data set below that certain percentage. In that example, 70 percent certain percentage of data exists and above that remaining percentage of data exists, but condition is that we have to arrange the data in ascending order.

So, where will arranging the data as in this case also you have showed why there arranging the data in ascending order any percentile mean below the particular percent particular point, 1 particular centimeter 5th percentile below that percentile value high percent data set are there above this 51, 42 centimeter which percentage of data is there 95 percent data is there.

So, what is percentage? What is percentile? So, percentile is a specific position or specific point in the data set below that certain percentage of the data exists and above that remaining percentage of the data exists. So, percentile is not any individual or is not any say height this is the height value. So, height is not the percentile or that student is not the point seventy discrete percentile height mean percentage is used for the data. So, his high value is the percentile neither the student is 5th percentile neither the height is 5th percentile that height value in the data set is 5th percentile, his height value 142 centimeter is the specific data which we can mention as 5th percentage for the data set.

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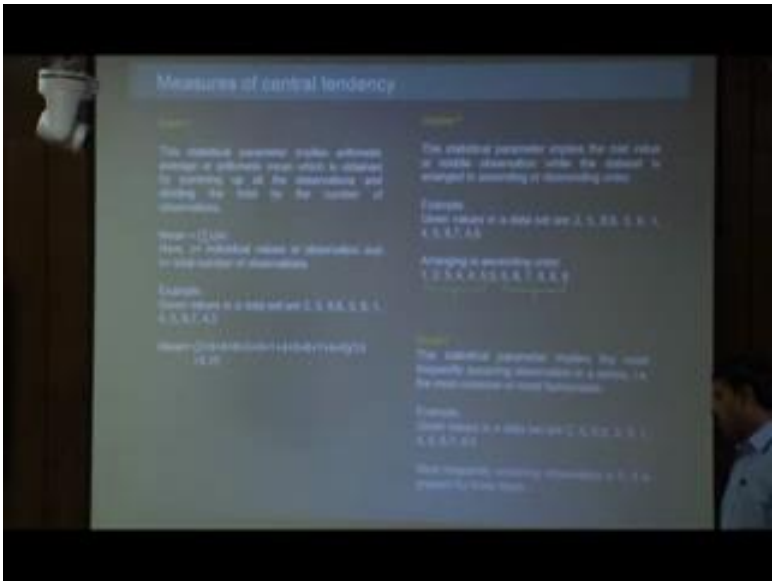

Now, moving forward then to other anthropometric parameters as statistical sorry statistical parameter which have also important for understanding the anthropometric and percentile calculation of anthropometric and bio mechanical data is mean median mode. So, mean median mode these are called central tendency of the data. So, what is mean all of we know mean is the statistical meaningful, how you can define mean? Mean is the statistical parameter implies arithmetic average or arithmetic mean which is obtained by summing up all the observations and dividing the total by the number of the observation.

So, this is expressed as like this. So, x is the individual observation all the individual observation we have to sum up then we have to divide by n of n is the number of total number of observations, for example, if we give an example of an data set add these data sets have this data 12, 5, 8, 6 in this data are there. Then how we can calculate arithmetic average or mean then we have to sum up all the values and then we have to divide by the total number of points in the data sets. So, in this point and data set there are total 13 data. So, you have to divide it by 13 then we are getting mean value or average value for the data set.

Now, next is the median, this is also another central tendency of the data or data set what is median? Median is the need value this statistical parameter implies the mid value or

middle observation, while the data is arranging ascending or descending order the same data set if you consider and then if we arrange them in ascending order from lower value to higher value then whatever is the mid value that is called the median. So, here we are adding you can find this side there are 1, 2, 3, 4 total 6 number of data points are there above this value there are total 6 number of data points. So, mid value is the height. So, for this data set height is the median.

Next mode, there is another parameter for central tendency that is the mode this statistical mode parameter is the most frequently occurring value in the data set that which in the data set ten particular value, which is coming for more number of times that is called mode. With the same data set example we can mention that in the data set we can find, 5 is coming for how many times 5 is coming for 1, 2, 3; 3 times, 5 is coming 3 times. So, 5 is the mode, for median also 5 and mode is in this case module also 5.

Because in the data set 5 is coming for 3 times, now 1 important thing here generally for all are the everyday purpose for use arithmetic our journey then first importance of mode or median there are some situation, where median maybe more expressive for central tendency tell me because the central value or the mean value for the data set may be expressed more by median than mean, when it happens see in the data set if few values are too small or too high you know.

In this example, if few data in general it is starting from 140 and gradually increase to 180 centimeter, but at this end at 1 end either the bottom side or top side or bottom side we will find if 1 or 2 values are there say 140 centimeter and another value is only 120 centimeter, another 122 centimeter. If 1 or 2 values at the 2 ends are very smaller or very larger then what will happen due to pages of those data the average value or the arithmetic means actually does not show the central tendency, in that case median will be the greater of central tendency.

So, in the data set where 1 or more number of the values very small or very large values are there in the data set, which actually relating which actually effecting the mean value due to fiddles of the that values at the lower end or higher end if it is effecting the mean in the scenario median may the better entity.

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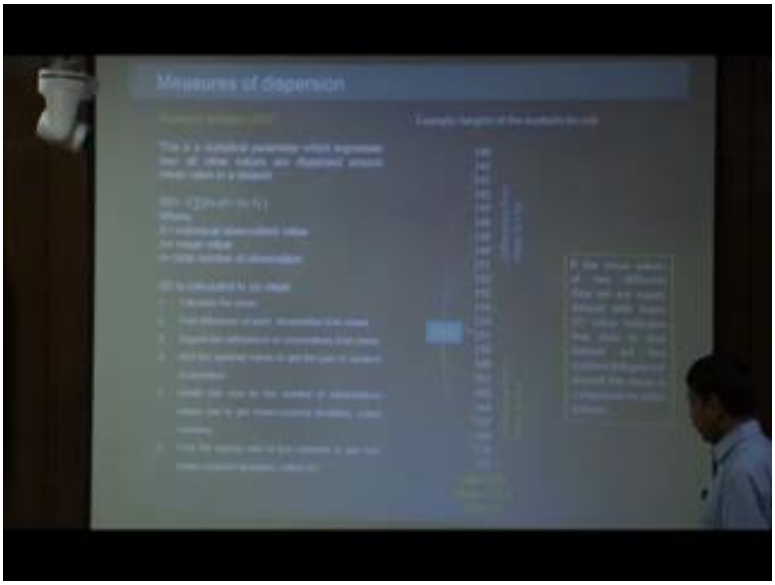

Now, next important statistical parameter is standard deviation. You are coming to this example say, this is also height; students height in centimeter. It is starting from 140 centimeter and ending at 171 centimeter we are assuming. So, sum is this and mean value this much and relative calculated standard deviation. So, mean value is 150 centimeter. So, its mean value position is somewhere here in between 155 to 157. So, mean value actually lies in between these 2 values. So, all the data in the data set are arranged in ascending order. Now, people look at the mean value 155.8 centimeter, from that mean value these 152 centimeter there are some distance few values are nearby 150, is nearby 154 is going away, 153, 152 in this way it is gradually the distance is increasing 140.

Similarly, this side also from 155, 161 gradually the distance is increasing. So, actually in the first assign mean is clear mean is the arithmetic average. Now, what is standard deviation? So, standard deviation actually indicates how all this data points are dispersed or scattered along this mean value. If this is the mean value from that mean value how all other distance are away from whether this values are nearby mean value or away from the mean value.

So, for the purpose, how we can calculate this standard deviation? So, standard deviation is calculated with some formula what do you do ask to calculate the mean value receive the mean value then from the mean we make the difference. So, make the difference from mean minus individual observation. So, 155 minus 155, 155.8 minus 155 then again we can make this type of 155.8 minus 153. In this way we can make calculate the different, first you have calculate the mean. Secondly, you have to calculate the difference of individual observation from the mean.

Now, if you look at this side and these values are lower than 155.8 centimeter. So, whenever you minus all the individual values from 155.8 centimeter it is giving positive value all the differences are positive. But on the other hand, why we are subtracting 155 minus 158 there you are getting negative value. So, this side why we are making the difference between 150 centimeter and individual values then what is this side the differences from the this individual value those values difference from the mean value is coming in negative. So, for this purpose what do we do to make all these negative value to convert it positive at the same this side is already positive. So, what we do we add the then we go for square the difference of the observation.

So, first we calculate the mean then we calculate the difference between mean value and individual observations, whatever difference you are getting then you have to open you have to the square of that value then all this side value as well as this side value will come positive, then you have to sum up all the differences you have to sum up after squaring. So, add the square curves to get the sum of squares and deviation.

Then you are getting the square value then divide the sum by the number of observation minus 1 to get the mixed value deviation. Now, keep their total and this is the sample in this sample how many values are there. So, for example, here 20 values are there in 20 data are there, out of the 20 data where then their degree of freedom is the degree of freedom means, but now 1 important degree of freedom degree of freedom means in a data set how value can be changed or the data point can be changed other than the particular value if the total number of data in a data set is trying to be. So, for the particular position or particular value each value can be changed to another nineteen values.

