Applied Ergonomics
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Lecture – 6

Hello, and welcome to this lecture. This lecture will be covering the rest of the part in which we have the. Previously we have discussed about the cardiovascular system and respiratory systems, their component and their functioning, and other responsible factors for understanding of physical ergonomic part.

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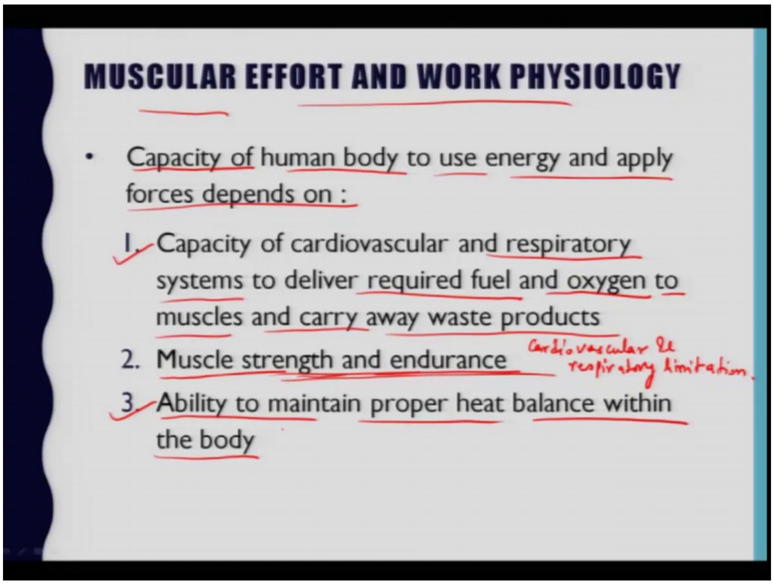

So, now we will focus towards the understanding of muscular effort and work physiology. So, whenever you perform any work in any manual work situation, whether it be a sport or uplifting any device or system, and taking to the other place. So, that muscles expansion takes place and the energy requirement is there so that muscles of the body expends energy and apply forces to perform the work.

So, the capacity of a human body is to use energy and apply forces depends on the following; the first kind of factor is, the capacity of cardiovascular and respiratory systems to deliver required fuel, and oxygen to muscles for energy generation purpose and carry away the waste products. So, again the capacity of the human body to use energy and apply force depends on the muscle strength also and endurance. So, this muscle endurance is dependant largely on the cardiovascular system, and in fact, respiratory systems limitations so that particular thing as a dependent on your muscle strength and endurance, is depended on cardiovascular and respiratory limitations, you can say; and obviously, the building of a lactic acid and other waste products to the muscles.

So, the third kind of dependent factor is the ability to maintain proper heat balance within the body. So, we will also discuss the thermo regulation in detailed in the forth coming slides. So, now, these are the factors, and that is why we need to study about the cardiovascular and respiratory capacity and energy expenditure.

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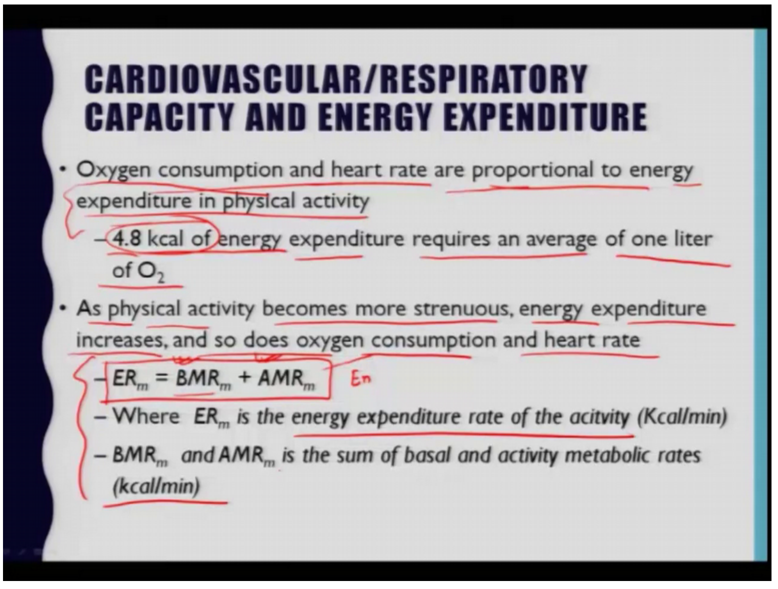

So, now we will discuss about the cardiovascular respiratory capacity and energy expenditure. So, in that, this oxygen consumption and heart rate are proportional to energy expenditure in physical activity. So, that we have even discussed in the previous lecture also, that greater oxygen consumption heart rate and perspiration are three principle reactions, which caused, because of the increased physical demand over the human body; so this rate of oxygen consumption and heart rate.

Now in fact, this rate of oxygen consumption by the body is proportional to the heart rate, at least in the steady state. So, several research studies have demonstrated this proportionality. So, that is particular I have taken from some research paper, and furthermore the amount of oxygen consumed by human engaged in physical activities, is approximately proportional to the quantity of energy expended; so an energy expenditure of this amount. This 4.8 kilo calorie requires an average of 1 liter of oxygen. So, as per the physical activity becomes more stannous energy expenditure increases, and so does the heart rate and oxygen consumption.

So, in this way, if we want to calculate the energy expenditure rate; that is the, that is written here. So, that energy expenditure rate can be calculated with the help of the formula that we have utilized before some lectures; so in this lecture, particularly if we want to calculate this particular expenditure rate. So, we have to sum up the basal metabolic activity, or in fact, basal metabolic rate and this AMR. AMR is the activity metabolic rate. So, both are expressed in kilo calorie per minute.

So, in this way we can find out the estimate of energy rate requirement, which is essential for our calculation and as well as for ergonomic analysis. So, basically this daily total metabolic rate can be determined by summing the energy expenditure rate multiplied by the respective times, during which they apply in a given 24 hours of period, and then adding the digestive metabolic rate in that.

So, the metabolic rate while sleeping is equal to the, this particular sleeping metabolic rate is equal to the basal metabolic rate.

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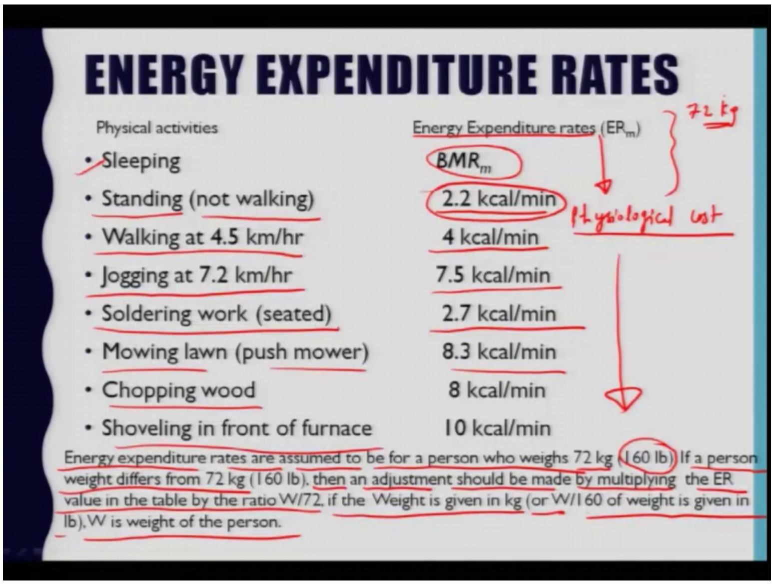

And as well as I will show you there are some of the physical activities and energy expenditure rate that you can analyze with the help of this table. So, here you can see that energy expenditure rate for certain physical activities is shown here. So, like energy expenditure rate, as assumed for to be, for a person who weighs. Let us say 72 kg. So, this energy expenditure rates are assumed to be for a person, who weights 72 kg or 160 pound. If a person weight differs from 72 kg, then an adjustment should be made by multiplying the ER value in the table by the ratio W by 72, if the weight is given in kilogram. And W upon 160 of the weight is given in the pound. So, W were, W is the weight of the person.