So, that is why for the particular value total degree of freedom is 19. So, in the curve what is sample if you assume there are total n number of data points then degree of freedom for that data set is a minus 1 will have to divide that square some with the n minus 1 that is the degree of freedom then as you have already seen mean if n is here n is the.

Now, we are coming to the statistical expression in the statistical expression what we can see n is the mean value mean value this is the mean value minus x is the individual observation either this side or that side all these individual observation this may come positive or negative for that purpose we are make we are putting square in all the differences in positive form when it is coming in positive then we are dividing it by n minus 1 total number of observation minus 1 as the degree of freedom,, but if we tell this the sample data then if it is the population data or very big data number of sample size is very high or very big sample size or population data in that case is taken instead of n minus 1 we can use n.

Similarly, here we are using as it is a small sample we are using n minus 1 then as initially for making all the difference which are in negative or either in positive in positive mode we square it. Now, as we put the square now again we are putting the square root pole expression then it is given actually 1 expression that is expressed in that how all other values in the data set are dispersed for mean value. So, mean value minus individual value then square that after squaring divide it. So, that after squaring whatever and sum up and whatever value is coming that is having n number of data then to get the average value we are diving that expression n minus x square divided by n minus 1 then you are getting the average value after getting the average value as we put that square now again your putting the square root.

So, ultimately standard deviation is has statistical expression which is expressing that how while the data arrange in ascending order or descending it may be also descending order while the data is arranging in the ascending order descending order then from the mean value how other values are arranged dispersed around the mean value. Now, this is very important the if the mean value of 2 different data sets are equal data with the lower

standard deviation value indicates that data in that data set are less scattered or less dispersed along the mean in comparison to another data set.

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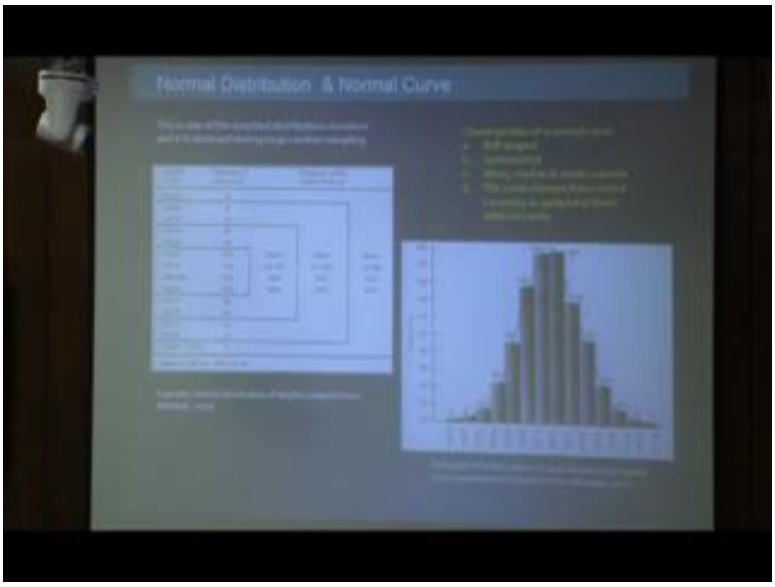

We are giving that example, this data set are there. So, this is the 1 data set and this is the mean value now as we mention what is standard deviation we mentioned standard deviation expresses how all other values in the data set are dispersed along the mean value from this mean value few data nearby few data away from the mean.

So, it is like this some value are nearby some value are away. So, ultimately is for this data set mean value is coming to say 40 and standard deviation is coming to 5, another data set where mean is the same, mean value is same in this case also mean value is 40, but standard deviation value in how all other values are dispersed on the mean value. If we calculate that 1 then the standard deviation is coming to 2 in both the cases mean value is same 40, but in this case standard deviation is 2 in this case standard deviation is 5.

So, what does it mean in this case all values are more dispersed on the mean in this case values are nearby mean value that is why standard deviation is less. So, standard deviation actually expresses how all other data in the data set are dispersed on the mean

value, if those are nearby mean value then those are nearby mean values then standard deviation value is less. If those data points are dispersed on the mean value or away from the mean value then it is coming, then standard deviation value is more. Now, next is normal distribution and normal curve. So, normal distribution is 1 type of standard distribution which occurs in pie chart. So, generally as we are discussing about frequency diagram. Similarly, if we look at this table then it would be easier to understand what is normal distribution see if the, but first we need to know why we find this normal distribution.

Generally while you talk about normal distribution we mention we will get this type of bell shape curve, but when we get when the data collection is random sample size is peak random data collection is there and then you are getting this type of bell shape curve then we can mention that data is following normal distribution pattern So, how does this happen? See, if we consider the height value for a particular group of students or a particular population. So, for example, 142.5 below this how many students are there? 3, 145.5 to 147.5 how many below 148 centimeter to 145 centimeter; 8.

Then below 145, next is this frequency for each group, 145 to 145.5 or 147.5 how many students are there? 50. So, in this way with the small integral if each group number of students is given here, then what you are taking at the below range 3, 8 gradually it is increasing and at the end also middle it is values more at the end it is again reducing even in any population even, for the example of the big class room, if we find how many students are gained all number is very less 1 or two. Similarly, how many students in a class are very smaller in size answer is very least 1 or two.

But more number of students with average body dimensions is found. So, further purpose if we put this type say, 48 for x-axis. If you look at this graph on x-axis, this is the height value and this is the small interval 142.5 centimeter, 142 to 145 centimeter then 147.5 centimeter. So, within this each interval, how many students are there? At the smaller lower data range 142, below 142.5 centimeter all the students are there. 142.5 to 145.5 how many students are there, 8 students are there. 145.5 to 147 centimeter, 50 students are there. So, in that way that we can see why they are going towards the mid range the number of students in the particular group is gradually increasing.

Again from the mid range while we are moving towards the higher range higher values of the height then number of students in a particular group is reducing. So, as I mention. So, this is the height value on x-axis, we said the height value and y-axis we have kept the number of students in that particular group that is the frequency.

So, number of the students in the mid range 157, 157.5 or 160 centimeter in that range the number of students are more, but while we are going to the lower side or we are going to the higher side of the height value the number of students in that particular group, it is reducing ultimately you are getting this type of bell shape curve.

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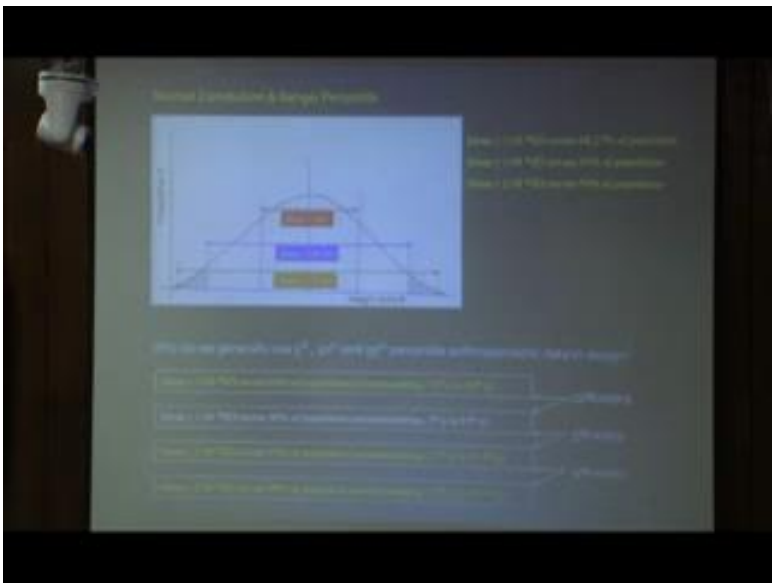

So, this bell shape curve is called normal distribution or normal curve while the data set for the normal distribution there will get type of normal curve. So, few characteristics are mentioned here. So, that should be bell shaped, it is generally this type of curve is observed then symmetrical from the mid line both side are similar mean, median and mode. If any data set follow normal distribution pattern then this very important of your vision that mean median and mode everything co-inside and the curve changes from the center convexity towards concatenation at the both end lower end as well as upper end. Now, non normal distribution and range and what is the reaction with percentage, in this graph on x-axis we are getting height in centimeter and on y-axis this is the frequency.

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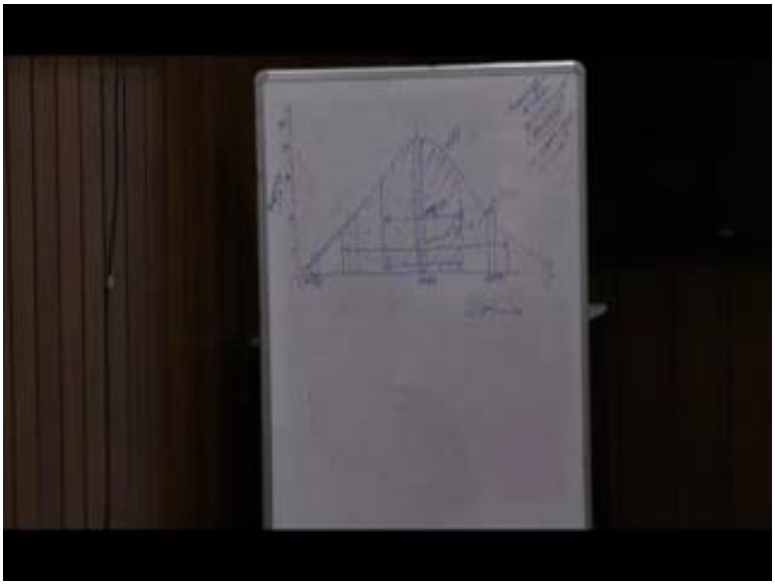

Now, if we draw the same thing here, putting height in centimeter on x-axis and on y-axis, you are putting the frequency, frequency in number of students in that particular group. Now, for a particular class is starting from 140 to 142 centimeter, within this group how many students are there? Only 1 or 2 students are there. So, this side number of students; total 50 students are there, this is 25, this is 20, this is 10, this say 30, 40, 50. So, 140 to 142 centimeters how many students are there? Only 2, 3 students are there.

In the next group, how many students are there? The number is more 140 to 144 centimeter; similarly, in this way while will we are coming to mid range see that 160 centimeter then number of students, 162 centimeter within that range number of students are more how many students are there say, 40 students are there in that range. Similarly, while we are going to upper side it is 180 centimeter; 2, 182 centimeter within that range again number of students are placed in between say, 172 to 174 centimeter within that range number of students are relatively more.

Similarly, here number will be more. So, ultimately we are getting this type of bell shaped curve because student with average body dimension or average height value or any other body dimension their number is more students with lower body dimensional value their number is less similarity students with higher body dimension value their

number is also less. So, we get this type of bell shaped curve now for this data set or for these students, we are assuming mean value say, 160 centimeter and standard deviation value is say, 3 centimeter. So, for particular population if the mean value is 160 centimeter, this is the mean value 160 centimeter and standard value is 3.

Now, from the statistical analysis find any data set for the normal distribution, then it is observed that as it is mentioned here mean plus 1 standard deviation value covers 68 percent of the population means from the mean value, if this the mean value point from that 160 centimeter mean plus 1 standard deviation value power 68 percent of the population from the mean value, if we go 1 standard deviation up or 1 standard deviation down. So, this the mean value from mean value if you go 1 standard deviation up 1 or 1 standard deviation down then it is actually covering these are the mean value points mean value from that we are going to plus 1 SD or minus SD, it is actually covering what percentage of population it is actually covering 68 percent of the population this is observed for any data set which is following normal distribution.

Now, mean plus or minus 1 SD, it will cover 68 percentage of the population. Now, from the mean value if we go 2 SD from here, if we go 2 SD this side up or 2 SD down then value where it is little 1.96 SD. So, the mean value is almost 2. So, mean plus 1.96 SD covers 95 percentage of the population. So, if know the mean value 160 centimeter from that 1 step first case mean value plus minus 1 SD 1 into standard deviation c. So, 160 centimeter plus or minus 1 into standard deviation value 3, this actually covers 68 percent of the population, from the mean value 160 centimeter, if we go 1 time standard deviation value is 3, 1 into SD value 3 actually that within that range means 160 centimeter plus 3 with 163 centimeter to 160 minus 3, 157 centimeter within this range 68 percent of the population exist.

Similarly, from the mean value 160 centimeter if we go 2 into SD, SD value is 3 it is actually covering 95 percent of the population to be actual, value is 191.96 and I am putting 1.96. So, mean plus or minus 1.96 SD, SD value is 3 here. In this case example we have mentioned SD value is 3. So, mean value plus or minus 1.96 SD within that range how 95 percent of population is covered. So, 160 minus 6, 154 centimeter to 160 plus 6, 166 centimeter you can write in the opposite. So, 157 to 166 centimeter within

this set we are covering 68 percent, 154 to 166 centimeter, within this range here we can cover 95 percent of the population. So, from the mean value it will go 2 standard deviation from this mean value it will go 2 into standard deviation value then actually we can cover 90 percent, this actually covers 95 percent of the population.

So, this range the same thing is also shown here. So, from that mean value, this is the midpoint mean value or the mean value before you go 1 SD upward or 1 SD downwards. So, here we get that example that is the point 60 centimeter is the mean value from that usually, if we have 3 centimeter positive or if you subtract 3 centimeter within that range 60 within this center doted portion, it covers 60 percent. Similarly, from the mean value that mid line if we go almost the SD 1.96 time standard deviation, from this point to this point it actually covers 95 percent of the population and mean plus minus 2 into standard deviation, it actually covers 99 percent of the population.

So, in this way we understand that if we can for a data set or whether that is anthropometric data or bio mechanical data from that data if we can calculate the mean value and we have the standard deviation value with us then we understand from that mean either we will go within some range positive reaction or negative reaction 1 SD up or 1 SD down, if it covers 68 percent main value, 1.96 SD positive side, negative side within this range it covers 95 percentage of the population mean plus 2.58 SD, then it actually covers 99 percent of the population.

Now, 1 important thing generally for the design purpose we mention the do you want to use 5th percentile, 58 percentile, 98 percentile and anthropometric data twice. From this graph as we are discussing if we extend that then we understand mean plus minus 1 standard deviation actually covers 68 percent population, but what will you get actually accommodating mean plus 1 SD, if we calculate that actually give us the 84 percentage mean minus 1 into standard deviation value whatever value we will get that is actually 60 percentile data.

So, in from 60th percentile to 84 percentile actually, we are covering 68 percent of the population. Similarly, from mean value it will go 1.64 SD in positive reaction or negative

reaction which is actually covering 90 percent of the population mean, we are accumulating 5th percentile to 98 percentile.

So, in that you can mention same, we are mentioning this is covering 95 percent means remaining portion this side remaining portion is 2.5th percent, 5 percent this side also remaining portion is 2.5 percent. Similarly, if we want to cover mean plus 1.64 sd, it covers 90 percent of the population. If it covers 95 percent population, it means 5 percent population is below that range and 5 percent population is above that range only. It is covering mid 90 percent mean, this is the mean value say, this point is 160 centimeter from that if we go 1.64 times SD value then availability that point is actually 98 percentages.

So, you can easily calculate, in other way how to calculate 90th percentile data, if the data set for a normal distribution then with the mean value, if we add 1.64 times SD then you are getting 95th percentile value mean value minus 0.564 SD then you are getting 5th percentile value. So, within this range mean plus minus 1.64 SD actually, you are covering starting from 5th percentile and ending at 95^{th}, 0.98 percentile the in between 2 percentile, 90 percent of the population is covered. Similarly, from mean value if with the mean value, if we add 1 times SD actually we are calculating 84 percentile data. Similarly, with mean value if we subtract 1 SD then actually we are calculating 16 percentile data. So, from 16 percentile 2, 84 percentile the range which range we are covering 68 percent of the population.

So, in that way in mean curves 1.96 SD, it covers 95 percent of the population mean plus 1.96 SD actually, gives us the value of 97.5th percentile data mean minus 1.96 SD give us the value of 2.5th percentile. So, starting from 2.5th percentile to 97.5th percentile, we are accumulating 90 percent of the population. Next 1 with the mean value, if we add or subtract 2.58 SD then actually we can cover 99 percent of the population or data set it means it actually starting point is 0.5th percentile and end point is 99.5th percentile.

Now, the question why do we use 50th of 98 percentile? So, generally 50th percentile is called average dimension we will discuss in detail. So, starting from 5th and ending at 95^{th}, if we understand this graph then we from that we can visualize this that mean in

plus minus 1 SD covers 68 percent. If we increase it to mean plus minus 1.64 SD we are cover actually 90 starting from 68, now we are covering 90 percent. So, if we increase the SD value from 1 from 1 to 1.64 actually we are covering another 22 percent of the population, if you consider all the mean 1 is the you can cover 68 percent of the population, but if we talk considered mean plus minus 1.64 SD then your combine 90 percent of the population.

So, what is the extra percentage we are powering, but using this 0.64 SD more we are actually covering 20 percent extra similarly if we go for 1.96 SD then we can cover 95 percent. So, what is the increment from the 90 percent, now it is 95 percent earlier it is 90 percent, now it is 95 percent. So, only 5 percent extra you can accommodate. But, this indicates that while we are increasing the SD value from 1 to 1.64 it is accommodating a good amount it is increasing the accommodation of good amount of population that is 22 percent extra,, but for 1.64 SD if we increased almost 1.64 to almost 1.96 2 then although we are increasing the accommodation of 5 percent extra 2.

So, we should not go for this we should go for only this 1 which is better become as much this standard deviation value what is the standard deviation value means actually we can explain in some other way say, for example, if we are designing this chair in this chair. So, if this is the mean height of the chair for mean height of the chair seats and height is 40 centimeter this 40 centimeter seat and height or you can draw it. So, this is a chair.