So, in the similar way, this energy expenditure rate which can also pronounced as a physiological cost or energy expenditure rate, so for various physical activities. So, here you can see that if you sleep, so your energy expenditure rate is equivalent to the BMR. if you are standing and not walking, so your energy expenditure rate will be 2.2 kilo calorie per minute. if you are walking at mild speed, let us say 4.5 kilometer per hour.

So, your energy expenditure rate will be 4 kilo calorie per minute. If you are jogging at certain speed, let us say 7.2 kilometer per hour, so your energy expenditure rate will be 7.5. If you are in a sitting condition, you are doing some work; so 2.7 kilo calorie per minute, mowing lawn push mower 8.3 kilo calorie per minute, chopping wood, the shoveling in front of furniture. So, there is a series of physical efforts or in a sitting condition or standing or walking or in a running conditions. So, there are defined energy expenditure rate.

So, with the help of which we can calculate our this particular energy expenditure rate, also as a whole and daily metabolic rate, we can also calculate with the help of these defined values.

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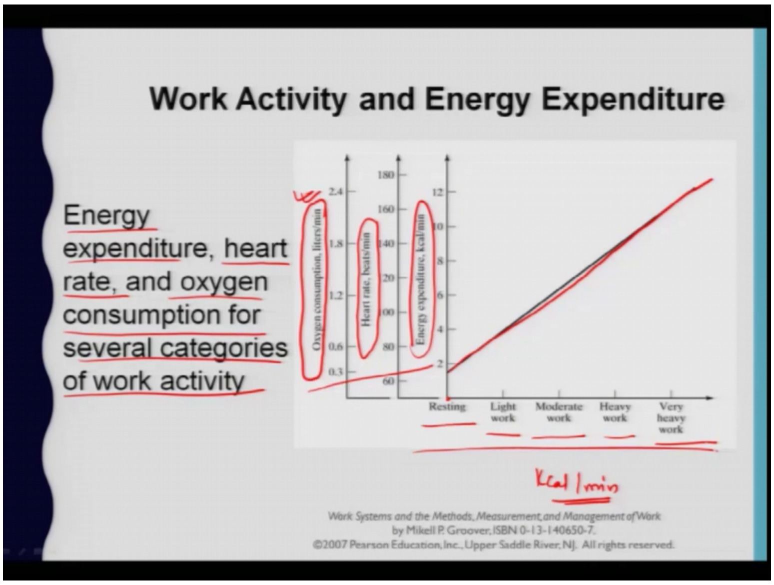

So, now before that we need to understand this particular energy expenditure rate; heart rate and oxygen consumption rate, for several categories of work activity. So, as you can see from this graph, every type of physical activity requires a certain rate of energy expenditure when performed at a study base. So, these energy expenditure rates are some time referred to as a term that I have used recently that physiological cost. So, the physiological cost of the activity to the human body that can be expressed as a kilo calorie per minute. So, here their various work activity; like resting is at the origin light work, moderate work, heavy work, and very heavy work.

So, in that steady phase, there is a constant line that has been drawn. It is indicating that it is proportional to the basically this, if you take this oxygen consumption. So, the rate of oxygen consumed by the body is proportional to the heart rate. Heart rate can be expressed as a beats per minute at least in the steady state, and is also proportional to the, like energy expenditure rate. So, the amount of oxygen consumed by humans engaged in physical activity is approximately proportional to the quantity of energy expended. So, in this way we can have sufficient information regarding this energy expenditure rate, which is related to the certain kind of physical efforts. Now, it is time for doing some numericals.

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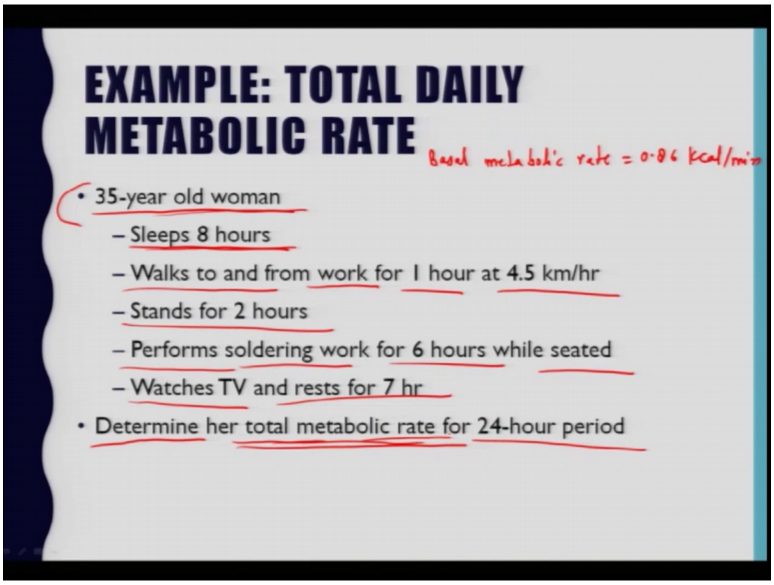