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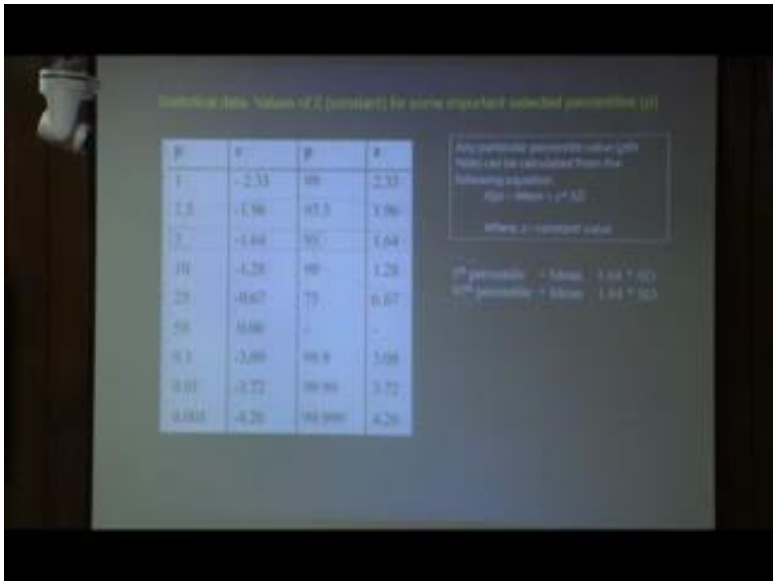

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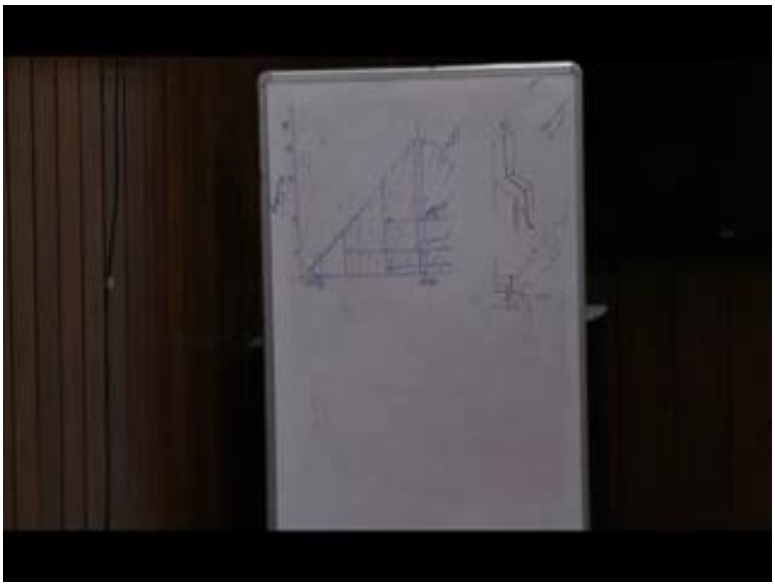

This height is 40 centimeter. So, here assuming that lade height or that chair is mean value is 40 centimeter. So, how you decide it that what should be the lade height of that chair. So, for that purpose we have collected anthropometric data from the anthropometric data set you have calculated the value of the mean value or 50th percentile value. So, mean value of the 50th percentile is coming to 40 centimeter.

Now, for that particular 40 centimeter, this is lade height value for the chair we need design this 1 what should be the value for this purpose what is the corresponding anthropometric value what is the human body dimension for that that is we call perpetual height in general term, we can mention is lade height of human. So, 1 human being is sitting there we need to consider these are all lade height, this is lade.

If you imagine this human being, when that human being is sitting this is the dimension need to consider exact anthropometric valuable we call it perpetual height that height from below up to the bottom surface of the soul. So, that is the perpetual height. So, perpetual height we are measure the perpetual height of a big sample and we are getting calculating the mean value is 40 centimeter. So, accordingly if we design this chair as per the 40 centimeter perpetual height then 50th, 50th percentile person can sit comfortably because it is as per his body dimension now from that height, if we now from side view the chair initially it at the mean value that is 40 centimeter.

Now, if we increase this height the standard deviation value of that anthropometric variable is 2 that anthropometric variable means perpetual height or you can mention lade height. So, perpetual and the standard deviation value is two. So, with mean plus from go 1 SD 1 SD means 2 centimeter 40 centimeter if you go 40 centimeter to 40 2 centimeter or you can come to 38 centimeter from that mean value, if you go 2 centimeter up or 2 centimeter down with 1 SD 1 time SD then you can accommodate 68 percent of the mean value.

But if you go mean plus 1.96 SD up and down 1.96 SD means almost 2 SD mean plus 1 point any way. So, if you consider 1.64 SD now how mean this is the mean value for mean value if we go 1.64 SD then we can cover. So, this 1.64 SD then we can cover from this is the mean value from that mean value we are increasing 1.64 SD up 1.64 SD down then within this range from this point to this point how much percentage you are covering you are covering 90 percent of the population.

So, initially you are using mid from mean value 1 SD up 1 SD down we are covering 68 percent now from the mean value we are going 1 up and 6, 4 SD 1.64 SD down within that range we are covering 90 percent. So, actually we are increasing the accommodation

22 percent more people. So, for that purpose you should go for you also try to accommodate 90 percent 90 your are accommodating 90 percent of the population means it is starting from 5th percentile to and ending at 95th percentile 5th to 95th percentile shuffle people with this perpetual height or lower level height starting from 5th percentile to 95th percentile in between this 90 percent of the population they will be able use this seat if the height adjust ability of the seat we adjust like 1.64 SD up and down.

So, from mean value this is beneficial for us. From mean, if you go 1 SD then all of them can cover 68 percent, but from mean if we increase of decrease 1.64 SD then we can cover 90 percent. So, extra 22 percent can be covered or can be accommodated after that again, if we increase the SD value only we can increase accommodation of 5 percent from 1.64 SD if we increase to 2.58 SD then we are increasing only 9 percent. For that purpose we do not go because as much as standard deviation value means as much as adjustable feature, we add then the facility will become fragile it will be broken easily for that purpose we should not go we should not go for increasing the SD value as much as possible.

If we increase you can increasing mean plus 2 rules SD 3 SD you can increase, but with that increment the number of perpetual or the percentage of the population being accommodate that is very less for that purpose, we will concentrate on this area this area means mean plus 1.64 sd. If you use then you can cover 90 percent of the population means we are considering 5th percentile to 95th percentile of the anthropometric data. If we use the 5th percentile to 95th percentile then anthropometric data then we are covering actually 90 percent population.

But for that purpose how much SD you are using only 1.64 times SD. So, this is very good compromise because we can also increase the standard deviation, but as much as standard deviation will increase mean we will increase the more adjustable feature that system on that facility will be highlighted and it will be easy to break down. So, this is the reason for which to accommodate more number of people we go for up to accommodating 90 percent population is 5th percentile to 98 percentile,, but we should not go for accommodating point 5th percentile to 98 percentile, 99 percent percentile

because in that case in that case we have to use 2.58 times SD why do we use more SD value or mean we are making the adjustable feature more, it is becoming much more fragile and only very limited number of people are being accommodated with the increase of standard deviation value. So, for this small reason, we use keep the 98 percentile data to accommodate the 90 percent population where only we use 1.64 times SD.

Now, already we discuss this one that we know the mean value and standard deviation value for a data set which is falling normal distribution then we can calculate various percentile value first percentile, second percentile or 5th percentile or 50th percentile as per our economy.

So, here these are the z is the constant value here is also the constant value if you want to concentrate calculate say, for example, 5th percentile or 98 percentile value then how to calculate? This is the constant value for a specific percentile if you want to calculate then will have to go for mean value plus or minus standard deviation value see if want to consider 5th percentile, calculate 5th percentile value then what we will do from mean obviously, mean means 50th percentile mean value indicates 50th percentile value in case normal distribution.

So, if the 50th percentile value obviously, 5th percentile value will be less than that for that purpose we have to go for minus this value is the minus. So, mean minus 1.64 times. So, this minus 1.64 times if you have to calculate 5th percentile then with standard deviation then you have to multiplied minus 1.64 SD mean minus 1.64 times SD then you are getting 5th percentile value. Similarly, if you want to calculate the 98 percentage value then how you have to precede mean value or 50th percentile value with 50th percentile value we have to add 1.64 times SD then we will be able to calculate 98 percentile value.

Similarly, see if you want to calculate 25th percentile value, in that case what you have to do to calculate the 25th percentile data mean minus 0.67 SD then you will be able to calculate 20 percentile value. Similarly, if you want to calculate 75th percentile value, for that purpose we have to calculate mean plus 0.67 into standard deviation then we get the

75th percentile value. So, from this type of standard values of z we can calculate various percentile of the constant value with the constant we have to multiply or calculate a standard deviation value to calculate various percentile data.

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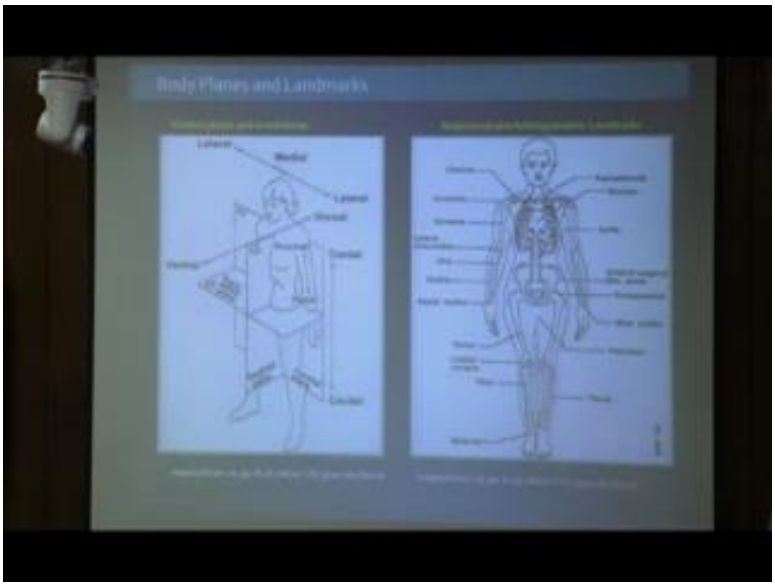

Now, body planes now after so far what we discussed. So, far we discussed if we recall. So, few basic statistical parameters like percentage then percentile gradually moved to various types of central tendency mean median mode mean is the 50th percentile value in case of normal distribution because in case of normal distribution, mean, median and mode value coincide. Then we again discussed about standard deviation value, how it is calculated and what is the meaning of standard deviation, then normal distribution, then we mention we also discussed how if you know the mean value and standard deviation value for a particular data set which is following normal distribution.

Then we can calculate various percentile value at the same we understand that how much specific range either 68 percent or 90 percent or 95 percent population within which range it is actually be covered. So, that is also shown here that if we understand know the mean value of standard deviation value then we can calculate and we can accommodate certain percentage of the population.

Then this is the same calculation of percentile, now after understanding this basic statistics now we are looking towards ordinary topic anthropometric and bio mechanical data. So, for that purpose initially you should know we think it about the human anatomy body planes and various landmarks.

So, basic knowledge of human body, this body planes are important here you can see we can describe human body through various planes. So, if you look at this plane this 1 there are deviation value which is mentioned x, y, z deviation. So, if forward reaction is x and upward deviation is z then this plane is called xz, xz plane forward direction inform if we mention forward direction is x upward direction is z then this periscope exists this periscope sagittal plane.

So, what is sagittal plane is doing? Sagittal plane is actually the plane dividing our body in left and right half. So, this is the plane in front of your body if we assume that forward direction is x-axis upward direction is z-axis then this xz plane it is dividing our body into 2 halfs this is called sagittal plane another is if you look at this plane this plane yz plane if we mention y-axis is side wise z-axis upward y-axis side wise and z-axis upward. So, this plane is actually yz plane yz plane is called corner plane this corner plane dividing our body in frontal forward and backward frontal and backward or ventral and dorsal half.

So, this plane is called corner plane. So, 1 is sagittal plane that is dividing our body into 2 halfs, left and right. Similarly, this plane yz plane dividing our body frontal and backward portion back portion in ventral or dorsal half that is called corner plane similarly there is another plane that is if x-axis forward and y-axis is side wise x forward y side wise then this plane this plane is called transfers plane. So, this dividing our body into 2 haves up and down

So, this planes are very important because while during anthropometric and bio mechanical discussion or bio mechanical study while you are discussing human body parts or its movement then you have to explain that see, for example, you are disturbing hand movement then we have to mention in which direction x, y, z coordinate system at

the same time in which body plane that particular body parts is moving. So, defining the posture defining the human body motion these planes are very helpful.

Now, similarly if you look you should also know walk with students or students which is important to understand basic anatomy of the human body the skeleton structure number of bones how these bones are arranged in the human body all these information is very much important for digital human module because in digital human model what we do as we have mentioned earlier also that is actually human body representation digital human modeling is cad representation of human body. So, if we know basic anatomy and the structure of human body then it will be easy for us to understand digital human model creation and it use for the different types of ergonomic evolution

So, from any anatomy book we can go through and we can understand and we can understand that how those bones are attached to 1 another different types of joints are there and the same time landmarks there is another for landmark there are some specific point s in the body which we can clearly identify from outside, so that if you want to measure human body dimension say if I want to measure hand dimension then from this point to that point. So, there are some specific points on the body should be identified which can be easily identified by some other person also and from those say if you mention that lower arm plane from where to start and where to end how do we define for that purpose specific bony marks on the specific position of the body portion though we have to identify too specific or any other folding we have to identify from we measure the body dimension. So, different landmarks are for example, one is acromier. So, this, if you want know that this is the acromeir position then those people know those points then it will be easier for us to measure human body dimension.

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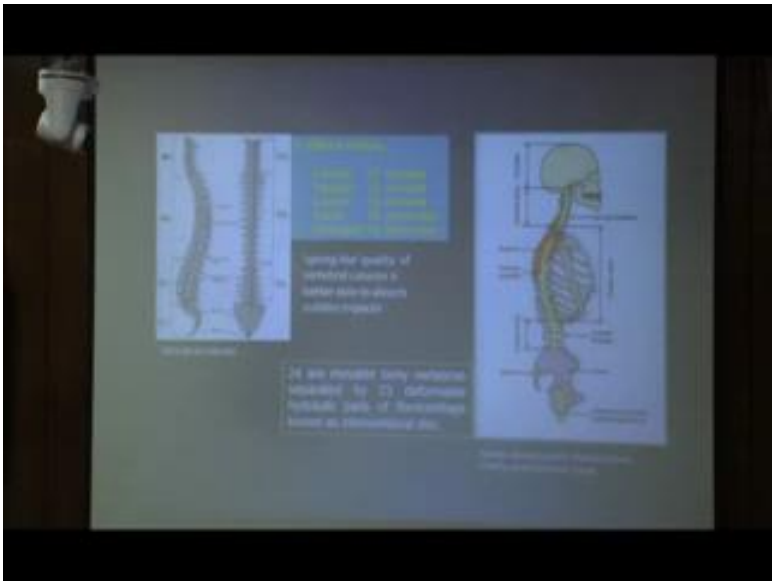

Now, if you at all overall skeleton structure. So, this the vertical column where all skull is attached this vertical column same vertical column or our back bone is made up of many bones if we look at the cervical portion or neck portion, how many bones are there? There are total seven bones seven numeral bones with seven numeral bones we can move on neck.

Then next portion is the thoracic portion or chest portion, there are total 3 numeral bones are there. Next in classic portion in thoracic portion, chest portion there are total 3 numeral bones next portion is called lumber portion. So, first neck portion, then thoracic, then lower back portion this portion is called actually lumber area. This lumber area there it is representing like this in lumber area how many bones are there five numeral bones are there lumber area is very important for our discussion because our forward bending or side wise bending or rotating even bending backward all this actually happening with the help of this lumber bones these are very flexible.

So, for hour we are talking about sitting ergonomics works station ergonomics then lumber motion is very important because this flexible portion actually allows us although all other movable bones are movable thoracical or cervical, but our bend forward bending or leaning or your are leaning backward. So, this actually happens due to this

thoracic and lumber bones and this in lumber area during heavy load carriage or load lifting or weighting there is competition we will discuss further.

Next is the sector next portion is the sector portion this is the sector portion. So, what is sector portion there are actually five immovable bones. So, if we see the back side view then we can see these are the sector portion. So, actually there are five vertebrae those five vertebrae used together and those are immovable similarly proximal portion what we call tail portion in proximal portion there are four immovable bones.

So, in this way total there are 7 and 12, 19 and 10, 5 and 4, total 33 bones are there as this 2 portion immovable and those bones are fused. So, actually this is coming to 24 24 movable bones and this 2 are these five fuse to only making only 1 structure and this four immovable bones are fused and they are also making 1 structure. So, there are total these are the seven (Refer Time: 86:09) five five and four number of bones.

Now, in between if you look at this vertebrae in between 2 vertebrae mean 2 bony structure there is some soft piece material that is called inter vertical disk 24 movable bones in vertebrae are separated by 23 deformable hydraulic pads of hydro cartilage minus inter vertical disk. So, in between 2 vertebrae this portion is a actually inter vertical disk. So, during our bending that inter vertical disk actually get compressed.