So, I have taken one example to calculate total daily metabolic rate. in this that particular example if you can see from this slide, that a 35 year old woman is there, she sleeps for 8 hours. In fact, you can resemble your case also with this, and you can find out your total daily metabolic rate with the help of, because the activities are more or less similar, and you can also calculate your daily total metabolic rate. So, here coming back to this question that 35 year old woman sleeps for 8 hours. She walks to and from work for 1 hour at 4.5 kilo meter per hour, she stands for 2 hours, she performs soldering work for 6 hours while seated, she watches TV, and rests for 7 hours.

Now, determine her total metabolic rate for the 24 hours, 24 hour period. So, since I have given you this particular physical activity chart, which is giving the corresponding energy expenditure rate. So, based on that you can predict this particular total metabolic rate; so we know that the basal metabolic rate that we have calculated in the previous example as 0.86 kilo calorie per minute.

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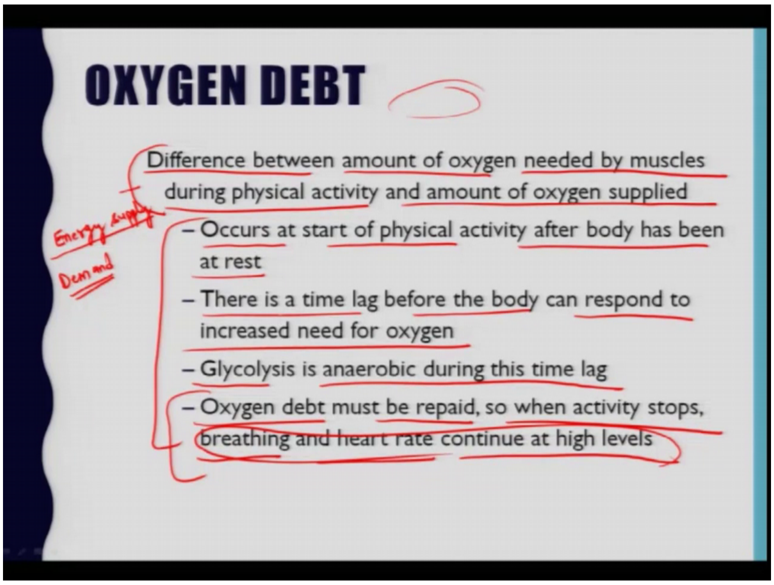

So, that we have since A in the previous lecture, we have calculated the daily basal metabolism for 35 year old woman, who weighs 130 pound. So, that question we have solved in the previous lecture. So, now, we will take help of that, and we can solve for this daily total metabolic rate for 24 hours period. So, now, we have what we have to do. We have to calculate the total energy, so this particular example if you are taking.

So, the basal metabolic rate we have calculated as 0.86 kilo calorie per minute for this value, you have to see at the previous lecture. So, the calculation of total metabolic rate is A, I have summarized in one table. So, I am giving you the solution. So, that you could have a complete understanding of how you can calculate your own energy expenditure rate by putting all sort of physical efforts, and corresponding energy expenditure rate.