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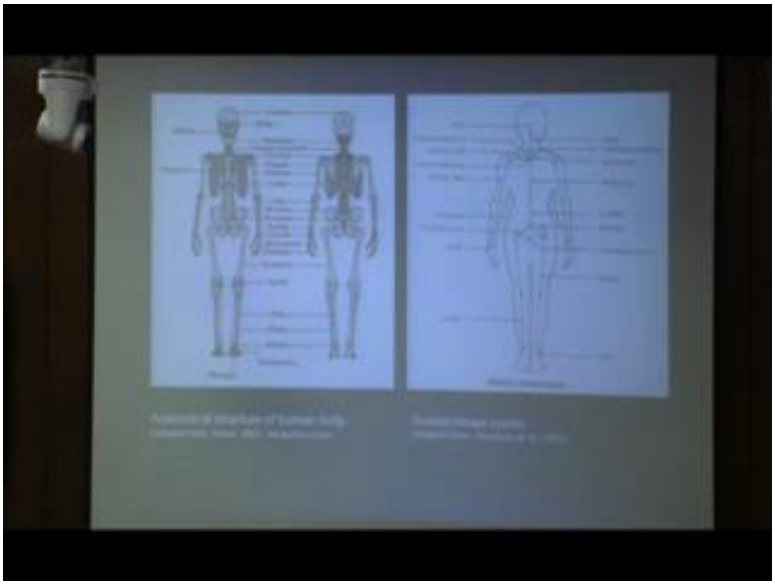

Next as we are discussing about anatomical structure, this from another source. So, various body parts if we talk about hand. So, we at least we have basic knowledge thus there are how many bones are there are there. So, upper portion there is numerous bones and lower arm there are 2 bones radio.

So, this type of and though how was the joint type was the how that body that particular body joint moves to this basic knowledge is important otherwise it will not useful for use to use digital human modeling software creating human model and going for the various types of ergonomic evolution and why do we later on while in this course why do we discuss about the creating the digital human model then this point skeleton linked system then how human body can be represented with link segment various body segment those are joints with this linked structure. So, this linked system.

The same hand upper arm lower arm are from how we can represent with linked segment that is actually showing the skeleton linked system this will be very much helpful if you understand this 1 clearly then this will be help for our making digital human modeling.

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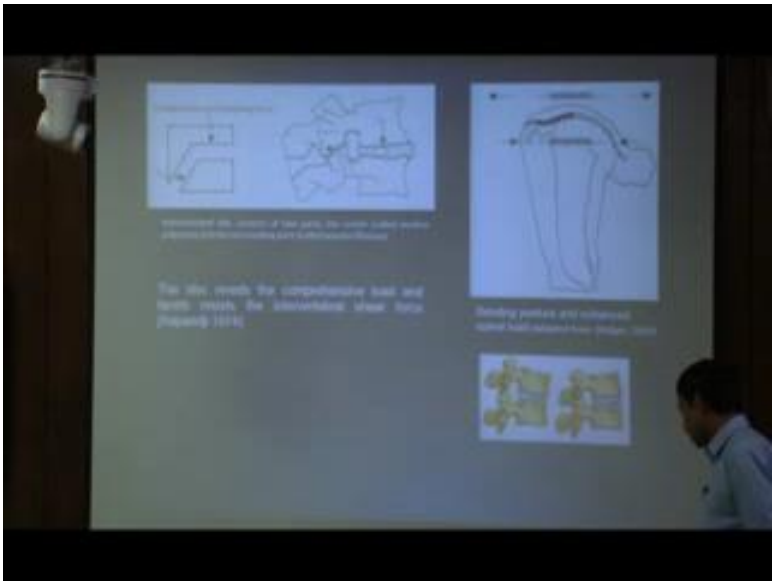

Now, continuation to our earlier slide earlier we are discussing about inter vertebral disk in between 2 vertebrae there is inter vertebral disk. So, what happens in the inter-vertebral disk? There are this type of this is a say that 1 vertebra and another vertebra in between 2 vertebrae there are inter-vertebral disk. So, why we are bending forward? Then, what is happening this side? One side it is getting compressed another side it is expanding. So, what happens while there is compressive force inter vertebral disk consist of 2 parts that is the central part is called the center called nucleus power process and surrounding called sperm annulus hydroceles this regarding the inter vertebral disk.

Now, we are discussing about the force due to this movement of the vertebrae while we are bending forward and backward say if we are moving forward then what is happening then this corner while you are moving forward or bending forward then here it is getting compressed. So, what type of compression is here there is compressive force is there when there is a compressive at the same time this side there is shearing force. Similarly, here while we are bending backward then here is the compressive force. So, due to all various type of bending twisting rotating body action in the inter vertebrates there is inter vertical there is change in the pressure sometimes there is compressive force sometimes there is increasing shearing force. In 1974 he mentioned the disk resist the compressive load and accept there is a inter-vertebral shearing force.

So, this actually help us in registering the compressive force or there is compression at the same time this type of facet joint of the vertebrae it helps in registering the shearing force.

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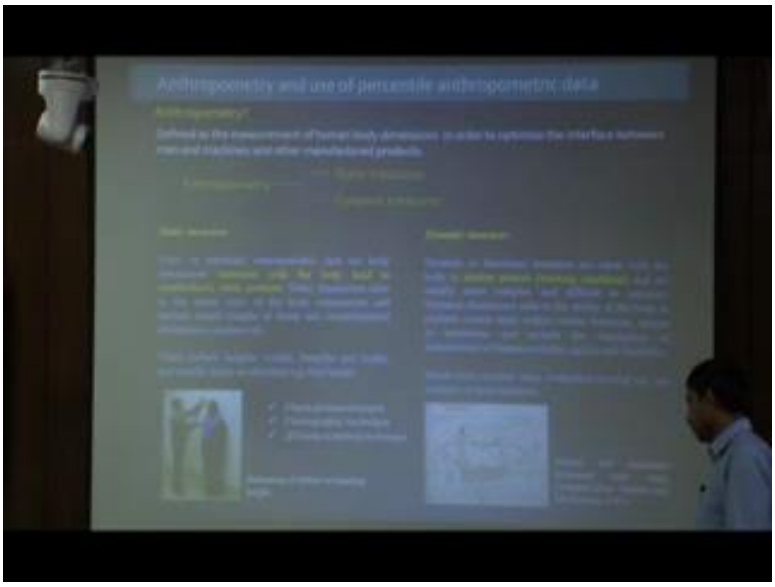

Now, coming to our main topic that is anthropometric and use of anthropometric data, first we know what is anthropometric anthropometry? Anthropo means latest to him and metriy means measurement. So, anthropometry actually indicates the measurement of the human body. So, it is defined as measurement of human body dimension in order to optimize the interface between man machine and other manufacture product. So, this measurement of human body is of 2 types 1 is static measurement and another 1 is dynamic measurement. So, this is also mention as static anthropometry and dynamic anthropometry.

So, what is static anthropometry? Static anthropometry while human body is in the static posture with either seated or standing posture means there is no movement why human body human body physics static posture that thing whatever body dimension we are measuring following standard measurement procedure with standard instrument that is called static anthropometric measurement example static anthropometric measurement. Say, for example, hand weight. So, what is the length of lower arm or upper arm what is

the height of the face. So, all this measurement you can take by human bodily in static posture sitting height while some is seated on the chair then you can measure the height from the ground up to the head this the sitting height from the ground to the head height. So, that is sitting height.

Similarly, while someone is standing then in the standing posture you can measure from the ground is the actual point. So, actual height, in the case in different static posture you can measure human body dimension that may not be ours linear on the length or breadth that may be the circumferential dimension say wrist circumference or hand beat diameter. So, different types of linear or circumferential diameter measurement you can take. So, static measure static or structural anthropometric data or body dimension wizard with body building standardized ethic posture static dimension refer to the actual sizes of the body component and include simple length or linear and circumferential dimensions contours etcetera these includes height, weights, breadth, width and usually imply no direction. So, their direction is not in potential.

For example, foot length now, how these anthropometric measurements are taken? In earlier days physical measurements with anthropometric heat anthropometric rods different types of telecast people use to take physical measurement. There is also other technical photo graphic photo premier photo graphic technique in photo graphic technique photo is taken from front view or side view and after that scale we can or with chart paper we can calculate the body dimension.

But, nowadays there is 3D body scanning technology with 3 d body scanner what you can do you can scan the whole human body and from the scan data we can go for measure number of body dimension including linear dimension or. So, any other non-linear dimension he can measure even you can measure at every cross section what is the area of the human body, when advancement of technology which city body is now which is much easier and to get more accurate data of human body shape and sizes. Now, dynamic measure dynamic or functional measures are taken with body while it is in motion. So, in this case the body was in static posture in this case body is in dynamic posture.

So, while body id in movement then whatever body dimensions are or dimensions are measured that is called dynamic measurements and usually more complex and difficult to measure dynamic dimensions referred to ability of the body to perform certain task within certain distances spaces or enclosures and include the description of measurement of human mobility agility flexibility. Show 1 example, if you want measure the range of motion of this hand. So, this hand in this particular example this called friction. So, friction or this is opposite direction that is extension. So, we can measure the complete range of motion. So, this is not in static posture. So, you have to measure the complete range of motion of this hand when it stars from the up from this point.

So, if we consider the initial position this 1 then this the extension then it is go in this much friction. In this way friction extension adaption and adaption different types of resolving give and take, this actually to measure the dynamic posture comes posture condition. Similarly, we can measure the region that computer itself while some 1 is seated in the seated condition what is his total reach area mean each area each volume around which particular human can access. So, this re chamber of reach home comfort zone all are described under dynamic anthropometric measurement.