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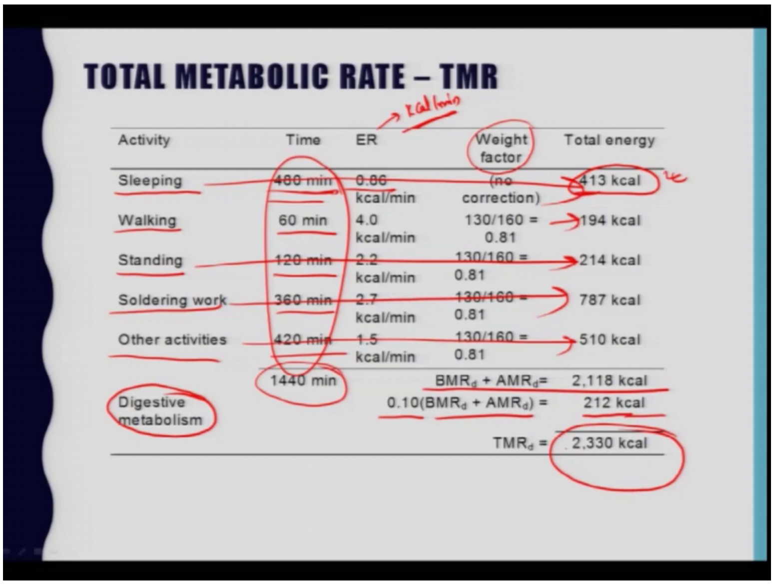

So, these are the activities that has been listed in the question; that is sleeping. So, the sleeping timing is 48 minute, walking 60 minute, standing 120 minute, soldering work 360 minute and other activities 420 minutes. So, this is the given data, and the total as a total minute she is expending as A 1440 minute. So, the energy expenditure rate corresponding to that can be taken from, in fact, this particular table. Now, we have to also consider the weight factor and energy corresponding to that. So, if you multiply with the time and energy rate, you will be having total energy.

So, since energy rate is in kilo calorie per minute. So, if you multiply with minutes. So, kilo calorie will be left. So, total energy is 413 kilo calorie corresponding to sleeping activity for walking activity. This is 194 kilo calorie for standing. The total energy is 214 kilo calorie; soldering work 787 kilo calorie, other activities are 510 kilo calorie. So, if you will add some, everything. So, apart from that BMR, AMR is 2118, but you will have to consider the digestive metabolism, which is 10 percent of this BMR plus AMR. So, it comes out as a 212 kilo calorie. So, now, if you will add those things as a whole, total metabolic rate will come out as a 2330 kilo calorie. So, this is the kind of solution that is required here.

So, now the next thing is oxygen debt. So, we will try to understand what this oxygen debt is all about; so here if you can see this slide. So, there is a difference between amount of oxygen needed by muscles during a physical activity and amount of oxygen supplied. So, suppose this, why this oxygen debt is coming into picture, because there are times when demand for energy by the muscles is greater than that can be supplied by the reactions, that we have listed in the previous slides. So, this imbalance between energy supply and demand occurs at the beginning of the physical activity, after body has been at rest. So, immediate or asking the body on immediate the physical effort. So, body sudden gives you some sort of debt, and then when you take rest. So, that regaining of that particular debt takes place. So, that oxygen debt is, that is coming in that way.

So, in order to fulfill the demand of the present movement were that itself can be easily understand with the basis of these four lines, that occurs at the start of physical activity, after body has been at rest. And there is a time lag before the body can respond to, increase the need of oxygen, and the glycolysis is anaerobic, during this time lag the oxygen debt must be repaid. So, when activity stops breathing and heart rate continue at high levels in order. Why this. These are the reactions that you get when you sudden force yourself in the running, and then when you stop running then, or even then also your breathing and heart rate does not stop.

So, even that continues at a high level. So, that is the oxygen debt that is happening there. So, the continues oxygen supply is required in order to perform the work, as well as when you stop and in order to maintain that steadiness in the various parts of the body.

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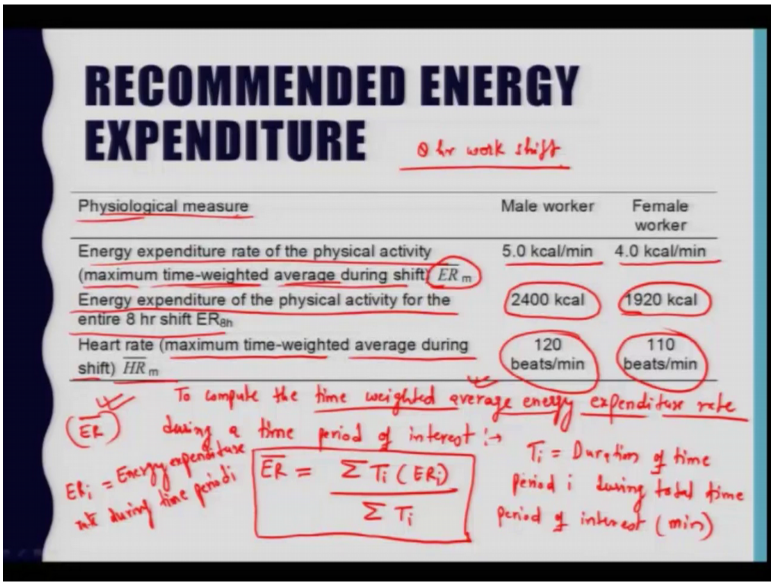

So, as per as recommended energy expenditure limit is concerned; so for the physical being, physical well-being of a worker. So, it is important that workers energy expenditure rate and heart rate be kept within a reasonable limit over the course of a shift. So, numbers of recommendation have been proposed in the ergonomic literature.

Let us say for an 8 hour shift this particular table that has been provided, it listed out the guidelines and which are representative here. So, the guideline values assume that the male and female workers are in very good physical condition. They do not suffer from any chronic debases. So, in that context these are the recommended guidelines for energy expenditure, and heart rates for an 8 hour, for an eight hour work shift that if you would look at the physiological measure. So, energy expenditure rate of the physical activity that can be expressed as a maximum time weighted average during shift. It is expressed in the bar ER for male worker, this 5 kilo calorie per minute, and for female worker 4 kilo calorie per minute.

So, as far as energy expenditure of the physical activity for the entire 8 hour shift; it is 2400 kilo calorie for male worker, and for female worker it is 1920 kilo calorie, and as far as heart rate is concerned; that is expressed in the maximum time weighted average during shift. So, it is 120 beats per minute is recommendable, and for female worker 110 beats per minute is recommended. So, the value of energy expenditure rate and heart rate is given here. And in order to calculate this, time weighted average energy expenditure rate during a time period. So, we can use the equation that I am going to write here.

So, in order to compute mathematically if you want to calculate, so to compute the time weighted average energy expenditure rate during time period of interest can be. So, it can be written as. So, energy expenditure rate can be determined by the summation of total time multiplied by energy expenditure upon total time. So, were this ER is the time weighted average energy expenditure rate. So, this is the ER time weighted average energy expenditure rate; that is ER bar. It is expressed in the kilo calorie per minute, and Ti is the duration of time period. Let us say I, during total time period of interest which can be expressed in a minute.

So, ERI, basically this is ERI. So, ERI is energy expenditure rate during time period, I and the summation is carried out over all the individual periods o in the total time period.

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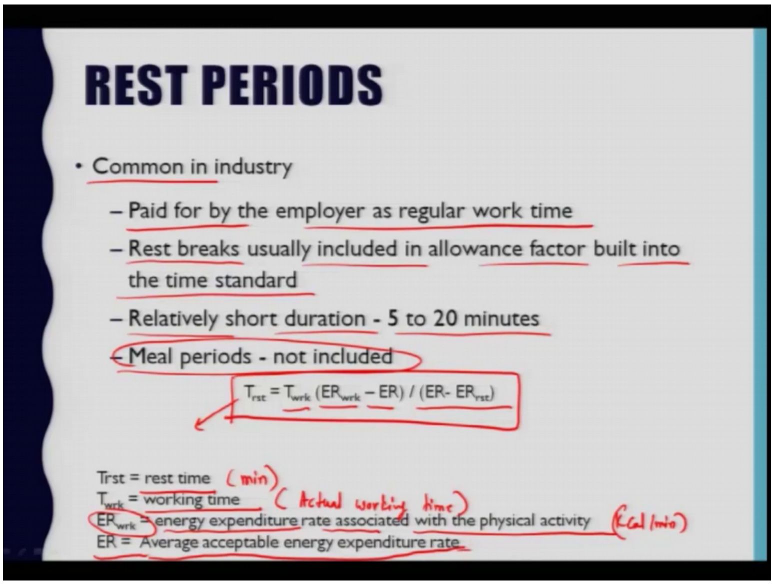