So, basic for a say that is static it is while what is this static posture then the human body dimension will static designing then dynamic means if some on is leaning forward 1 step forward leaning bending in during that time total area covered by the total distance by the we can measure under dynamic anthropometric measurement. So, then it will mentioned like reach zones comfort zone what these envelop etcetera and design under this dynamic.

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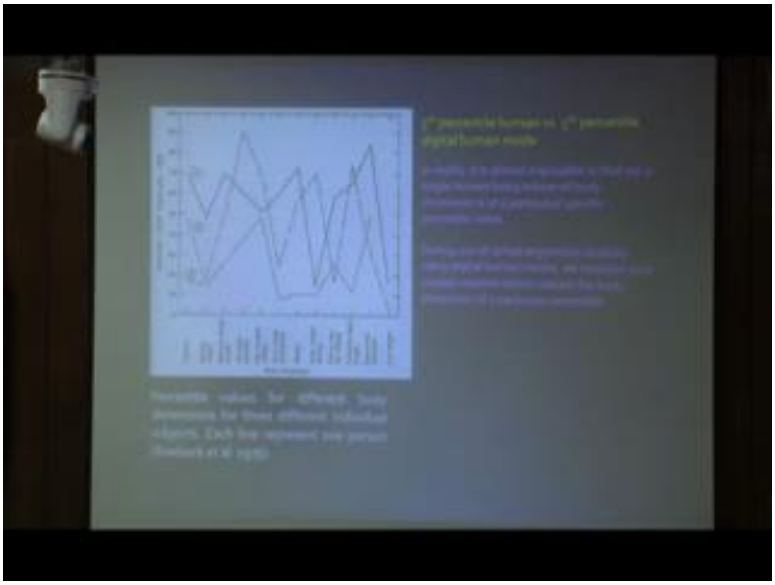

Now, if you look at this graph, this is adapted 1975. So, here there are total 3 graphs 1 2 3 and the lines characteristics of lines are also defined. So, what is this? This is human various human anthropometric variables structure means standing heights sitting height in this way high height. So, various defined variables anthropometric variable are listed on x-axis, y-axis what is there this is percentile value of course, I personal and their data collected in 1950. So, here actually 3 persons data are there. So, for 1 individual I you see this is the graph for the third individual this is the graph.

So, what does it indicate? So, indicates that if we consider the first person his structure is 78 percentile, but first person the structure is 78 percent, but if you consider this 1 his sitting height is actually 50th percentile. On the other hand, for the same person this is knee height, sitting knee height it is coming to say for 15th percent, 15th percentile for single individual. These for this particular individual this different body parts are of different percentile. So, how does it happen? So, if you measure the per population if we measure the height value of a population and if you find some my height value 95th percentile it does not mean that if we measure the hand dimension of all the people and calculate what is the percentile value of my hand name it may not be 98 percentile, my lade height value or stretcher is 95th percentile it does not mean that my hand limb or leg limb is also be 95th percentile it may be of different percentile.

So, this is the typical example is provided by viva cattle that for their single individual different body parts. It is the percentile value is actually different, if we consider the third person in this case for his stretcher value is near about 28 percentile, but his hip wrist sitting is coming that is coming to 58 percentile. So, always stretcher is near about 28 percentile of 15 percentile, but his this point if the sitting is coming to 58 percentile. So, it clearly shows that for a single individual all the body dimension may not be of a particular percentile, if some one's height or handling is at the particular percentile say, 98 percentile. It never means other body parts will be of 98 percent or is nearby, it may be something different also.

In reality, 5th percentile in reality it is almost impossible to find out the singe individual his all body dimension particular percentage value this very important step that in reality, if we find particular individual. If you take the example of me only as I already mentioned my structure is 98 percentile it does not mean that my hand length is also 98 percentile or my leg length is also 98 percentile all my leg length is also 98 percentile it may be my hand length 80th percentile my wallet or my perpetual height it is just the 68 percentile.

It may in reality we cannot find any single individual whose all body dimension is of a particular percentile value, but while we are creating digital human model for virtual ergonomic evolution then we create this type of human model 5th percentile human model or 90 percent human model what does it mean in that case if we consider such a situation that all the body dimension have a particular percentile value 5th percentile human model mean all the body dimension of the particular human or digital human model is 5th percentile value, but in reality it is the question,, but that type of optimal condition is considered. So, that all the 5th percentile anthropometric data can be represented by creating the 5th percentile digital human model and that digital human model we can use for various type of design dimension evolution.

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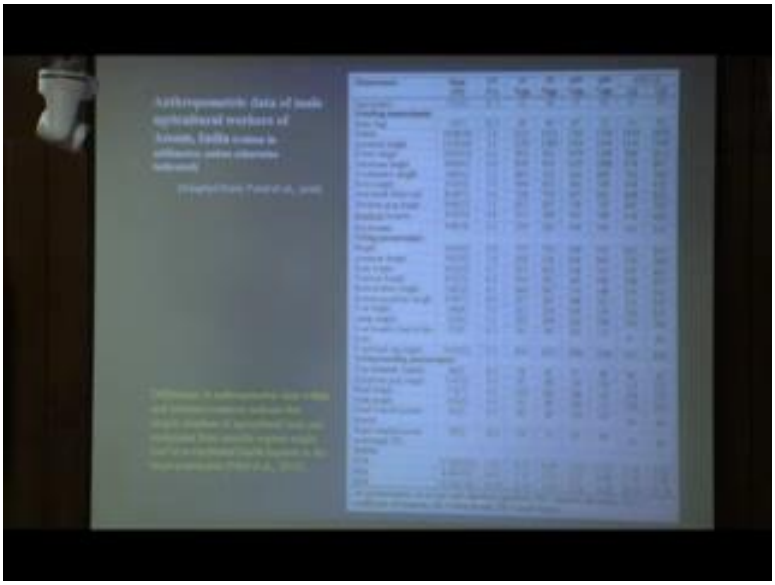

Now, this is 1 sample data that how the anthropometric data represented these are various measurements in body parts this is standing measurement sitting measurement sitting standing combined measurement. So, structure acromion height l y is defined anthropometric variables are here and this side mean value in bracket this standard deviation value this taken from anthropometric data of male agriculture workers of Assam, India. So, agriculture worker of Assam state from India this value is taken and adapted from 2016.

So, in from the data set we can see that if you consider she stretcher or standing height standing height is 1628 millimeter and now first this calculated as calculated is following normal distribution. So, you can calculate easily first percentile 5th percentile 98 percentile and 99 percentile and those data we can use as per our requirement. So, this anthropometric data collection and its percentile calculation is very important because while are designing any facility or any product then we use this percentile anthropometric data to ensure human body dimensional compatibility with the products physical dimension.

For example this particular research work for a letter differences in anthropometric data while discovering the compression of anthropometric data of Assam agriculture workers

with various region of anthropometric data or various region of India as well as from other country then he mention then mention that differences in anthropometric data within and between countries indicate that simple adoration of agricultural tools and equipment for specific region might lead to occupation hazard in target population.

Because there is anthropometric variation if any 1 blindly adapt 1 product or equipment from 1 country to another because human body dimension of the particular country is defined from the country as from the product or the equipment or instrument has been imported say, for example, for Indian population if we bring some product which is actually made for USA population considering the human body dimension of the USA population if the product is direct is directly brought to India then that product may not be compatible with Indian human, Indian body language because that product actually has been made considering the anthropometric database or the American that may not that may not match with the anthropometric requirement of in a population.

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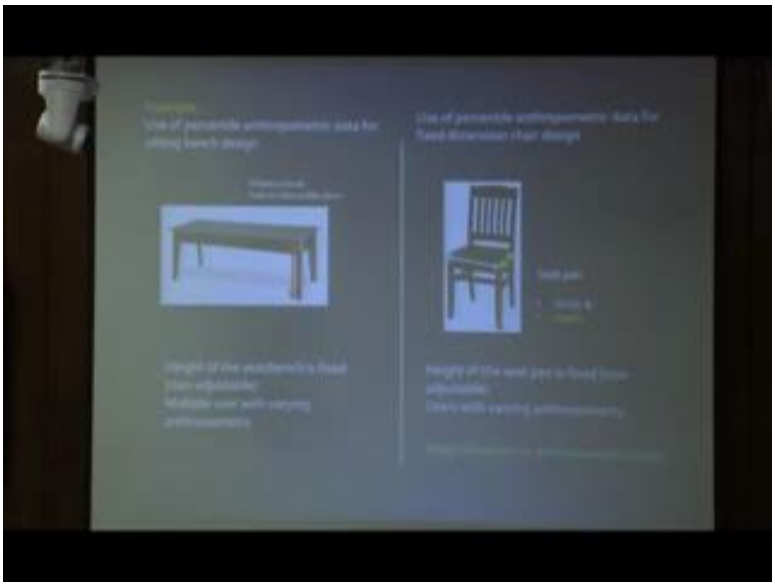

Now, if we discuss about the use of percentile anthropometric data then first we discuss about this example we take example of a bench either it may be primary school of the primary school children this type of bench 4-5 students are sitting together or this type of bench kept in the park that is actually multiple user when we can sit there. So, you can be

specified for a particular individual. So, if we get the example of this bench for a class room. So, if we want to design a bench for a class room will have to decide the lade height for that bench. So, this side dimension is the lade height for deciding the lade height first will be the lade height what is the corresponding anthropometric valuable for that purpose anthropometric data or corresponding human body dimension is coagulate height or perpetual height.

Now, if it is asked as per which percentile data of the perpetual height or lower limb height this bench should be designed. So, that all student in the class room can use comfortably. So, for this purpose we have collected anthropometric data of the students that that valuable is perpetual height. So, here measure the perpetual height of the students from that we have calculated 50th percentile data, 5th percentile, 50th percentile and any way.

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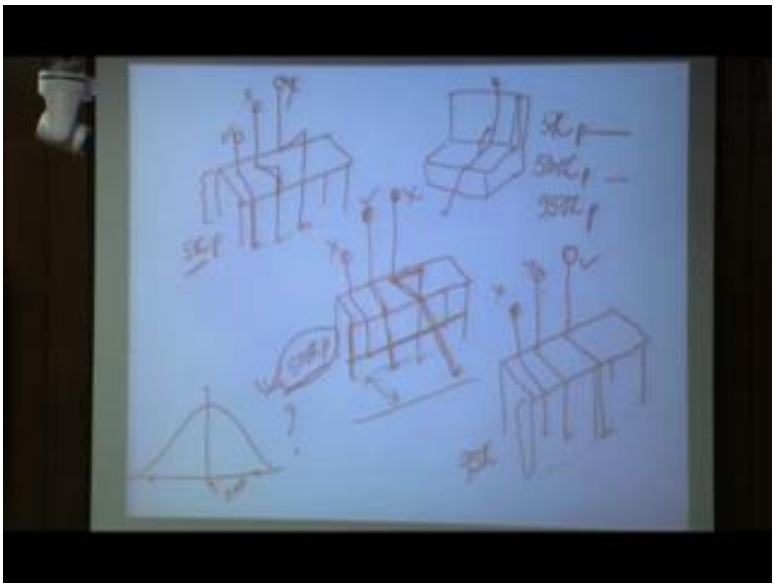

So, it will be easier to show here say for example, for that class room we have to calculate the perpetual and the perpetual height you measured and calculated 5th percentile then 50th percentile and 95th percentile and 98h percentile. So, we know the perpetual height of the students another calculated peak 50th and 98 percentile perpetual height now you want to design a bench. Now, the question is know which percentile data

will you use for this purpose you want to design the lade height of the bench if we ask which percentile of perpetual data should be used for deciding the height of this bench if you answer it is 5th percentile then what is happening one-fifth percentile student he is sitting comfortably its leg is exactly matching with the height of the bench.

So, the 5th percentile student is sitting comfortably because this height this perpetual height is matching with the bench height it is designed as per his perpetual height. So, 5th percentile student is comfortable. So, what about 50th percentile while the above student with above dimension is coming he actually facing the problem of placing that if 98 percentile students come then his perpetual height is what he is also facing the problem of rising only if you design this 1 as per the 5th percentile perpetual height data then 5th percentile is comfortable, but 50th percentile and ninetieth percentile is not comfortable.

Similarly, next no then we will design as per the 50th percentile, if we design as per the 50th percentile what will happen as you have designed as per the 15th percentile. So, 50th percentile student his perpetual height is exactly matching his sitting. He is sitting comfortably it is exactly matching which is perpetual height. Now, 5th percentile student is sitting there his leg is hanging. So, this is design as per the 50th percentile student is comfortable, but 5th percentile, here it is 5th percentile, 5th percentile, 50th percentile, 90th percentile. In this case why we design as per the 5th percentile perpetual height then 5th percentile student is comfortable, but 90th percentile, their 50th percentile that is rising for 98 percentile there is more rising situation.

In case of while you are in 5th percentile for deciding the lade height why you are using 50th percentile perpetual height for deciding the lade height of the bench then 5th percent students are comfortable, but 5th percentile they are leg is hanging and in case of 90th percentile there is a problem of rising, so they are facing the problem rising because this is small in case of them. So, they are not comfortable they are also not comfortable. In third scenario, if you design the bench height as per 90th percentile then what will happen to 90th percentile?

Then 90th percentile students below body dimension, they are sitting comfortably. It is matching with body dimension this height, but they are comfortable. But 50th percentile their leg is hanging and 5th percentile and their leg is also hanging. So, they are not comfortable. So, with percentile data of the perpetual height should we use. So, that most of the student can sit comfortably answer is 50th percentile, but in every case if you use 5th percentile perpetual height data then 5 percent, 5th percentile students with 5th percentile perpetual height value he or she is comfortable, but the people with higher percentile perpetual value they are not comfortable if you use 50th percentile data then 50th for students with 50th percentile perpetual height he or she is comfortable and other students around 50th percentile value are maybe comfortable, but the students at the lower end that is 5th percentile or 90th percentile perpetual height value they are not comfortable.

Similarly, while you are using 90th percentile perpetual height value or designing this lade height of the bench then student with 95th percentile value 90th percentile perpetual height value they are comfortable, but for 50th percentile and 5th percentile their leg is actually hanging. So, what should you do to accommodate more number of people wide range of students, what should we do? We should go for 50th percentile. Why? 50th percentile because if we use 50th percentile value then what will happen good number of student will be accommodated who value is nearby 50th percentile, they will accommodated. If we consider if we recall that earlier the answer is lying here if we look at the normal distribution curve. So, normal distribution curve if we use 50th percentile data then most of the students perpetual height value from that mean value of the 50th percentile value most of the students perpetual height value or lade height value will be near by the value.

So, good number of students will be available to accommodate that 1 because in any population for anybody dimension most of the people for the particular body dimension more number of students belong to nearby average value. For that reason, if we design that bench height according to 50th percentile perpetual height then obviously, 50th percent students with 50th percentile perpetual height they can sit comfortably and also students with little bit more perpetual value, for example, say 60th percentile or 40th

percentile, they can also see if little bit discomfort, but if we use 5th percentile perpetual height for designing the bench then what will happen.

But if you use 5th percentile perpetual height for designing this bench only 5th percentile students their number in mean students with the lower body dimension lower perpetual height value their number is less from the normal distribution curve, it clearly mention that if we see the normal distribution curve more number of people are near by the mean value this mean value is 5th percentile value. But less number of people is there towards 5th percentile or 90th percentile.

So, more number if from this bells shaped curve it appears that more number of students perpetual height value is concentrated around the mean value if we use 50th percentile perpetual data for this purpose then good number of students will be accommodated whose value are near by the mean value or the 50th percentile value, but if we use 5th percentile perpetual height 5th percentile then only the few number of people were at the broad side they will be accommodated, but good number of students whose lade height lade height or perpetual height value is more than the 5th percentile they will be comfortable to sit.

One the other hand if you use 95th percentile then 98 percentage at the this side have percentile value only few students nearby that they may be accommodated there, but good number students whose lade height or perpetual height value is less than the 95th percentile starting from the 98 percentage to first percentage these wide range of students they will find difficulty to accommodate this to use this facility. So, for this purpose also what is the final answer, who use 5th percentile perpetual height value for designing this deciding this lade height of the bench. So, that 5th percentile student 5th percentile student is 50th percentile perpetual height value will be will concede comfortably and all other students whose perpetual height value is nearby 50th percentage. They will also be avail to use that facility and their number is also big.

Because, as we mention from the bell shape curve data in normal distribution pattern is concentrated around the mean value, as we are moving away from the 50th percentile value the number of frequency is gradually or the number of individual in that side is

gradually decreasing more number of people are concentrated around the mean of 50th percentile value in both the end it is gradually reducing. Then what will you do? So, we will use 50th percentile for this purpose then what will happen for others in this case for we are using 50th percentile. Now, 50 percentile concede per 5th percentile or for lower percentile we will foot position who traced. So, we will design a foot trace. So, students with lower perpetual height value they can sit with lower perpetual height value they can sit by keeping their leg on the foot wrist.

On the other hand, what about the 98 percentile? For 98 percentile, we have to suggest them keep their leg forward. So, that they can accommodate their leg, they can rest their thigh on the seat and they can extend their leg forward. So, this is possible. So, instead of rising they can extend their leg forward direction. For that purpose, we have made it sure there is sufficient space. So, that leg stretching in forward direction is possible.

With the same line, if we consider the sofa, while you designing the sofa then what we do then? Generally, sofa height of the sofa is less why because it is assumed that while people are sitting the sofa their posture will be relax posture, while doing relax posture and people will his angle is almost 120 degree or 100 degree then they will extend their weight forward. So, enough height is not required for that purpose because whose is using that sofa, who is sitting on the sofa he or she will extend his leg forward due to his body bending backward while this angle generally, it happens when this is coming more than 100 degree automatically, this angle will become 100 or 120 degree.