So, this particular oxygen debt turn in fact, one of the. So, there is one more topic that is very essential in most of industry workers that is rest period. So, a person cannot work efficiently for a prolong work, prolong period of time. So, it requires rest. So, that rest period generally is a bit common in industries. So, and they should be included and paid by the employers in fact, paid for by the employers as regular work time. So, in most of the situations rest breaks are of relatively short duration, that can be lasting from 5 to 20 minutes, according to the US Department of Labor, and this rest breaks are often included in the allowance factor; that is built in to the time standard for a task.

So, on the other hand, that meal period, in fact, that lunch period, is not going to be counted as a rest break. So, they are not included in the time standard, or paid for the last paid for as work time; so usually a 30 minutes. So, these things are very important as far as rest period is concerned. So, this is bit common in industry, this is paid for by the employers as regular work time rest breaks. Usually included in allowance, factor builds in to the time standard relatively short duration. It is about 5 to 20 minutes, and meal period is not included in this rest period.

So, overall if you want to calculate mathematically that rest period; so there is a formula through which you can calculate this rest period. So, in this way you can predict the rest period, this will give you just a rough idea about how much time you are working continuously, and in that continuous work what period of, like what span do you have to spend for as a rest period. So, this is a formula that T rest equals to T work ER work minus ER upon ER minus ER rest, in which this T rest is the rest time, which is expressed in the minute. This T work Twrk is the working time, it indicates that how much time the worker spends actually working.

It is a actual working time, and another thing is ER wrk, it is energy expenditure rate associated with the physical activity; that is expressed in the kilo calorie per minute, and ER is the average acceptable energy expenditure rate.

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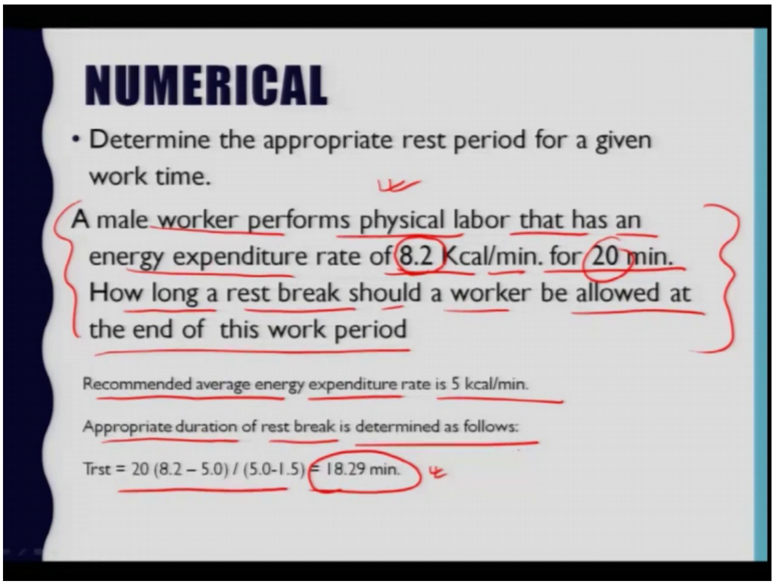

So, now it is time for solving one numerical. So, this numerical is for you, it is just about putting the appropriate value to this formula, and your job is done. So, the kind of question that I have put for you, is to determine the appropriate rest period for a given work time. So, a male worker performs physical labor that has an energy expenditure rate of 8.2 kilo calorie per minute for 20 minutes. How long a rest break should a worker be allowed to the end of this work period. So, in these situations you can also find your rest period with the help of the given data. So, since recommended average energy expenditure rate is 5 kilo calorie per minute.

So, the appropriate duration of rest break is determined as follows. So, the formula that you have to use, that I have mentioned in the previous slide. This is the formula that you have to use as T work ER work minus ER upon ER minus ER rest. So, this all the values, that is appropriately telling what particular the value is this, this and. So, these values you have to put in the formula, and you will get the result as a rest period. So, in this condition, the rest period that a person has to, male worker has to be given is 80 18.29 minutes.

So, that is all for now.

Thank you.